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ABSTRACT

This document is intended for anyone having the responsibility for the policy or the practice of examination and selection systems in physics, whether at the completion stages of secondary education, or the entrance stages of higher education. The book contains 13 chapters written by authors from 11 different countries. Each chapter was written and/or edited to include the general features of: the country's system of entrance examination; the results and uses for university admission; the examination methods used; the statistical analysis of results; the links with schools, teachers, and pupils; and opinions on the quality and the effects of using the examinations. The chapters presented, including participating countries, are as follows: (1) "Introduction to the Study" (Paul Black); (2) "Entrance to the University of Botswana" (Wacek Kijewski); (3) "University Entrance in Brasil" (Marcos de Fonseca Elia and others); (4) "The National Examination in China" (Shu-tong Cong); (5) "The National Examination in Egypt" (R. Kamel Wassef); (6) "The French System of Entrance Examinations (Francoise Langlois); (7) "National Entrance Examinations in Hungary" (Ervin Gecso); (8) "The University Tests in Japan" (Tae Ryu); (9) "University Entrance in Poland" (Tomasz Plazak; Zygmunt Mazur); (10) "Sweden - School Assessments and Central Tests" (Kjell Gisselberg, Gunilla Johansson); (11) "The A-Level Examination in the U.K. (Ken Dobson); (12) School Grades - Standard Tests the U.S.A. System (E. Leonard Jossem); and (13) "Issues and Comparisons" (Paul Black). ZWH

PHYSICS EXAMINATIONS FOR UNIVERSITY ENTRANCE

An International Study

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PHYSICS EXAMINATIONS FOR UNIVERSITY ENTRANCE

An International Study

Prepared under the Auspices of the International Commission on Physics Education

Sponsored by UNESCO

Edited by Paul Black

Education Sector

UNESCO

ED-92/WS-15

PREFACE

The document series has been established as part of the UNESCO Science and Technology Education Programme to encourage the international exchange of ideas and information, cooperation and mutual understanding.

This volume, developed at the initiative and with the collaboration of the International Commission on Physics Education of IUPAP/ICSU addresses Physics Examinations at the College Entrance level, drawing on experiences from 11 countries.

It is hoped that University professors, who have to set and administer entrance academic requirements, school systems personnel in charge of establishing objectives, curricular experiences and evaluation in secondary education as well as teachers and practitioners interested in assessment will find in this volume a useful reference.

There is no intention to precribe any particular content or technique, rather it is to discuss the issues involved and present ways in which they have been addressed in diffrent contexts and cultures.

UNESCO is indebted to Dr. Paul Black, the editor of this volume, for his leadership and dedication as well as to the authors of the different chapters who have generously shared their experiences and insights. The views and opinions expressed herein are those of the editor and authors and not necessarily those of UNESCO.

ED/92/WS/15

Physics Examinations for University Entrance

An International Study

Contents

Editor's Acknowledgements

The idea for this book arose from discussions in the International Commission on Physics Education. Its members, and particularly its chairman Professor Leonard Jossem, promoted and helped to develop the idea from a discussion point to a productive project. Through their interest and support, the help and involvement of UNESCO was secured, and particular thanks here are due to Raphael Ferreyra for his positive interest in and help with the implementation of the project.

The heart of this project was a two-day workshop held in August 1991 at the Nicolaus Copernicus University in Torun, Poland, immediately after the biennial conference of GIREP - the International Group for Research in Education in Physics. The organisers of that meeting cheerfully bore the task of looking after an additional meeting, and to them, including particularly Professor Jamiolkowski, Dr. Jozefina Turlo and Dr. Magda Staszel, I would like to express thanks. They made it possible for the authors from the several countries involved to complete two days of intensive work which laid the foundations for the chapters which are collected in this book.

This leads naturally to the last acknowledgement, which is to the authors of the chapters from eleven different countries. They have accepted a common brief, produced their manuscripts in English, kept admirably to deadlines and answered their editor's queries and requests with prompt courtesy. My particular thanks to them are coupled with thanks to the many others who, by suggesting suitable authors and, in several cases, by working to formulate the task and then passing it on to colleagues better equipped than themselves, have helped to achieve authoritative contributions from all of the countries. To all of these I couple thanks with an expression of hope - that I have not distorted their message too much by my editing.

March 1992

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Chapter 1 : Introduction to the Study

Paul Black

For Whom is This Book ?

Anyone having responsibility for the policy or the practice of examination and selection systems in physics, whether at the completion stages of secondary education, or at the entrance stages of higher education, should find this book to be directly relevant to their work.

It should be of more general interest to several broader audiences, as follows :

- physics teachers and examiners in upper secondary schools and in the first years of university work

- those with interests and roles similar to the above, but in other areas of science education

- readers with particular interest in the study of assessment systems and techniques

- anyone who, being interested in the recruitment and supply systems for future physicists, believes that the secondary/tertiary interface is a very important component of that system.

The Origins of the Study

The idea for this study first arose in meetings of the International Commission on Physics Education. Given the importance of examinations on the development of physics education, it was felt that a study which could report on practices and lead to critical and constructive comparisons between different countries could have an important influence on the future of physics education.

It was clear that with very modest financial resources, any venture would have to be limited in scope and designed to take full advantage of our richest resource, the expertise and commitment of those associated with the commission. The limitation accepted was to study one level of examination. The level was chosen and defined as the examination system which a country uses to decide entry to university education, in particular to degree courses in physics.

No choice could have ensured strict comparability between countries,

given the diversity of educational systems. The advantages of the choice made were threefold. First, the definition was largely free from ambiguity. Secondly, the importance of this level of examination is evident, given its influence on the lives of young people and on the recruitment of future physicists. Thirdly, interest in it is very strong across the physics education community because it is the interface between the school and higher education sectors.

It was of course clear that there would be difficulties. An examination in physics, like any other instrument that acquires any operational significance, cannot be understood except as a product of the social and intellectual context in which it functions and for which it is produced. Our study could recognise this, but its capacity to explore the contexts in depth would clearly be limited.

At the same time, there would be an objective feature : one set of physics examination questions can be judged as more insightful and effective than another, even when the two are produced for identical purposes and within the same constraints. Physicists across the world can understand one another's questions better than they can understand one another's societies, and many would be more interested in learning from these products than in learning why and how they are produced and used. Thus, there has been a tension, between producing a case study in comparative education in physics, and producing a source book of physics questions. In the event, a compromise has been struck.

Developing the Idea

The originally vague aim was sharpened into a design for a book, which would comprise a set of chapters, each about the system in one country, and some commentary. The choice of countries was made by combining ideal criteria with practical possibility. The ideal criteria involved representation across the whole globe, across different cultures and political systems, across different educational systems and traditions, across different stages of wealth and economic development. The practicalities were of two sorts. The commission had to identify an author or authors in each country who would be both knowledgeable and willing. The number of countries had to be set by a compromise between adequate range and variety on the one hand, and adequate detail per country within the limitations on the overall length of a book. The outcome is to be seen in Chapters 2 to 12.

The content for each country chapter was first proposed by postal circulation leading to the collection of specimen questions with explanatory text. Those so involved were then invited to join a two day workshop in August 1991, held immediately after the end of the biennial international conference of GIREP - the Groupe International de Recherche sur l'Enseignement de la Physique. Thus, for two days, a group

of about twenty met on the campus of the Nicolaus Copernicus University in Torun in Poland and listened to descriptions of the systems in one another's countries. This led to debates about the structure of the book, ending with agreement on a uniform structure to be adopted by all contributors. One author, Ken Dobson, wrote a draft chapter within a fortnight and this was circulated to the other contributors as a model, with the formal specifications.

The outcome of the agreements made in Torun was the eleven chapters which follow. They have been edited, more or less heavily according to need. It was agreed by the authors that the chapters should not necessarily be of uniform length; some examinations, such as the Nuffield examination in Britain, would need more space to bring out and exemplify features of interest which were not found elsewhere. It was agreed that as much space as feasible should be found for sample questions.

Structure of the Country Chapters

Each chapter has been written and/or edited into seven main sections as follows :

General Features of the Country System
The Results and Use for University Admission
The Examination Methods Used - General Outline
- External Examinations
- Internal Assessments
- Preparation and Marking
Statistical Analyses of Results
Links with Schools, Teachers and Pupils
Opinions on Quality and Effects.

Sample questions, which would be particularly relevant to the third of the above sections, are not incorporated into the main text, but are placed at the end of each chapter. Of the country chapter pages, about 30% (54 pages) are devoted to sample examination material.

There are variations between the chapters. Variations in the content and internal sequence of the main sections have been preserved where the nature of the required explanations justified them. It has been possible for some countries to produce data which are just not available in other countries, so some give details and data which others lack. The numbers of pages of exemplary material varies, between 3 and 11, across the chapters, largely because there is a much greater range and variety in some countries than in others. Authors were not required to offer bibliographies, but some did so and these have been incorporated.

Issues and Questions

The reaction at the Torun workshop as participants heard about their different systems was of interest, intrigued surprise, occasionally amazement, as the various stories unfolded, coupled with puzzlement over details about how this or that system operated, or ever could operate, in practice. Such puzzlement is in part an inevitable reaction to an account of an unfamiliar system. It is to be hoped that the dialogue at Torun, and the chapter structure which emerged from it, will help to ensure that the accounts are as fully explanatory as possible.

The interest, intrigued surprise, and occasional amazement, bear on the principal aim of this book. History, traditions, social and political needs, and a variety of influences, including international exchanges, have combined to produce systems which reveal on comparison, a complex pattern of similarities and differences. Any one feature could be used to place the eleven countries studied here into a set of categories. However, in respect of other features, there would then be strong differences between those within any one category and equally strong similarities between some in different categories. For this reason, no simple categorisation has been attempted. The country chapters are not presented in a set of groups or in any significant sequence - the sequence is alphabetical by name of country.

For rather similar reasons, no editorial commentary is offered with individual chapters. Such comment could serve the function of directing the reader's attention to particular features in a chapter. This editor feels that, given the uniformity of structure and presentation between chapters, the striking features of each will make themselves known. At the same time, every chapter gives a picture, in its particular combination, of features which should be looked for in all. Commentary on these will be offered in the closing chapters.

It could be useful, however, to list at this stage some of the issues which readers might bear in mind as they study each chapter. This list is not exhaustive - others might find different ideas equally important. It is intended as a stimulus to the making of comparisons between countries. Such comparisons are particularly important here because this is one route by which this study could encourage fresh thinking, both about the need to improve physics examinations and about ways in which such improvement might be secured.

National systems may be described as controlled or free. The physics syllabus may be specified by a national government, by a local authority, or left to the choice of schools. In the latter case, it may be that there is indirect control on schools, notably by those who set the examination targets which the school must help their pupils to attain. Similar distinctions arise with regard to textbooks.

With regard to examinations, entrance to universities may depend on national examinations, on examinations set by universities themselves, or by results of both of these. Where there is no central examination, there may be one or many sets of examinations - depending on whether and how universities collaborate or accept examinations conducted by other bodies.

A very important variable is the proportion of any one age cohort which reaches the top end of secondary schooling and the degree of selectivity imposed at this stage to limit the numbers entering university education. There are wide variations here, which affect the importance of examinations and the levels of performance in them which matter. The ways in which performance data are combined or aggregated may also be important, for example because they can determine whether or not performance in physics is particularly significant in entry to physics courses

The role, of the schools themselves and of their teachers, in providing their own assessment information about their students, and the importance given to this information, are also interesting aspects. Linked to this are the scope and seriousness of any liaison and feedback links between the schools, any external examining systems and those in universities who operate the associated selection systems.

For the actual examinations themselves, the nature, variety and scope of the types of examination instrument used can be strikingly different between countries. The aims that these instruments test and reinforce require careful scrutiny, which should be linked to questions about the validity of the examination. Issues of reliability also arise, and here the sophistication and degree of care taken in composing the examination instruments, and in analysing their outcomes, is an important feature.

More difficult to compare are the qualities, and in particular the levels of difficulty, of the questions or other demands made of pupils. The samples available here have to be judged against the level of performance required on those items, as well as against the proportions of the age group who are to be selected by the examinations.

Finally, there are two ultimate questions that arise. Does the examination system select the best people, and does it have positive and helpful rather than negative and restrictive, effects, on the quality of teaching in schools? The first of these questions is almost impossible to answer.

Chapter 2 : Entrance to the University of Botswana

Wacek Kijewski
Wim Kouwenhoven

General Features of the Country System

Botswana is a land-locked, semi arid, sparsely populated country covering the Kalahari Desert in Southern Africa. It is similar in size to France but the population of about 1.4 million is smaller than that of the Polish capital Warsaw. It became independent in 1966, after being a British protectorate. After years of poverty the country now experiences one of the highest increase in GNP in the world due to the export of diamonds and beef. Half of the population has an age below 15.5 years. Naturally this puts pressure on the education system. Free education in Botswana has been gradually introduced since 1980.

The Botswana formal education system has three phases:

- 7 years primary education
- 5 years secondary education (divided into 2 years junior secondary education and 3 years senior secondary education)
- tertiary education

The Government of Botswana is committed to a system of 9 years basic education for all. At this moment about 60% of primary school leavers are admitted to the junior secondary schools. It is expected that this percentage will increase to 80% in 1996 (the end of the coming development plan period). However, it is projected that by 1996 access to the senior secondary schools will have dropped to 25% of the junior secondary completers. The higher education system is, in general, strictly oriented to manpower needs.

Tertiary education is given in various institutions. There is only one university: The University of Botswana in Gaborone. It has four faculties: education, humanities, social sciences and science. There are affiliated faculties of engineering and agriculture. For training in other fields, such as medicine and architecture, students go abroad. The university is basically an undergraduate institution and has only recently started to offer master's courses. Other institutions for tertiary education are the Polytechnic, the Agricultural College, the Colleges of Education (for junior secondary teachers) and the National Health Institute.

The 23 government aided senior secondary schools finish with the Cambridge Overseas School Certificate (COSC) examination at the ordinary level ('O'-level). There is one private school which also offers

'A'-level (advanced level) courses. Almost all the students go abroad after obtaining their A-level certificate and do not continue with tertiary education in Botswana.

In order to qualify for admission to the University of Botswana, and similar post-secondary institutions, secondary school leavers have to attend a year of Tirelo Setshaba, the national study/service scheme.

The main route to science degree studies, including physics, is the Pre-Entry Science Course at the University of Botswana (PESC) which students enter after the COSC O-level exams and the year spent on Tirelo Setshaba. This course was started in 1977. Its objectives are to upgrade secondary school leavers in the basic sciences and mathematics, to improve their use of English in scientific communication and to compensate for differences in the programmes followed by students at secondary schools : in short, to prepare students for academic work. The course runs from early January until the end of July. In this way the course fits between the moment students leave the Tirelo Setshaba scheme in December and the start of the university academic year in August. Most of the students in PESC are of the age 18, 19 or 20, although older students are not uncommon.

This chapter will describe the PESC examination, which serves as the university admission examination.

The subjects taught in PESC are Mathematics,Biology, Chemistry, Physics, English, Study Skills and Computer Awareness. The courses aim to remedy any deficiencies in the secondary school knowledge and so bring all students to a 'good O-level standard', but also to upgrade to a level beyond the secondary school syllabus. A further component of the course is an extensive programme of career guidance.

The course started as a project funded by the Dutch Government in close cooperation with the Free University of Amsterdam (FUA). In 1982 the project became a normal department within the Faculty of Science at the University of Botswana. FUA continued to support the programme by providing assistance in setting up a computer awareness course, creating computer assisted remedial programmes and where necessary giving assistance in educational research.

Students can be recommended for a degree study in science, or for the Diploma in Mathematics and Science Education programme, at the university on the basis of their PESC results. Some students are not recommended for a science course at university level.

In the past, students were admitted to PESC after a selection procedure based on selection tests. After the introduction of the compulsory year, Tirelo Setshaba, the PESC department could know the COSC examination results before the admission date, so it was decided from 1989 that selection for PESC should be based on COSC results only.

During PESC the time spent on Physics is about 20% of the total teaching time. This compares with the proportion of time which may be spent on physics - between 15% and 20% - in the last two years of secondary school. Students in the specialist science stream at senior secondary school study physics as a separate subject, together with mathematics, the two other sciences and other subjects. In the last two years 6 periods per week are used for each science and 7 periods for mathematics. About 80% of the PESC students have studied Physics as separate subject at Senior Secondary School; the rest will have studied some physics as part of a more general science course.

The physics course consists of five units, the topics being scientific method and motion, motion and force, force and energy, electric circuits, and electromagnetism.

Those who pass in PESC may, after a common Year 1 in the Science Degree programme, continue their education in different directions. Options are the BAgr (agriculture), the BEng (engineering), the BEd (education) and the BSc programme. Students continuing in the BSc programme may go abroad after the second year to study for science based degrees not offered in Botswana, such as medicine. Students who continue in the science degree programme can take physics as a combined, or as a single, major.

Table 1 gives an example of the enrolment of students into Year 1 of the science degree programme in the academic year 1990-1991.

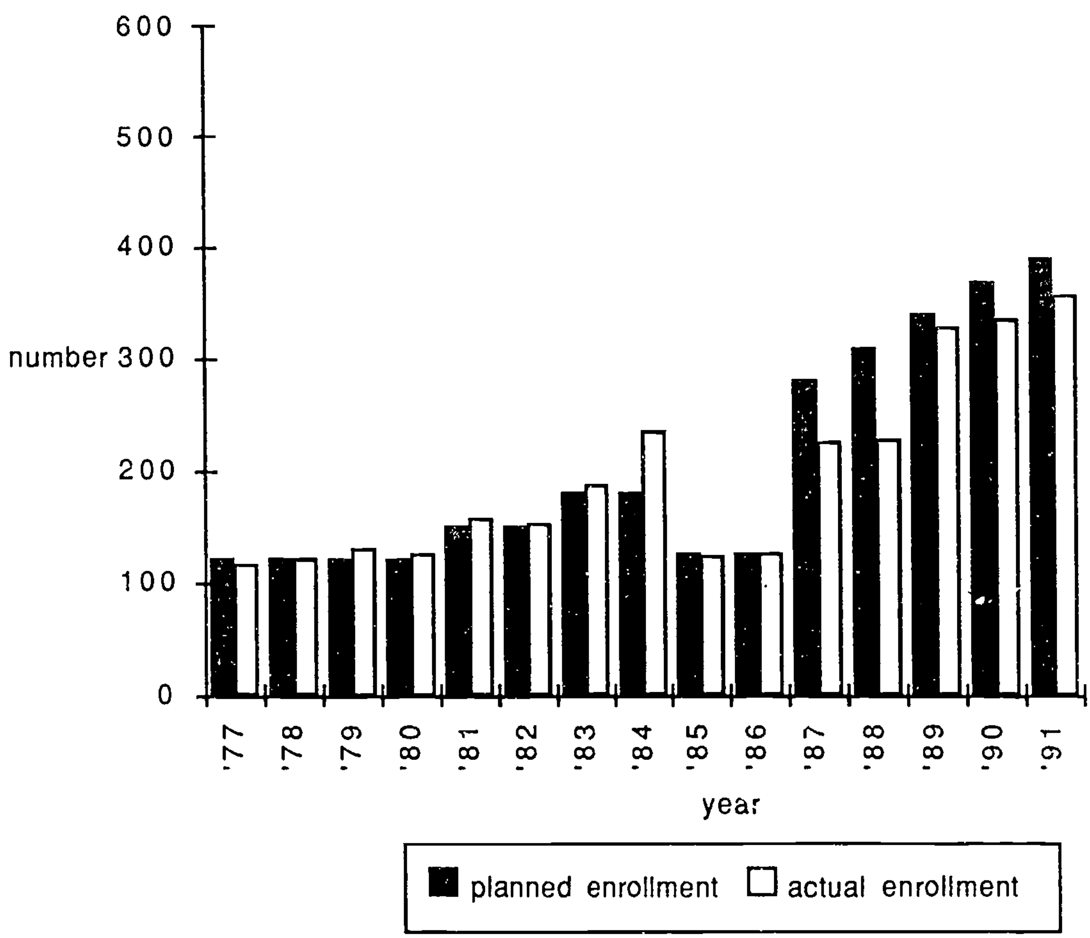
Table 1 : Numbers and Enrolments at Various Levels in Botswana

	MALE		FEMALE		TOTAL	
	N	%	N	%	N	%
Total number in age group:	57000		69000		126000	
Number in Form V (Sen.Sec., 1988):	1994	3.5	1405	2.0	3399	2.7
Number writing O-level Physics					850	0.7
Number entering PESC 1990:	268	0.5	53	0.08	321	0.25
Number completing PESC 1990					260	0.21
Number taking Physics in Yr 1 (BSc) '90/'91:	142	0.25	29	0.04	171	0.14
Number (estimate)graduating BSc with Physics 1994:					15	0.01

The number of students writing COSC examinations is increasing (e.g. 4656 in 1990), but in percentage terms the number of students writing physics is decreasing (25% in 1988, 21% in 1990). In the COSC examination a pass with credit is given for grades 1 to 6, a normal pass for grades 7 and 8 while a grade 9 is a fail. For physics in 1988, about 47 % of those taking COSC obtained a pass with credit, whilst for those admitted to PESC the proportion was 83 %. The girls admitted to PESC had a much lower rate of physics credit than the boys. The minimum requirements for entry to PESC are now a grade 7 in the three main sciences and a grade 4 in mathematics.

Of the 336 students who entered PESC in 1990, 278 completed successfully. Of these, 278 passed in mathematics and 251 passed in physics. In their subsequent study, about 70% of those who were successful chose a First Science course with physics as one of the main subjects and a further 15 % chose corresponding diploma courses; 50 of the 58 who failed had intended to take such courses.

Figure 1 : PESC Enrolment From 1977 to 1991



PESC is still expanding, in line with the Government's priority for the training of manpower in the science based professions. Figure 1 shows the enrolment into PESC over the past 15 years : the projected intake for the near future presumes a continuation of the upward trend which started in 1987. The 'dip' in the enrolment in 1985 and 1986 is due to the fact that Tirelo Setshaba became compulsory in 1985; half of the intake did TS first and enrolled in 1986, the other half did PESC first in 1985 and completed TS at a later stage. Over these years, the proportion of those entering PESC who have been admitted to a degree course has fluctuated between about 68 % and 44 %, whilst the proportion who have either left or failed to obtain recommendation for a degree or diploma course has fluctuated between about 13 % and 29 %.

The average results in PESC physics do not fluctuate much over the years.Table 2 shows results for the past four years. Tests are kept similar over the years so that the average values in the results may be compared.

Table 2 PESC Physics Results - Expressed in Percentage Marks

YEAR	MEAN	STAND. DEV.
1987	60.6	10.8
1988	60.4	9.0
1989	59.1	10.7
1990	62.1	10.2
1991	61.3	10.5

The Results and Their Use for University Admission

Admission into the BSc programme is based on the results obtained in PESC. Because students may drop one science subject in Year 1 of the BSc programme they may score in one science subject as low as 30%. The bottom line for the other two science subjects is 40%. The minimum score required for mathematics is 50%. An additional condition is that students should have at least two subjects out of mathematics and the three sciences at 60%.

Table 3 gives the results in PESC physics of those who completed PESC and of the students who went on to take physics in Year 1. It can be seen from this table that more than 80% of the students studying physics in Year 1 passed PESC physics with a score of more than 60%.

Because access to the science degree programme at the University of Botswana is determined by the performance in PESC, no external examination boards are involved. The PESC department itself tries to monitor the keeping of a uniform standard from year to year ; Table 2 above is relevant to this point.

Table 3 : Physics results in PESC 1990

RESULTS	MALE			FEMALE			TOTAL		
	N	(N*)	%	N	(N*)	%	N	(N*)	%
< 30%	1	(0)	0.4	0	(0)		1	(0)	0.4
30 - 39%	1	(0)	0.4	1	(0)	2.6	2	(0)	0.8
40 - 49%	29	(1)	12.9	5	(0)	12.8	34	(1)	12.9
50 - 59%	54	(20)	24.0	17	(13)	43.6	71	(33)	26.9
60 - 69%	92	(78)	40.9	13	(13)	33.3	105	(91)	39.8
70 - 79%	39	(35)	17.3	3	(3)	7.7	42	(38)	15.9
> 80%	9	(7)	4.0	0	(0)		9	(7)	3.4

The numbers N and the %'s refer to the overall results.
(N*) are those who went on to take physics in Year 1.

The Examination-Methods Used

The physics course within PESC is divided into 5 units. The first 4 units consist of 4 teaching weeks and the fifth unit consists of 3 teaching weeks. In total there are 19 teaching weeks in the course, and in each week there are 2 hours of lectures, 4 hours of practical work and a 1 hour tutorial.

At the end of each unit a unit test is given. During the whole course 2 practical tests are given, usually on mechanics and electricity and at the end a final practical test is held which covers all units. A theory post test at the end of the course covers all material from the five units. The final mark is based upon the marks scored in the tests, with weightings of 10% to each of the 5 unit tests, 25% to the theory post-test, 7.5% to each of the course practical tests and 10% to the final practical test.

The unit tests and the theory post tests have the same structure. Each consists of two parts: section A and section B. Students have to answer all questions in both sections. Section A usually has 30 multiple choice questions with one correct answer out of five alternatives. No working is requested. This section is designed to test basic concepts and ability to solve problems from different areas of the syllabus. Example 1 shows 5 questions from the 1991 final post-test.

In setting and selecting the multiple-choice questions, the following criteria are used : -

- the multiple choice part should cover the whole of the course material;
- a test should start with some easy questions and gradually get more difficult;
- the questions should not demand too much arithmetic;
- answers, including reading, should not take more than two minutes;
- guessing by estimation, "clever guessing", should be rewarded.

Section B consists of 6 - 8 open ended questions. Working is required. This section tests understanding, correct analysis and use of logical steps leading to the answer. Some credit is given for a correct approach even if the answer is not correct. Also some credit is given if a certain part in a complex analysis is understood (e.g. correct formula used or correct concept but the answer is not satisfactory). Problems with a string of intermediate answers are avoided. A numerical answer must have a correct number of significant figures and a unit. Example 2 shows two of the questions of this type from the 1991 post-test.

Students are given 150 minutes to complete the whole of the post-test and they have to return the question papers with their answer sheets. The marks are divided between the two sections with 60% for A and 40% for B. Usually the same question is marked by one and the same lecturer/marker for all groups.

Each year, questions from the section A of the previous year are slightly modified i.e. numerical data are changed, letters representing correct answers are reshuffled, and a few questions might be changed completely as a result of analysis of the questions. In this way a uniform standard can be kept from year to year so that comparisons of students' performance can be made. Questions in section B are changed every year; thus, unlike Section A tnese can be returned to the students after marking.

It is difficult to conduct practical tests as there are 12 groups of students, 28 - 32 students in each group, and only 2 laboratories available at any one time. In order to avoid passing of information from group to group when groups have the test at different times, the topics in a practical test, together with all details such as instructions and circuit diagrams, are made known to the students about one week in advance. In the questions, students are tested on their skills of taking measurements, using relevant instruments, building a circuit, drawing a graph and producing a correct presentation of their results with correct accuracy and/or significant figures. Examples 3 and 4 show questions from the final practical test set in 1991. The first part of the test comprises three short experiments to be carried out in 50 minutes; the experiments are set up beforehand. The second part consists of about 6 short written questions testing the skills and knowledge required in practical physics.

Statistical Analyses of Results

Some limited statistical analysis of the COSC O-level examinations is published in the BOTSA Magazine, the journal of the Botswana Science Association. This journal is made available to all science teachers in the country. There has also been some research to assess the reliability of COSC results.(see M. Kahn (1989) The Cambridge School Certificate: how standard is it? BOTSA Newsletter 14, No.1).

For the PESC results, one statistical analysis which is carried out annually is to calculate correlation coefficients between the PESC results and the results both of the COSC and of the students in the Year 1 of the main university course (see G.W. Kouwenhoven (1991) The Predictive Value of COSC Results in the Selection of Students for the Pre-Entry Science Course at the University of Botswana. International Journal for Educational Development , Vol 11, No 1).

Typical sets of correlation factors are given in tables 4 A and 4 B below:

Table 4 A : Correlation factors between the COSC and the PESC physics results.

	PESC'88	PESC'89	PESC'90	PESC'91
COSC'86	0.55			
COSC'87		0.42		
COSC'88			0.61	
COSC'89				0.59

Table 4 B : Correlation between the PESC and the Year 1 physics results.

	Yr1 88/89	Yr1 89/90	Yr 1 90/91
PESC'88	0.66		
PESC'89		0.50	
PESC'90			0.69

All physics test questions and the results are analyzed for their reliability and validity. For the multiple choice questions (nos 1 - 30 in section A), standard facility and discrimination indices are calculated. The values of these indices for the sample questions shown are given with Example 1. The facility indices give the proportions of students answering a question correctly. The questions which are too easy (90 - 100% correct answers) or too difficult (0 - 30% correct answers) are analyzed; the questions may be

changed or replaced, or the teachers concerned may be asked to change their presentation of the relevant topics.

Discrimination indices are found by taking the difference between the success rates (the number succeeding divided by the total number) on a question of the top 25% of students and the success rate of the bottom 25%. The maximum possible value is 1; if this index turns out to below 0.2, and particularly if it is zero or negative, the question is analyzed in order to examine why the same or a lower number of the best students answered the question correctly in comparison to the weakest students. Often this is due to misconceptions of a certain idea, or the question has some feature which misleads, or it is too difficult for all students so that it cannot differentiate effectively. In such cases, either the question is amended, or feedback is given to the lecturer concerned with a request to improve the presentation of the relevant topic.

Links with Schools, Teachers, and Pupils

Because the COSC examinations are used in the secondary school, there is no direct communication about PESC. However, PESC staff visit the schools yearly to give some feedback to the teachers about the performance of their students in PESC. During these visits students are informed about PESC and the possibilities for a science based career.

In PESC testing is done without any external moderation. The physicists who teach the course in PESC are in charge of designing the tests for continuous assessment and for the final examination. The tests used for continuous assessment are returned to the students and they are provided with answer sheets and marking schemes on the essay type questions (not the multiple choice questions). The examination regulations in the university require that for the final examination the answer booklets remain with the university.

Opinion on Quality and Effects

On entry to the PESC course, students are not confident about their physics. A questionnaire given to students at the start of the 1989 PESC asked to rate the confidence they felt about various subjects in their school (COSC) examinations on a 5-point scale, from very well prepared at 5 to not prepared at all at 1. Table 5 shows the results obtained from about 300 responses, together with the mean COSC grades of the students (where the highest grade is 1).

Table 5: Confidence and Achievement in COSC Examinations

Subject	Mean	Std.Devn.	Mean COSC Results
Mathematics	3.69	0.94	2.2
Chemistry	3.37	0.98	3.7
Physics	2.88	1.04	5.0
Biology	3.39	0.96	3.2

The pre-entry science department tries to create a teaching environment where lecturers are always available to answer questions and to give other forms of general extra help. Because the final and more or less official examinations have a weight of 1/3 in the final mark,the rest being determined by the assessment marks produced during the course and based on unit tests and practical tests, they are not perceived by the students as big hurdles even although they are seen as important.

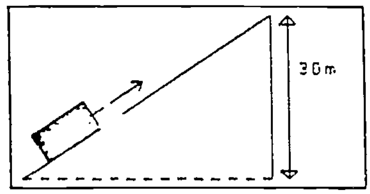
Decisions to continue studying physics are probably determined more by career choices; for example, many male students give engineering as their career preference. As mentioned above, female students seem to have more problems with physics than males. The female students responding to a questionnaire about their preferences indicated physics as one of their least favourite subjects.

Example 1 : Four Multiple Choice Questions from Section A of the 1991 Physics Post-Test

18. A car drives at a velocity of 22 m s^{-1}. Suddenly the car has to brake. The car covers a distance of 55 m while braking. Calculate the acceleration of the car while braking.

A. 2.5 m s^{-2} B. 8.8 m s^{-2} C. -8.8 m s^{-2} D. 4.4 m s^{-2} E. -4.4 m s^{-2}

19. A heavy crate of mass 1.4×10^2 kg has to be lifted up, to a position 3.0 m above the ground. An incline is used for this purpose. The work done by the effort to pull the crate along the incline is 6.5×10^3 J. Calculate the increase in potential energy, and hence find the efficiency of the incline.

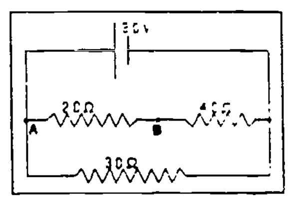


A. 28% B. 65% C. 0.65% D. 82% E. 155%

20. A body is tested for its charge. It is brought close to the plate of a charged electroscope (no contact). The deflection of the leaves will:

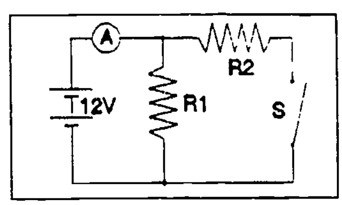
A. Stay the same if the body is positive and the electroscope negative
B. Decrease if the body is negative and the electroscope is positive
C. Increase if the body is positive and the electroscope is negative
D. Decrease if the body is negative and the electroscope is negative
E. Decrease if the body is positive and the electroscope is positive

21. In the circuit shown the battery has a negligible internal resistance. The potential difference between points A and B is:



A. 0.50 V
B. 1.0 V
C. 1.5 V
D. 2.0 V
E. 3.0 V

22. In the circuit shown in the figure battery has a negligible internal resistance. When the switch S is closed the reading of the ammeter is 3.0 A. When the switch is opened the reading is 2.0 A. The values of the R_1 and R_2 respectively are:



A. 6.0 Ω and 4.0 Ω
B. 6.0 Ω and 8.0 Ω
C. 6.0 Ω and 12 Ω
D. 4.0 Ω and 6.0 Ω
E. 4.0 Ω and 12 Ω

The discrimination (D) and Facility (F) values for the above were : -

Question No.	D	F
18	0.52	0.44
19	0.28	0.82
20	0.31	0.85
21	0.52	0.46
22	0.48	0.79

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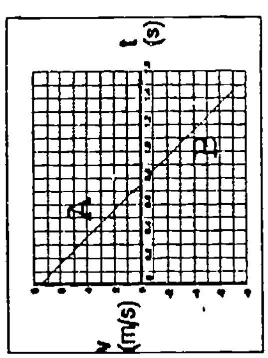
Example 2 : Two Short Answer Questions from Section B of the 1991 Physics Post-Test

The mark scheme for Question 1 assigned 6 marks, 1 each for parts (a)A and (a)B, 2 for part (b) and 1 each for (c) and (d).
The mark scheme for Question 3 assigned 7.5 marks, 1 each for parts (a) and (b), 1.5 for (c) and 2 each for (d) and (e).
There were seven questions in Section B with total marks of 40, out of 100 for the paper as a whole.

SECTION B. SHOW THE WORKING.

NAME AND NUMBER:

1 A ball is thrown up and falls down again. The figure shows the v-t diagram for this motion. The graph stops at the moment the ball touches the ground (t = 1.5 s).



a Describe in accurate physical terms the motion taking place in part A of the motion. Do the same for part B.

Part A ....
....
Part B ....
....

b. The initial velocity is ......
The velocity at the highest point is ....
This point is reached at time t = ...
The maximum height reached is: (show working)

h = ...

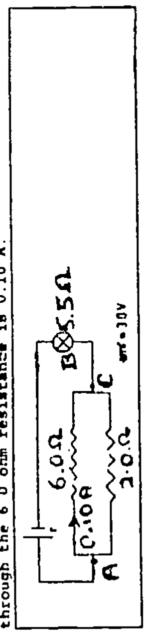
c Find the average velocity for the whole motion.

$v_{average}$ = ...

d Give the direction of the resultant force on the ball in the following cases;

	Direction of resultant force;
In part A of the motion;	
At time t = 0.75 s ;	
In part B of the motion;	

3. A cell has e.m.f. 3.0 V and an internal resistance r. This cell forms the power supply of a circuit as shown below. The current through the 6.0 ohm resistance is 0.10 A.



(a) How much electrical charge passes through the 6.0 ohm resistance in 65 s?

(b) What is the current through the 2.0 ohm resistance?

(c) What is the total resistance between points A and C?

(d) What is the p.d. across the bulb B ?

(e) What is the internal resistance of the cell ?

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Example 3 : Two of the Three Short Experiment Questions from Part I of the 1991 Practical Physics Post-Test.

The circuit diagram shown with Experiment C was not in the original question; it is shown here to illustrate the answer that was required.

Experiment A : Stretching of a horizontal spring

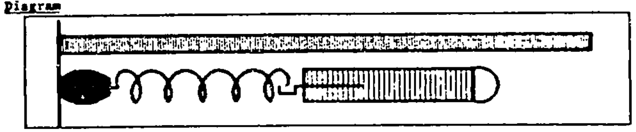
Apparatus

Fixed G-clamp and spring, spring balance, ruler, setsquare.

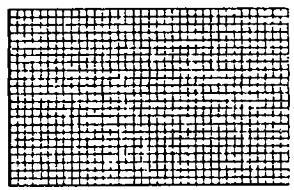
Instructions

You are to determine the spring constant of a spring. The spring will be kept horizontal while stretching. A spring balance is used to apply a force. Realise four measurements including possibly the zero reading on the spring balance and the maximum reading on the spring balance. A graph of the measurements is to be made and from the graph (so not from the measurements) the spring constant is to be found. Clearly show in the graph which values were used for calculation.

Diagram



Measurements



Calculations

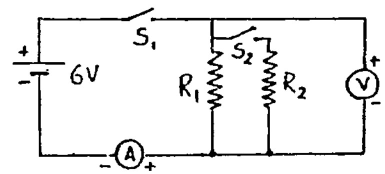
Springconstant:

Experiment C : Resistance

Aim: To determine the resistance of two resistors in the circuit given.

Apparatus

A circuit has been set-up. DO NOT ALTER THE CIRCUIT.
Draw the circuit diagram of this circuit. Include relevant polarity signs.



Measurements and Results

Close switch S1 only and measure the voltage and current. Do this also with both switch S1 and switch S2 closed.
Write down the results of the measurements in the table given below.
Complete the headings first

	Current	Voltage
S1 closed, S2 open		
S1 closed, S2 closed		

Calculations

Use the results to calculate the values of R1 and R2.

R1 =

R2 =

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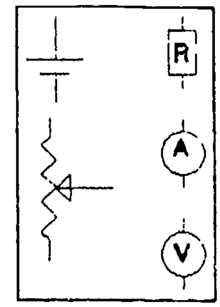
Example 4 : Three of the Six Questions from Part II of the 1991 Practical Physics Post-Test.

3. Mpho was asked to measure the relation between V and I for resistor R.
The apparatus that is available is shown in the box.
The rheostat must be connected as a potential divider.
In the space below draw the circuit diagram of the circuit that Mpho has to build. You may use as many leads as necessary in the diagram.



4. Suppose you have available:

a micrometer screw gauge
a vernier calipers
a meter rule

Which will you use to measure:

1. the length of a matchbox ....
2. the thickness of your room-key ....
3. the height of a table ....
4. the thickness of this paper ....
5. the length of your thumb ....

5. The specific heat capacity was determined in the following way:
The mass of an amount of water was measured.
The water was put in a metal kettle on top of a wooden table surrounded by stagnant air.
There is an electric heater element in the kettle. The stationary water was heated during a measured time.
During that time the voltage across and current through the heater were measured. At the moment the heater was switched off, the temperature increase was measured.

List of apparatus:	Top pan balance	Stopwatch
	Metal kettle with heating element	Thermometer
	Voltmeter	Ammeter

Find at least 3 sources of experimental errors in this experiment and describe ways to reduce those.
Note: You are not allowed to replace any of the listed instruments by more accurate ones. Sources of error must be other than that. You are allowed to add items to the list.

Chapter 3 : University Entrance in Brasil

Marcos de Fonseca Elia
Susana Lehrer de Souza Barros
Sergio Costa Ribeiro

General Features of the Brazilian System

Examination System

Student performance in middle and high schools is assessed within a restricted framework of objectives and standards defined by the individual teacher taking into consideration school directives, with no external components to evaluate, normalize or moderate the results. Lacking in reliability, such school data is unsuitable for selection purposes and, therefore, the universities have to base their selection on external examinations. The only record of 12 years of school studies taken into account is the high school diploma of the candidate.

The external University Entrance Examination (UEE) system has changed over time in line with the social-economical-political demands of the country. For instance, up to the late 60's physics examinations were only required for candidates for university science (natural and bio-medical) and technological courses. Their objectives, programmes and examination papers were organized by the specific faculties. The level was very demanding but, on the other hand, the quality of teaching in the old secondary schools insured the preparation of the students, so that the number of approved students exceeded the number of university places available for them.

This excess contingent of qualified students grew larger and louder at a time politically convenient for the government and, following educational policies recommended by the World Bank, education acts were passed in 1968 and 1971 which transformed drastically the country's educational system.

After 1971, the larger numbers of applicants and the lowering of school teaching standards have given to the UEE system a mass character and it has to deal with far too many unprepared applicants. On the other hand, the geographical dimensions of the country as well as the school differences between the regions (e.g., illiteracy rate in the N/NE region is about 50% and in the S/SE one is 15%) have led to several not necessarily comparable examinations, in spite of the similarity of the programmes on which they are based.

Up to now, the UEEs have consisted of paper and pencil examinations, called "Exame Vestibular", covering the common core academic subjects of the high school curriculum (Biology, Portugese Language and Brazilian Literature, Chemistry, a Foreign Language, Geography, History, Mathematics and Physics). The minimum level required from, and the weight given to, each subject differs between university courses and between geographical regions of the country. Within a given area of knowledge the applicants may choose more than one course.

In addition to their function of selecting for university admission, the UEEs serve other less explicit purposes, such as:

1) School ranking : in the absence of a true school diagnostic system, the results of UEE are the only parameter that can be used to rank schools in relation to the performance of their students. This use is unofficial and informal, but there is a consensus that schools that succeed in getting more students into the university are "better".

2) Formative: some educational policy makers and researchers believe that these examinations can have good effects in improving work in schools, in opposition to others who think that at most they are only good mirrors of that reality.

3) Profit making: since formal school teaching is inefficient, there exists throughout the country a parallel informal private system for intensive training ("cram" courses) with highly paid teachers, which prepares candidates specially for the UEE.

The organization of the UEE has the following structure:

- Control : the government lays down general directives for the system, the Undergraduate Teaching Council of each university, individually or in a regional pool system, prescribes the detailed plan for the examinations, using subsidies from the academic departments; the external public community interferes in this process through various means, reacting mainly to criteria of convenience and individual interests.

- Administration : multidisciplinary university examination boards or independent "Testing Service Foundations" administer the system; in both cases, secondary teachers may participate in the process, preparing the questions and marking the answers.

-Financial support : this comes mainly from candidates' fees, but the university budget adds partial support when needed. In most cases, the infrastructure is provided by the university administration.

Physics Teaching

The federal government defines a minimum curricular program for all levels of education throughout the country. Local educational authorities implement these programs and define curricular objectives for each discipline using the directives given by the federal authorities. This centralization accounts for the similarity between the physics syllabuses found in different regions of the country.

In the lower primary school, science is taught by a single teacher trained at secondary level . Science is taught with emphasis on biological (nature) concepts and there is little or no practical activity in the majority of schools. Topics seldom include physical science concepts, since the teachers are ill prepared in the subjects. Sometimes - not always - their training includes a watered down physical sciences semester of approximately 2 hours/week.

The upper primary (middle) schools introduce physics as a subject for the first time in the 8th grade. The teachers have a university degree majoring in biology with two semesters of physics and they rely heavily on textbooks, so that these usually determine both the topics to be studied and the level of teaching. The textbook treatments introduce the basic concepts of classical physics rather superficially, using definitions, equations and formulae rather than phenomena. Practical work is absent in many schools and when introduced is very precarious, being done in order to accomplish a task considered "important" by parents. The assessment of students at this level is designed simply to pass or fail students and is carried out by the individual teachers.

Following the 1971 reform act, physics has been taught in high schools over three years for 2 to 4 hours per week. The official program covers classical physics, distributed as follows: classical mechanics (40%), heat (20%), electricity (20%), geometric optics (10%), waves (5%) and magnetism (5%). This program content is seldom fulfilled, since the time required to "overcome" the potential barrier of mechanics is larger than provided for, due to the extremely poor performance of students in mathematics and the very small amount of time spent on practical activities. There is virtually no laboratory work in the public school system, for several reasons, including lack of support from the authorities to keep the laboratories in working order, lack of time to allow for teacher preparation, low pay and the absence of any external evaluation of such work. Presently, many teachers are becoming conscious of this shortcoming and are trying to do something, yet in an inefficient and unsystematic way.

In short, in spite of the time spent in physics classes, the physics taught in secondary school cannot be considered effective, either in preparing students for the UEE, or in fulfilling its main function of educating future citizens for the technological era in which we live.

Physics undergraduate courses are offered in 44 universities or colleges, leading to bachelor or secondary teaching diplomas after 4 years of study. For the majority of the institutions, these two degrees have a common core physics curriculum covering classical and modern physics in the first three year course. During the senior year, students bound for a B.Sc. undertake further studies in quantum mechanics, electromagnetism and nuclear physics, while the teacher trainee students attend classes about educational subjects and have supervised teaching practice in the schools. Graduate programmes in physics are offered by 18 - mainly public - universities or research centres.

About 30 undergraduate university courses require physics as a compulsory discipline within their curriculum. In general, physics is taught in the first two years of studies and the content differs, depending on the career area (e.g. bio-medical or technological areas) or even from course to course within a same area (e.g. engineering or geology courses).

Some Brazilian Educational Statistics

Some data about the Brazilian education system are given in Table 1. This

Table 1 : Numerical Data for the Brazilian Education System

Average rates as % of the age 7 years cohort, which numbers 3.5 million

School Level		Enrolment per grade	Entry per year	Graduation per year
First: Primary & Middle School (8 grades)		97	94	37.2
Second: High School (3 grades)		31.1	28.3	21.2
Third: All University Undergraduate Courses (4 years on average)		10.7	9.7	6.8
Undergraduate Physics Courses (4 years)		0.28	0.057	0.013
Fourth: University Graduate Physics Courses	Masters (2 years)	0.023		0.0049
	Doctorate (4 years)	0.017		0.002

table shows the average enrolment rate per number of school grades and the yearly school entry and school degree rates, separately by school level. These rates are in percent of the 7 year old cohort age group and have been calculated from data given in references [1,2,3]

As can be seen, only about 37.2% of the age group complete (graduate at) the first compulsory school level. Since only 4% do not have access to school, this low degree rate is due basically to pupils repeating years. The average repetition rate reaches, on average, 27.7% per year, against respectively 10% and 62.3% for the drop-out and promotion rates (Costa Ribeiro, 1991)[1].

From those who finish the first school level, only 28.3% of the total cohort go into the secondary school. So, according to Costa Ribeiro[2] ". . . the student's social and economic family background produces a great distortion in the social-economic status of secondary students. The vast majority of them regard this level of education just as a preparatory step for admission into college or the university. . ."

Table 1 shows that the repetition and dropout rates are not significant in the secondary school. However, each year 1.1 million new students - 31.4% of the age group - apply to the universities and colleges but only about one third of these are selected.

The effects of poor school education can be seen at the university level. Firstly, because about 20% of the total university available places are not filled because of lack of qualified applicants and, secondly, because only 6.8% of the age cohort obtain a university degree each year compared with the average rates of university entry of 9.7%. For the university physics courses the situation is even worse. For instance, as can be inferred from Table 1, for each Brazilian age cohort of 3.5 million of children there is an expectation of 2000 freshmen students, 500 graduates, 170 masters degrees and 70 doctorates in physics per year.

The primary reason for such low outcome rates in physics is that in Brazil the industries mainly reproduce products and goods designed abroad and, so, there is no place for physicists in product development. Consequently, the physics courses have low social prestige and so attract candidates who are not only few in number, but who come also from mainly low social-economic family backgrounds and with low academic performance[6]. Fortunately, it is also true that among the few there are some of the highly motivated students that support Brazilian academic physics.

The picture presented above is not a happy one and does not qualify the country's education system as a paradigm of "good procedures" However,

even within such a system, the country succeeds in keeping up a level of excellence in certain areas of studies, such as the basic sciences. Brazilian physics, in particular, has a good reputation and is often mentioned as a system that functions in the midst of failure elsewhere. Professor A Salam, Physics Nobel Prize (ICPE Newsweek Dec 90) refers to Brazilian physics as " 'bright' and not belonging to the 3rd world".

The Results and Their Use for University Admission

As described above, the only data considered for selecting students for the universities are produced by the entrance examinations. The entry decision has always been based on a weighted composite score over all the subjects, using cut off criteria.

During the past 20 years, the cut off criteria for entry to the university have changed radically and not primarily for academic reasons. For instance, until 1971 a minimum (arbitrarily set) attainment of 50% was required for each subject. In that year, this criterion was changed by a government act and from then until 1988 only a zero score in any subject would eliminate a candidate. It is worth mentioning that, since practically all UEEs were constructed using objective multiple choice questions, no candidate was ever disqualified for zero score unless he or she missed the examination.

Based on the autonomy given to the universities by the Brazilian constitution in 1988, the undergraduate councils of each university became responsible for defining the UEE models. Because the lack of a general testing service for the country, and in the total absence of external official evaluations in any phase prior to the UEE that would, technically speaking, point out to the advantages of one method over another, a variety of models emerged across the country. These are now being evaluated and adjusted to improve efficiency and quality. However, given that the standard of high school education suffered a marked decline over the past 20 years, it followed that no significant changes in the entry criteria could be introduced without corresponding reforms in the high school system, since, otherwise, there would be too many vacancies in the universities.

The majority of the examination models used by the universities can be basically classified into two dimensions: (i) whether they are unified for all courses or separated by knowledge areas, and (ii) whether the examination is applied in one or two phases (eliminatory and classificatory respectively). In the unified case, the examination papers are the same for all applicants, but the weight given to each one may differ according to the applicant's choice of course.

Table 2 shows three different models, with the the minimum achievement required for admission into undergraduate physics courses, indicating also the weight given to the physics UEE papers. The general conclusion is that there is too much effort going into the organisation of selection based on achievement requirements which are far too low.

It is worth noticing that such loose minimum requirements as shown are worst for those courses (e.g. physics) where the UEE ratio of candidates to places is lowest. And, since with the exception of the UNICAMP UEE, only one single correct answer in the physics examination paper will be enough to qualify a candidate for the physics undergraduate course, as far as these courses are concerned, the universities are not trying to select those students applying to study physics.

Table 2 : UEE Examination Models and Requirements of Three Universities

University - Physics exam.weight	Model and Minimal Requirement
UFRGS - 3 (RioGrande do Sul)	Model:unified single phase covering 9 papers Minimal Requirement: at least 30% correct answers in all objective questions of the nine papers and 25% in each paper separately
UFSC - 2 (Santa Catarina)	Model:unified and single phase covering 8 papers Minimum Requirement: at least 5 right answers in Portugese language and Brazilian literature and 1 right in the subject papers considered compulsory for the intended course
UNICAMP - 1 (Campinas)	Model: Unified & 2 phases, with only writing and general knowledge papers in the first, and 8 papers in the second Minimum Requirement: only those with at least 50% in the 1st phase called for 2nd phase; in latter need at least 30% in physics and a non-zero score in all other papers

The results of the university physics entrance examinations are used as a partial requirement for admission to all courses, with higher weight for those in the science and technology areas. The mean performance of the candidates is generally very low, between 20% and 30% of the full score, but significant differences may be found depending on the type of course or knowledge area for which they are applying. For example, those applying for mechanical engineering, or medicine or law, may have better

physics marks than those applying for physics. In fact, as mentioned above, there is "pre-selection process"[6] in that candidates choose the course and university institution according to their chances of success.

The performance in the physics examinations is essentially the same as for the other basic science subjects and two studies[10,11] that compared the performance of candidates across four main sub-areas of physics content over, respectively, nine and six UEE and using different methods of analysis , did not find noticeable differences in performance between the sub-areas. For example, one study found that the lowest mean was 31.6% in waves, and the highest 33.6% both in mechanics and in thermal physics.

An analysis over several years of mean physics scores for one UEE (CESGRANRIO), on questions grouped according to the types of ability that they test (using Bloom's taxonomic categories), shows median success rates of about 50 % for knowledge, 35% for comprehension, 18% for analysis and 9% for synthesis. These results show that candidates are acquiring knowledge and limited comprehension from their school physics.

The Examination Methods Used

General Outline

The descriptions in this section are based on study of documents describing eight different versions of the UEE, five from individual universities and three from collaborations or pools of several universities. This sample covers the main types of institution and the main regions of the country. It has been selected to be representative of the national characteristics, as well as of the extent to which different methods and criteria are used to define the policies of admission of students to the higher education system and, more to the point, the peculiarities of the physics examination component. Details of the sample are given in Appendix 1.

From the purely structural point of view, the university admission requirements have the following common features:

i) a valid high school diploma (internal component)

ii) a satisfactory performance in a written pencil and paper examination covering the common core high school curricular subjects (external component)

iii) no practical examination

iv) similar physics programmes and topic distribution

For the external component, the general objectives, models, type of questions, methods of preparation and marking schemes, may vary throughout the country and we shall try to give a general description of interpretative character, based particularly on the sample mentioned above.

General Objectives

With the aim, of illustrating the style of the physics examination questions, and of showing what they are trying to assess, we inspected the examination papers and came out with the following conclusions (sample questions are given in Appendix 2) : -

a) The physics content tested is mainly classical mechanics and electromagnetism, both covering about 50% of all questions, with a trend for modern physics questions to be introduced - see examples 1 and 2.

b) In addition to the physics content, the other generally accepted method of classification is according to the types of ability tested, as follows : -

i) knowledge of the order of magnitude, dimensions, units and significant figures - example 3 ;

ii) knowledge of experimental or theoretical results as indicated explicitly in the syllabus program - examples 1, 2 and 4 ;

iii) comprehension of fundamental physics laws and concepts using daily life situations as background - examples 5,6 and 7;

iv) application of physics concepts and laws to scientific, daily life or historical situations, and requiring reasoning and quantitative (numerical/graphical) problem solving abilities - examples 8,9 and 10.

Types of Questions

Until the late 60's, the physics questions used by the university academic departments were of the problem solving type. The multiple choice type of question was introduced in the UEE at the same time as the law of 1971 made these examinations obligatory for admission so that they began to be set for very large numbers of candidates. The use and convenience of this type of question soon became apparent to teachers, struggling with many teaching classes and large numbers of pupils. Unfortunately, they did not

master the techniques of formulating such questions and were apparently training the students to find the right answer by means other than the comprehension of the respective content. The reaction to this misuse, and the poor educational practices associated with it, led to the rejection of multiple choice questions, which in Brazil have been considered as the "mother of all evils" in their effects on both primary and secondary school systems.

A practical consequence of that rejection was the start of attempts in 1988, following the autonomy given to the universities, to move back to open questions, justified by the hope that such an initiative would have a positive influence on high school practices. This attempt is costing a lot of time, money and effort to the universities without the rewards, either of being effective in exercising the expected beneficial influence on high schools, or of leading to better selection of candidates, as the poor performances in the physics examinations indicates.

The types of questions now in common use by the examination boards are:

i) multiple choice questions with five options;

ii) multiple true/false assertions;

iii) open questions with numerical answer between 00 and 99.

iv) short answer questions

v) open questions with justification

The first three above can be marked by computer, whilst the last two require teacher marking. Only one type (computer or teacher marking) is normally used when the UEE has a single phase, but in a two phase UEE model combinations of them can be found, mainly with the computer marking being used for the first elimination phase.

Preparation of the Examination Papers

Each university, or testing service, examination board may serve one specific institution or a pool of them. For example, the FUNVEST examination board serves three universities, Sao Paulo, Santa Catarina, and Sao Paulo/Sao Carlos, while CESGRANRIO, as a private foundation, prepares one UEE for a pool of 12 private institutions and another one for a university in Rio de Janeiro.

The examinations are prepared by a technical group set up at each of the testing units. There are no strict criteria for selection of members of such

groups. Interested physics faculty are invited to participate and each group generally includes amongst its 4 or 5 members one secondary teacher selected for his or her outstanding performance as a teacher. It is common for such a group to remain unchanged for several years.

The preparation of the questions and the setting up of the examination follows closely the general objectives (as set out in the "General Objectives" section above) and topics of the prescribed physics programme (set out in appendix 3). The general objectives also prescribe the levels at which candidates should operate, and individual boards work out a reference matrix of topics against levels, taking into account the official programme specification and maintaining constant the distribution of the questions in respect to these two aspects only.

Specialists in evaluation, language and psychology check the questions from different technical perspectives, in order to ensure the validity and fairness of the examination. The revision and final version of the paper remains the responsibility of the examination board, as well as the typing, copy-editing and quality of presentation of graphs and diagrams. The complete process, from the setting by the board until the finished product, takes about four months to be completed.

The Marking Scheme

For computer marked questions only the correct answers are scored - there is no penalty for wrong answers. Teacher marked questions require large number of markers who are recruited amongst secondary teachers and physics faculty staff. They receive training in advance, and as a further guard against marker subjectivity, the questions are generally marked by two independent teachers, following the official mark scheme. This scheme is prepared by the members of the examination board, and tested in practice before the actual grading is done. For example, in one UEE the actual grade is the average of the grades of the two markers, but where there is a discrepancy equal to or greater than 1.0 score points, the computer will signal the problem and the papers which will be graded by a third teacher.

For security reasons, the examination papers of the candidates are not identified by the graders and, also, the names of these graders are unknown to the candidates. In many cases candidates may request revision of the grades for the teacher marked questions, but nevertheless the official marking criteria are never published.

Statistical Analysis of Results

In Brazil, there is a potentially huge data base with about 1.3 million UEE candidates every year. It is our opinion that these data have not been systematically used by either the government or the universities, in order to produce useful diagnostic statistical information. However, exceptions should be made in the case of some examination boards, and in addition, some researchers publish a significant number of research papers and theses (see the bibliography), in spite of the difficulties they find in gathering data from the many disparate sources.

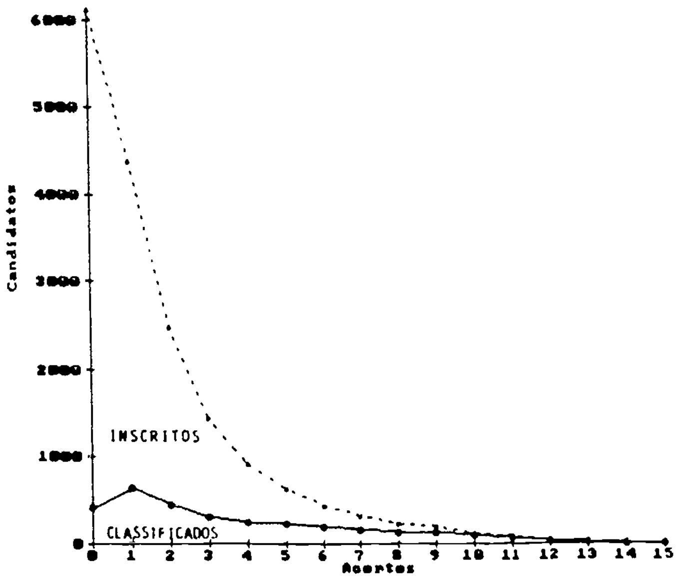
For instance, some of the examination boards belonging to the UEE sample used here publish technical reports, basically containing general statistical information, item analyses for each paper and a detailed profile of the candidates, constructed from a socio-economic questionnaire.

For a physics examination paper included in a typical report (UFSC, 1991)[17], information would normally be given about the facility and discrimination indices of the questions, both for all candidates and separately for those who pass, as well as the distribution curves of numbers of candidates against the numbers of right answers. Score distribution data of those who pass are also produced separately for each course. Given the short time that the examination boards allow for preparation of the examination papers, technical analyses of the questions are never performed at a pretesting stage. Figure 1 shows distribution curves for the physics paper for the Federal University of Santa Catarina in 1991.

Looking at this information one could readily conclude that in general the UEEs have been reasonably well prepared by the examination boards and, therefore, the fact that the outcome is unsatisfactory has little to do with the assessment instrument and more with the inefficiency of the basic school system. The extent to which the information and evaluation previously available has been taken into account, by decision-makers and academic staff in charge of preparing the new examination papers, could well be questioned. The common fact in Brazil is that the UEE has been a very sensitive matter, frequently taken as a "scape goat" for the educational failures of the high school and, therefore, discussion and decisions about the system are often based on political grounds.

Figure 1 : Distribution of Scores in a Typical Physics Examination

The broken line is for all candidates for whom the mean score was 1.8 out of 15. The full line is for those who satisfied the entry requirements (all courses), for whom the mean was 3.7



Links with Schools, Teachers and Pupils

Some examination boards invite secondary teachers to participate in the preparation of the examinations , as well as in the marking procedures, and their moderating influence can be felt in the level and type of questions included in the examination papers.

Secondary teachers are also under pressure from students and students' parents to recognise the official programmes for the entrance examinations, and to teach all the topics in these programmes. There are even cases where topics belonging to the official school programme, but not in the examination programmes, are never taught. In this way, feedback between the examination boards and the secondary school does operate effectively.

On the other hand, the diagnostic elements contained in technical analyses of the questions that some of the examination boards take care to prepare and publish (UEE Reports), drawing attention to common learning difficulties, have had little effect on the performance of students. Many teachers teaching in the last grade of high school, and those working in the special admission courses, do prepare candidates for the UEEs by

working on questions that gave trouble in the past, often by "drill training". Nevertheless, when the same types of question appear year after year, there is no significant change in the scores.

Official information about the UEE is communicated via a "Manual for Candidates" and this information, together with other materials originating from the universities and examination boards, are published regularly in the newspapers and media, telling students about the type and level of the examinations, giving samples of questions from past examination papers, and communicating about courses and career prospects. Unofficial answers to the the examination boards questions are also published in the newspapers, to give the students the basis on which they might ask for revision of the marking. However, for security reasons, the criteria used for grading and the names of the members of the boards are never communicated officially.

A new project, mounted by the CESGRANRIO agency which serves a pool of 16 universities, is designed to evaluate externally the performance of students throughout the three years of high school. This continuous assessment experiment, which will begin in 1992, has been experimentally accepted by several universities of Rio de Janeiro. It is expected that it will improve the links between the UEE and the secondary schools, and also exert a beneficial influence on the teaching itself.

Opinion on Quality and Effects

As discussed in the study by Costa Ribeiro[7], the results of the UEE confirm the admission of candidates determined mainly by socio-economic factors. That is, in terms of selective discrimination, the UEE succeeds in separating the potential university candidates from the rest. On these grounds the assessment instruments can be considered adequate for their selection function, and can in principle discriminate fairly well for the desired performance in physics (and for all other subjects). However, because the cut-off criteria are based on the political decision to fill up all the available places, in the specific case of physics bound careers there is a critical situation, due to the fact that the ratio candidate/place is very low. Thus in 1992 the minimum score in one university for the medical school was 68%, whilst for physics it was 33%. This situation permits the admission of a candidate with no more than a non-zero score, perhaps with only one correct answer, in the physics examination!

There is a genuine expectation from the examination boards that it should be possible to improve the "quality" of the UEE, either as a selection instrument or as an external component of the education system that could influence and effect the secondary schools. This search for

improvement is one reason for the lack of equilibrium of the examination models, which have been changing almost every years for the last five years.

In the first case, given that "pre-selection" is mainly determined by non-academic factors, it does not seem feasible that a better discrimination between candidates could be achieved only by improving the quality of the examinations. That is to say, under circumstances where the signal/noise ratio is low, the need is to improve the signal first rather than the measurement instrument.

In the second case, the expected "beneficial" influence on high schools cannot be achieved. On the one side schools, students and parents pay attention to the curricular programmes presented by the UEE boards. On the other hand, the teaching at all levels is of such a low quality that what is going on in the vast majority of the schools is a "make believe", since the whole system of evaluation is internal to the school. In most instances, it is left to the teacher to test what he/she taught, without any organized pedagogical assessment, even at the school level, either of the quality of the instruments used to appraise learning, or of the adherence in the teaching to the basic objectives appropriate for the discipline[5].

Nevertheless, it is our opinion that, as a point of departure, the UEE results constitute an excellent data bank for the analysis of the country's educational system. Under these circumstances it might be expected that the technical results of the UEE, as the single existing external assessment of the Brazilian educational system, would serve the purpose of portraying the performance of university bound students, who form the majority of the students who finish high school. The validity of this type of study could only be substantiated bearing in mind the sort of questions that were raised about proposals for the national monitoring of student's scientific attainments in the United Kingdom (Association for Science Education, 1978):

- To whom are the results to be given?
- Who will interpret the results?
- How is the interpretation to be used?
- What end products will help teachers and schools?

Appendix 1 : Institutions and Groups Used as the Sample for the Review of the Examination Papers

Region	Estate	Institution	Numbers of candidates
North/ North East	Paraíba	Federal University	22 000
	Pará	Pool of 3 Universities	20 000
Centre/ South East	Rio de Janeiro	CESGRANRIO (Pool of 16 Universities)	12 000
		Federal Univ (UFRG)	30 000
	Sao Paulo	FUVEST (3 Universities)	100 000
		UNICAMP (State University)	25 000
South	Santa Catarina	Federal University	20 000
	Rio Grande do Sul	Federal University	25 000

Appendix 2 : Typical Questions Selected From the Sample UEEs

Example 1 (Rio Grande do Sul - 1991)

In 1989 it was widely advertised in the media and among scientific circles that there were new alternative methods to obtain nuclear fusion. The expectations were not confirmed. What is truly known today, is the same as was known at that time: nuclear fusion is obtained at temperatures as high as those existing. . ., and, unlike the process of nuclear fission used in nuclear power stations, ...radioactive wastes.

Indicate the answer that will correctly complete the two empty spaces in the text.

(A) in the surface of the Earth - produces
(B) in the surface of the Moon - produces
(C) in the surface of the Moon - does not produce
(D) in the centre of the Sun - does not produce
(E) in the centre of the Sun - produces

Example 2 (Santa Catarina - 1992)Question 15 (UFSC/91)

Select the CORRECT statements, add the respective values and mark your answer card.

When discussing the photoelectric effect it is correct to state that:

01. in a photoelectric cell, the speed of the emitted photoelectrons increases when the wavelength of the incident radiation decreases.
02. in a photoelectric cell, the speed of the emitted photoelectrons increases when the wavelength of the incident radiation increases.
04. in a photoelectric cell, the speed of the emitted photoelectrons will be larger if strong red light were used instead of weak violet light.
08. in a photoelectric cell, the kinetic energy of the electrons removed from the surface of the metal depends on the intensity of the incident light.
16. in a photoelectric cell, the kinetic energy of the electrons removed from the surface of the metal depends on the frequency of the incident light.
32. the emission of photoelectrons from a photosensitive plate can only occur when the incident light has smaller wavelength than a given critical value, which is characteristic for each metal.
(in this type of question, the numerical values of the options are so chosen that the sum of any combination of them gives a unique value, so the student's sum identifies his set of choices)

Example 3 (FUVEST agency of 3 universities Sao Paulo - 1989)

In May 1988 Mars had its closest approach to Earth. On that particular day, people observing the planet were watching the light emitted by the sun some time before. Approximately how long before? Consider the orbits of the Earth and of Mars as being perfectly circular and coplanar, with radii of 150.000.000 km and 231.000.000 km, respectively.

a) 81 light years
b) 2 hours
c) 30 seconds
d) 8 minutes
e) 17 minutes

Example 4 (Rio Grande do Sul - 1991)

Analyse each of the following statements relating to electromagnetic waves and indicate if they are true (T) or false (F).

( ) The times that light takes to go from the Sun to the Earth and from the Moon to the Earth are the same.

( ) In vacuum, the speeds of light and of microwaves are the same.

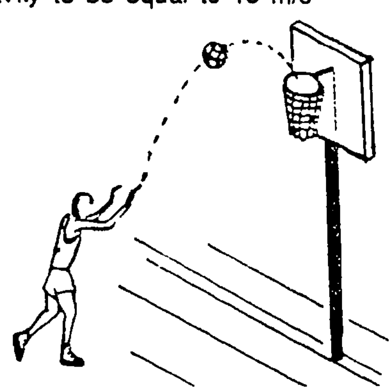
( ) In vacuum, all electromagnetic waves have the same frequency.

Select, obeying the sequence of the statements, the correct indications

(A) T - T - F
(B) T - F - T
(C) F - T - F
(D) F - T - T
(E) F - F - T

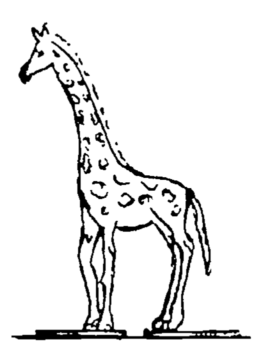
Example 5 (Rio de Janeiro - 1989)

A basketball player is tossing a "free lance" ball into the basket. The trajectory of the ball is shown in the figure. Find the direction and orientation of the resultant of the forces acting on the ball, at the instant shown in the picture. Calculate its intensity, knowing that its mass is 0.65 kg and taking the acceleration of gravity to be equal to 10 m/s^2



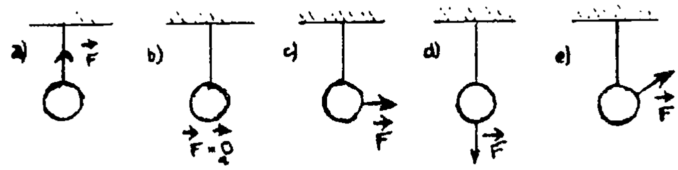
Example 6 (Rio de Janeiro - 1990))

In order to weigh a giraffe, two identical scales are used, as shown in the figure. The two front legs are set on scale 1 and the backward legs on scale 2. With the giraffe at rest, scale 1 reads 400 kgf and scale 2 reads 300 kgf. How much does the giraffe weigh? Justify your answer.



Example 7 (Paraiba - 1991))

The vector that better represents the resultant force acting on a simple oscillating pendulum when the pendulum is at the lowest position of its trajectory, moving from left to right, is



Example 8 (Campinas - 1988)

Imagine you have a guitar in your hands. One of its strings of length L, has a linear mass density (mass per unit length) equal to U under a force of tension T. In these circumstances, the speed of propagation of sound in the string is given by :

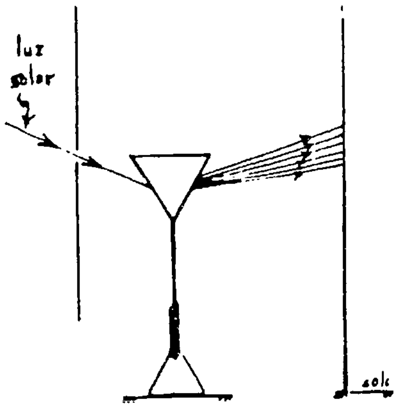
$$v=(T/U)^{1/2}$$

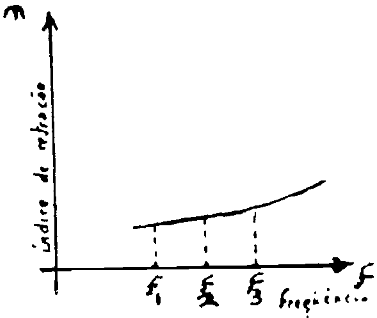
a) Indicate what should be done to double the frequency of the sound produced in that particular string and describe quantitatively what will happen to T,U and L.
b)Find another way to reach the same objective. Analyse also, for this new method, what will happen to T,U, and L.

Example 9 (Rio de Janeiro 1989)

A passage of Newton's Opticks is transcribed below
". . .in a very dark chamber I made a small hole in the window, in such a way as to let a certain amount of light come through. I placed a glass prism (triangular), in front of the hole, in such a way that the refracted light will be incident upon the opposite wall. It was a very agreeable amusement to observe the intense colours there projected. . ."

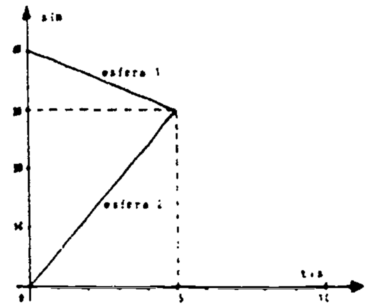
The figure below illustrates the experiment. The dispersion curve for frequencies in the visible is also shown, for the material of the prism.





Consider three colours, 1,2, and 3, that have frequencies f1, f2 and f3. Locate, in increasing order, the heights in relation to the ground, of the projections of these colours as they appear on the wall. Justify your answer.

Example 10 (FUVEST agency of 3 universities Sao Paulo - 1989)



Two spheres of 2,0 kg each translate without friction along the same line on a horizontal table. After colliding they continue moving together. The graph represents the position of each of the spheres as a function of time before the instant they collide.

a) Find the kinetic energy before collision.
b) Show what the graph will look like up to t=10 s.
c) Find the energy dissipated in the collision.

Appendix 3 : The Topics Assessed in the Examinations as Indicated from Analysis of the Programmes of the UEE Sample

Topic	Content	UEE Programme
CONTENT FREE	-Measurements and order of magnitude -Significant figures -Graphical representation of physical laws - Scalar and vector quantities	ALL
MECHANICS	- Kinematics - Linear, circular and harmonic motion - Newton's laws - Gravitation - Conservation of linear momentum - Work and energy - Conservation of mechanical energy - Mechanics of fluids	ALL
HEAT	- Temperature and thermal equilibrium - Thermal processes - Ideal gases - 1st law of thermodynamics - Concept of entropy	ALL
WAVES	- Transverse and longitudinal waves - Acoustics - Waves in mechanical media - Electromagnetic waves - Optics	ALL
ELECTRO MAGNETISM	- Electrostatics, Coulomb's law - Electric fields, electrical current - D.C. currents - Magnetic field, Ampere's law - Electromagnetic induction - Electrical measurements	ALL
MODERN PHYSICS	- Quantisation of energy - Wave and particle properties - Atomic structure - Natural radioactivity	UFRGS*
HISTORY OF SCIENCE	- Knowledge of the work of great scientists who contributed to the development of physics	UFSC**

* Federal University of Rio Grande do Sul ** Federal University of Santa Catarina

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Chapter 4 : The Unified National Examination in the People's Republic of China

Shu-tong Cong

General Features

There are 1 075 universities and colleges in China at present, all of these being full-time regular institutions of higher education legally approved by the State Education Commission (SEdC). These institutions recruit their new entrants each year from all over the country or from designated regions through the National Unified Entrance Examination to Higher Education (NUEEHE).

Admission to higher educational institutions in the People's Republic of China is a national unified system. Its features include: centralized policy making; unified production of test items and administration of the admission examination; centralized assignment of admission quotas; admission and placement operations conducted in each province.

The SEdC is the agency of the Central Government in charge of admission to higher educational institutions and its responsibilities are delegated to the admission committee at a lower level of government during the admission process.

Even although the above procedure has been operated for some years, reforms and modifications are likely to be implemented with reforms developed for the upper level of secondary schooling, the senior middle schools. The SEdC decided in August 1990 that, starting from 1990, Local Unified Senior Middle School Leaving Examinations (LUSMSLE) should be gradually extended throughout the country over 3 to 5 years. LUSMSLE is by nature a provincially administered senior middle school leaving examination recognized by the state testifying to the scholastic achievements of school leavers. It is conceived as a means to check and evaluate the quality of instruction in general senior middle schools, and also a means to examine or check whether the school leavers have essentially attained the goals set forth in the syllabi of the required general education (academic) subjects in their scholastic endeavour.

By its very nature LUSMSLE will be quite different from NUEEHE as a mechanism for selection. The setting of examination papers, the implementation of LUSMSLE, the correction of examination papers, the statistics of scores, and the reporting of records will all be carried out in a

unified way by the provincial authority concerned. Beginning with the school year 1991-1992 LUSMSLE will be administered in about 20 of the provinces. In the summer vacation of 1991, the current year senior middle school leavers in three provinces all underwent LUSMLSE. In support of these undertakings, the SEdC had specially designed new set of examination papers for these three provinces, with some change in the format of the examination papers, and in the number and combination of subjects to be examined. This is dubbed new-style NUEEHE in contradistinction to the old-style NUEEHE.

Middle schools are divided into junior and senior stages, each of which lasts for three years. Some physics is taught in the 2nd and 3rd years of the junior stage. For the senior stage, there will be a transitional period of 2-3 years, during which the new style and the old style of senior middle school curriculum will co-exist. In the old style, 3 years of physics is required, and the study of physics usually takes 4 hours teaching time each week. In the new style, physics is to take 3 hours in a week in the first two years, and 4-6 hours in the third year as an elective course for those students who will take the NUEEHE for the science and engineering group.

Table 1 shows the numbers enrolled into higher education in the last few years, and also indicates that about 25% of the 2.5 million graduates from the senior middle schools are able to proceed to university or college courses. Statistics for 1988 showed that about 97% of school-aged children were in primary schools, and about 70% of those completing primary schools continued their study in junior middle schools. The diagram of Table 2 shows how the enrolments are distributed amongst the main fields of study.

Admission to University Courses

The Admission Plan

A national admission plan is formulated by the SEdC and related state planning agencies according to the needs of national economic and social development, as well as the conditions and capacities of the higher educational institutions. Within this plan, each university or college, on the basis of personal requirements, middle school development, and employment capacity in different regions, allocates the number of new students to be designated to each province and draws up an admission source plan which is distributed to the admission committees of the relevant provinces.

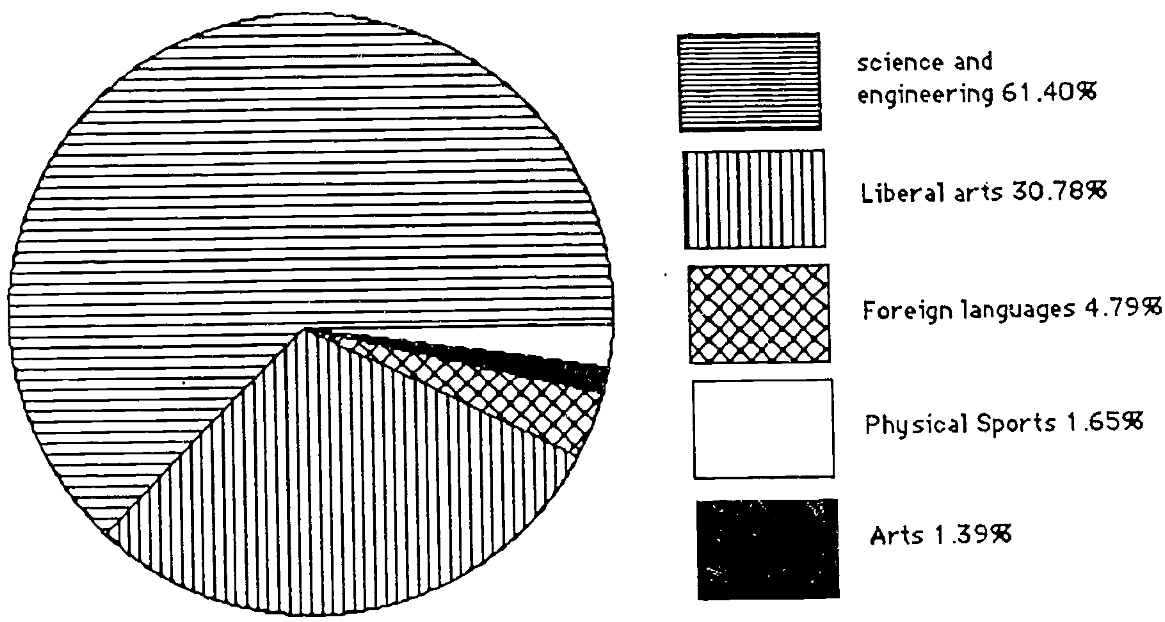
Table 1 : Enrolment Numbers for Higher Education - 1986 to 1990

Numbers are in Units of 1000 Students

Year	Enrolment Number	Number of GSMS*
1986	572.0	2,240.4
1987	616.8	2,467.8
1988	622.0	2,603.1
1989	618.9	2,552.4
1990	609.0	2,329.6

* GSMS : Graduates From Senior Middle Schools

Table 2 : Distribution of Admissions by Subjects in 1988



The Method of Application

An applicant fills in an application form to indicate his or her choices of university, department, and subject. The application and admission process is divided, according to department and subject, into two categories. The first category covers science, engineering, agriculture, and medicine (including physical education and sports), the second category covers liberal arts and social sciences (including foreign languages and arts). An applicant can choose only one category.

In accordance with the two categories, entrance examinations are also designed respectively for the two categories. Applicants choose the entrance examination category in accordance with their application category.
For candidates in the first category, the following seven subjects are examined : politics, Chinese, mathematics, physics, chemistry, biology, and a foreign language. For the second category, six subjects are examined : politics, Chinese, mathematics, history, geography, and a foreign language. A full score in all subjects is 100 except for Chinese (120), mathematics (120) and biology (70).

In the new plan, each senior middle school leaver who successfully passes LUSMSLE, when sitting for new-style NUEEHE, may choose from several combination-groups of examination subjects, the group of subjects deemed most suitable to develop his or her potential. In comparison with the old-style NUEEHE the number of subjects being examined will be reduced by 2 or 3. The tentative scheme of combination-groups approved by the SEdC are as follows:

First group: politics, Chinese, history, and a foreign language;
Second group: mathematics, Chinese, physics, and a foreign language
Third group: mathematics, chemistry, biology, and a foreign language;
Fourth group: mathematics, Chinese, geography, and a foreign language.

How Admissions are Decided

In principle, admissions are decided on the basis of an overall evaluation of an applicant's moral, academic (intelligence) performances, and physical condition.

A candidate's intelligence is evaluated mainly on the basis of his or her performance in the entrance examination, which functions as the main device of selection.

However, it should be noted that a single entrance examination does not provide a complete sound basis to assess a candidate's "intelligence".

Hence, efforts have been made to upgrade the entrance examination, which still remains a major means of selection, as well as to supplement it with other forms of assessment. In the case of a particular university or department that has specific admission requirements, an exclusive entrance examination or some special subject examinations might be given by each province or by the university.

Moreover, an entrance examination exemption system and recommendation system are established. The number of higher educational institutions that admit recommended students and the number of secondary schools designated to recommend students, as well as the number of students to be recommended, are limited to a small number. A middle school graduate is qualified to be recommended to higher education for his or her excellent moral, academic, physical, artistic and practical work performances, or for his or her excellent performance in the National Physics or Mathematics Competition. A candidate is recommended, with his or her personal approval, by his or her graduating middle school to a particular higher educational institution. After investigation and evaluation, the higher school decides to admit or reject the candidate.

Most admission decisions are made in special admission sessions, held by each province after the release of the results of the entrance examination. Groups of representatives from the higher education institutions participate in these sessions. In a provincial admission session, candidates who have passed a political- moral inspection and a health checkup, are sorted by their entrance examination scores. According to the admission quota in the Admission Plan, a cut-off score is decided to produce a qualified candidate group which numbers slightly more than the admission quota. In the qualified candidate group, candidate files are sorted by first university and sent to corresponding university representatives. In the case of rejections for first choice courses, candidate files are sent to second choice university representatives, and then, if still rejected, to the third choice. The university representatives would review candidates' files and evaluate candidates' moral, academic, and physical performances and the admit the best of the qualified candidates.

The Form of the Examination

Construction of the National Examination

The National Education Examinations Authority (NEEA) is the agency under the SEdC for implementing and administering nationwide examinations. The nationwide examination under the jurisdiction of the

NEEA is normally created in four stages, namely, test development, test administration, test paper scoring, and score analysis and reporting.

Test development starts with test paper profiles proposed by subject committees according to guidelines laid down by the SEdC. Each subject committee (about 10 members) prepares a test syllabus and draws up a test framework and a specification for item writing. These guidelines specify in detail the level of knowledge and ability required and the relative weights to be given to different types of test items; a sample examination paper forms part of the specification

Under the instruction of subject committees, subject secretaries from the NEEA organise test development groups which collect items, hold discussion sessions, screen items, make up test papers, prepare answer keys, and establish scoring standards.

The format specified for the physics examination is set out in Table 3. Four types of question are used. Example 1 gives samples of each of these types of question. The distribution of the assigned marks amongst the main topic areas is given in Table 4.

Table 3 : The Format of the Physics Examination Paper for 1990 and 1991

	number of questions	scores per question	percent age
multiple choice questions I	13	2	26%
multiple choice questions II	8	3	24%
fill-in-the-blanks questions	8	3	24%
open-ended calcul. questions	4	not equal	26%

Table 4 : Distribution of Marks amongst the Topic Areas

	mechanics	heat	electricity	optics	atomic physics
1990	34	11	40	10	5
1991	34	11	36	14	5

A particular feature of the multiple choice questions is a strategy to allow for the possibility that some good physics questions may have multiple

answers, whilst at the same time reducing the probability of scoring by guesswork. Some multiple-choice questions are designed in such a way that among the four or five options, there are one or more than one correct response(s). In the machine-scoring of these questions, a full score is given when an answer includes all correct responses, a partial score is still given when an answer misses correct responses but does not have wrong ones, and, of course, zero score to an answer that has even one wrong response.

The guidelines for the physics paper specify that about 10% of the marks are assigned for items which test directly the memory of content and definition, about 75% are for testing ability to deal with application of principles and tackling problems, and about 15% for testing knowledge concerning experiments. There are no direct tests of experimental work. At present, there is no feasible way of doing this with more than 2 million candidates each year.

Analysis of the Results

It is incumbent upon the NEEA to sample data from candidates nationwide and to evaluate the quality of the test papers. This is done by analysing such features as the level of difficulty, the standard deviations, the power of discrimination and the reliability. Comparative studies are also made to analyse the level of candidature of various regions and various categories of entrants. Annual reports are produced on each subject test. These include the test paper, the answers and the scoring scheme. They also include proposals for improving the setting of the test paper for the next year, and proposals for the improvement of teaching in the middle schools. All provinces nationwide also do some similar statistical and analytical studies; their results are used as reference materials for their middle school teachers to improve their teaching.

Comments on Quality and Effects

One difficulty facing attempts to reform the NUEEHE is the problem of meeting, in a single examination, the requirements for selection and for promoting teaching and learning in the middle schools.

For the selection function, the system works effectively, but selection through only a single examination consisting of 33 short questions cannot be very accurate.

For promoting teaching and learning, the examination has a good effect on the top students. But since, up to the present, only about 20 to 25% of graduates can be admitted to higher education, the examination undoubtedly turns into a highly competitive one. Thus for a long time, many have been embarrassed by the unilateral pursuit after higher rates of success in admission to higher education, because of its adverse effects on school life. Teaching and learning are excessively examination-oriented and many schools suffer from unfair treatment because of their low success rates. In science, for example, teachers are tempted to neglect experimental work in order to spend time preparing students for the written tests.

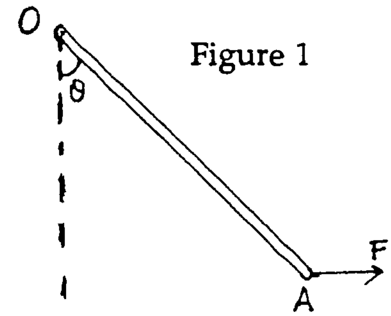
There is no achievement test designed to evaluate the extent to which school leavers satisfy the requirements for school graduation, so that the general public regard the NUEEHE achievements of a school as the sole, or main, criterion for judging the quality of a school or of its graduates. However, whilst only a small proportion can achieve admission to higher education, a very high proportion of those leaving the senior middle schools have met the graduation requirements and are well qualified as school graduates. The new development of the LUSMSLE has been conceived as a policy measure to help solve these problems.

Example 1 : Samples to Illustrate the Types of Question Used in the National Entrance Examination

1) Multiple-choice question (with only one correct option)

A rod may pivot freely about 0 (see Fig 1) in the vertical plane. A horizontal force F is acting at the end of the rod making the rod rotate slowly from vertical to a position θ (θ < 90°). Let M represent the torque of F about 0, which of the following statements about the process of rotation is correct ?

Figure 1



A. M increases and F decreases
B. M increases and F increases
C. M decreases and F increases
D. M decreases and F decreases

2) Multiple-choice question (with one or more correct options).

A conducting coil is placed perpendicular to magnetic field as shown in Fig. 2. The positive direction of the magnetic induction B and the induced current are defined as shown in Fig. 2. When the magnetic induction

Figure 2

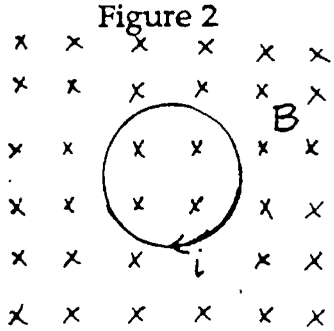
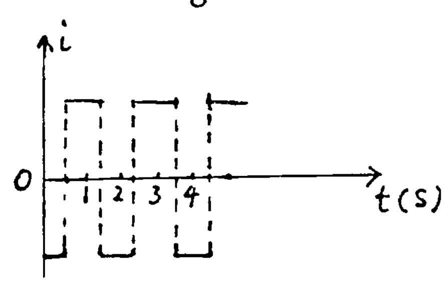
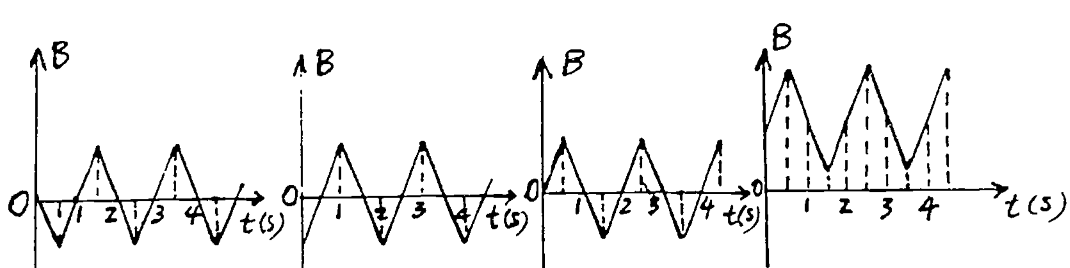


Figure 3



varies, the variation of induced current with time t is shown in Fig. 3. Which of the following graphs describe(s) the variation of the magnetic induction with time t?



A. B. C D

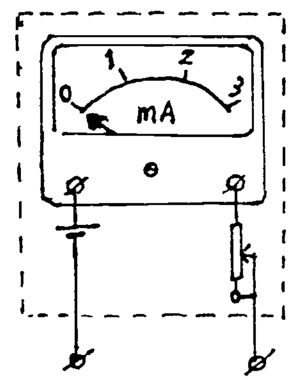
Example 1 : National Examination Question Samples - continued

3) Fill-in-the-blanks questions (including graphical construction)

First Example

One type of ohmmeter consists of a milli-ammeter connected to a series resistor and a battery, Fig. 4. The emf of the battery is 1.5 V. If zero resistance corresponds to full-scale deflection (3 mA),________Ω corresponds to the 2 mA scale deflection, ________Ω corresponds to the 1 mA scale deflection.

Figure 4

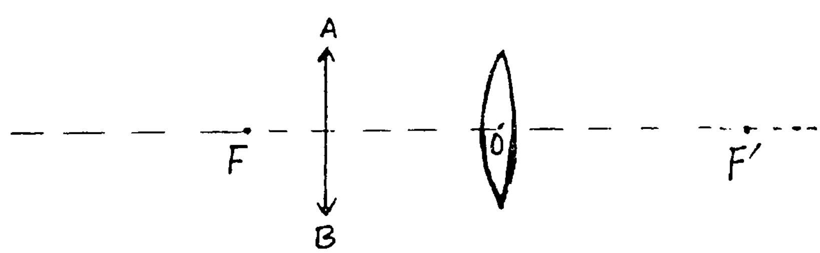


Second Example

An object AB and a thin convex lens are placed in position shown in Fig. 5, where F and F' are the foci of the lens, O is the optical centre of the lens.

a) Find the image by drawing rays.
b) Show the region (by shading the area) in which the image of the object AB can be seen with the eyes.

Figure 5



Example 1 : National Examination Question Samples - continued

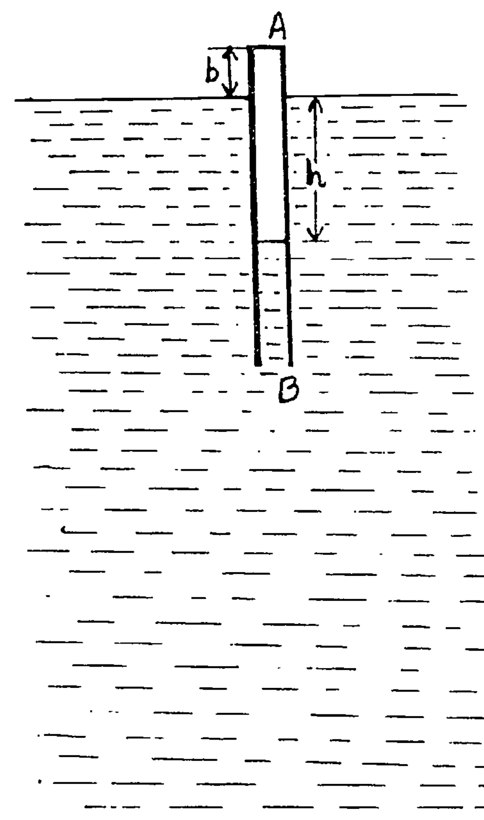
4) Open-ended calculation question

A 40 gram glass tube with end closed is inverted in water; some air is left at the top of the tube. In stable equilibrium, the position of the tube is as shown in Fig. 6, where b = 1.0 cm. The cross-sectional area of the tube is 2.0 cm^2 ; the atmospheric pressure is 1.0 x 10^5 Pa; neglect the thickness of the glass and the mass of the air in the tube:

a) Calculate the value of h (see Fig. 6)

b) If the tube is pressed downwards into the water slowly until the top of tube reaches a certain depth, below this depth the tube will not float up when it is released. Calculate this depth and discuss the stability of the tube at this depth.

Figure 6



Chapter 5 : The National Examination in Egypt

R.Kamel Wassef

General Features

The examination for admission to Egyptian Universities is the Secondary School Certificate Examination. It is equivalent to the A-level physics examination in the English system. Students spend three years study in the secondary schools after they have been successful over a period of nine years in the primary and preparatory schools.

The student's time in school is divided among the different subjects according to the distribution of marks in these subjects in the examination, which is as follows :

Physics	60	Chemistry	60
Mathematics	160	Arabic language	60
English language	50	French language	30

Total mark 420

Students in the Preparatory School (3 years) study from the beginning physics, chemistry and biological science as well as mathematics. All subjects are compulsory in the Egyptian schools except in the last year in the secondary school, when the student has to choose either the mathematical sciences (the pattern given above) or the biological sciences where mathematics is reduced to only 80 marks and biological science is introduced weighted at 80 marks. The school timetable involves six hours work for six full days per week. The student has to pass in each subject separately to be allowed to the next grade.

Table 1 gives numerical data about students in secondary school and entering universities. About 500 students are admitted to each of the 14 faculties of science each year. Not more than 10% of these are admitted to study physics degrees.

Table 1 : Numerical Data for Secondary Schools and Universities

Total number in one age group in school :	about 225 000
Mean age of students in secondary school:	age 17
Distribution of secondary students amongst courses :	
Studying mathematical sciences	about 13%
Studying biological sciences	about 31%
Studying arts and literature	about 56%
Percentage taking mathematical sciences and entering a degree course engineering	about 7%
Percentage entering science faculties	about 3%

The rest of those who succeeded went to other faculties, notably medicine, agriculture and commerce, and other institutes.

The majority of students in Egypt go to government schools which are free i.e., they do not charge any fees. There are also private schools which are financially supported by the government which charge some fees, and other private schools, including some teaching in foreign languages (English, French, and German), which charge even higher fees. Table 2 shows the percentages of students entering the different types of school.

Table 2 : Percentages of Population in Different Types of School and Pass Rates

Kind of School	% population	pass rate
Government schools	about 70%	63%
Private schools supported by Government	20%	60%
Private schools with fees	5%	25%
Foreign Schools (teaching in foreign languages	3%	90%
Students from outside	2%	50%

In 1991, the number of students (boys and girls) who applied to sit the secondary school certificate examination was about 250 000. About 160 000 students - 64% of the entry - succeeded in all subjects. Table 3 shows the percentage success rates in different subjects for 1990 and 1991.

Table 3 : Success Rates in the Secondary Certificate Subjects

	year 1990	year 1991
<u>All students</u>		
Arabic language	96.6%	93.4%
English language		89.6%
French (2nd language)		98.2%
<u>Students studying biological science</u>		
Mathematics	58%	79.0%
Physics	87%	90.7%
Chemistry	88.9%	90.3%
Biology	90.0%	94.0%
<u>Students studying mathematical science</u>		
Mathematics	78.1%	88.1%
Physics		82.6%
Chemistry		89.9%

<u>Final results in 1991</u>

	Biological science	Mathematical Sc.	Arts
Applied	76 897	32 681	140 453
Attended	76 435	32 489	139 845
Succeeded	49 983	21 002	88 654
pass percent	65.4%	60.5%	63.4%

The grades of the students are usually given in terms of marks. Only the sum of all marks taken by a student counts for admission to universities.

Until 1990, students could enter Egyptian universities by a "back door", using success in gaining a British GCE certificate O-level. This level is far below that of the Egyptian secondary school certificate which is equivalent to the A-level of the British system. This entry route to university has now been stopped; it was noted that these students had a high failure rate in university examinations. Although the secondary school certificate is criticised for being too difficult for candidates, yet the high quality of the

students entering universities helps in maintaining the quality of science studies at the undergraduate level.

Admission to Egyptian University Courses

All the universities select candidates on the basis of the students' total mark obtained in the secondary school examination. The faculties of medicine, pharmacy, dentist, and agriculture take their students from the branch of mathematical and physical sciences as well as from the biological sciences. When students apply for university admission, they have to select thirty choices of different faculties and universities, in order of priority. The place where the student lives is also taken into consideration. All this information, together with the marks obtained by each student in the examination, are fed into a computer to distribute the students over the different faculties of the different universities such that every faculty gets only the number of students needed.

For students in the biological science branch, the faculties of medicine are the most popular, whilst the faculties of engineering are the most popular for students in the mathematical science branch. Thus, these faculties recruit the best students; the data given in Table 4 illustrate this effect. There is no particular emphasis on any subject in the process of selection for any particular university. The total mark of all subjects is the only criterion used, given only a condition that a pass mark has to be obtained in every one of the individual subjects. The pass mark in physics is set at 50% (60 out of 120). Whilst a student admitted to study physics would have to achieve an overall mark of over 70%, the mark in physics itself would not have to be greater than the pass mark.

Table 4 : Percentage Marks for Admission to Different Faculties

Faculty of Medicine	minimum of about 86%
Faculty of Pharmacy	minimum of about 81%
Faculty of Engineering	minimum of about 84%
Faculty of Dentistry	minimum of about 80%
Faculty of Science	minimum of about 76%
Faculty of Commerce	minimum of about 68%

The Form of the Examination

Preparation

In Egypt, education at university level is totally free from charge - the student pays only a registration fee. All Egyptian universities are financed by the Government and the Ministry of Education controls admissions. The final secondary school examination is set by specialists in the Ministry of Education. The names of the members of the committees who are invited to write the examination questions in the different fields are kept top secret. These committees change from one year to another. They are asked to keep up to the standard of each year. The examiners are given the text books that the Ministry of Education has assigned for students and all of the questions should come from these books. A university professor usually joins each examination committee.

After the examination paper has been set, full model answers are prepared with the distribution of marks over the different parts of each question. These model answers are the guides for the marking of the papers.

The Question Papers

The time period of the examination paper in physics is three hours. Six questions are given of which the student has to answer only five. The weight of this paper is 60 marks making about 15% of the total mark for the sum of all subjects.

The questions in the physics paper should show the student's understanding in a variety of ways. Each question is formed of several parts from different sections of the syllabus. This prevents the student from omitting parts of the syllabus by counting on the optional choice of five questions out of six. In this way all areas of the syllabus are well covered.

The three main parts of each question also test different aspects of knowledge and understanding. One part may be about practical skill in physics, another may require problem solving, another part could be a multiple choice question, and yet another might test the student's comprehension in a long answer question. Questions of this type are clearly demonstrated in the typical examination shown in Example 1.

Admission is based entirely on the result of written question papers. There is no practical examination, and no use is made of teachers' assessments or of course-work in schools.

The examination marking

As described above, the assessment of the student in physics is based on only one examination paper involving six questions. This is a unique paper for all students in Egypt. After the examination, the answer papers are gathered and are given secret code numbers. They are then distributed over several regional correction centres controlled by the Ministry of Education. The marking of the papers is done by secondary school teachers, working, usually, in groups of six persons. One person in a group is responsible for correcting a particular question in the paper. The group members sit round a table and the answer paper circulates amongst them in turn so that each one marks his question. After this process the paper goes to another group of six senior teachers for paper revision.

Sometimes, certain parts of the examination can turn out to be rather difficult. Such effects are explored before the large scale marking starts, by marking a sample drawn from different regions of the country; after the sample has been marked, a statistical analysis of the results is made. According to the results obtained, a slight redistribution of the marks between the different parts of each question might be made.

After the marking process has been completed, a reappraisal is made for two kinds of papers:

- those who are border-line cases;
- those who obtain full marks on the paper.

Students whose performance has been impaired by illness, and/or other special circumstances, are given another chance to sit the examination next time.

Statistical Analysis of the Results

As mentioned above, the examination marks of each student in all subjects are entered into a computer together with the following data: -

- the student's list of thirty choices given in order of priority;
- the student's home address for geographical distribution.

After calculating each student's total marks, and taking into account the numbers to be admitted in each faculty, the computer distributes the candidates over the faculties of the thirteen Egyptian universities. The resulting assignments are published in the newspapers. Students are then asked to contact the universities to which they are admitted to complete their registration.

Statistical results of the examination are declared involving the following information:

- the numbers of students who attended, and the numbers who succeeded
- the pass rate for each branch, biological, mathematical and arts
- a comparison of the year's result with those of the previous year
- the frequency distributions, of the numbers of students against the mark ranges, in each of the subjects.

These analyses are published partly to show the public that the examination of the present year has a standard of difficulty much the same as that of the previous year.

Links with Schools, Teachers and Pupils

Since education is controlled by the government, the reference books of study are provided free to all students at the beginning of each year. Together with the books for each subject, a booklet containing the examination questions of previous years is provided for each subject. Model answers are also given, particularly for the examination of the previous year. This helps students to understand how the marking is carried out; it also gives them examples of how examination questions should be answered.

Opinion on Quality and Effects

Although the present system for selecting students is quite fair according to the marks they achieved in the final examination, yet it frequently happens that a student who is very eager to go to a medical faculty can, for example, find himself studying commerce or law! Sometimes this unwanted study affects the performance of the student. For this reason, students from families who could afford the cost tried to enter the university by "back door" routes. One of these routes, the use of the British GCE O-level as a substitute for the Egyptian entrance examination, has already been discussed above, and is no longer possible.

A second "back door" involves sending the student to be registered in any college in a foreign country and then asking the Egyptian authorities to transfer the student to an Egyptian university in a course parallel to the one in which the student is registered abroad. In general, students entering in this way do not do well in their studies and often become failures.

At present there is a tendency to increase the emphasis on the subjects needed for specialization in the selection process for university admission.

Example 1 : The Physics Examination Paper for 1990

Use the following constants when needed:

Boltzmann's constant = 1.38×10^{-23} Joule / Kelvin.
Avogadro's number = 6×10^{23} molecules / mole.
$g = 9.8$ m/sec ^{2} ln 2 = 0.693 $\pi = 22/7$

Answer FIVE ONLY of the following questions:

1-a) Which of the following statements are right and which are wrong ? Rewrite the incorrect statements in a correct form:

- In a capillary tube, when the angle of contact is less than 90° , the liquid will be depressed, and the free surface will be curved outwards.
- The value of the instantaneous induced electromotive force resulting from an AC electric generator obeys the following relation:

$$E = NBA\, 2\pi\nu \ \sin\, \omega t$$

- An immersed body in the liquid contained in a beaker will sink to the bottom if the buoyant force acting on the body is less than its weight.
- The angle of magnetic inclination over the Earth's surface equals 90° along the magnetic equator and equals zero at each of the Earth's magnetic poles. (4 marks)

b) State the application of the Wheatstone Bridge. Derive the mathematical relation used and draw a labelled diagram for the bridge in its circuit. (4 marks)

c) The mass of a sample of a gas is 3.2×10^{-3} kg and occupies 2.24 Litre at STP (Standard temperature and pressure). Find the square of the average velocity of the gas molecules in this sample at 100° C. (4 marks)

2-a) What is the difference between each pair of the following:

- An elastic body and an inelastic body ?
- Fleming's right-hand rule and Fleming's left-hand rule (with respect to their application) ?
- Magnetic Susceptibility of a diamagnetic substance and that of a ferromagnetic substance ?
- A regular solid and a glassy solid ? (4 marks)

b) State Faraday's first law in electrolysis. Draw only a labelled diagram for the circuit used to verify this law. (3 marks)

(continued)

Example 1 : The Physics Examination Paper for 1990 - Continued

2-c) A submarine is located horizontally in sea-water. The interior of the submarine is maintained at sea-level atmospheric pressure and at temperature equals 23° C. Find:

1) The force acting on one of the submarine's windows of a circular shape, radius 21 cm and thickness 5 mm, whose centre is at depth of 50 m from the sea-level window.

2) The amount of heat lost per hour through the considered window. Given that: The density and the temperature of the sea-water around the submarine are 1.03×10^3 Kg/m^3 and 13° C respectively and the thermal conductivity of the glass

= 0.8 Joule. sec^{-1} $metre^{-1}$ $Kelvin^{-1}$ (5 marks)

3-a) Complete the following statements:

- The liquid begins to boil when .... to the external pressure exerted on its surface.
- On introducing some arsenic atoms into a germanium crystal, the charge carriers of electrical conductivity through such a crystal are........ ...... and this type of crystal is called ....
- The eddy currents are used to .... in ....
- The shunt of the current is a .... resistance connected with the ammeter in ....and is used to ....

b) Give reasons:

- If an electric current passes in both a circular coil and a straight wire located inside the coil with its axis along the axis of the coil, the straight wire will not be affected by any magnetic forces
- The presence of a small portion of alcohol vapours with the argon gas in a Geiger-Müller counter.
- No balance point is obtained on the potentiometer wire (mention two reasons only)
- Mixing green light and magenta light gives white light. (4 marks)

c) An AC circuit consists of a 50 Hertz power source, a capacitor of $\frac{700}{22}$uF, a resister of 50 ohms and an inductor (whose ohmic resistance is neglected) all are connected in series. Measurements show that the potential difference across the capacitor equals that across the inductor = 20 volts. Find:-

- The inductance of the coil.
- The intensity of the current passing through the circuit.
- The maximum value of the electromotive force of the power source.
- The phase angle between the voltage and the current in the considered circuit. (6 marks)

Example 1 : The Physics Examination Paper for 1990 - Continued

4-a) Show the difference between the spontaneous and stimulated transitions between the atomic energy levels. State the characteristics of the emitted radiation in each case.
(3 marks)

b) Draw for each of the following relations its characteristic curve, then write the mathematical formula which describes such a curve:
- The specific heat of metals and their mass numbers.
- The thermo-electromotive force for a thermocouple and the temperature. (3 marks)

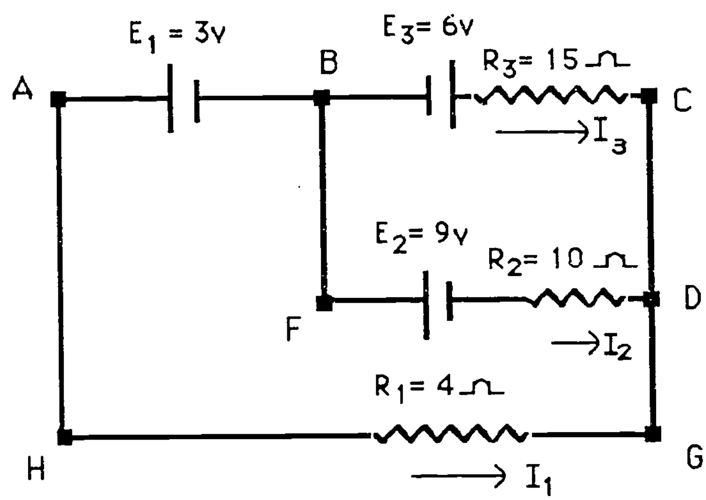
c) A sample of a Thallium element $^{207}_{81}Tl$ of 16 gm emits beta radiation and is converted into an isotope of lead (Pb). The half-life of the decay process is 5 minutes, answer the following questions:
- What is meant by each of the following terms:
isotopes - isobars - isotones ?
Give examples for each.
- Explain what is meant by "a half-life of 5 minutes for such a decay".
- Find the mass of the Thallium element $^{207}_{81}Tl$ left in the sample after 1/3 hour.
- Calculate the decay constant of the Thallium element $^{207}_{81}Tl$.
- State (without explanation) two methods for radioactive waste disposal. (6 marks)

Example 1 : The Physics Examination Paper for 1990 - Continued

5-a) <u>What is meant by</u>:
- Seebeck effect and Peltier effect in thermoelectricity?
- The sensitivity of a galvanometer?
- The fluid dynamic lift, explain how it occurs?
- Cohesive and adhesive forces of materials?

($3\frac{1}{2}$ marks)

b) Find the currents I_1, I_2, and I_3 in the circuit shown in the given figure, applying Kirchhoff's laws.
Are the assigned directions of the electric currents shown in the circuit correct or not? ($5\frac{1}{2}$ marks)



c) <u>Complete the following</u>:
- Lenz's law states. . . . .
- Bernoulli's equation involving the flow of liquids through pipes states. . . . .
- The pressure law of gases states. . . . . (3 marks)

Example 1 : The Physics Examination Paper for 1990 - Continued

6-a) Define each of the following physical quantities and write the unit used to measure each of them:-

- the specific resistance of substance
- the specific heat of a substance
- the coefficient of surface tension of a liquid
- the coefficient of viscosity of a liquid (3 marks)

b) Draw (without explanation) a labelled diagram for the structure of the Ruhmkorff spark coil (induction coil). State the function of the capacitor at the break of the circuit. (4 marks)

c) Two dissimilar springs A and B are made of the same material. The upper end of the spring A is firmly attached to an upper support. A horizontal pointer of negligible mass is fixed at its lower end and moves against a vertical scale graduated in centimetres. The reading indicated by this pointer is 10. Then the upper end of the spring B is suspended from the lower end of the spring A while the lower end of B is provided with a pan and a horizontal pointer of negligible mass. This pointer also moves against the same vertical scale. The common axis of the two springs is vertical.

It is noticed that the readings of the two pointers are 13 and 30 respectively. An unknown mass is added to the pan. The unknown mass exceeds the total mass of the spring B and the pan by 100 gm. The readings of the two pointers become 17 and 42 respectively.

If the mass of the spring B is 200 gm, find:

1-the mass of the pan

2-the unknown mass

3-the spring constant of the spring B. (5 marks)

Chapter 6 : The French System of Entrance Examinations

Françoise Langlois

General Features of the School System

The general structure and content of the school curriculum are decided and defined by the education ministry in Paris, but their implementation depends on the *Recteurs* of each of a set of 28 regional academies. Each academy is run by a *Recteur* who is in charge of the administration of all levels of education in the region. S/he is helped by several different *inspecteurs* who supervise the pedagogy concerning either the primary or the secondary levels.

The curriculum definitions are set out in prescribed detail in the *programme* and the *reférentiel* : -

- the *programme* indicates the topics which must be taught,
- the *reférentiel* gives very precisely the limits of the *programme* and a list of what exactly the pupils must know as knowledge and skills, which defines a core; it contains also a list of abilities and skills (*capacités*) to be assessed; a list of *capacités* is given in Example 1 at the end.

The school system has three main stages as follows :

Primary School	Lasts for 5 years from ages 6 to 11
Collège	Lasts for 4 years from ages 12 to 15
Lycée	Lasts for 3 years from ages 16 to 18

The national examination at the end of the lycée is the baccalauréat and this is the main examination for determining university entrance. There are several alternative routes at the lycée, with corresponding alternative forms of the baccalauréat, and there are options within each of these. For one of these, the general education route, the sequence over the three years is as follows :

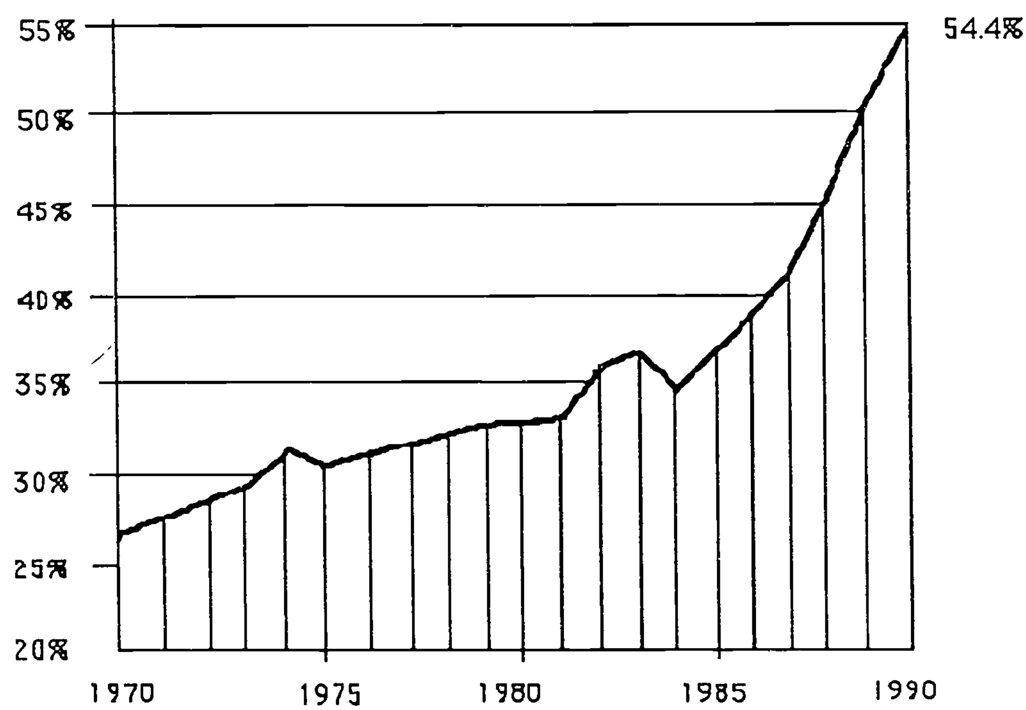
General Education	First year - one type	
	Second year - two types	Non-scientific
		Scientific
	Third year - five types	Non-Scientific : A,B
		Scientific : C,D,E

Each of the alternatives A,B,C,D,E can lead to the Baccalauréat Général.

For the second route, called technical education, the general sequence, with scientific and non-scientific options in the last two years, is similar, but there are only two options in the last year, G (non-scientific) and F (scientific), both of which lead to the Baccalauréat Technologique. There are other routes concerned with professional and apprenticeship training, leading to the Baccalauréat Professionels : these will not be discussed here. The examination to be described in this chapter is the scientific *baccalauréat* (C, D or E).

Two years ago the government decided that in the future 80% of an age group must gain the baccalauréat level - presently only 48,1% of an age group takes it. Figure 1 shows the evolution of the proportion of the age group reaching the level of the baccalauréat.

Figure 1 : Proportion of the Age Group Reaching the Baccalauréat



The baccalauréat has the same structure for all pupils. It is organized at the end of each school year - about the end of June or beginning of July, at the same time in the whole country. It consists essentially of written tests. An extra session is organized in September for students who are prevented, for example by illness, from taking it in June. The organisation

and administration is done by the academies. Table 1 gives data for the entry and success rates for the various branches of the baccalauréat in 1990

Table 1 : Data for Baccalauréat entries in 1990

All percentages refer to the total number in the age group and are approximate

Total number in age group	about	900 000	
Studying for all Baccalauréats	about	535 139	
for the Baccalauréats général:		332 638	(34%)
for the Baccalauréats technologiques (F & G)		169 406	(19%)
Studying for scientific Baccalauréats générals	total	155 294	(17.2%)
	C	67 184	(7.5%)
	D	77 773	(8.6%)
	E	10 337	(1.1%)
Successful in all Baccalauréats		391 274	(43.4%)
Successful in scientific générals Baccalauréat	total	123 505	(13.8%)
	C	57 398	(6.4%)
	D	58 099	(6.5%)
	E	8 008	(0.9%)
in scientific technologiques Baccalauréat (G)		30 663	(3.5%)

The Structure of the Science Teaching

In the French system, physics and chemistry are never separated. They are taught by the same teachers and the ability of the pupils in each subject is - officially - never evaluated separately. They are globally named *sciences physiques* in the official texts, but since more than half of the teachers are physicists, the word physics covers often both subjects. (The association of French physics and chemistry teachers is the *Union des Physiciens*).

In the *collége* (12 to 15 years old) all pupils have the same curriculum. Then they can choose between long or short studies. The *lycée* is the long way. During the first year in the *lycée* (for 16 years old) the curriculum is again the same for all pupils. At the end of this year they have to choose between (or they are oriented to) a scientific or non scientific syllabus.

For the scientific option, the first year class is the same for all. A distinction between the curriculum exists only in the last- third year - class. Here, there are three options : mathematics and physics (série C), mathematics and biology (série D) or mathematics and technics (série E).

However the curriculum in physics and chemistry is approximately the same in the three *séries*. The difference bears mainly on the importance given to each subject in comparison with the others.

Students have to chose only between different séries for the whole year. This is a general feature of the French system: pupils have no possibility of choice inside a given structure, so that, for example, a flexible system of credit accumulation is not possible.

In the collège, about 1.5 hours per week used to be devoted to physical science, but this is due to change from 1991 to no hours during the first two years and 2 hours per week in the third and fourth.

Table 2 : Hours per Week of Teaching of Physical Science in the Lycée

	first year	second year	third year
lectures	2	3.5	3.5
practical work	1.5	1.5	1.5

Table 2 gives the number of hours per week devoted in the lycée to physics and chemistry. The lectures are given to the whole class and the practical work to a half class (24 pupils maximum); this practical work consists of laboratory work or problem solving training. The total teaching time for all subjects in the second and third years is between 24 and 30 hours per week each year, depending on extra options which may be taken.

These times may be compared with the times given to mathematics - 6 hours per week, rising to 9 in the last year for options C and E - and to biology, with totals for lectures and laboratory of 2.5, 2 and 5 hours per week in the three years respectively.

The times devoted to physics and chemistry are approximately the same (50% - 50%) in the first and second years. In the third year, the split is still 50% - 50% for option D, but shifts to 60% physics, 40% chemistry for options C and E.

Admission to University Courses

For higher education there is a general route involving no selection leading to many university courses. There are two highly selective routes, however. The first concerns the *institut universitaire de technologie* (I.U.T.) or polytechnics. These institutes belong to Universities but are autonomous particularly in their choice of their students. They are divided into several departments (chemistry, mechanical engineering, biology and so on). The studies last two years and are sanctioned by a degree called the *diplome universitaire de technologie* which allows the holder to get a job or possibly, with very high marks, to study at the University or Engineering schools.

The second selective route is for preparation to enter the *grandes écoles*: These are prestigious engineering schools with competitive entrance examinations. Special preparatory courses are provided, in institutions which are administered within the secondary school system, to prepare students for these entrance examinations over two or three years (*classes preparatoires*). As no certificate is delivered if a student fails in these special entrance examinations these students register also at the university for a "free entrance" route. In this route, they don't follow teaching but can get through the examinations. Moreover in some cases, and in some universities, according to the results at the grandes écoles entrance examination they can get the "équivalence" of the diploma that students obtain after two years in a normal university course (known as the DEUG). Table 3 gives data on the numbers taking the various routes.

Table 3 : Data on Courses Entered by Students Who Obtained the Baccalauréat in 1990

Students entering the university	45 040	(5% of age group)
Students entering the I.U.T.	18 585	(2% of age group)
Entering after scientific Baccalauréats :		
C	22,2%	of the 18 585
D	32,3%	
E	14,6%	
Entering after technical Baccalauréats	25,8%	
Students in the special preparatory classes		
Total	39 537	(4% of age group)
Entering these after scientific Baccalauréats :		
C + E	63,6%	of the 39 537
D	7,6%	
Entering these after technical Baccalauréats	4%	

There is in principle no selection for university admission. The Baccalauréat is the certificate which allows entry to the university of the student's choice. The filling of a form and the payment of fees (about 1000 FF or about $200) is all that is needed for registration. The capacity of the university is the only factor which can limit the number of students and thus, implicitly, introduce the possibility of selection: this is the real situation in the academies of the Parisian region.

The situation is totally different for entrance into the I.U.T or the special classes preparing for entry to the *grandes écoles*. To be admitted to these, students have to fill in special forms (one form for each I.U.T department for instance) where they must indicate, in order of preference, 3 institutes or special classes. They must also provide a copy of their school report book and an opinion of their teachers concerning their capacities to follow their proposed study involved. Students who register in this way very often register also at university in case all of their applications fail. If they are admitted at an I.U.T they are automatically dependent on the university, but in the *classes preparatoires* they have to confirm their registration if they want to sit for university examinations.

Each I.U.T or each *classes preparatoires* make its own selection with its own criteria. This selection is done by a board of teachers of the institute. The board will take into account not only the results in scientific subjects but also in other subjects, such as foreign languages, and other data: for example the age of the candidate and the grade of the Baccalauréat.

In the first and major stage of the selection, the marks of the Baccalauréat cannot be used since it is done before it has taken place. The marks used are those given by the teachers during the classes of the second and third years, which are written on the school report book. Sometimes they don't take into account the marks of the last months because the data are collected before the end of the school year (around the end of April). However, the result of the Baccalauréat is necessary for final selection. Although selected in the first stage, pupils who fail their Baccalauréat cannot be accepted. A new application must be made in the succeeding year but the chances are not then the same. In particular, an older age is a handicap - youth is always an advantage for selection in France.

The Form of the Examination

School Assessment

Each pupil has an official school report book which follows him through the four years in the *collège*, and another for the three years in the *lycée*. This book contains reports of marks and teachers' comments, given at the

end of each term. On each report, teachers write the average of the marks they gave over a period of two or three months and a personal comment on the work of the pupil. A staff meeting is held at the end of each term. During this meeting the behaviour of the class and the individual performances are discussed. A personalized assessment, taking all aspects into account, is then written in each pupil's report book.

The External Examination

The Baccalauréat consists essentially of written tests (except for foreign languages). The nature of the papers is approximately the same in the different sections. There is only one paper for physics and chemistry, with separate exercises for the physics and the chemistry. This examination lasts for 3.5 hours. The duration of the whole written examinations is 4 days.

The difference between the sections C,D,E depends on the weight attached to the marks of the different papers. These weights are given in table 4

Table 4 : The Weights of the Different Papers for Each Option

	maths	physics	biology or technics	all other subjects
C	5	5	2	11
D	4	4	4	11
E	5	4	4	11

Preparation of the Examination Paper

In setting the baccalauréat, these academies collaborate in four or five groups (for metropolitan France - there are others for overseas). Thus one version of the baccalauréat was set in 1991 jointly by the academies of Amiens, Lille and Rouen.

Three papers for each subject must be prepared each year for each type of baccalauréat : one for June, one for September and an alternative one for substitution in case of difficulties.

The papers use problem solving types of questions. Each paper consists of a definite number of exercises in physics or in chemistry (table 5); one

exercise must concern an experimental device (involving for example an experimental description, or a choice of apparatus). The questions are structured to lead the candidate through the exercises, sometimes becoming more difficult towards the end. Useful data, with no superfluous data, are provided. Candidates are allowed to use pocket calculators. A sample set of questions is given in Example 2.

Table 5: Numbers of Exercises in the Physical Science Papers

	total	physics	chemistry
baccalauréat C/E	5	3(total of marks: 13)	2(total of marks:7)
baccalauréat D	4	2 (total of marks: 10)	2 (total of marks: 10)

Any one exercise cannot be worth more than 7 marks, and a correct answer to the exercise concerning the experimental device must be given a minimum of 5 marks.

Those preparing the papers must take into account the *référentiel* and the *capacités* (see Example 1 at the end of the chapter). Only the *capacités* A are assessed in the baccalauréat. A question using a knowledge or a skill not in the *référentiel* assesses automatically the *capacité* C; the *capacité* B is not assessed at all in the examination.

The work of preparation is done by a team of, at most, three or four high school teachers, in charge of classes at the examination level, coordinated by a professor of university (who has taught for a minimum of six years). All this process is supervised by the *inspecteurs* (general and local). The teachers do all this work without fees, as extra work. There is one team for each of the collaborating groups of academies - 5 or 6 in all.

In March of the year before the examination, the team for preparing each kind of paper is selected - one for the June paper, one for the September paper, one for the substitution paper. A member of this team stays a minimum of two years and a maximum of four years. The university professor is the chairman. The *inspecteurs* will coordinate the work of the different teams. At the outset, the team has to compose three papers using several contributions.

These contributions are prepared during the holidays (July) by four or five other teachers who are asked by the administration to write a draft paper

following the general instructions of the baccalauréat. Each teacher writes a complete subject without knowing or contacting the other teachers.

The team can choose the totality of one proposed paper, mix several proposals or, if necessary write a completely new paper. It proposes also the marking for each exercise that is used for the examination.

Scrutiny of the Papers

Each draft is submitted to one or two teachers who must solve the problems completely under the same conditions as a candidate; they first verify that no data are missing and that the formulation is correct. Secondly, in so far as they know the ability of their pupils, they report on the likelihood of their pupils being able to solve this set of questions.

The drafts, the solutions and all the reports are submitted to the *inspecteur* who verifies that the questions are not too difficult or outside the program. and writes a report, with recommendations, to the team. Following these recommendations the team writes a second draft which is tested under the same conditions as the first one.

At the end of this procedure, three reports are made for each of the three papers: one from the teacher who tested the paper, one from the team, and one from the *inspecteur*. Each report must clearly indicate whether or not the paper can be chosen as the next examination paper.

The *recteur* has to make the final choice between the papers which have obtained three positive reports. If no one fulfils these conditions, s/he can call for a meeting of all those consulted and if no agreement is obtained he will use a paper which has been accepted a previous year and not used.

The Boards of Examiners

A typical board of examiners consists of teachers for each subject, who are the teachers who will mark the papers in the subject, and is supervised by a professor of the university. The members of the board are selected by the administration from teachers of the second or third year lycée courses. The board is different between June and September. The members of the board are paid for each pupil they mark, but this payment is quite small for the work required. Some of the members of a board may have been involved in setting the paper, but this is a separate exercise, separately administered.

Each board deals with about 100 pupils. Five or six boards are grouped in the same administrative centre which is located in one of the *lycée* where the pupils sit the written papers. A teacher may mark the paper of

his own pupils (because of the anonymity) but is not allowed to ask his pupils at any oral examination.

Marking

Each paper is marked out of 20. The candidate's marks for each paper are weighted and added. A student must get a total of marks equivalent to 50% overall. However, only the total is taken into consideration - there are no minimum levels in individual topics or subjects. Because there are no other conditions, some candidates can obtain a scientific diploma with very low marks in the scientific subjects.

Students who have more than 8/20 but less than 10/20 have to take an oral examination in three subjects, which they can chose from those taken in the written test. The best of the two marks - the written and the oral one - is retained for the final total.

The results of the graduate are classified on a scale of special grades as follows :

total equal to or more than :	10/20	Pass	-passable
	12/20	Quite Good	-assez bien
	14/20	Good	-bien
	16/20	Very Good	-très bien

The school report book is given to the board of examiners. The jury may use this record if the student needs only few marks to reach the total required for a special grade or to be allowed an oral examination.

As soon as students finish the written examination, the scripts are collected by the administration and numbered to preserve anonymity. The day after, the teachers of the board come and collect their scripts for marking. In each subject, a meeting is organized with one representative coming from each examination centre. The representatives look at the marking scheme proposed for the paper and decide how to apply this scale: for example to clarify what is essential in an answer if it is to earn the maximum mark. The meeting may recommend moderation or severity in particular aspects of the marking. After the meeting, each representative will explain the results to the other markers in his board.

The examiners mark the scripts at home within around 10 days. The board then meet again in the centre with the scripts, record the marks , calculate the total for each candidate and decide whether the candidate has passed, is authorized to attempt the oral examination or has failed. The chairmen of the different boards compare the marks given by the different examiners and use this information to be more or less indulgent at the final stage.

Table 6 gives data for the proportions of candidates in the different grades in 1990.

Table 6: Percentages of candidates in the different grades in 1990

Option	Total Pass as % of entry	*Assez Bien*	*Bien*	*Très Bien*
C	85,5	29,9	11,8	2,5
D	74,7	20,1	3,1	0,2
E	77,7	20,6	4,7	0,5

The marks are sent to the candidates. When a candidate doesn't agree with the marking, he can ask for his script and scrutinise the detailed marking written by the examiner. A candidate can lodge a complaint within one year after the examination. Thus the markers have to keep all the information about their marks, and about the questions they asked in any oral examination, for a year. The number of complaints is usually small and few of them succeed.

Analysis of the Results

All numerical data are available in the "National Centre for Pedagogical Information" in Paris, and in its regional offices, one of which is located in every academy. This national information is not systematically communicated to the teachers who must ask for it when needed. Usually, a school's statistical results are presented in the school's assembly hall at the beginning of the new school year. Everybody can compare particular results with the national averages which are published in newspapers or by radio and T.V.

The national newspaper "*Le Monde*" publishes every month a special issue devoted to education ("*Le Monde de l'Education*"). This newspaper gives comparison between the success of the different high schools and many statistical data. These data are collected by the journalists themselves and some are missing.

No statistical studies of the marks are published: for example nobody knows the distribution of marks for each marker and for the examination as a whole.

Links with Schools, Teachers and Pupils

Programmes and *réferentiels* and all instructions for the baccalauréat in each *lycée* are given through an official bulletin issued by the Ministry for Education (B.O.: *bulletin officiel de l'éducation nationale).*

Some *Capacités* to assess are not taught in science lessons ; for example, for the use of the French language, it is usually not possible for the science teacher to be allowed to take part in the French lectures.

One of the *inspecteurs* job is to verify that the teachers follow the official curriculum but as the *inspecteurs* visit each teacher once every five or six years the efficiency is low. The same problem appears when a teacher gives systematically too easy or too difficult assessments: the system has no real procedures or sanctions to help impose a modification on his behaviour, as long as this behaviour is not professional misconduct.

During the holidays following the examination, all the papers submitted to the candidates are collected and published. The teachers use these past papers to train their pupils to solve all the exercises from the past two or three baccalauréats. However, these pupils are not then really trained to think by themselves on scientific questions. They know the core very well but have no ability at all for the *capacité* C (develop scientific processes). This can be a serious disadvantage in their studies at university level.

Opinion on quality and effects

At present, this examination mode is criticised for its cost, the complexity of its organisation and the way it takes up the time of individual teachers and professors. Another criticism bears on the fact that the whole work of the candidate is evaluated in a single examination, and for the scientific part, that the examination is only a written test, and it tests only the ability to solve a certain type of problem. It is said that the only abilities required are essentially memory, speed and no real thinking activities.

New structures will exist from September 1992 for the first year, and in 1994 for the third. The options C,D,E will disappear. *Première et terminale* will be "scientific" only, with a core for all pupils and options. In this perspective a new baccalauréat will have to be in existence by June 1995.

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Notes d'information (available in C.R.D.P- Regional Centres for Pedagogical Information)
90-17: Population universitaire 1989-1990
91-33: Résultats du baccalauréat général, technologique et professionel (1991)
91-39: Baccalauréat (1990)
90-25: Classes préparatoires aux grandes écoles 1980-1989

Address for Reference:National Centre for Pedagogical Information
(C.N.D.P)
45, rue d'Ulm, Paris, France.

Example 1 : The Abilities to be Assessed in Physics and Chemistry

These lists must be communicated to the pupils during the school year.

The assessment must take into account the different abilities. One exercise must if possible assess only one or two *capacités.* In the new school textbook, the assessed *capacités* are indicated at the beginning of the exercises.

A) To have specific knowledge in physics and chemistry
- 1) scientific knowledge
  - a) vocabulary, symbols, units
  - b) order of magnitude
  - c) definitions, laws, models
- 2) skills
  - a) practical skills
  - b) theoretical skills

B) To know how to use knowledge and skills which are not specific to physics and chemistry
- 1) to access to the knowledge from different sources
- 2) to use the French language
- 3) to use mathematical tools
- 4) to use others techniques of expression

C) To develop a scientific processes
- 1) to choose or develop a model in physics
- 2) to organise the steps of a solution
- 3) to pass a critical judgment
  - 1- in a situation related to a known situation
  - in the experimental field
  - in the theoretical field
  - 2 - in an unknown situation
  - in the experimental field
  - in the theoretical field

Example 2 : The Physics Questions From a Baccalauréat Papers

The three questions below formed the physics component of the paper set, for Options C and E, jointly by the Academies of Aix-Marseille, Montpellier, Nice-Corse and Toulouse .

1 - AIX-MARSEILLE, MONTPELLIER, NICE-CORSE, TOULOUSE

PHYSIQUE

Exercice 1 (5 points)
Mécanique (mouvement d'un solide sur un plan incliné)

Exercice 2 (3 points)
Optique (image par une lentille convergente)

Exercice 3 (5 points)
Électricité (détermination de la capacité d'un condensateur)

CHIMIE

Exercice 1 (4 points)
Solutions aqueuses (dosage de l'acidité d'un vinaigre)

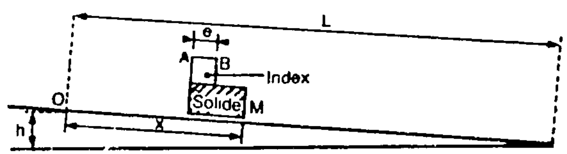
Exercice 2 (3 points)
Chimie organique (détermination de la classe d'un alcool)

ÉNONCÉ

PHYSIQUE

Exercice 1

Accélération de la pesanteur : $g = 9{,}80 \text{ m} \cdot \text{s}^{-2}$.



Un solide S de masse $m = 60{,}0$ g peut glisser sur un rail OO' de longueur $L = 1{,}60$ m dont l'extrémité O a été soulevée de $h = 1{,}00$ cm (la figure n'est pas à l'échelle). Le solide est abandonné, sans vitesse, du point O. Il est muni d'un index de carton de largeur $e = 2{,}00$ cm. Lors du passage du solide par le point M à la distance x de O, un chronomètre mesure la durée θ qui sépare le passage des 2 extrémités A et B de l'index, tandis qu'un second chronomètre mesure la durée totale t du trajet OM.

Les résultats des mesures sont indiqués dans les tableaux suivants.

x (cm)	0	5,0	10,0	15,0	20,0	25,0	30,0	40,0
θ (s)	-	0,198	0,157	0,132	0,117	0,106	0,097	0,087
t (s)	0	1,68	2,10	2,47	2,81	3,13	3,37	3,78
v ($\text{m} \cdot \text{s}^{-1}$)	0	0,101	0,127	0,152	0,171	0,189	0,206	0,230

x (cm)	50,0	60,0	70,0	80,0	90,0	100,0
θ (s)	0,080	0,076	0,073	0,071	0,070	0,069
t (s)	4,20	4,60	5,00	5,32	5,70	6,03
v ($\text{m} \cdot \text{s}^{-1}$)	0,250	0,263	0,274	0,282		

1) *a*) Compléter les tableaux en calculant la vitesse instantanée v du solide pour les deux valeurs de x supérieures à 80 cm.
Représenter graphiquement sur papier millimétré, les variations de v en fonction de t.
Échelles : 4 cm pour 1 s ; 5 cm pour $0{,}1 \text{ m} \cdot \text{s}^{-1}$.

***b*)** On étudie le mouvement du solide seulement pour x inférieure à 40 cm.
Exprimer v en fonction de t pour cette partie du mouvement.
Quelle est la nature de celui-ci ? Quelle est son accélération ?

2) En supposant que le solide est soumis pendant tout son mouvement à une force de frottement d'intensité f due à l'air, colinéaire au vecteur vitesse mais de sens contraire, établir l'expression de l'accélération du mouvement du solide en fonction de h, L, m, f et g.

3) *a*) En utilisant les résultats des questions **1) *b*)** et **2)**, montrer que tant que x est inférieure à 40 cm, la force de frottement sur l'air est pratiquement indécelable.

***b*)** Calculer l'accélération moyenne du mouvement pour x comprise entre 50 et 60 cm et calculer la valeur correspondante de f.

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Example 2 : Physics Questions From Baccalauréat - continued

Exercice 2

On dispose de deux lentilles minces L_1 et L_2 de vergences $V_1 = 10{,}0$ dioptries et $V_2 = -8{,}0$ dioptries.

1) Déterminer les distances focales (images) $\overline{OF'_1}$ et $\overline{OF'_2}$ de ces deux lentilles. Préciser la nature divergente ou convergente de chaque lentille. (On indiquera quelles sont les significations de ces deux termes.)

2) On place une des deux lentilles à une distance $d = 11{,}0$ cm d'une diapositive de hauteur $h = 24$ mm ; l'axe optique de la lentille est perpendiculaire au plan de la diapositive et la rencontre en son centre.

a) Quelle est la lentille à utiliser pour obtenir une image sur l'ecran?

b) Déterminer par le calcul la position et la hauteur de l'image de la diapositive.

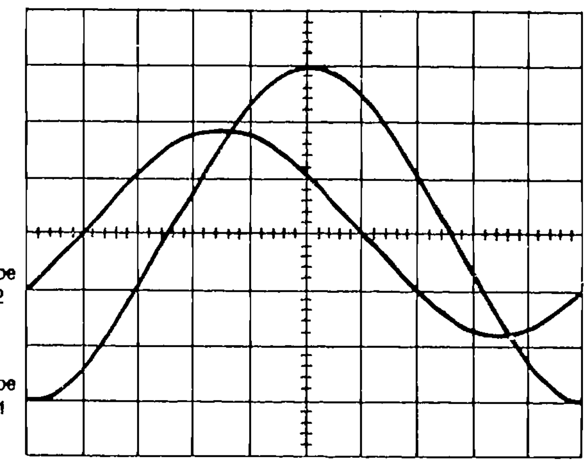
Exercice 3

On dispose d'un générateur basse fréquence délivrant une tension sinusoïdale de valeur efficace constante. Entre ses bornes on branche, en série, un resistor de resistance $R = 1{,}00$ kΩ et un condensateur de capacité C inconnue que l'on veut determiner.

1) On regle la fréquence du générateur sur $f = 1{,}00$ kHz et on visualise la tension aux bornes du générateur et celle aux bornes du resistor grâce à un oscillographe, dont voici l'ecran :

courbe n° 2

courbe n° 1



Déviation horizontale : 100 µs/div

Déviation verticale : voie A : 0,5 V/div
voie B : 0,5 V/div

(1 division sur le dessin correspond aux côtés des carreaux).

a) Faire le schéma du montage électrique en indiquant comment l'oscillographe est relié au circuit.

b) Quelle est la courbe qui donne la tension aux bornes du générateur et quelle est celle qui donne la tension aux bornes du résistor? Justifier les réponses.

c) Quelles sont la tension efficace aux bornes du générateur et l'intensité efficace du courant qui traverse le circuit?

d) Donner la valeur de la capacité C du condensateur. (Justifier les calculs.)

2) Afin d'obtenir une valeur plus précise de la capacité C on place dans le circuit entre le résistor et le condensateur une bobine de coefficient d'auto-inductance $L = 0{,}100$ H. On règle la fréquence du générateur jusqu'à ce que la tension aux bornes du résistor ait l'amplitude maximale, la nouvelle fréquence du générateur est alors $f' = 1{,}43$ kHz.

Établir l'expression de la capacité C du condensateur en fonction de L et de f'. Calculer la valeur de C.

Remarque : dans cet exercice, les questions 1) et 2) sont indépendantes.

Chapter 7 :National Entrance Examinations in Hungary

Ervin Gecsó

General Features

Hungary has a single national examination system for admission to university degree courses. Candidates have to take entrance examinations in two subjects. Each examination usually consists of oral and written components. The physics examination is a subject examination which students have to take if they want to enter specialised courses in subjects such as medicine, science or technology.

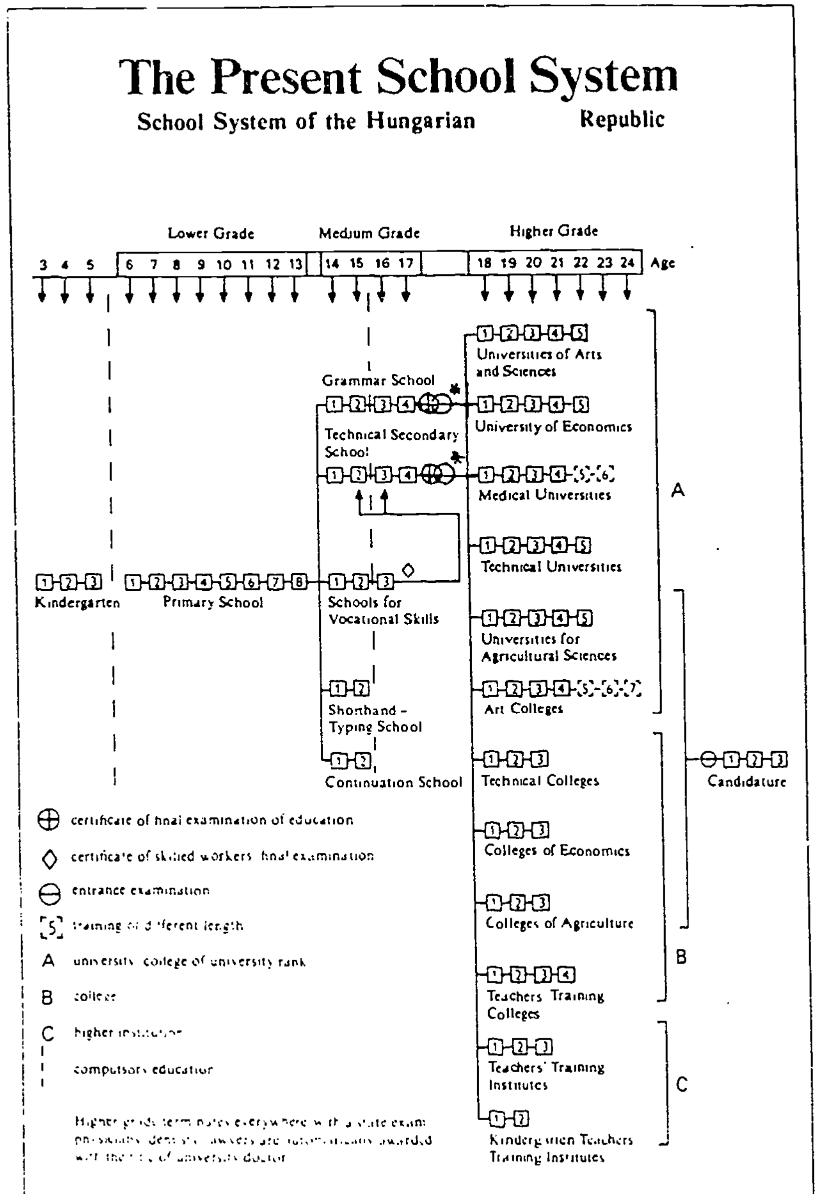
As Table 1 (on the next page) shows there are several types of secondary schools. In recent years, about 94% of the students finishing the last grade of primary schools at age 13 continued their education. About 20% of them enrolled in Grammar Schools, 27% in Technical Secondary Schools, and 43% in Schools for Vocational Skills.

Grammar School students study at least 14 separate subjects. Physics is obligatory in all 4 years. Students spend about 8% of their school time studying physics, and a further 15% studying chemistry, biology and earth science, which are also obligatory. Students also have the option of studying extra physics in the last two years, taking for this an extra proportion of about 3.6% of their school time. Those who take physics in the entrance examination have usually taken this option. Students in the Technical Secondary Schools also study at least 14 separate subjects. Physics is obligatory and students also spend about 8% of their school time studying it. However, in most cases it is the only science subject, although there are Chemistry, Biology and Earth-Science courses where particular branches of study require them. There is no optional physics, but students usually study electronics, or electrotechnics or mechanics or any other technical subjects depending on the branch they have chosen.

Of those who enter the university entrance examinations, 28.5% (11754 candidates) attempt physics as one of their two subjects. For comparison, 40.4% attempt mathematics, 20.2% biology, 6% chemistry, and 44% attempt the most popular subject, Hungarian.

The number of students who obtained a degree in physics in 1990 was 285, representing about 0.5% of the age cohort. However, almost all of these took their degrees as part of teacher training - only 46 took a degree as a qualification to become a physicist, and only 4 of these were women.

Table 1: Diagram Showing the Main Features of the School and Higher Education Systems in Hungary



* These two examinations have a common component

Admission to University Courses

Students have to take two types of examination. The first, the Maturity Examination, has to be taken in five or six subjects, of which three, Hungarian language and literature, history and mathematics, are obligatory. The Maturity Examination as a whole is only obligatory for those who wish to go on to the second set of examinations, in which they attempt the university entrance examination in two subjects. As table 2 shows, some students take both sets of examinations in the same year.

Table 2 : Numbers taking the Maturity and Entrance Examinations in 1990

	Grammar School	Technical Secondary School	Total
(a)Number of students finishing last grade	24617	30357	54974
(b)Number succeeding in Maturity Exam.	24136	28930	53039
(c)Success Rate - (b) as percent of (a)	98%	95%	96%
(d)Number taking entrance examination	29093	11516	*41261
(e)Number entering university course	11039	4204	**15469
(f) Success Rate - (e) as percent of (d)	38.9%	36.5%	37.5%

*Of these, 58.5% also took the Maturity Examination in the same year
** Of these, 64.1% took the Maturity Examination in the same year

Students have to choose physics as one of their two university entrance examination subjects if they want to enter courses in medicine, pharmacy, all kinds of engineering, physics, chemistry, mathematics, geology, meteorology, and teacher training involving physics, mathematics, or technical subjects.

The entrance examination consists of both oral and written examinations. A student's maximum total mark is 120, of which 60 marks are derived from the secondary school and 60 from the entrance examination papers. The 60 marks from the secondary school are determined by marks obtained in the following subjects: mother language, history, mathematics, foreign language, physics and one of the following subjects: biology, second foreign language, chemistry, geography, technics, knowledge of education. A student is given a mark out of 5 for each subject in each of the last two years of secondary school. A typical student's mark may thus be made up as follows : -

	III. grade	IV.grade
mother language	4	5
mathematics	5	5
history	3	4
physics	5	5
English	4	4
biology (option)	4	4
sum	25	27 = 52 points

The 60 marks for the entrance examinations are distributed between the two examination subjects. Thus for physics as one subject there are 30 marks, divided equally between the written and the oral components.

The standards required in order to secure university entrance are determined by the Ministry of Education - in the light of target numbers and on the basis of recommendations of the universities. The numbers change each year. In order to arrive at these standards, the complete distribution of the results, i.e. the sums of the marks derived from the secondary school and the marks obtained for the entrance examinations have to be used.

Students can only be admitted to a university (or other higher grades of education), if they obtain :

- at least 30 examination marks in the course of the entrance examinations (irrespective of the school assigned marks) and
- at least 70 marks in total, including the school marks.

Table 3 gives data on the application rates and entry standards for several departments in three universities.

The Form of the Exar·ınations

The two subjects which a student chooses for the entrance examination must also be taken in the Maturity Examination. The choice of these two subjects will be constrained by requirements of the university faculties or courses which the student wants to enter. In order to avoid requiring a candidate to take two examinations in the same subject, there are special common-maturity-entrance written examinations for mathematics, physics, chemistry and biology. This means that there are two kinds of final physics examination. One is for those who choose physics as one of their options for the Maturity Examination but do not want to take the physics university entrance examination (First Version). Th· other (Second Version) is the common-maturity-entrance-written physics examination for those who choose physics also as an entrance examination subject.

Table 3 : Application Rates and Entry Standards for University Courses

Branch	Number of applicant			Application rate*			Standards**		
	1988	1989	1990	1988	1989	1990	1988	1989	1990
	Faculty of Science, Eotovos University, Budapest								
mathematics and physics	147	178	186	1,5	1,7	1,7	100	100	101
chemistry and physics	10	8	13	0,7	0,5	0,9	101	101	100
mathematics and technics	27	12	18	1,4	0,5	0,9	98	96	97
physicist	58	54	67	2,3	2,2	1,9	113	118	114
mathematician	30	34	35	1,5	1,7	1,2	110	116	110
geologist	-	29	54	-	2,1	5,4	100	101	105
meteorologist	37	23	17	4,6	2,9	2,1	108	103	105
chemist	27	30	43	1,4	1,5	1,4	105	108	100
	Technical University, Budapest								
architect	248	269	369	2,5	2,2	2,5	109	120	115
mechanical	479	339	433	1,6	1,2	1,4	98	95	87
chemical	195	184	240	1,9	1,4	1,4	92	90	101
electrical engineer	805	731	958	2,0	1,6	2,3	107	104	104
	Medical University, Budapest								
general physician	1058	1025	929	3,5	3,4	3,3	112	114	108
dentist	246	202	184	4,1	3,4	3,1	111	110	103
pharmacist	294	279	200	2,1	2,0	1,4	96	97	90

*The ratio of applicants to guiding number
**Required in order to be sure of a pass for entry to a university

In the First Version the student may make a choice between only oral or only written forms of the physics examination. In the Second Version candidates have to take both the common-maturity-entrance written physics examination and an oral physics entrance examination. The organisation of the Maturity Examination is the responsibility of the schools concerned, but the written problems for the external component are set by the Ministry of Education. Thus, the final examination for the secondary schools is external and internal at the same time. The organisation of the entrance examinations is the responsibility of the National Office of Admission in Higher Education (NOAHE).

The Examination Methods Used

In the First Version, physics may be examined by a written paper only. In this case every candidate will write the paper at the same time all over the country. The students have a book entitled "Synthetic Collection of Exercises and Problems in Physics", published in two separate volumes, one for the Grammar Schools and one for the Technical Secondary Schools; both contain more than 2000 problems. The examination problems are chosen from these books, so they may be known by the students before the examination.

On behalf of the Ministry of Education, an expert in the National Institute of Public Education compiles five sets of problems from these books (five sets for the Grammar Schools and another five sets for the Technical Secondary Schools). Every set contains six problems. After revision by two practising teachers, the corrected versions are sealed in five separate envelopes. On the morning of the examination day (there are separate days for Grammar Schools and for Technical Secondary Schools) a representative of the Ministry of Education chooses one from the five sealed envelopes in a TV studio in front of the camera. The expert then opens the chosen envelope and announces the numbers of the tasks which comprise the written physics examination. The event is transmitted live on T.V. and radio. The students have 4 hours to work on the paper.

Example 1 shows the questions selected for this version in 1990 and the marks assigned. In choosing the six questions, the expert has to conform with rules prescribed by the Ministry. These include the following requirements :

- there must be one theoretical problem, one question on the analysis of the results of experimental measurements, and four on problems involving numerical work
- the questions must make the candidates think and must help to elicit the level of development of the candidate's thinking in physics.
- pocket calculators and tables of functions may be used.

The Second Version of the physics examination is the common-maturity-entrance written exam. The NOAHE sets up a separate committee to compile the test-paper in each subject. The physics committee has eleven members, all of whom are qualified physics educators. Most of them are teachers in the different universities and only three are secondary physics teachers. They work on a test-paper, in strictest confidence, for five months and usually make six or more parallel versions. The NOAHE chooses one of the six versions. Example 2 gives in full the written examination set in 1990. In this examination, as in the Maturity, candidates have to attempt all of the questions.

The other part of the entrance examination is the oral part. For this part, the board of examiners has a president and two examiners for the examination subjects who are teachers of the faculty. Usually a secondary teacher (who may be an examiner as well) and a representative of the students are on the committee also. Between 10 and 14 candidates take the oral examination per day before a board of examiners from two subjects. The length of the examination is 30-40 minutes per candidate. The members of the committee try to judge the ability to reason of the candidate and in what manner he/she can apply knowledge. Usually the examiners give qualitative questions - questions designed to set one thinking - to the candidate. Example 3 gives a set of such questions.

It is generally believed that the oral is not an objective or impartial assessment, and there are no written rules about the assessment of an oral. However, an oral does establish a living connection between the candidate and the examiners. It gives an opportunity to observe the behaviour of the candidate in an unexpected situation, and to judge such qualities as: types of reaction, flexibility of thinking, sense of phrasing, and other personal characteristics. Adequate knowledge of physics is not by itself a sufficient condition for becoming a professional, whether in physics or in other professions.

For the First Version of the physics examination, when the "oral only" version is chosen, it is a typical external examination. The examiner is a school teacher and the chairman is sent by the authority. The oral maturity physics examination consists of

- a short report about a topic of physics (in this part of the oral, the student has time and freedom to express ideas in his/her own words) 10 minutes
- a short execution of an experiment or measurement (it may be a simple demonstration experiment too) 10 minutes
- and of course an open-ended question for problem-solving 10 minutes.

For preparation, the student has a further 30 minutes.

The Marking of the Examination

Marking guides and suggestions about the marking are prepared for both the First Version and the Second Version of the written examination to promote uniform evaluation of students' attainments.

For the First Version (the Maturity Examination), on the day after the examination, one possible solution of the problems, and the suggested marking guides are sent by the NIPE to the schools. These are also published in a newspaper at the same time. The school teachers correct and mark the papers using the distributed guides. It is the chairman's duty to supervise this work. For the Second Version, all candidates sit the paper at the same time, coming to one of a set of centres. There is one centre in each town where there is a university. Each candidate produces two copies of his/her answers, one of which is sent to the candidate's school to serve as the "Maturity Examination". The other is used for the entrance examination.

The Marking Scheme

On the solution sheets, one possible solution of each item is included. However, in addition to the published solutions, a score has to be given for any right solution of the complete item, or for a specified sub - section: full marks are given wherever a problem is solved according to correct principles and is numerically correct. The published maximum score for each question cannot be exceeded.

Solutions which are only partially correct have to be evaluated with great care. However it follows as a matter of course in these cases, that it is impossible to give precise and unambiguous instruction about the ways in which marks are to be given. However, several general rules are given to enhance uniform practice.

Where a question is made up of several parts, then each part is evaluated separately and given a mark for that part. Where an answer is incorrect simply because of a numerical error, 75 to 80 percent of the maximum mark is given. Where a wrong answer to one section has been penalised, it is accepted as correct wherever the result has to be used in a later section. The numerical values of answers are accepted if they are within 5 percent of the correct value. Any system of weights and measures is accepted if it is appropriate and is used consistently.

The marking has to be carried out and recorded in such a way that a supervisor can check it on a later occasion if required. The physics paper is marked out of 100, and the marks are subsequently converted to a 15 point scale by a scaling which is linear apart from giving a scaled mark of 15 to all raw scores of 90 or above.

Analysis of the Results

There is no statistical publication for the "Maturity Examination" in Hungary. It is not necessary for schools to give feed back about their results to the students. However, the National Office of Admission in Higher Education (NOAHE) collects, analyses and reports on the entrance examination every year. The data for each candidate are stored in a computer. There are three important publications of the NOAHE concerned with the results of the entrance examinations.

The first is "Entrance Examinations in Higher Education". It is intended mainly to inform the authorities. It contains full data about the results: the numbers of applicants, the marks derived from the secondary schools own marking, the marks obtained in the course of entrance examinations, the distribution of results according to student gender, the types of the secondary schools and the district. Other data include the numbers of candidates who were successful for entry to the different kinds of university and to other higher education courses, and of course all data are given separately for each entrance subjects.

The second publication is "The Results of Secondary Schools in the Entrance Examinations for Higher Education". This provides feed-back for the secondary schools and the local authorities. It contains the name and address of each secondary school (Grammar Schools and Technical Secondary Schools) which entered candidates in that year, and the results of their candidates for each of the different universities. It also reports separately on the school generated marks and the written examination marks. It also gives the numbers of

- all candidates attempting the examination,
- the successful candidates (who reached the standards required),
- the candidates who have achieved admission to somewhere.

The third publication is entitled "Written Problems from Entrance Examinations and possibilities on Higher Education" and is a book for the intended candidates. It contains all kinds of test questions used in the course of the entrance examinations in the previous year, the numbers of applicants, the application rate - the ratio of applicants to target numbers, and the standards required in order to be sure of a pass for entry to each type of course in each university.

Table 4 shows statistical data for the Second Version of the entrance examination, giving the scaled marks out of 15 for the written and oral components separately.

Table 4 : Data for the Second Version of the Physics Examination

	Written Exam. Marks			Oral Exam. Marks		
	Mean	St.Dev.	r*	Mean	St.Dev.	r*
All candidates	7.21	3.93	0.46	9.27	5.05	0.62
Male	7.80	3.92	0.52	9.46	5.52	0.63
Female	6.00	3.68	0.43	8.97	4.77	0.64
Successful Candidates	9.16	3.60	0.12	12.19	2.81	0.08
Male	9.84	3.33	0.20	12.48	2.63	0.10
Female	7.70	3.71	0.17	11.73	3.02	0.16

r* is the correlation coefficient between the external examination marks and the schools' own, internal, marks.

About 35% of the entrants are women, and they account for a slightly smaller proportion of the successes. The data show that women do relatively better on the oral than on the written components. The correlations with the school's own results are modest, and it is interesting that they are higher for the oral rather than for the written component. The much lower correlations for those who succeed is probably an artefact, arising because correlations between any two sets of data are bound to decrease if a limited range only of the data is selected. It is remarkable that in Hungary there is a strong aversion to tests in general and in particular to the close-ended (so-called multiple choice) types of examination question. Such questions are not used in the written entrance examinations and other features of standardised or psychological testing, including for example the pre-testing of questions, are not incorporated.

Links with Schools, Teachers and Pupils

Links with schools teachers and pupils are achieved mainly through the feed-back publications, and the inclusion of teachers in the various examining groups as already described. The books of problems from which the questions for the First Version of the examinations are selected are another form of feed-back.

Comments on Quality and Effects

The aims of the entrance examination do not reflect and support the practice of good physics teaching in Hungary. It is concerned only with the solving of written problems, so that candidates are not interested in doing experiments or in making their own measurements. An examination like the Nuffield examination is more detailed and authentic reflection of the

aims that good physics teaching ought to have. However, we have more than 11000 candidates taking the physics entrance examination at the same time and in a few centres! The correct assessment of physics attainment demands hard work and much time per person even without any practical assessments. However, current practice might be throwing away useful data by condensing all the information about a candidate into only one number.

Example 1. The Written Examination in Physics for 1990 - First Version

The Selection Announced

I. Numerical tasks	Score
37.14	10
2.47	15
10.29	15
16.23	20
II. Analysis of an experiment, theoretical problem	
15.73	20
27.44	20
	sum: 100 points

The serial number of each task is in accordance with the serial number of the tasks in the Synthetic Collection of Exercises and Problems in Physics for Gymnasium (Tankönyvkiadó, reference number 81304)

Grading

Sum of Scores	Grade
0 - 19	fail
79 - 100	very good

The Selected Questions

37.14. Radium, with a mass number 226 and an atomic number 88, emits alpha rays. What is the atomic number and the mass number of the new atom that remains?

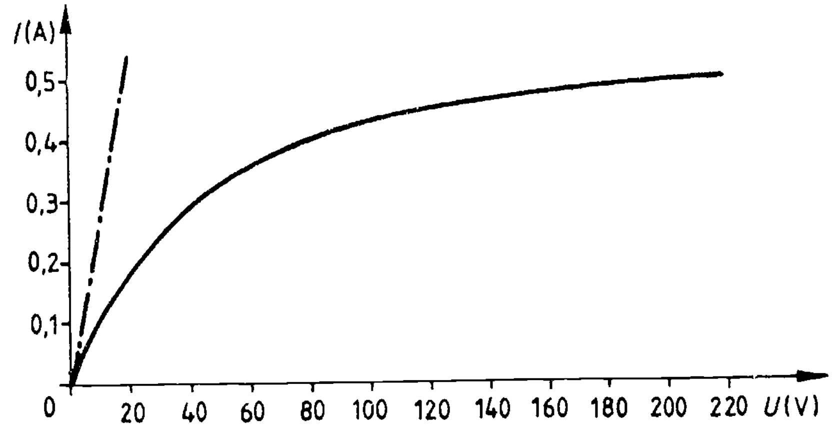
2.47. A flywheel that was rotating at an initial rate of 4000 revolutions per minute stops with uniform deceleration in 2 hours. How many revolutions does it complete during this time?

10.29. A compressed spring pushes apart two trolleys having masses of 0.2 kg and 0.3 kg respectively, in such a way that the trolleys that were initially at rest are separated by 60 cm after 5 s. The mass of the spring and friction are negligible. What is the velocity of the trolleys?

16.23. An electron accelerated by 1500 V is shot in a direction perpendicular to the magnetic induction into a homogeneous magnetic field. The initial velocity of the electron is zero. What is the magnitude of the magnetic induction if the electron is moving along a circle having a radius 1 cm?

Example 1 : First Version Examination- Continued

15.73. Why does Ohm's law not hold for the filament of an incandescent lamp? Analyse the graph showing the current consumption of a lamp as a function of the voltage applied to it. What is the resistance of the lamp at room temperature and at its working temperature at 220 V? What is the power of the lamp?
The tangent to the curve corresponding to U=0 V is also shown in the diagram.



27.44. The heat capacity of a calorimeter was determined in the following manner. 1.2 kg of water was poured into the calorimeter. Some time later its temperature was measured and was found to be 12°C. Then, 0.5 dm^3 of 80°C water was added to the water in the calorimeter. The temperature of the water became 30°C and it remained constant while the water was being stirred continuously. What is the heat capacity of the calorimeter?

Example 2 : The Written Examination in Physics for 1990 - Second Version

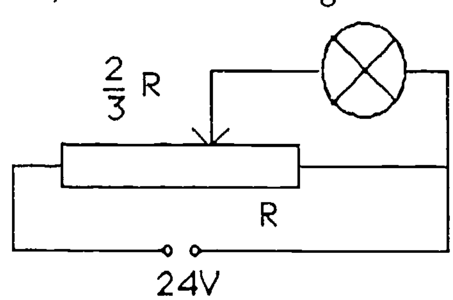
The problems may be solved in any order. You have to solve only one of the two alternatives in Problem 3.

1.) A motorcycle starting from a standing position is moving with uniformly increasing velocity along a horizontal circle having a radius 20 m. Its tangential acceleration is 2 m/s^2 in magnitude.

a) After what length of time will the magnitude of the acceleration have risen to double the starting value? (score 10)

b) What is the angle between the directions of acceleration and velocity at this time? (score 5)

2.) From a battery having a voltage of 24 V and negligible internal resistance a consumer device is cperated having an operating voltage of 6 V and power 30 W, shown in the diagram.



a) What is the resistance R if the consumer device has the required operating voltage? (score 10)

b) What is the power consumption of the resistance R? (score 5)

3.A) <u>This option is recommended to applicants for medical higher education</u>

The upper measuring range of a human hemometer is 40 kPa.

a) How long a tube is needed, if we produce such a pressure by a mercury column filling a vertical tube?

$\rho_{Hg} = 13.6\ Kg/m^3 \quad g = 10\ m/s^2$ (score 4)

b) How long a tube would be needed if we use water instead of mercury? (score 4)

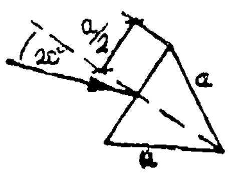
c) Write down the minimal work which is needed to fill up the perpendicular tube in the a) and b) cases, the tube having the same cross section in both cases. (score 7)

Example 2 : Second Version Examination - Continued

3.B) In a pipeline nitrogen is flowing at a pressure of 5×10^5 Pa and its temperature is 17°C. 2.5 kg gas passes through the cross section of the pipe having a surface of 6 cm^2 in 5 minutes.

a) What is the density of the flowing gas? (score 8)
b) What is the drift speed of the gas? (score 7)
$N_A = 6 \times 10^{23}$ per mol; $k = 1.38 \times 10^{-23}$ J/K; $R = 8.31$ J/mol K
1 mol nitrogen has a mass of 28 g.

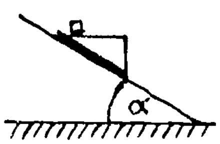
4.) The cross section of a prism is an equilateral triangle. The refractive index of the material of the prism is 1.6. A light ray falls onto one of the faces of the prism at the mid-point shown in the diagram. The angle of incidence is 20°.



a) What is the angle between the emerging ray and the face from which it emerges? (score 9)

b) What are the velocity of the propagation of light and its wavelength in the prism, if the energy of the light's photon is 4×10^{-19} J
$h = 6.6 \times 10^{-34}$ J s; $c_{air} = 3 \times 10^8$ m/s (score 6)

5.) A wedge is situated on a 30° slope and a cube stands on its horizontal surface.



Both are moving with an acceleration down the slope. Two minutes after the start their common velocity is 6.5 m/s. During these two minutes the work of the frictional force of the slope acting on the wedge is 6.8 J
($g = 10 \text{ m/s}^2$).

a) What is the mass of the wedge? (score 12)
b) What is the frictional force acting on the cube? (score 8)

6.) From a very long distance an alpha particle is coming near to a free lithium nucleus, which was originally at rest, along the right line connecting the two particles. Regard the particles as uniform points. What was the initial energy of the alpha particle, if it approaches to within 10^{-14} m of the lithium nucleus? (score 20)

$m_\alpha = 6.64 \times 10^{-27}$ kg; $q_\alpha = 3.2 \times 10^{-19}$ C; $m_{Li} = 1.15 \times 10^{-26}$ kg;

$q_{Li} = 4.8 \times 10^{-19}$ C

$k = 1 / 4\pi\varepsilon_0 = 9 \times 10^9 \text{ N m}^2 / C^2$

Example 3: Schedule of Questions for an Oral Examination

1) What is the direction of the force exerted by an ideally slippery surface on another surface slipping on it? How is this direction modified if the surface is not ideally slippery?

2) Examine, by using the fundamental law of dynamics, why bodies are in a stress-free state during their free fall. Explain on this basis why we feel that we are closer to weightlessness when floating on water than when we are standing on the ground.

3) Can internal forces change

- the translational energy
- the rotational energy
- the total kinetic energy of a body ?

4) Suppose you have to give electric charge to a body. In what ways can you fulfil this task?

5) Does the electromotive force of a battery depend on the resistance connected to it?

6) By what experiment could you decide whether electromagnetic waves are transverse or longitudinal? Give a procedure for the visible spectrum and for radio waves.

Chapter 8 : The University Tests in Japan

Tae Ryu

General Features

The examinations to be described are the National Center Test (NCT) and the entrance examinations of Kyushu University and Sophia University. In Japan, two sets of examinations, the one National Center Test and many entrance examinations are administered annually. The National Center Test is required for all students entering any of the national and public universities, and for some faculties of private universities as the first stage of their entrance examinations. An additional entrance examination is administered by each university. There are 507 universities and 593 junior colleges in Japan in 1990 (Table 1). The dates and methods for these entrance examinations are different not only between different universities but also between faculties and sometimes even departments in the same university. I shall describe the tests for Kyushu University as an example of a national university and Sophia University as a private university.

Table 1 : Numbers in Higher Education - Institutions and Students

	Universities		Junior Colleges	
	No. Inst.	No. Student	No. Inst.	No. Student
National	96	100,991	41	5,825
Public	39	14,182	54	9,931
Private	372	377,167	498	219,439
Total	507	492,340	593	235,195

(Information provided by the Ministry of Education)

Students between ages 15 and 18 spend three years in high school and usually study 8 subjects in each year for 30 - 32 hours per week. All students have to study physics for one hour per week in the first year and some can choose to study more of it, for four hours per week, in either the second or the third year. So the total study of physics can take between 1% and 6% of a students' time in high school.

Before high school, all students study 9 subjects in each year of the lower secondary school (three years, students' aged 12 - 15). The students have to study physics for 1.5 hours per week in the first year and second year, and two hours in the third year . The total study of physics takes about 5% of a student's time in the lower secondary school.

Table 2 : : 1990 Data : Population and Higher Education Numbers

Group	Number in 1000's		Percent
Total number in age group (18 years old)	2 005		100 %
Entrants to high school (1987)	1 886		94.3%
Graduates from high school	1 767		88.1%
Candidates for university and college	1 160		57.9%
Graduates from high school in 1990	868		43.3%
Others	292		14.6%
Entrants to university and college	728		36.3% *
Universities	492		24.6% *
Colleges	235		11.7% *
Candidates for the National Center Tests	431		
Graduates from high school in 1990	265		13.3%
Others	165		
Candidates in physics in the National Center Tests	136		6.8% *
Studying physics in high school		about	35%**
Entrants to science related faculties ***	142	about	7%
National and public universities	50		
Private universities	91		
Studying physical sciences and engineering	105		
biological sciences	25		
medical sciences	12		

* All entrants including students more than 18 years old

** Estimated from the circulation of physics textbooks in high schools (reference 1).

*** All students of physical science, half in biological science, and three quarters in medical sciences take physics courses in high schools (ref. 2).

Table 2 gives data on the numbers and percentages studying high school and university courses in physics. There are no direct data for physics courses in high schools. However the proportion of the circulation of physics textbooks to the age groups in high schools indicates the ratio of enrollment. It has decreased rapidly over the past 10 years ago, from about 80% to 35%. The main reasons for this decrease in the physics enrolment is the change in the National Curriculum in 1982. However, it is also believed that another reason is that the physics problems of the university entrance examinations have become more and more difficult. A new national curriculum, in which physics will be no longer be compulsory but will be an option among a variety of courses, will start in high schools in 1994. Many physics teachers worry that this new curriculum will lead to further falls in the enrolments for physics.

Admission to University Courses

Admission to universities and junior colleges is done by each institution, based on competitive selection using the scholastic achievement test. Admission is based mainly on an aggregate over all subjects taken by candidates in the entrance examinations. Some faculties and universities have plural examinations to select candidates. There are about ten thousand sets of examinations organised by universities nationwide. The numbers and types of subjects in the tests required of candidates vary from course to course and the weightings of the results of the various subjects for selection also differ between faculties or departments. Most private universities admit between 10% and 50% students, on the basis of recommendation from their upper secondary school principal, to a special form of entrance examination. Such recommendations can only be made by high schools selected by the university and assigned a limited number of recommendations. Some national and public universities also admit between 5% and 30% of students using the same recommendation system. However, this system differs in detail between different faculties and universities. Table 3 shows the process and timings for the university admissions procedure.

National and Public Universities

All candidates for entrance to national and public universities must take a two stage examination. The first stage is given by the National Center for University Entrance Examination in January and the second by the individual university in February or March. The numbers and types of subjects vary, between 5 and 1 subjects in both stages according to the faculty or university. I shall describe the National Center Tests, together

with the examination courses for faculties related to science in Kyushu University as an example.

Table 3 : The Process of Admission to a University

Month	National and Public Univ.	Private Univ.
Oct	Application for NC Test	Application for Recom.
Nov	↓	Taking Recom. Test→Result
Jan	Taking NC Test	Application to Universities
Feb	Application to Universities	Taking Test of Univ.→ Result
March	*Taking Test of Univ.→Result	(*Some Univ - late February)

The National Center for Universities Entrance Examination

The National Center (NC) for Universities Entrance Examination was founded in 1977 to improve university entrance examinations. The purpose of the National Center Test is "to measure the achievement of the fundamental studies in the high school curriculum, and its scores are used as one of the bases on which admission are made."

The members of the Board of the National Center Test are the president of the Center and presidents of universities, representing the Associations of National, Public and Private Universities. All national universities and local public universities, and 16 private universities, participated in the National Center Test in 1990.

These universities use the results of the test to select their candidates at the first stage and also to select entrants at the second stage. The total number of applicants in 1990 was 430 542 , with 62% of them in the 18 years old age group and 28% older than 18. 72% of the applicants were boys, and 28% girls. The total number of examinees was 408 350. Table 4 shows the number of candidates, and the average and standard deviation of marks for some of the subjects in the National Center Test in 1990. The National Center sends the results of their marks not to the examinees, but to universities at the request of the universities.

Table 4 : Scores in the National Center Test

Subject	Candidates	Full Mark	Average	Std. Dev
Japanese Language	400,078	200 (100)	133.1 (66.6)	29.8 (14.9)
English	406,532	200 (100)	137.6 (68.8)	36.3 (18.1)
Japanese History	121,260	100	73.9	16.7
World.His.	115,112	100	64.5	18.1
Geography	118,064	100	65.9	13.2
Maths.1	353,010	100	73.4	23.4
Maths.11	327,034	100	64.3	22.6
Physics	132,123	100	74.1	17.1
Chemistry	164,026	100	67.8	18.1
Biology	122,073	100	62.1	16.1
Earth/Space	21,148	100	66.1	17.8
Science 1	3,124	97	51.6	14.6

The numbers in parentheses denote percentages

Kyushu University

Kyushu University has 10 faculties, the following 6 being related to science: Science, Medicine, Dentistry, Pharmacy, Engineering and Agriculture. At the first stage each faculty selects students who take Japanese, English, Mathematics I and II, one Social Study and one or two Sciences in National Center Test, using the aggregation of subjects' marks with weightings as shown in Table 3. The science faculty requires one examination at the second stage, whilst the others require two examinations which are called former term and later term examinations. 90% of entrants are selected in the former and 10% in the later, by using the total mark of the first stage and second stage examinations. The weights of subjects for all faculties for the former term and three faculties for the later term are shown in Table 5.

Table 5: Subjects and Mark Weightings for Kyushu University

	FormerTerm		Later Term					
Courses	6 Faculties		Medicine		Engineering		Agricultr.	
1st Stage	time (min)	mark	time (min)	mark	time (min)	mark	time (min)	mark
English	80	100	80	50	80	100	80	100
Japanese	80	100	80	100	80	100	80	50
Math.	120	100	120	100	80	100	120	150
Social	60	50	60	50	60	50	60	50
Science	60	50	120	200	60	50	120	150
2nd Stage								
English	120	200	90	150	90	100		
Math.	150	250			120	150		
Science	150	250						
Paper							180	300
Oral								
Integrated								
Total		1100		650		650		800

A few students may choose French or German instead of English
In the first stage, one (60 min.) or two (120 min.) have to be chosen from Physics, Chemistry, Biology and Earth Science. Two are required in the second stage, with choice restricted to Physics, Chemistry, Biology for Medicine, and Physics And Chemistry both required for engineering.

In 1990, there were 8 124 applicants and 2 411 of them were successful. Each faculty selected about 90% of the entrants in the first stage tests. 3 145 candidates took the physics test in the second stage examination. The percentage weight of the mark of physics test relative to the total is about 16%; 4.5% is for the physics of the National Center Test and 11.4% is for the physics test of the second stage in Kyushu University.

Private Universities

77% of university students study in private universities. As private universities are less controlled by the government than national universities, there is great diversity in their entrance examinations.

However usually three of four subject tests are required for an examination for each course. Almost all entrance examinations of private universities are done in February before the second stage entrance examinations of national and public universities (Table 3).

A student can choose to take up to about 10 different course examinations of private universities, and 2 of national universities. Therefore the ratio of applicants to entrants is much higher in private than in national universities. Because the numbers of students per marker are large and times allocated for marking and selecting are quite short in the private sector compared with the national universities, the methods of entrance examination used by the private universities are simpler and many private universities use only multiple choice tests. The case of Sophia University is described below as an example.

Sophia University

There are seven faculties in Sophia University. However only the Faculty of Science and Technology requires a physics examination for entrance. Each department of the Faculty (Mechanics, Electronics, Mathematics, Physics and Chemistry) has two kinds of examinations: one is based on the recommendation by high schools and the other on written tests alone. For the written test route, most science courses require results in English, Mathematics, Physics and Chemistry , but physics does not require chemistry, whilst mathematics requires only English and mathematics. The total examination time and the maximum total marks are the same for all departments while the actual subjects required and the mark levels required to obtain admission differ from one department to another.The physics department gives equal weight to tests in English, physics and mathematics. Only the mathematics department uses a second stage of examination, which in this case is just a test in mathematics lasting 120 minutes and including in that time written and oral tests.

Sophia University uses school data in the recommendation system; 435 high school principals were asked to recommend their students as applicants in 1990. For the university as a whole 1102 students were recommended and 648 of them were successful. The criteria for selection include school data, results for a common English test and for examinations by each department, for example, mathematics and physics tests may be given by the physics department. The examinations for entrants by this route are not the same as those used for those applying through written tests alone. Table 6 shows the numbers of entrants and numbers who gained admission by the two routes.

Table 6 : Data for the Entrance Examination of Sophia University

Departments	Entrance Examination Applied	Entrance Examination Entered	Recommendation Applied	Recommendation Entered	Total Entrants
Mechanics	1,257	233	73	40	90
Electronics	1,161	234	50	19	80
Chemistry	1,120	318	68	37	90
Physics	1,232	145	62	29	50
Mathematics	329	53	50	19	40
Total	5,099	983	354	161	350*

* All successful students of the recommendation system became entrants; however, only less than 20% (189/983) of those successful in the entrance examination became entrants because most of them would succeed for several other universities also and might not then choose Sophia.

Examination Fees

There is an examination fee for each set of examinations, both for each individual university's tests and for the National Center Test, which candidates must pay for themselves. The entrance fee of each course in a national university was set at a uniform rate of 13,000 Yen (about 100 U.S. dollars) for 1991. For the National Center Test, candidates who take more than three subjects must pay 12,000 Yen and others 8,000 Yen. The entrance fees of each course in the private universities vary between 20,000 Yen and 55,000 Yen, and the average is about 30,000 Yen. The entrance examination is a very important source of income for private universities. The National Center has 101 permanent staff in addition to the examiners and other members of committees; however they are supported by national funds.

The Form of the Examination

General Outline

The physics problems used in the entrance examination of the various universities have common feature in their styles and structures, but they vary in quality from university to university. Physics tests aim to evaluate the achievement of physics studies in high school and the students' ability to solve problems. All high schools teach the same physics course as prescribed by the national curriculum. The Ministry of Education published annual reference books about the preparation of tests for all

subjects and distributed copies to all universities until 1986. Examiners prepare problems by making reference to such books, to the national curriculum Course of Study and to the text books which are authorized by the Ministry of Education.

The objectives for physics in high schools are described in the Course of Study as "To make students understand principles and laws of physics by carrying out observations, experiments, etc. on force and motion, electricity and magnetism and atoms which are selected from among natural matters and phenomena, thereby developing students' ability and positive attitude to consider things on the basis of physics." The contents of the physics tests must be chosen from the contents of the Course of Study: Force and Energy, Force and Motion, Wave Motion, Electricity and Magnetism and Atoms.

Most physics tests consist of three or four structured questions. Methods used are coded answers; multiple choice and only numerical value answers, and short answers; completion, formula and numerical calculation, and short description. Coded answers are used by the National Center and private universities. National universities use mainly short answer questions. Times allocated to physics tests vary between 30 min. and 120 min.

The External Tests

The physics examination paper of the National Center Test contains 22 multiple choice questions grouped around four topics. to be answered in 60 minutes. This method and structure has been maintained since the examination was instituted, but since 1990, the detail has been greatly improved by considering teachers' opinions. Example 1 shows the questions on two of the topics for a typical test, together with the schedule for the whole test.

The physics examination paper of Kyushu University sets 3 structured problems to be tackled in 75 minutes. Two of these each require a set of short answers, 16 in all, the third asks for the filling in of gaps, 12 in all, in a set of sentences about a third topic. These questions require students to answer not only by manipulating formula but also by using graphs and describing their ideas. Example 2 shows a complete paper of this type.

The physics examination paper for Sophia University is composed of multiple choice questions distributed as follows :

8 questions in 60 minutes for departments of Mechanics and Electronics,
12 questions in 90 minutes for the Physics Department,
4 questions in 30 minutes for the Chemistry Department.

Example 3 gives some questions taken from a Sophia University physics examination.

Some of the same questions are used both for the Physics Department and the Chemistry Department tests.

The physics test for entry to physics by the recommendation route consists of short answers, including open questions, to be answered in 120 minutes.

None of the entrance examinations includes any tests of practical work in physics. There are no tests involving use of equipment and the samples surveyed give little emphasis, in the written items, to questions about students' laboratory work.

Internal Assessments

Schools submit school data to support university applications. For school data, teachers evaluate students' achievement in each subject in the form of five grades between 5 (maximum) and 1 (minimum). For example, Sophia University requires school principals to recommend only from those students who obtain more than grade 4 on average over all subjects studies in all three school years. However because there are no common criteria shared between schools, teachers usually evaluate students relative only to their own schools standards and criteria. Because there is a wide variety of academic level of students from school to school, university examiners believe that the reliability of school data is quite low, and generally they don't want to use them to select students for admission.

Preparation and Marking

The processes of preparation, of marking and of analysis of results for the entrance examinations are secret in Japan. Usually universities do not publish even their examination problems and correct answers officially. Only the National Center publishes some information on its tests. The preparation and marking of tests are done by teaching staff of universities and not by school teachers. There is no pre-testing of items, even by the National Center, but the Center does post-testing using some volunteer students of Tokyo University every year.

For the National Center Tests, there are two expert committees, one for Test-Setting and one for Review of Test-Items. The members of the Test-Setting sub-committee of physics are 10 - 20 physics professors of universities. The term of membership is two years, and half of them are replaced by the newly appointed members every year. Only the name of

the chair-person is published; the names of the others are secret even after the tests. The members of the Review of Test-Items sub-committee are professors with experience as chair-persons of the Test-Setting sub-committee, and they check the test-items prepared by that sub-committee. It takes 18 months to prepare a physics test. Marking of the test is done by computers and the results are sent to universities two weeks after the test.

For the universities' tests the physics papers are prepared by staff of each university. The number of staff who are preparing physics tests in universities varies between 1 and 10. The average is 5.7 persons for national universities, and 4.2 for private universities (reference 4). The average number of markers of physics tests is 9.9 for national and 6.5 for private universities. The average time allocated to mark physics tests is 2.7 days in both national and private systems. The average ratio of candidates marked per marker per day is 129 for private, and 50 for national universities.

Analysis of the Results

Each university and the National Center have data from statistical analyses of the results of their examinations but they seldom publish them. Some of the data is used as reference in preparation of next year's examination in their own institutions. The National Center publishes only the average mark and standard deviation of each subject every year. A chair-person of the setting committee for physics has written an article (reference 5) on the physics tests with an analysis of the results, including discrimination data, for a circular to the universities in 1985. This is the only occasion on which such detailed data have been published. However, recently physics chair-persons have begun to publish such analyses together with comments on the examination performance.

The National Center sends results of tests to universities but not to students. However,students have to decide which course examinations to attempt for their the second stage university examination and need feedback on their first stage to guide them. This is provided by private companies. After the test, students send their recalled answers with names of their desired university courses to several major companies in the education related industry. The companies collect such answers and analyse them statistically, and they send students an estimate of their result together with their prediction of the lowest marks required for successful with each university. Students choose where to apply to universities by referring to such data. The companies publish many guide books, on how to apply to universities, for students, parents and teachers, analysing results of questions and of their own similar 'try-out' examinations. Table 7 shows some examples of the ranking of universities by private companies.

Table 7 : Ranking of Universities by Bottom Average Marks*

(a) Physics Departments of National and Public Universities

Bottom Average Marks	Sujects of Entrance Exam, Required by Each University				
	5 subjects	4 subjects	3 subjects		2 subjects
	Eng.Japa. Math.Sci:2	English Math.Sci:2	English Math.Sci.	Math Sci:2	Math Sci.
69	*Kyoto			"Kyoto	"Tokyo
68	*Tokyo				
66		*Osaka		"Tohoku	
65		*Tohoku " Tokyo Ins Tech	"Osaka		"Kobe
64		*Tokyo Ins Tech			
63		*Nagoya			"Hokkaido

continuing to 52. Sci:2 means 2 subjects of science, Physics and Chemistry
Dates of Exam.: *: 5~10 March, ":12~23 March
*Lowest average marks of successful entrants

(b) Physics Departments of Private Universities

Min.m. Marks	4 subjects	3 subjects
	English,Math.Physics,Chemistry	English,Math.Physics
69	Waseda Univ. (19 Feb.)	
66	Keio Univ. (14 Feb.)	Sophia Univ. (8 Feb.)
65	*Science Univ. Tokyo (12 Feb)	" Kansai Gakuin (7 Feb.)

continuing to 50. *: Science I and Physics, ": Physics or Chemistry
Dates of the examination are shown in parentheses

Links with Schools, Teachers and Pupils

Generally there is no direct official feedback to students and teachers from examiners based on the results. In some local areas, notably Osaka, Hokkaido and Nagoya, physics teachers in universities and high schools

have meetings after the entrance examinations to discuss physics problems privately. Some of these meetings are organised by local branches of the Physics Education Society. The National Center asks physics educators and high school teachers to present their opinions about the tests in two ways: collecting reports from their society or association, and by the chair-person of the Test Setting Sub-committee listening directly to some teachers . The Physics Education Society set up a committee to assess the physics problems of the National Test when it first started 13 years ago and this committee sends out, to about 350 out of 1400 members, questionnaires to investigate their opinions about the physics problems in the test. A report based on analysis of the responses is submitted to the National Center every year. The National Center publishes a report on the test which includes such opinions.

The committee of the Physics Education Society also discusses the physics problems of some universities and publishes reports in the journal of the society. Such discussion is mainly focussed on the validity of the problems, the adequacy of the contents, and the levels of difficulty for the candidates. There are a few discussions about the aims, the methods and the marking schemes for the examination.

Opinion on Quality and Effects

In Japan, students are under pressure of competition to enter high graded universities. Students tend to study hard only in preparation for the entrance examinations. Although the objective of the physics course laid down by the Ministry of Education is "to make students understand principles and laws of physics by carrying out observation, experiments. . ", few universities test the achievement of this objective, especially the ability to make observations and to experiment. Students believe that, in order to succeed in physics examinations, it is better to memorise formulae and to master the techniques for solving harder theoretical problems quickly than to do experiments, or to look for training in scientific thinking (references 6 and 7).

The National Center Test was introduced to improve such situation but the initial purpose has not yet been achieved . Both the National Test and many private universities' tests use only multiple choice coded answers problems. These promote training in solving skills amongst students, who use similar 'try-out' examinations provided by the education related industry. One result of these procedures is to increase passive attitudes amongst our students. The National Center Test is mainly used to select examinees not only for entrants to each university but also for applicants of all national and public universities ranked by the education related industries. Therefore competition between students has become more widespread and more serious.

Before the introduction of the National Test, entrance examinations of national universities were done in March. The National Test is done in January and it disturbs teaching schedules in high schools whose term ends in March (reference 8). Usually topics involving atoms are taught in high schools in January and February and teachers want to exclude such topics from the contents of the National Test.

It is said that the physics problems in the universities' entrance examinations are becoming harder, requiring more theoretical knowledge and complicated calculations. This trend in turn makes physics textbooks harder. Investigations of students' opinions indicate that physics is not thought to be interesting for the majority of students and, being a hard subject, it is not wise to choose it for the entrance examinations. The number of enrolments to physics courses in high schools is decreasing and physics teachers have to accept that they must teach chemistry and biology.

The physics problems of the National Test also became harder in the late 1980's. The average mark of the physics test was down to 53% in 1989. At that time, the Physics Education Society published a special issue on the physics problems in university entrance examinations in which the members criticized the physics problems strongly. After that examiners have tended to make easier problems, taking into account the opinions of teachers and other educators.

Today, high school teachers and some university professors are aware of the severe effect of entrance examinations on the teaching of physics in high schools and want to improve the situation. We need educational analysis of examinations, discussion of their validity and reliability, and consideration of their effects on teaching in schools. A review is needed to make sure the aims, methods and marking schemes are adequate to assess the the achievements of the study of physics. More, and more varied, types of assessment must be introduced in the university admission tests.

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Example : Some Multiple Choice Questions from the Center Test -Together with an Outline Schedule of the Whcle Paper

Physics (Center test January 1990 60 min)
(Number of problems:1-4, Number of answers 1-22, Points 100)

Problem 1 As in Figure 1, the top end of a light spring of force constant k is fixed on an inclined plane of slope angle 45° to the horizontal plane. A small object of mass m attached to the bottom end of the spring is put on the inclined plane along the maximum slope angle. Let μ the coefficient of static friction between the inclined plane and the small object, μ' the dynamic (moving) one, and $\mu' < \mu < 1$. Let g the magnitude of the acceleration of gravity. Select one answer among suggested answers in each case of the following questions (Q1-6). (28 points)

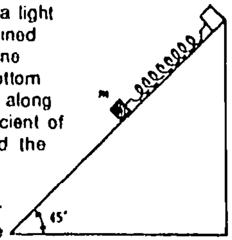

Fig 1

A When the small object is put on the place where the spring is natural length and released from rest, it starts to slide along the maximum slope angle of the inclined plane. Let us consider the motion of the small object sliding down. Let x the distance of move of the small object along the slope.

Q1 What is F, the component of the force acted on the small object along the maximum slope angle, at distance x ? Let us support that the positive direction of the force is downward along the inclined plane.
$F = \boxed{1}$

① $mg + kx - \mu' mg$ ② $mg - kx - \mu' mg$

③ $\frac{1}{\sqrt{2}}mg + kx - \frac{1}{\sqrt{2}}\mu' mg$ ④ $\frac{1}{\sqrt{2}}mg - kx - \frac{1}{\sqrt{2}}\mu' mg$

⑤ $\sqrt{2}mg + kx - \sqrt{2}\mu' mg$ ⑥ $\sqrt{2}mg - kx - \sqrt{2}\mu' mg$

Q 2 How much work W_g is done on the small object by the gravitational force in the travelling x from the starting point ?
$W_g = \boxed{2}$

① mgx ② $\sqrt{2}mgx$ ③ $\frac{1}{\sqrt{2}}mgx$

④ $-mgx$ ⑤ $-\sqrt{2}mgx$ ⑥ $-\frac{1}{\sqrt{2}}mgx$

Q 3 And, during the time, how much work W_μ is done on the small object by the friction force between the small object and inclined plane.
$W_\mu = \boxed{3}$

① $-\mu' mgx$ ② $-\sqrt{2}\mu' mgx$ ③ $-\frac{1}{\sqrt{2}}\mu' mgx$ ④ 0

Q 4 Find the kinetic energy T of the small object after travelling x in terms of works W_g, W_μ and W_k which is the work done on the small object by elastic force of the spring, $W_k = -\frac{1}{2}kx^2$
$T = \boxed{4}$

① W_g ② W_k ③ W_μ ④ $W_g + W_k$

⑤ $W_g + W_\mu$ ⑥ $W_k + W_\mu$ ⑦ $W_g + W_k + W_\mu$

Q 5 The small object slides down on the inclined plane, then the speed of the object becomes zero. If the increase in length of the string at the moment is given by $X_{max} = a\frac{mg}{k}$, what is the coefficient a ?
$a = \boxed{5}$

① $1 - \mu'$ ② $\sqrt{2}(1 - \mu')$ ③ $\frac{1 - \mu'}{\sqrt{2}}$

④ 1 ⑤ $\sqrt{2}$ ⑥ $\frac{1}{\sqrt{2}}$

⑦ $1 + \mu'$ ⑧ $\sqrt{2}(1 + \mu')$ ⑨ $\frac{1 + \mu'}{\sqrt{2}}$

B Next, the small object is put on the place where the spring length is x' longer than natural one and released from rest. If the increase in length x' is in some region, the small object must keep still by friction.

Q 6 If the region of x' for the rest of the small object is expressed by

$$b\frac{mg}{k} \leqq x' \leqq c\frac{mg}{k}$$

what should be the coefficients b and c ? $b = \boxed{6}$ $c = \boxed{7}$
Suggested answers of $\boxed{6}$ and $\boxed{7}$

① μ ② $\frac{\mu}{\sqrt{2}}$ ③ $1 - \mu$

④ $\frac{1 - \mu}{\sqrt{2}}$ ⑤ $1 + \mu$ ⑥ $\frac{1 + \mu}{\sqrt{2}}$

Example 1 : Center Test - continued

Problem 4 Read the following descriptions and answer the questions below (Q1 - 3) . (20 points)

A gas consist of a large number of molecules moving randomly towards a great variety of directions Let us suppose that the molecules of the gas like small balls of mass m are closed over a container of volume V. The force exerted on the wall of the container by one molecule equals the product of $\boxed{19}$ given to the wall by the molecule in each elastic collision and the rate of the number of collisions. Hence, the pressure P of the gas (the force exerted on a unit area of the wall by all molecules of the gas) can be expressed,

$$P = \frac{Nm\overline{v^2}}{3V}$$

where $\overline{v^2}$ is the average value of the square of the velocity of all molecules If we assume that the gas is an ideal gas and the gas constant is R, the equation of state of the gas (Boyle and Charle's law) is PV = $\boxed{20}$. Hence, it is found that $\overline{v^2}$ is proportional to the absolute temperature T.

Q 1. Select one correct term among the following ones (1) -(7) in each case $\boxed{19}$ and $\boxed{20}$ in the sentence above.

(1) velocity (2) impulse of the force (3) kinetic energy

(4) potential energy (5) $n\frac{R}{T}$ (6) $n\frac{T}{R}$

(7) nRT

Q 2. If $\overline{v^2}=aT$, what should be the proportional constant a? Select one correct answer among the following suggested answers (1) - (6) The Avogadro's number is N_0.

a = $\boxed{21}$

① $6mN_0R$ ② $3mN_0R$ ③ $2mN_0R$
④ $\frac{6R}{mN_0}$ ⑤ $\frac{3R}{mN_0}$ ⑥ $\frac{3R}{2mN_0}$

Q 3. Assume that air is an ideal gas of molecules which average molecular mass is 30 and R = 8.3 J/(mol•K). Calculate roughly the average speed $\sqrt{\overline{v^2}}$ of molecules of air at the temperature 300 K. Select one correct answer among the following suggested answers (1) - (7). The molecular mass M equals the product of Avogadro's number N and the numerical value of the mass m of a single molecule measured by the gram unit.

$\sqrt{\overline{v^2}}$ = $\boxed{22}$ m/s

① 6000 ② 2000 ③ 1000 ④ 700
⑤ 500 ⑥ 300 ⑦ 100

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Example 1 : Center Test - continued

Physics Test by Centre of Entrance Examination of University in Japan
January 1990 (1 hour, 100 points)

Problem (points)	Question (points)	Answer Numbers	Correct Answers	Contents
P. 1 (28)	A 1 (5)	1	4	force's component on inclined plan
	2 (5)	2	3	work by gravity
	3 (4)	3	3	work by friction
	4 (4)	4	7	kinetic energy
	5 (4)	5	2	place: speed 0
	B 6 (6)	6	4	region: speed 0
		7	6	
P. 2 (25)	A 1 (5)	8	4	nature of sound
	B 2 (5)	9	4	wavelength from data
	3 (5)	10	5	frequency of standing wave
	4 (5)	11	2	speed in metal rod
	5 (5)	12~13	1,6	shorter rod
P. 3 (27)	A 1 (6)	14	2	heat by resistance
	2 (7)	15	1	magnetic flux density in coil
	B 3 (6)	16	8	induced current
	4 (8)	17	4	induced electric motive force by change of magnetic field
		18	6	
P. 4 (20)	1 (10)	19	2	impulse of force
		20	7	$PV = nRT$
	2 (5)	21	5	$V^2 = ?\ T$
	3 (5)	22	5	average speed of molecular

Example 2 : Physics Problems from the Entrance Examination of Kyushu University

Appendix 2. Physics Problems of Kyushu University (75min 125marks)

[1] Answer each questions below Choose an appropriate answer from options in { } for question (7) and (8) (45marks)

It is Taro's job to take apart two electric fans to pieces and clean up them to put them away in his home at the end of summer When he took off blades from the two fans, something aroused in his mind what would happen if he put the shafts of the two fans on the same level and switch the two fans on, then put a plastic ruler on the shafts? He tried and found the ruler to be thrown away immediately to the direction of revolving of the two shafts Then Taro turned the direction of one of the fans so that both fans would revolve inward as shown in Figure 1. This time, the ruler began to do reciprocating motion when it was placed on the two shafts Taro pondered on the mechanism of the motion as below

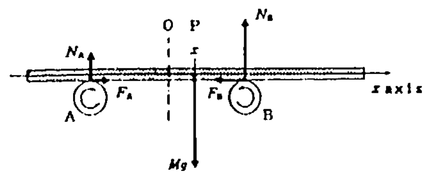


Figure 1

Let A represent the left shaft and B represent the right one as shown in the figure Take the original point O at the central point between A and B and x axis to the right direction horizontally. Now represent displacement of the center (the center of mass) of the ruler by coordinate x.

Letting M represent the mass of the ruler, g represent the gravitational acceleration, the gravity acting on the ruler is Mg downward The ruler is supported by shafts A and B upward with normal forces N_A and N_B. Therefore always $N_A + N_B = Mg$. If the center P of the ruler is at the original point O, the normal forces by the two shafts are equal Then if $x = 0$, $N_A = N_B = (1/2)Mg$ However if the center P of the ruler moves to the right from the original point O, the right shaft will receive additional force so that the normal force N_B will increase by certain amount N and the normal force N_A will decrease by the same amount. If P moves to the left, the reverse process occurs

The two shafts are revolving so fast that the ruler is always slipping on them. Therefore frictional forces F_A and F_B whose directions are shown in the figure are always acting on the ruler at the points where it touches the shafts A and B. Let μ represent the coefficient of kinetic friction between the shafts and the ruler.

(1) Express the frictional forces F_A and F_B in terms of M, g, N and μ.

(2) Find F, the x component of the net force acting on the ruler?

Taro realized the motion could be understood easily by considering that the additional force acting on the ruler changes proportionally to its displacement from the original point. Based on this idea, answer each question below.

(3) Let us consider that N, the increase of the normal force due to the displacement of P from O is proportional to the displacement x, and it is expressed as $N = kx$ with a positive constant k. How can you express the equation of motion of the ruler? Let α represent the acceleration of the ruler.

(4) What is the name of the motion which follows this equation of motion? Express the period of the motion in terms of M, μ and k.

(5) When we put the ruler on the shafts quietly so that P is on the place at the distance d from O, how is the range of x in which the ruler does reciprocating motion?

(6) Taro replaced the ruler by another ruler of the same shape and material but with a different mass, however the period of the reciprocating motion changed little. State briefly what you conclude from this?

Example 2 : Physics Problems - Kyushu University - continued

(7) Then Taro increased the speed of rotation of the two shafts The period of the motion { (a) became shorter, (b) became longer, (c) stayed almost the same }

(8) Then Taro stuck a sheet of sandpaper to the bottom (the side which touches the shafts) of the ruler, and tried the same The period of the motion { (a) became shorter than, (b) became longer than, (c) stayed almost the same as } that of the motion without the sheet of sandpaper

(9) State briefly the reason of the result of (8)

[2] We have made a circuit which consists of a photoelectric tube, an ammeter, a voltmeter, a slide rheostal and a battery as shown in the Figure 2 We measure electric current between the anode P and the cathode C Let ν [Hz] represent the frequency of monochromatic light which falls upon the photoelectric tube. Let V [V] represent the voltage between P and C. When the contact point S is between m and a, the potential of the anode is lower than that of the cathode Therefore electrons emitted from the cathode by photoelectric effect are decelerated by the opposite direction force when they come close to the anode As we move S towards a, the value of the voltage between P and C increases, then the current stops and the ammeter indicates 0 at V_0 [V] V_0[V] changes as ν [Hz] of irradiated monochromatic light changes The data of the experiment, V_0 (using an unit of energy) with some ν are shown in the table Where e [C] represents the charge of an electron and 1 eV (1 electron volt) means the energy got by an electron accelerated by 1 V of the electric potential difference, 1 eV = 1 6 x 10^{-19} J Answer each question Let the number of significant figure be two (40 marks)

photoelectric tube

monochromatic light

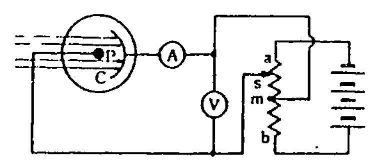


Figure 2

$\nu (\times 10^{14}$ Hz)	8.0	10.0	12.0	14.0	16.0	18.0
eV_0(eV)	0.9	1.7	2.6	3.4	4.2	5.1

(1) Let K[eV] be the maximum value of the kinetic energy of electrons escaping from the cathode by photoelectric effect Find the equation of K using V_0 and e.

(2) Draw a straight line which shows the relation between K and ν, on the graph of the answer sheet, using the data in the table Let the unit of X-axis be 10^{14} [Hz] and Y-axis [eV]

(3) Find the slope of the straight line, h[Js]. What do you call the h?

(4) Find ν_0[HZ], the value of X-axis at the intersection of the straight line and X-axis What is the physical meaning of ν_0?

(5) Let -W[eV] be the value of Y-axis at the intersection of the straight line and Y-axis Find the numerical value of W. What is the physical meaning of W?

(6) When we exchanged the photoelectric tube to another one with different material of the cathode, we got W = 4.0[eV] Draw a straight line which shows the relation between K and ν of the tube on the same graph sheet of the answer of (2).

(7) Next, when S is moved between m and b, all electrons escaping from the cathode are collected in the anode, because the potential of P is higher than one of C. If we increase only the strength of the light 2 times without change of the frequency, how many times of the current will flow?

Example 2 : Physics Problems - Kyushu University - continued

[3] There is a circuit which consists of a cell E (1 50V), a resistor R(1 00Ω), two capacitors, C_1 (1 00 μF) and C_2(1 00 μF), and a circuit changing switch which has two contact points A and B, as shown in Figure 3 At first there is no charge in C_1 and C_2 Complete each sentence of questions, supplying a sentence for [i], only a numerical value for [h] and [k], and a numerical value with an unit for others. (40 marks)

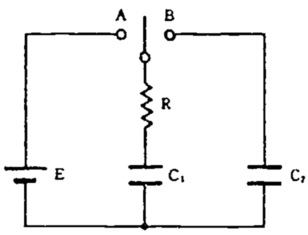


Figure 3

(1) First, we contact the switch with A, and at the instant14 9 mA of the current flows thorough the resistor R Therefore we can calculate the inner resistance of the cell E as [a] After enough time passing, the change of C_1 is [b] and its electrostatic energy U_1 = [c].

(2) Next, we switch from A to B, and at the instant the current which flows through R is [d] After enough time passing, the charge of C_2 is [e] and the voltage between two plates of C_2 is [f]. At the time, the sum of the electrostatic energy of C_1 and C_2 is [g] and it is [h] times of U_1. The cause of the differences of the energy can be explained as following; [i].

(3) Next, we contact the switch with A and after enough time to charge C_1 passing, switch from A to B again. After enough time passing again, the voltage of the plates of C_2 becomes [j]. In order to make the voltage of the plates of C_2 more than 90 % of the voltage of the cell, we must repeat the process at least [k] times After that the voltage of the plates of C_2 is [l].

Example 3 : Physics Problems from the Entrance Examination of Sophia University

Appendix 3 Physics Problems of Sophia University (60min 150 marks)

Choose the most appropriate answer from options (a),(b),(c),(d) and (e) for each question

[1] 1) The radius of the earth is 6.4×10^{x} m
x= (a) 4, (b) 5, (c) 6, (d) 7, (e) 8
2) Atmospheric pressure is 1.0×10^{x} N/m
x= (a) 2, (b) 3, (c) 4, (d) 5, (e) 6
3) One mole contains 6.0×10^{x} molecules
x= (a) 19, (b) 20, (c) 21, (d) 22, (e) 23
4) The range of human hearing is between the frequencies 2×10^{x} Hz
x= (a) 1~3, (b) 1~4, (c) 2~4, (d) 2~5, (e) 3~5
5) The frequency of electromagnetic waves in FM broad casting is about 10^{x} Hz
x= (a) 4, (b) 6, (c) 8, (d) 10, (e) 12

(10 marks)

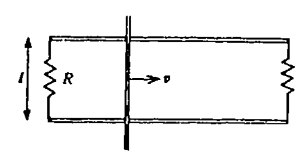
[2] Which of the following methods would be effective to increase the capacitance of a capacitor ?
1) To enlarge the volume of the conductive plates
2) To close the two conductive plates each other.
3) To insert an insulator which has a high dielectric constant between the plates
4) To choose a metal which has a low electric resistance as the material of the plates
5) To insert a magnetism which has a high magnetic permeability between the plates
(a) 1) & 2), (b) 2) & 3), (c) 3) & 4), (d) 4) & 5), (e) 5) & 1)

(8 marks)

[8] The radius of the moon is about 3/11 times of one of the earth, and its mass is about 1/81 times of the earth The distance between the moon and earth is about 60 times of the radius of the earth
1) How many times of the gravitational force acted on a body on the moon compared with the one on the earth
(a) 10 times (b) 100 times (c) 500 times (d) 1000 times (e) 5000 times
2) An artificial satellite which orbits the moon has the same period as one of another satellite which orbits the earth with orbital radius R. What is the orbital radius of the moon's satellite ?
(a) 81R (b) R (c) R/4 (d) R/9 (e) R/81

(15 marks)

[9] Two parallel copper bars (with interval l [m]) are connected by two identical R ohm resistors at the both ends of each bars as shown in the figure. There is a uniform magnetic field with flux density B[Wb/m^2] in direction vertical to the plane which includes the two bars. To move another copper bar with a velocity v[m/s] on the bars as shown in the figure, how much work [J] per unit time is needed ?



(a) $2l^2vB/R$ (b) 0 (c) $l^2v^2B^2/2R$ (d) l^2vB/R (e) $2l^2v^2B^2/R$

(15 marks)

Example 3 : Physics Problems - Sophia University - continued

[10] The points O, P, Q, R, S, and T line up vertically with equal intervals An object is released from O freely with no initial velocity

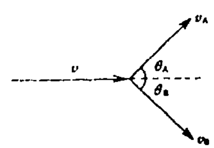
1) The average velocity at O and T is equal the instantaneous velocity of the point which is in the interval of following

(a) between O and P (b) between P and Q
(c) between Q and R (d) between R and S
(e) between S and T

O ×
P ×
Q ×
R ×
S ×
T ×

(14 marks)

[11] There are two balls A and B of same mass The ball A moving with velocity v(m/s) collides with the stationary ball B After the collision, A moves with speed vA in direction with the angle θ_A to the direction of the initial velocity of A, and B travels with speed v_B in direction with the angel θ_B to the initial velocity of A Assume the collision is completely elastic



1) The formula of vA using v and θ_A is :

(a) $v \cos\theta_A$ (b) $v \sin\theta_A$ (c) $v \cos^2\theta_A$ (d) $v \sin^2\theta_A$ (e) $v \tan\theta_A$

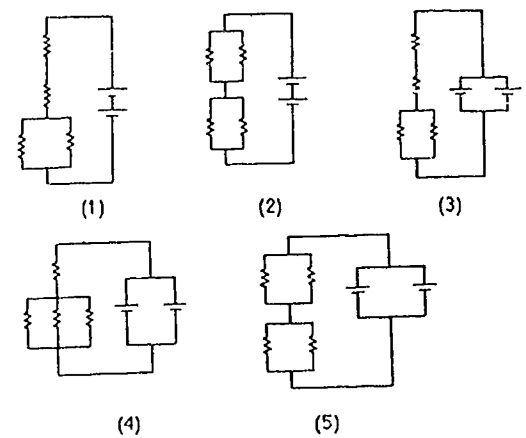
2) The relation between θ_B and θ_A is :

(a) $\theta_B = \theta_A$ (b) $\theta_A + \theta_B = \pi/2$ (c) $\theta_A + \theta_B = \pi$
(d) $\tan\theta_B = \sin\theta_A$ (e) $\theta_A + \theta_B = \pi/4$

(16 marks)

[12] There are five circuits which consist of two identical cells of V volts and four identical resistors of R ohms as shown in the figures from (1) to (5) Which of the following is the correct order from the smallest amount of heat produced in the circuit par unit time to the largest?

(a) 3-4-5-1-2 (b) 4-3-5-1-2 (c) 2-4-5-1-3
(d) 5-3-4-2-1 (e) 1-2-3-4-5



(15 marks)

Chapter 9 : University Entrance in Poland

Tomasz Plazak
Zygmunt Mazur

General Features of the Country System

In Poland the transition between secondary (high) school and university is controlled by two examinations. The first is the school-leaving Maturity Examination ('matura'). This is obligatory for admission to universities, but there is also a second step, which is an entrance examination organized by each university, and in some cases separately by each faculty.

Physics is first taught in the last three years up to age 15. Then at secondary (high) school, which lasts four years, students have between 12 and 15 compulsory subjects. The physics course lasts four years in the 'liceum' schools or three years in the 'vocational' (technical) schools - in this second case there is no physics in the last year. Physics is compulsory for all students, but the time spent depends on the type of school and on the type of course chosen by the student varying from 5% in the technical schools to 11% for the mathematico-physical option in the 'liceum'. There are different syllabuses for different types of schools and options, but for any of them they are the same for the whole country.

The school-leaving Maturity Certificate is in two parts. The first is run by the school and can be taken in all the 10 to 13 subjects that a student has studied. The second part comprises a written examination in 2 subjects and an oral examination in 3 subject; Polish language is included in both of these. Physics can only be taken as one of the options allowed for the oral examination. The written part of the examination is set by the education office of the provincial government (Poland is divided into 49 provinces). The oral part is set by the school within guidelines set by the province (e.g. 3 types of question are specified and each candidate must attempt one of each type). The final grades for both the written and oral parts are awarded by the school and there is no established way of checking that different schools are using the same standards and criteria.

Table 1 : Data About the Proportion Studying Physics at Various Stages

The total number of 19 year olds (in 1990) was about 540 000. The data below are (approximate) percentages of this number.

Attending the last year of secondary (high) school	36%
Achieving a pass in the Maturity Exam	30%
Taking a university entrance examination	24%
Becoming a student at university level	12%
Taking the entrance examination in physics	9%
Achieving a pass in the entrance examination in Physics	6%
Doing any physics course at their university	5%
Studying for a physics degree at university	0.2%

Some numerical data are given in the Table 1. The total number taking the entrance examinations in Physics over all the various universities is about 48 000. Of this number 66% take the examination at Technical Universities (TU), 14% at Medical Academies, 8% at the conventional (classical) universities (U) and Pedagogical Universities, 6% at Agricultural Academies and 6% at other types of institution. This chapter will present a description of the entrance examinations at the Technical University in Krakow(AGH), at the University of Wroclaw, Faculty of Physics (UW) and at the Medical Academies (MA).

The Results and Their Use for University Admission

Use of the examination results

The results of both the school, the "matura" and the university examinations are expressed in on a scale of 5 grades, interpreted as 5 (very good), 4(good), 3 (sufficient pass), 2 (insufficient). For the universities' entrance examinations grades 4.5 and 3.5 are also used.

For admission to most universities, university entrance examinations in three (sometimes four) subjects are required, together with results in the Maturity Examination in five subjects. In the case of technical universities or physics faculties, Mathematics, Physics and a Foreign Language must be taken in the university examination, whilst a restricted range of options is specified for the 5 school results. Usually the final admission scores are expressed on a 100 point scale, with a maximum of 20 points for the certificate of maturity and 80 points for the university examinations. The

20 points are derived from the average of the school grades in the five subjects, whilst for the university examinations, 65 out of the 80 are derived from the average of the physics and the mathematics grades, with the foreign language grade accounting for the other 15.

The candidates with the largest numbers of points are admitted, but there is a prerequisite of at least a pass grade in every examination subject. The Medical Academies (MA) are an exception to the above rules; these rely only on the results of their own multiple choice test. Some exceptions to this general rule existed in the past, when e.g. additional points for 'good' (peasant, worker) social descent or 'good' profession (police, army) were added. Some other factors like the recommendation from school or the results for the school certification as a whole, have in practice little influence on the admission decisions. However, for some faculties, an interview with candidates has been organised as an additional criterion in the past.

The general policy for these examinations is controlled by the Ministry of Education, which decides such questions as the numbers and types of examination, the principles on which admission decisions are to be taken, how exemptions may be granted, and so on. However, the tendency now is for the Ministry to resigns gradually and leave control to the individual universities. As explained above, the Maturity Examination is specified in part by the provinces but controlled mainly by the schools.

Entrance Examinations

Each candidate chooses one university, applies to one faculty and takes that faculty's entrance examination. The examination papers may be papers prepared centrally by a Ministry commission, who provide the same set of papers for all universities of the same type, but different sets for different types, but in recent years individual universities have been allowed to set their own.

National uniformity in the standards of examinations is ensured partly by obligatory syllabuses established by the Ministry. The uniformity was more secure when all papers were centrally determined. With the freedom that individual universities now have, the consistency of questions with the syllabus and the standards used in grading the answers may be interpreted in diverse ways - in practice a university may adjust these factors so that a satisfactory percentage of candidates passes the examination. In fact the standard and character of the examination papers and of the marking is determined by experienced examiners on the basis of the results from previous years, as explained below.

In many universities the examinations for some faculties are organized not only in July, which is the main examination time, but additionally in September if there are still vacant places, and in June for evening students. Thus, almost all the work is tripled.

The examinations are free of charge. All the work for the preparation of papers and organisation of the examinations, both in the Ministry Commission and in the University, is done without extra payment, and without any dispensation from the normal teaching and other work at the university. Markers receive a small, mainly symbolic, payment for their work. This system does not promote the development of regular research, standards control, improvement of papers, and so on, and there is no budget for such work. Thus the quality of the work on examinations depends mainly on the voluntary effort of individuals.

The Examination Methods Used

Generally an examination in Poland is written or oral, or uses both methods. Orals are used not only through adherence to tradition, but because many teachers believe that only in oral examinations can an examiner trace the student's thoughts and react by asking further questions. In an oral, it is possible to explore, in a unique way, the student's ability to communicate, to formulate his thoughts, to describe and explain physical phenomena, and to explain how and why new concepts and laws are established. In short, even although the difficulty of ensuring objectivity in examinations is recognised, there is a general belief that the depth of enquiry and the personal interaction that are unique to orals make them an indispensable method for assessment.

In this section, the physics component in four main examination systems are described. The first of these is the school 'matura'examination. The other three are university entrance examinations at :-

- the Technical University in Krakow(AGH)
- the University of Wroclaw, Faculty of Physics (UW) and
- the Medical Academies (MA).

School Examinations

For the school 'matura' examination, the only method used in physics is an oral examination. Since every school in the country prepares its own set of questions, it is difficult to give any general description. However, as a rule three questions are given to every one pupil. The first question usually requires some knowledge, the second needs more understanding of physical laws and the third is a problem to be solved which tests both

understanding and skill in calculations. Example 1 gives a typical set of three questions. One of the three questions used to be a practical problem but this now seems to be exceptional.

School students who are winners in the Physics Olympiad can gain free entrance to many faculties at all the universities. The questions in the Physics Olympiads are definitely more difficult than those of the 'matura'. They are mainly of the problem solving type, but as a rule practical problems are also included. However only a very limited number of students take part in the Olympiad.

The Entrance Examination at the Technical University (AGH) in Krakow.

Usually the Ministry has been recommending that both written and oral methods should be used. Sometimes only one is observed.

AGH has Ministry permission to organize its entrance examinations independently and over the years several types of examinations have been tested:

(1) Oral Examination
(2) Problem Solving
(3) Coded Answer (Multiple Choice)
(4) Structured (Constructed) Problem
(5) Short (Open) Answer

At first (1), later (2) + (3), and more recently (2) + (5) have been used.

Oral examinations have been used in the past. A candidate would be given a set of five questions chosen from about 50 such sets. The candidate had about 1 hour for preparation and about 30 minutes for the actual examination. Some typical questions are given in Examples 2.

For a paper on problem solving , 5 out of 8 (or 3 out of 5) problems are usually given, to be solved in 180 minutes (or 120 min). Operational skills, the understanding of physical laws and the ability to associate them, and data handling skills can all be assessed. Two typical questions are given in Examples 2.

Coded Answers questions are not commonly used in Poland and their introduction has been an innovation, adopted because of the advantages of objectivity, of covering many topics and of quick marking. At AGH, 50 or 60 questions are to be attempted in 150 minutes. The questions are designed to test not only the knowledge of some formulae but even more their application and the understanding of the physics involved; jumping to conclusions without careful reasoning leads to wrong results. Two typical questions are given in Examples 2 .

For Structured (Constructed) Problems, six such problems are given for solution in 120 minutes. Each problem is divided into several parts so that it can be tackled by answering several short questions in succession. By leading the student through the problem, the examiner can test both knowledge and understanding, with ability to draw logical conclusions from the previous parts.

Short (open) Answers questions are usually presented as a set of 20 questions to be answered in about 120 minutes. Candidates must actively formulate their answers, by contrast with the passive recognition involved with coded answer questions. Three such questions are shown in Examples 2.

At other technical universities methods (2) + (5) are usually used, but sometimes only (1) or (2). In most of them there is a shift from using questions prepared by the Ministry to preparing their own.

The Entrance Examination at the University of Wroclaw.

The entrance examination in physics comprises both a written and an oral part. The written examination consists of 5 questions and lasts 4 hours, and 4 of these are usually of the problem solving type, as in the example, taken from the 1990 paper, presented in Example 3. The fifth question, also shown in Example 3, is a long answer type, usually concentrating on the description of a phenomenon and of the related laws of physics.

The oral examination for each candidate is based on answering one set of four questions chosen from 40 such sets. Candidates have about 30-40 minutes for preparation and about 20 minutes for the oral discussion. Example 3 gives one of the sets of questions used in 1990.

The Entrance Examination for the Medical Academies

For many years the Medical Academies used a single, centrally organized, multiple choice test consisting of 180 questions in physics, biology, chemistry and foreign language. These questions were set in two 180 minute sessions on successive days. The physics component comprised 45 questions. A typical question is shown in Example 4. Some of the questions involve calculations which tend to be too demanding given the short time available per question.

A comprehension test was added two years ago. This consists of ten coded questions connected with a text on physics of about 3 pages which candidates must first read. The aim is to test candidates' ability to

understand the physics in the passage. Last year's topics were the effects of ionizing radiation and the applications of ultra sound.

Preparation and Marking.

For the centrally prepared examinations, a Ministry Commission used to be appointed. It comprised 7-8 persons, 3 school teachers and 4 representatives of universities. Before the commission started its work the Ministry had asked all the universities to submit their own proposals for questions. The collection of these provided preliminary material for the commission, but its members also prepared their own using ideas from this collection. The commission's work took about two months. The papers were sent to every university the day before the examination.

At AGH, the preparation of the university's own examinations starts several months before the July examination. A commission of about 6 members is nominated and these work in two separate sub-groups on the two papers, co-ordinated by the appointed chairman. Questions are discussed and amended in the sub-groups, checked for syllabus coverage, and further checked by submission to non-group members. This process produces an excess number of questions, from which the chairman makes a final choice. Next this set is given to an independent reviser, who reviews it and, after discussion with the chairman, gives final approval. Two independent sets are prepared in case there is disclosure of any of the questions or lest any technical trouble is revealed at a late stage. Almost all the work is repeated anew for the additional examinations in September and June.

Marking and Grading

The procedure at AGH starts with a detailed mark scheme prepared by the committee of examiners. The two papers have approximately equal weight and the questions within each paper each carry the same marks except that with short answer questions some carry 2 marks and some carry 3.

Shortly after the examination, the markers, numbering about 100 and including all who teach physics in the university, meet in two big lecture rooms, one for each paper. The marking scheme is explained, and the markers then work in these rooms for about two days until all scripts have been marked. This arrangement allows for discussion and further clarification with the chairman of examiners. Every script is marked independently by two markers and the average value taken. However if the difference of marks for any problem is greater than 2 out of the 10, or the difference of total marks for the paper is greater than 5, both markers must meet and resolve the difference or refer it to one of the examiners committee. In AGH, with about 2000, there are about 4000 scripts and 8000

markings to be completed. Marks for each candidate on each paper are processed by computer to give the examiners the following data :

* total mark for each candidate
* distribution of marks for each paper, and for the whole examination
* distribution of marks for each faculty and for each type of school
* data for each candidate by school, distribution of marks for schools.

The boundary marks for a pass and for the other grades are then proposed, taking into account the statistics and the implications for university admission. Then one or two of the examiners meet the vice-rector and the university enrollment commission to make the final decisions. Representatives of those Faculties with a small number of candidates usually press for lowering the pass boundary but the examiners usually oppose this. In the compromise which results, special care is taken over the mark for the 'very good' grade, because this is important for faculties with a large number of candidates. A typical outcome would be to place the pass at a minimum mark of 36% and the very good grade at a minimum of 92%.

For the physics faculties in universities, the procedure is simpler because the number of candidates is very small. However a successful candidate must pass both written and oral examinations separately.

At Medical Academies, the situation is different. The centrally prepared coded and comprehension papers are marked centrally by computer. Because the total number of marks is the only criterion for admission, and school grades are not taken into account, grades are not assigned, either for individual subjects or for the examination as a whole.

Statistical Analysis of Results

The description here refers to the AGH procedures only, as each university will be different. Computer calculations are used to:

1) analyze the distributions of marks and compare them with previous years;
2) compare the distributions between faculties
3) compare the distributions for different papers;
4) compare distributions for the separate questions of each paper
5) compare mean marks, standard deviations, and symmetries;
6) compare results and distributions for individual schools.

The data have revealed considerable discrepancies. Most striking are the big differences between candidates level of performance for different faculties. There are also considerable differences in level between 'liceum' type schools and vocational ones, and also between individual schools of the 'liceum' type.

The correlation between performance on one paper and others and the discrimination ability, for each paper and for each question are also scrutinised. When the multiple choice test was first introduced, research was carried out to explore its value compared with other types of examination. Correlations between the results of each type of examination and the results of the future students progress in their studies were computed. The main observation was that the multiple choice test had a significantly higher prognostic value than the other types of examination and higher still than the school grades. It was also revealed that groups of candidates checked by the test as uniform were assessed differently at oral examination by some examiners. The research also showed that the most difficult questions were those about mechanics and electromagnetism, especially those checking ability to draw full conclusions by applying the laws of physics.

Some statistical analyses of the general results of entrance examinations in Poland have also been made by the Ministry who used to publish an annual report with such data as the number of candidates per place, percentages of pass grades gained and of accepted candidates, with regard to types of subject, social composition, and gender. However such public information has now been neglected.

Links with Schools, Teachers and Pupils

At AGH, it seems that in practice the most influential interaction between the entrance examinations and physics teaching at schools has been exerted by publishing the books with sets of the university's examination questions - problems, coded answers, short answers, with some solutions - which are popular with schools.

The university provides an annual report for the Ministry about the examination, but it is doubtful whether such information reaches the schools. The computer information about the results of candidates is not sent to their schools. However some links with schools have been maintained. Delegated school teachers and the inspectors for the province attend the entrance examinations each year and prepare reports. Similarly one or two physicists from AGH (usually examiners) participate in matura examinations almost every year, writing a report on their observations for the province. From time to time meetings with school teachers have been

organized to discuss the entrance examinations. Every year university teachers hold meetings in many schools to discuss the entrance examination and their studies with pupils. Some school pupils participate in meetings organized for them at the university. The university has also surveyed the opinions of pupils concerning the multiple choice tests which they have taken, and the other types of examinations.

A small proportion of candidates attend so-called preparatory courses for the entrance examination organized on a fee paying basis by student organizations and others. The lecturers are often university teachers, knowing last years examinations and typical failings in answers. Such courses may last from two weeks (intensive) to several months.

Finally one small scale experiment has been tried for one year aimed at combining the 'matura' examination in some schools with the entrance examination to some Faculties. However, in practice the procedure was very similar to the normal matura, giving those pupils an easier chance of being accepted. However, this only applied to faculties with small numbers of candidates.

The Disorder from 1990

The examination system was more or less stable over many years, although there was a tendency towards reduction of Ministry control. Recently however, it has been decided that the Ministry will withdraw completely. Whilst this decision may have been a natural reaction against years of central control of everything, the result has been a rather chaotic situation. Many faculties abolished entrance examinations completely, starting with those who were short of candidates. Some accepted every candidate, some made decisions on the basis of the school certificate, and some have organized an interview only. There were faculties organizing only part of the examination (e.g. one subject plus interview) whilst some faculties, and in particular the Medical Academies, have kept the old examinations without any change. Some others even made their entrance examinations more important by no longer using the schools' grades.

The effects of these changes are manifold and sometimes unexpected. There has been a considerable growth in the numbers of candidates, especially for some faculties. Some observers claim that the effect in schools has been a rapid decline in the level of physics teaching, as pupils and teachers know there is no longer control from outside. However, many pupils are happy that the gates of some universities are open wider and that selection will depend on work done during the whole year. Some faculties are pleased with an end to their chronic shortage of

students. However, some who have had to cope with many more candidates than places may well decide to reinstate the examination. Thus, for many reasons, the future of entrance examinations in Poland cannot be predicted.

Opinions on Quality and Effects

According to the research made by one of us (T.P.) among Polish physics teachers, they believe that physics should be taught because it is :

- a source of understanding the laws of nature,
- a source of new technology and progress,
- a school of scientific of thinking and culture.

More specifically examinations should assess a wide range of aims in both theoretical understanding, laboratory work and applications of physics. To reflect such aims, an extensive, multi-component examination is required. However, the limitations of time, and of organization in Poland mean that only a narrow range of examination methods can be used. For example, there is no direct assessment of laboratory work.

The AGH examinations have been more successful than those of some other universities in assessing candidates ability to progress in their studies and in influencing school teaching. It seems that the examination selects those candidates with a basic knowledge who are able to use it and think physically. One positive feedback effect of the entrance examinations of all of the universities has been some improvement in students' ability to solve problems. But the main defect of the Polish system is the lack of any assessment of practical skills. It is also a pity that the carrying out of practical investigations and students' ability to research topics from printed sources are not reflected in physics teaching, although they are observed in some schools work, e.g. in biology.

More general is the problem whether Poland should develop a common national examination. Some would oppose uniformity and foresee the bad effects of 'teaching for the examination'. They would stress the advantages of local control with personal interaction and believe that the system of many examinations on a small scale is valuable for the country.

However, others would argue that the system which has existed in Poland dissipates effort and does not offer conditions for the preparation of a comprehensive,uniform and reliable examination. The recent changes have caused even greater fragmentation. In the opinion of the authors, a single national examination would be the best solution.

Example 1 : Typical School Examination Questions

1. Polarization of light. Describe a method for producing polarized light.

2. How does an electric dipole behave both in a uniform electric field and in a radial electric field?

3. A load of mass m is attached to a light string wrapped around a solid cylinder of mass M and radius R, mounted on a frictionless axle. The load starts from rest and falls a distance h. Find the velocity of the load at the given moment.

Example 2 : Questions from the Entrance Examination of the Technical University in Krakow

Oral Examination Questions

1. Explain the phenomenon of mechanical, acoustic and electrical resonance. Give examples.

2. Describe the conductivity of electrical current in liquids, metals and semiconductors showing similarities and differences.

3. Nuclear energy. Explain the structure and working of a nuclear reactor.

Usually two problems were also included into a set. Example:

4. Two bulbs adjusted to a voltage 120V have power of 115W and 60W. The bulbs have been connected in series with a source of voltage 220V. Will any of these bulbs burn out ?

Problem Solving Questions

1. A bullet shot with a velocity 30 m/s at an angle $\alpha = 45°$ bursts at the highest point of its trajectory into two parts of equal mass, in such a manner that one part drops vertically down without an initial velocity. At what distance from the place of shooting will the second part of the bullet fall down? Air resistance is neglected, and the gravitational acceleration $g=9.8\ m/s^2$.

2. An electrical circuit is built from a solenoid of inductance $L = 10^{-7}$ H and an air-filled capacitor, for which the square plates of side a=10 cm are placed at a distance d=6.4 mm. To what depth should the plates of the capacitor be immersed into a liquid with dielectric permittivity $\varepsilon=3$ to get resonance of the circuit with electromagnetic waves of wavelength $\lambda=3.14$ m ? Permittivity of vacuum $\varepsilon = 8.9 \times 10^{-12}\ Fm^{-1}$, velocity of light $c = 3 \times 10^8\ m\ s^{-1}$.

Example 2 - continued: Questions from the Entrance Examination of the Technical University in Krakow

Coded answer Questions

1. Assume that the force needed for towing of a barge is proportional to velocity. If for towing of the barge with a velocity of 4 km/hour the power of 4 kW is needed, then the power needed for towing of the barge with the velocity of 12 km/hour is

A. 12 kW B. 24 kW C. 35 kW D. 48 kW

2. Inside a loop of wire of a resistance R the magnetic flux changes uniformly - first slowly and then quickly, but in both cases by the same quantity. What can we say about the electric charge which flows in the loop in both cases?

A. in the first case flows greater charge than in the second case.
B. in the first case flows smaller charge than in the second case.
C. in both cases flows the same charge of a value depending on the value of the flux change, but not depending on the resistance R.
D. in both cases flows the same charge of a value depending on the value of the flux change and the resistance R.

Short Answer Questions

1. A proton, a neutron and an α-particle, all of the same momentum, enter a uniform magnetic field of flux density B, the direction of which is perpendicular to the direction of motion of the particles. Draw the trajectories of the particles and explain their courses.

2. In what way are X-rays generated ? Draw a typical spectrum of the radiation generated in an X-ray tube and explain its characteristic features.

3. Explain why the specific heats of ideal gas in the isobaric process and in the isochoric process are different. What is the difference $c_p - c_v$?

Example 3 : Questions from the External Examinations of the University of Wroclaw

Problem Solving Questions from the Written Paper

1. A copper block released from rest to slide down an inclined plane travelled a horizontal distance 1=40 m. The coefficient of friction between the block and the plane was f=0.5. If half of the heat released in this case went into the block, calculate its temperature rise taking its specific heat capacity as 400 J / kg K.

Long Answer Question from the Written Paper

4. What do you know about superconductivity?

Oral Examination Questions

1. Diffraction and interference of light.

2. Detectors of α, β and γ radiation.

3. Measurement of the atmospheric humidity.

4. Calculate the internal resistance of a battery if the power expended in the external circuit is the same for two values of the external resistance: $R_1 = 5\ \Omega$ and $R_2 = 0.2\ \Omega$

Example 4 : Questions from the External Examinations of the Medical Academies

Coded Answer Question

The ball of volume V and density ϕ falls with a constant velocity in a liquid of density ϕ_1. If the ball is at the depth h, then the heat released in the system can be expressed by :

1. Vgh $(\phi-\phi_1)$ 2. Vgh $(\phi_1 - \phi)$ 3. Vgh $(\phi + \phi_1)$ 4. Vgh ϕ_1

Chapter 10 : Sweden - School Assessments and Central Tests

Kjell Gisselberg and Gunilla Johansson

General Features

In Sweden there are no central examinations, and so there are no examination papers in any subject. Nevertheless there are nationwide tests in several subjects distributed to schools in order to ensure comparability of the standards of school assessment across the country. Marks are given from grade 8 in the secondary school, called the "Grundskolan".

A detailed National Curriculum for Swedish schools is decided by the Government. Thus there are no alternative curricula as almost all children are in "Grundskolan". Physics is taught as a part of a more general science survey course at the intermediate level of compulsory schooling which lasts for the three years before secondary school. In the lower secondary school, which is the upper level for compulsory school attendance, physics is normally studied as a separate subject. The time spent is about 4 percent of the total teaching time. (Physics, Chemistry, Biology and Technology will together take about 15 percent of the time).

The marking in the different subjects is entirely the task of the teachers. To assist them in this work and to ensure the same marking level throughout the country, National Standardized tests are distributed in grade 8 and grade 9. They are given in Swedish, English and Mathematics. The result is used to determine the level and the range of the average standard of the class. The individual marks will then be based on the result of the Standardized Test and of their tests and the work done in lessons and in the laboratory.

The certificate of marks in grade 9 is used for the admission to the upper secondary school or "Gymnasieskolan". More than 90 percent of all who reach the end of compulsory schooling go on to upper secondary school, where they can acquire a vocational education or prepare for higher studies. Practically everyone who wants to enter upper secondary school is admitted, but the competition for the attractive lines is sometimes fierce. This has not been the case, though, during the past 15 years with the Natural Science line and the theoretical Technology line.

The upper secondary school is divided into about 25 different lines and some 500 specialized courses. The lines vary in duration and have varying degrees of occupational emphasis. There are several three- or four-year theoretical lines of study. The most popular of these are lines with some form of vocational emphasis, i.e. the Economics and Technology lines.

There are five academic lines, Natural Sciences, Technology, Social Sciences, Economy and Liberal Arts. Physics is taught as a separate subject in the first two of these lines. The allotted periods for the different subjects studied in these lines is given in table 1.

In a couple of the other three- or four-year lines general science is taught. There is no national test in this subject.

Table 1 : Time Schedules for Natural Science and Technology Lines in the Upper Secondary S.hool

Subject	Periods per week in Natural Science Line			Periods per week in Technology Line		
	Gr.1	Gr.2	Gr.3	Gr.1	Gr.2	Gr.3
Swedish	3	3	3.5	3	3	2.5
Mathematics	6	5	4	6	5	4
Physics	2.5	4	4	2.5	4	4
Chemistry	3.5	3	2	3.5	3	-
Biology	-	2	3	-	2	-
Technology	-	-	-	5	4.5	-
Other technical subjects	-	-	-	-	-	12
Foreign Languages including English	6 or 7	6	3	6 or 7	6	-
Arts, Social Studies and other subjects	11	10	9	9	5.5	7

Of the total number of individuals, about 100 000, in one age group, about 45% choose the theoretical lines in upper secondary school. About 7 percent finish the Natural Science line and about 12% complete their studies in the technological line. Full data are given in table 2.

Table 2 : Numbers of Students in Upper Secondary and Higher Education Courses

Total Number in Age Group	about 100 000
Proportion in School (age 18)	90%
Proportion in School (age 19)	45%
Natural Science Line (1990)	23 542
Natural Science Line Year 3 (1990)	7 116
Technological Line (1990 - 4 year)	42 783
Technological Line Year 3 (1990)	11 507
Higher Ed. Students from Nat.Sci. and Tech. Lines (1989/90)	13 153
Higher Ed. Students in Physics	*188

* Higher Technical Education and Teacher Education not included

The upper secondary school, like the compulsory school, has a central curriculum. This contains goals, guidelines, syllabi and time schedules laid down by the Government. Swedish, physical education and civics or orientation for working life, are compulsory in all study programmes. English is compulsory for all theoretical lines of study and some vocational ones, and all students have to take a course of about 30 lessons in environmental knowledge.

Upper secondary schooling is currently being re-organised, and the description given above is confined to the present day situation. It is likely that the changes will not have any significant effect on the syllabi for Physics. The main changes will probably take place within the vocational programmes.

In the same way as in lower secondary school, standardized achievement tests (Central Tests) are distributed nationwide to assist teachers in their marking of their students. Some of these are distributed for use at the end of the third year of the upper secondary school, some for the end of the second year. For students taking physics and mathematics in the natural sciences or technology lines, both subjects are tested at the end of the third year.

It is expected that the revision currently planned will include changes in the marking system. At present, a norm-referenced marking system is used, but the plan now seems to be to introduce a criterion-referenced system. The main reason for this change is psychological. The competition between pupils for the higher marks - which are limited to a certain percentage in a norm-referenced system - does not enhance the desired cooperative atmosphere in the classroom.

The new marking system will of course affect the tests, but in which way it is not possible to tell at this stage. The present system is based on an assumption that the ability of the pupils does not change significantly over the years. In the future, reliance may have to be placed on the consistency of the judgments of a group of experts when, from one year to another, they will have to apply the criteria to decide what students should have achieved in order to attain a certain mark.

University Admission to University Courses

The Central Test is used to help the teacher determine the level and distribution of the marks in a class compared to other classes in the country.

The mark for each individual student is determined by the student's teacher from the Central Test, compulsory tests in the school, the teacher's own tests, assessment of experimental work in the laboratory and from assessment of work done during lessons.

The marks in Sweden follow a relative system and the National Board of Education has determined the distribution of the marks in Grade 1 of the Upper Secondary School for the whole country . This distribution is given in the middle column of Table 3. This ideal distribution can only be consistent between Grade 1 and Grade 3 if it is adjusted to allow for those students who drop out. This adjustment is made by collecting drop-out data from a sample of schools; the outcome is an adjustment to the imposed distribution. As students with lower marks drop out to a higher degree there is a shift towards higher marks (5 is the highest mark).

This required distribution is then compared with the actual distribution of marks obtained over the whole country, so that the raw marks (which are on a scale from 0 to 25) corresponding to each final mark can be specified in order to achieve the required distribution. The rules for translating raw marks to the final mark are then sent to schools. The teacher then has to assign the final mark for each student : in doing this, the teacher has to arrive at the same distribution for his classes as they obtained on the Central Test, but is free to assign marks to individual students within this

constraint. The right-hand column of Table 3 shows the final national outcome.

Table 3 : Theoretical Distribution of Marks in Grade 1 and Actual Distribution for the Central Test in Grade 3 - in 1991

	Percentages of Students	
Mark	Grade 1 (Theoretical)	Grade 3 (Actual, 1991)
5	15	18.7
4	28	28.4
3	34	38.0
2	18	13.7
1	5	1.2

Thus, students will obtain their final mark in a certain subject following the statistical distribution of the Central Test in that subject. Central Tests are given in Swedish, English, German or French, Mathematics, Physics and Chemistry. The teachers in other subjects have to consider the results in the Central Tests when marking students in a class.

Marks from all subjects (about 14) included in the School Leaving Certificate combine to an average mark (between 1 and 5). All subjects studied must be included in the average mark except for physical training, which might be omitted. The subjects in the School Leaving Certificate from the Natural Science and Technological lines can be found in table 1.

All applications to all universities are sent to the Central Student Admissions Office. The students usually apply to several universities and courses and for each course the average mark will place the student in order of preference.

From this year on 60% of the students will be admitted to university directly from the final average mark and 40% will be admitted from the result of The Swedish Scholastic Test which can be combined with scores from at least 5 years of employed work.

In the past few years interviews and special tests have been used as additional criteria for admission to certain university courses, for example medicine and architecture.

For most of the university courses there are special qualification requirements in addition to the school leaving marks. A mark of 3 in physics (and in mathematics) is required for university courses, where physics is studied, for example teacher education, engineering of many kinds, medical studies and so on.

Those who attain the specific minimum required in any specific subject then compete for admission on the basis of their overall average mark. The overall average required for entry to physics courses is in the region of 3.6 to 3.9, depending on the particular university. This range compares with 4.8 to 4.9 for medicine, 4.1 to 4.6 for engineering - including technical physics - and 4.4 to 4.6 for teacher education courses which include mathematics and physics.

The Examination Board

The Department of Education, Umeå University, was commissioned in 1985 by the National Board of Education to manage the Central Test in Physics (and Chemistry and Physics for Adult Education). A reference group of persons with long experience of physics education had already been appointed by the National Board. This board has now been replaced by The National Agency of Education and many decisions have now been decentralized to the local authorities. Thus the Department of Education in Umea is now free to appoint any person to the reference group. This group helps with the choice of problems, the mark scheme and other subject matters.

The National Agency of Education is responsible for the costs of the standardized tests. There is no fee for the students or the schools to participate in the Central Tests. On the contrary, it is compulsory. For the construction and handling of the above mentioned Central Tests, in Physics, Chemistry and Physics for Adult Education, and research in relevant areas the Department of Education at Umeå University receives roughly 2 millions SEK, which is about 360 000 U.S. dollars (printing and distribution costs are not included).

The Form of the Examination

General Outline

The physics curriculum is very detailed and starts with the following statement of aims :

The pupil will by physics education:

- acquire knowledge of the most important phenomena, the empirical laws and theories in physics and receive information of the development of modern physics.
- acquire knowledge of the physics, which is the basic for some important technical applications
- be acquainted to experimental investigation methods
- by mathematical methods analyse and solve simple physical problems.

There follows a specification of the main topics, in the following six areas :

- Mechanics and Heat
- Electricity
- Wave Physics with Acoustics and Optics
- Atomic Physics
- Cosmic Physics and Geophysics
- Measuring Techniques

Many sub-topics of the course are given and explained in detail. For example the following recommendations are given:

sub-topic - Collision, conservation and momentum
Instruction - Impacts with or without loss of kinetic energy
Experiment - Investigation of collision experiment.
Determination of mass from collision experiment. Determination of the speed of a pistol bullet of an arrow by means of a method using the law of conservation of momentum

Much time is normally spent on experiments. The Central Test has no experimental part but in many cases the test problems refer to experiments performed in the classroom or in the laboratory.

The National Board of Education specifies the approximate scores in each part of the course for the Central Test. These scores should not be regarded as fixed every year but rather as a mean value over several years. The scores are roughly proportional to the numbers of periods that are recommended in the curriculum for the different topics; however, there is

more emphasis on the later grades and topics mainly studied in Grade 1 may receive very little weight. Table 4 illustrates these features.

Table 5 : Scores for Different Topics in the Central Test

Grade	Topic	Number of periods recommended	Score
1	Electric Charge and Current	24	2
	Mechanics and Heat	48	2
2	Electric and Magnetic Fields	26	3
	Motion	57	6
	Induction & Alternating Current	29	4
3	Waves and Radiation	36	6
	Relativistic Effects	4	2
	TOTAL	224	25

In the marking it is assumed that at a class level there is a correlation between the class average over the students' skills and their results on the Central Test. As explained above, the Central Test result of a class has a direct influence on the average mark in Physics of that class. When the teacher is deciding the final mark of an individual student he has to take all the aims of Physics, as expressed above, into account. Thus, for instance, it is recommended that experimental tests taken in the laboratory should play a part in the assessment of students.

Whilst the system is generally accepted, some teachers criticize it on the grounds that the Central Test has a strong steering effect. Because the results of the test are of such importance there is a fear that many teachers will practise problem solving or perhaps better "item solving" to a great extent. Other aims of the Physics teaching may suffer and the experimental approach may be forgotten. Also there is a risk that any sub-topics for which it is stated that they will not be assessed in the Central Test will not be taught in school.

The External Tests

The Central Test in physics is a written test taken, at a fixed date and time, at the beginning of February of the third year of upper secondary school. The test lasts 225 minutes.

There are two parts A and B. The maximum score for the test is 25, 7 in part A and 18 in part B. Part A consists of seven multiple choice questions or short answer questions and Part B consists of six comprehension and calculation problems. Complete solutions must be given and the maximum score is 3 for each problem. The result is based on a student's answers on all items - there is no choice between items.

The questions in Part A this part are designed to test whether the student has understood a concept or an idea. Some of them will require little or no calculation, sometimes information is given in a diagram. Example 1 shows five questions, taken from the Part A sections of the 1990 and 1991 papers. The first of these is an easy item, to discriminate amongst the weaker students.

For Part B, complete solutions to the items must be presented. In this part the ability to solve more elaborate problems is tested. The students are requested to give an account of, and to explain, all steps taken. The instructions given for this part of the test are written on the front page and reads:

> Complete solutions are required. Notation and equations must be defined and explained. Units must be stated and the quantities must be rounded off with respect to the accuracy of the given data. The line of reasoning must be easy to follow. Any figures used in a solution must be large and neatly drawn using ruler and compasses. Necessary data which is not given in the question may be taken from physical tables. Correct solutions yield 3 points each.

Unfortunately it seems that the adherence to these rules varies from school to school. Many times a formula quoted on its own is accepted as an explanation; also some very poor figures are given full credit without deductions.

Example 2 shows three questions taken from the Part B sections of the 1990 and 1991 papers. The first of these, about the deceleration of a car when braking, was an easy problem which almost 90 percent of the students solved correctly. The second, which tested the idea of using models, was quite hard, with success rates of 49% for boys and 27% for girls - the context of the question, a game of golf, may be one cause of this gender difference.

The third example was also difficult - to tackle it students had to make measurements on a diagram given with the question. The marking scheme sent out to teachers for this question is also reproduced in Example 2.

These examples suggest that the fourth of the aims listed above - the solving of simple physical problems - receives much more emphasis than the other three. There is a long tradition of emphasis on this type of question, but it is now recognised that the lack of balance may distort teaching.

Internal tests and assessments

Teachers have full responsibility and authority for marking their students. The one rule that guides this work is that the class average of the final marks should not deviate by more than 0.2 marks from the class average mark on the Central Test. If it does, the teacher must present a written explanation to the school principal.

When deciding the final mark, the teacher has to compare all his students and judge their performance in class and in the laboratory. The results in the two main school tests normally given each semester will strongly affect the teacher's judgement. In this way the teacher arrives at a rank order for the students. After that he decides where to put the cut-off limits for the different marks in such a way that the condition for the class average mentioned above is fulfilled.

It is completely up to the teacher what emphasis he chooses to put on different skills. Some teachers will include results of laboratory experiment tests, others never use such tests. Most of the teachers rely heavily on the results of the main tests and many emphasise strongly the results of the Central Tests. The reason for this is of course that, in arguments to explain a mark to a student, a parent or a principal, it is much easier to defend such test results.

Preparation and Marking

The preparation of a test starts about 1.5 - 2 years before it is to be used. Teachers at different schools are invited to make up draft questions for the test. These questions are scrutinized by the above mentioned reference group. Some of these questions are selected for try-outs, about three times as many as are used in the test. About 2-3 weeks before the students sit for their test in the beginning of February some schools are invited to try questions that are intended for future tests. At that time one should expect that the students would be motivated and interested to do their best, but this is not always the case.

The results of the trials are reported in a secret report which is discussed at a meeting with the reference group. This meeting takes place in late May or early June. The results from the previous test are of course also discussed. A preliminary test is proposed; the questions and the distribution of different sub-topics in this proposal are scrutinized. Also, the difficulty of the different items and their discrimination power at different levels are discussed. Some of the items may be exchanged for others. When a decision of which items should go into the test is reached the wordings of the items are discussed. The items may be formulated and reformulated over and over again until everybody agrees.

In the beginning of September the group will meet again. This time there is a final discussion and a confirmation of the test that will be given at the beginning of February. During the summer the draft questions suggested by teachers have been sent in and the selection of items for the next trial is also made at this time.

The final version of the test is prepared at the University of Umeå and the papers are printed and distributed to schools. Together with the tests the schools also receive a paper with the correct answers and instructions on how certain deviations from a correct solution should be judged. Each teacher corrects the tests from his own class(es). If he finds it difficult to judge a student's solution he may make an inquiry to the reference group mentioned earlier. A sub-committee of this group will meet to discuss such inquiries and decide how to judge different mistakes in the students' solutions. If any difficulty seems to be of a more general nature and many teachers have inquired about it, a decision is included in complementary instructions that are sent to all schools. If only a few teachers seem to have met a difficulty a decision is taken and a letter with this decision is sent just to the teacher(s) concerned.

When the teachers have corrected the tests the results of a sample of students, selected by their date-of-birth, is sent to the university. For each student the points given on the individual items, sex, line (Natural Science or branch of the Technological line), and most recent school mark in Physics are reported. From this sample the distribution of raw marks is calculated and the limits for the different final marks are decided so that the distribution of marks will be appropriate. The calculations are made in Umeå and a suggestion is sent to the National Agency of Education for approval. A sheet of paper with these limits, the distribution of points and the raw mark values for the different items is sent to the schools so that the teachers can compute their results and adjust their final marks accordingly.

Analysis of Results

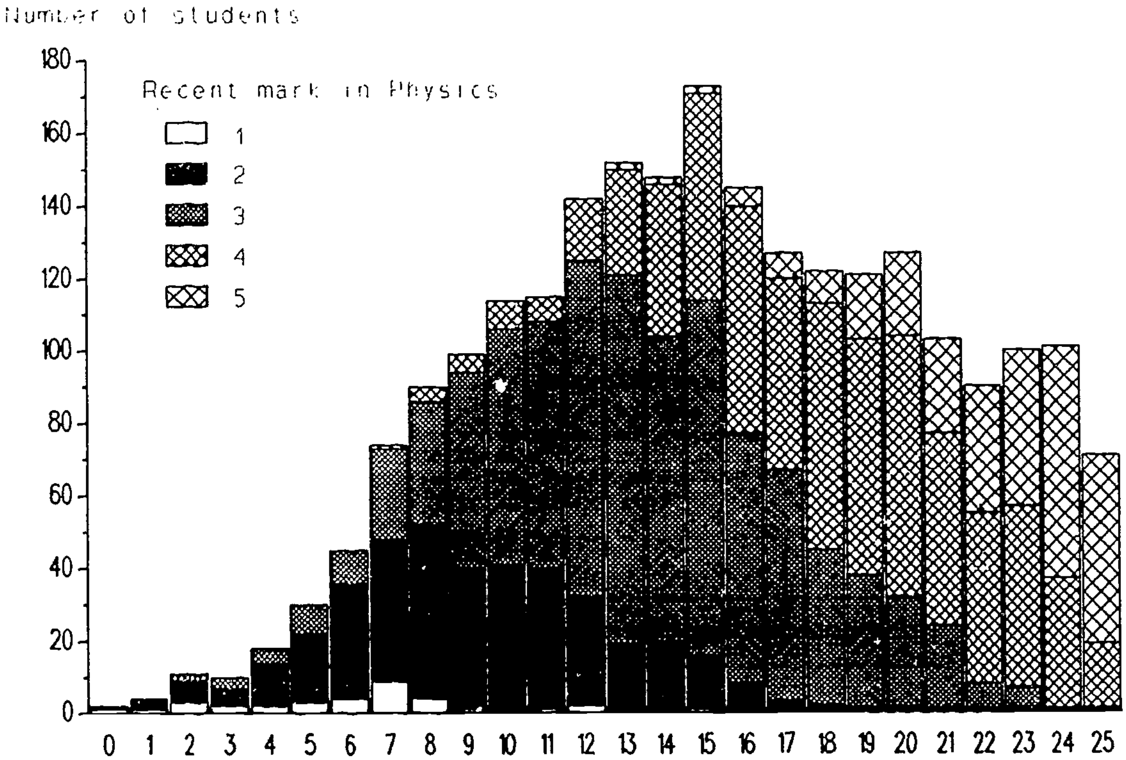
The Central Tests are distributed to the schools as a guide to the teachers for the marking of their students. Each teacher judges and corrects his own students; at the individual level the Central Test results play a limited role. As the underlying presumption is that the standard of the students remains roughly the same from one year to another, the difficulty of the tests may vary between the years. Thus there is no point in comparing the results from different years.

When the different items are selected, care is taken to ensure that certain groups of students won't be unjustly favoured. In Physics it is relatively easy to find problems where boys get much better results than girls. Difficult problems in electricity often yield much better results in the electrical branch of the technological line as the students here take separate courses in electricity which of course are more advanced than the electric parts of the Physics curriculum. For each item in the Central Test the average result for different groups of students is computed. This average result is then plotted against the average school mark in Physics of the same groups from the previous term. This plot can give evidence of bias; for example it can show that, on electricity items, students in the electrical branch have scored well above their normal performance in Physics. It is debatable whether this should be regarded as fair as these students obviously know more electricity, or unfair because they have had much better opportunity to learn than the other students. In a criterion-related marking system it would probably create less trouble than in the norm-related system which is used at present.

In judging the system as a whole, it is interesting to see the dispersion of the Central Test results of students with the same mark in physics in the previous term. The diagram in Figure 1 below shows that some students with mark 1 in school test had better results in the Central Test in 1990 than some with a previous school mark of 5. This fact seems to give a clear indication that the result of a single test should not be given too much importance.

During the last two years the scoring for the items in the B-parts of the tests have been analyzed. As earlier mentioned, the scores range from 0 marks to 3 marks in this part. Instructions on the number of points to deduct for different errors are distributed to the schools - as illustrated in Example 2. However, according to the analysis very few deductions of points are made. Most students will get either 0 marks or 3, less than 10 percent of the solutions are given 1 or 2 marks.

Figure 1 : Distributions of Central Test Scores for Students with Different School Physics Marks



Marks on the horizontal scale are the total raw scores in the Central Test.

Upper Secondary School Inspectors used to visit the schools regularly. They inspected the students' solutions on the Central Tests, which were kept in the school archives, and could criticise the way they were corrected. In 1982 the inspectors disappeared and have not been replaced. Thus there is now a risk that teachers will be less strict when correcting the tests and the analysis of the scoring indicates that this might be the case.

Links with Schools, Teachers and Pupils

The reference group for the Central Test has eight members at present. All of them have worked as physics teachers at different levels. At present two of them are working in Upper Secondary Schools and a third has just retired from such a school. Two are working at university level and one at a teacher training institution. Two are employed by the Department of Education at the University of Umeå - both of these are experienced physics teachers. The items in the tests are all suggested by active teachers

in the field. Thus in the preparation and handling of the Central Test there is a strong link with the teaching that is going on in the schools.

As one form of feed-back, a detailed report on the results of the test is prepared and distributed to the participating schools late in the spring semester. In this, comments are given about the different items and the marking instructions are explained. A breakdown of the results by different types of different groups is presented, for example boys and girls, students in the Natural Sciences line and students in the different branches of the Technological line, and also students with different marks in physics for the previous semester (as in Figure 1 above). Last year two classes of students who had sat for the test were invited to give their opinions on the different test items. Their answers were analysed and their views presented in the report. Although the test that year was considered to be one of the more difficult ones, they were very positive in their comments. The idea is to continue with this feature and to invite maybe three classes next time.

Comments on Quality and Effects

The system for awarding Certificates of Marks, including the system with Central Tests, is decided by politicians. In a way one could say that there is a continuous examination from the moment that a student starts in Upper Secondary School until he or she finishes. The Central Test is just one out of many instruments for judging the individual, but it plays a main role when the level of the class is to be decided.

Because of this role the test results are important and much time is spent in class to prepare the students for the test. Other tests in school will normally use the same format and old Central Test items are often used. Such items are frequently found also in textbooks and other exercises are of similar type. There is also a kind of consensus among physics teachers that questions in physics should be like that and the tests are considered to set a high standard.

The tests have little significance for university entrance. First of all because an individual student's mark is not based on his or her Central Test result and secondly because admission to higher studies is granted on the basis of the average mark in all subjects that are included in the student's Certificate of Marks.

Most students apply for post secondary education that will lead to a qualification for a definite profession as soon as it is completed, for example medical doctor, teacher or civil engineer. The number of students studying pure physics is very low.

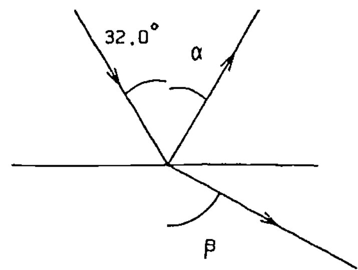
A new system for admitting students to the universities started this year. Between 40 and 60 percent of the places in various courses were admitted on basis of the results on a common Scholastic Aptitude Test. It is expected that several branches at the universities will start developing new admission tests especially made to suit each branch.

A new program system for the Upper Secondary school is being formulated and should be introduced in 1995 at the latest. The details are not yet fixed, but marking will not be relative or norm-related as it is now, but criterion-related. Thus changes must occur to the Central Tests and it is not even clear if the tests are to remain or to what extent they will be used by schools in the future.

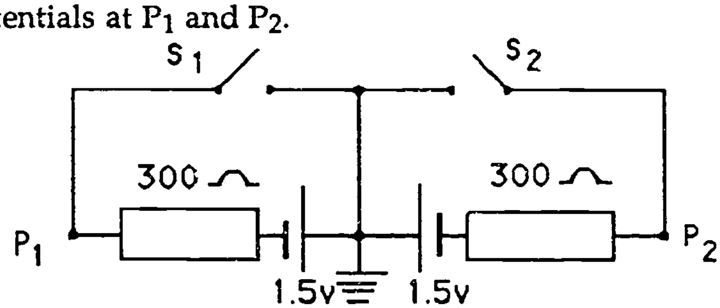
A few years ago it was decided that a Central Test in physics should be given in the adult education program. It was not possible to use the same test as the courses are not quite the same and there was no suitable date when identical tests could be given in the two courses. A test for the adult program had to be constructed with a content somewhat different from that of the Upper Secondary School Test. Calibrating the two tests so that the results are comparable, and so that there would be no injustice between adult and school applicants for university selection, has turned out to be a difficult problem.

Example 1: Five Short Questions Taken From Part A of Two Central Tests

1. A light ray strikes the boundary between glass (n=1.50) and air. Some of the light is reflected back into the glass and the rest exits into the air (see figure). Calculate the angles α and β.



2. Consider the circuit. The switch S1 is closed while S2 remains open. Find the potentials at P_1 and P_2.



3. The electric mains give an effective (r.m.s.) potential difference of 220 v. Find the peak value for the current passing through a 75 W light bulb which is connected to the mains outlet.

4. A metal ball with weight 30 N is vertically suspended by a spring of negligible mass. The ball is lifted just enough so that the force of the spring is zero. From this position the ball is released from rest. Find the force of the spring on the ball at the instant when the ball reaches its lower turning point and just begins to move upwards. Which of the following?

a) 60 N upwards b) 30 N upwards
c) 0 d) 30 N downwards e) 60 N downwards

5. One of the worlds largest solar energy plants is located near Falkenberg. The plant is intended to provide 2 GWh per year. The solar panels have a total area of 5300 m^2. Calculate the useful power per square meter solar panel which the solar radiation is expected to yield on the average during the daylight hours of the year. You may assume that the number of daylight hours is 12 h per day on average.

Example 2 : Three Questions Taken From Part B of Central Tests

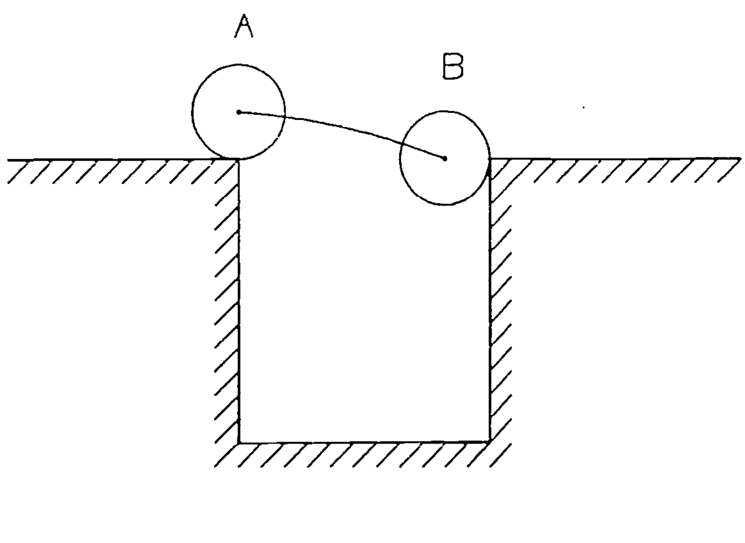
First example - No.8 from the 1990 test.

A car driver travelling at 70 km/h suddenly notices smoke from the motor. He is afraid that the car might start burning and therefore stops as quickly as possible. What length of time will his braking take if the braking force is 8.0 kN and the car with its driver and load weigh 1200 kg?

Second example - No.12 from the 1990 test.

In golf the aim of the game is to hit the ball into the hole. The last shot - the put - must not be too hard, otherwise the ball may pass over the hole without falling in. Make the assumption that the ball will land in the hole if it falls at least one ball radius before it strikes the opposite side of the hole. According to this model, find the greatest permissible velocity the ball may have at position A if it is to fall into the hole.

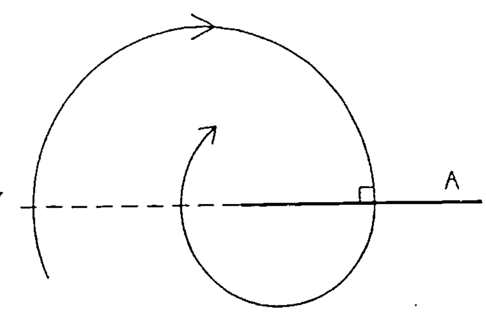
Radius of ball r=2.1 cm and diameter of hole d=10.8 cm



Example 2 continued - Questions From Part B of Central Tests

Third example - No. 12 from the 1991 test.

A charged particle moves in vacuum in a plane perpendicular to a uniform magnetic field. It strikes a thin lead foil A and passes through it. What percentage of its kinetic energy does the particle lose in this process? Measurements may be made in the figure which is drawn to some (unknown) scale. The charge on the particle is constant and its velocity is much less than the speed of light.



Marking Instructions

The instructions for correcting the students' solutions, sent out to the teachers read as follows for the third example above. The maximum score on the item is three points, and deductions are made from this according to the instructions : -

Uses kinetic energy remaining rather than kinetic energy lost	-1 p
Measuring fault that gives an answer outside the interval (64%, 70%)	-1 p
Solutions not explained by equations containing expressions for the force that acts on the particle	-3 p
Assumed numerical values for q, B or m	-1 p
Omitted the scale factor or assumed a numerical value	-0 p

Chapter 12 : The A-Level Examination in the U.K.

Ken Dobson

General Features

The examination described is the Nuffield A-level Physics examination. It is one of several forms of A-level Physics examination that schools in England Wales and Northern Ireland can choose to use.

Students likely to study Physics to degree level in these parts of the U.K. will usually have spent the last two years of school, between ages 16 and 18, studying for their 'A-levels' - the Advanced level of the General Certificate of Education (GCE). They will usually take just 3 subjects, spending about one quarter of their school time on each

Before A-levels, students will have studied 7 to 10 separate subjects for examinations at age 16 - the General Certificate of Secondary Education (GCSE). Most children are in state comprehensive - all-ability - schools, but a significant minority (about 7%) are in private, fee-paying schools. At present very few children study all three sciences for GCSE, with about 30% taking Physics. These are mostly boys (80%). In 1992 a new National Curriculum will begin operating at GCSE, and in 1994 most children will have spent 15% to 20% of their school time studying science. Physics, with Earth Science and Astronomy, occupies at least one-third of the National Curriculum in Science - say 2 hours a week for pupils aged 15 and 16. This could increase the potential number of A level Physics candidates.

Table 1 shows that in 1990 about 0.4% of the age group began degree courses in Physics at a university, and a further 0.2% took degree courses at polytechnics. Thus, in 1990 approximately 4 500 students began a degree course in physics.
The trend is for both A level and degree students of physics to decrease - between 1989 and 1990 there was a decline of about 4%. Table 2 shows the twelve most popular A level subjects in 1991.

Table 1 : Physics students
(in the U.K. - not counting Scotland)

Total number in year group (1990)	about	730 000
Proportion in school - age 17		53%
- age 18		36%
Studying A-levels	about	30%
Studying Physics at A-level	about	6%
(about 17% of these take the Nuffield A level)		
Achieving an A-level pass in Physics	about	4.7%
Going on to take a degree course of some kind	about	2.5%
Going on to take a degree course requiring Physics	about	2%
Going on to take a degree course in Physics	about	0.6%

Table 2 : The Most Popular A-Level Subjects in 1991

	Number of candidates	Relative percentage of total entry* (1990 in brackets)	pass rate %
English	79 137	11.4 (10.8)	85.4
Mathematics	75 006	10.8 (11.5)	74.6
Social Sciences	60 813	8.7 (8.2)	71.4
General Studies	52 191	7.5 (7.5)	69.6
Biology	46 539	6.7 (6.8)	72.7
Chemistry	44 450	6.4 (6.8)	77.7
History	44 064	6.3 (6.4)	80.1
Physics	43 401	6.2 (6.6)	76.1
Economics	43 163	6.2 (6.6)	72.0
Geography	42 446	6.1 (6.1)	78.9
Art and Design	31 161	4.5 (4.6)	89.8
French	30 801	4.4 (4.0)	85.8

*Students may take 1, 2, 3 or more subjects at A level so it is impossible to calculate how many different individuals the total entry represents.

Admission to University Courses

A level Grades

A levels give a result in the form of a grade. A to E are the pass grades (A is the best). Grade N is a 'near miss' and U means a performance too poor to be classified.

A typical set of statistics is given in Table 3 for the Nuffield Advanced Physics examination (1991).

Table 3 : Grades and Marks

Grade	A	B	C	D	E	N	U
Mark %	71+	62	54	47	40	32	<32
N(cum %)	16	30	45	62	80	93	100

N(cum %) = the cumulative percentage of candidates gaining each grade.

The Nuffield Physics course attracts many schools with good candidates, so the pass rate is higher than average for Physics.

Using the results

All universities select candidates on the basis of their A level results. For a Physics degree they will hope for candidates with a grade A or B, with an equivalent grade in Mathematics. But such students are hard to get, and a grade C or even a D will allow students to gain entry to a degree course somewhere, particularly if the grade in mathematics is a good one. For some courses, grades in two A-levels are sufficient, for others, three are essential. Compensation between different subjects may be allowed. Of course, the most prestigious universities (such as Oxford and Cambridge), and those with a very good reputation for Physics will attract the better candidates. Such universities can afford to demand the best results, such as three passes at grade A. Each university is free to fix its own entry requirements and to operate them flexibly. However, they leave the decision about standards of performance at A-level to those who set and mark the examination papers. All the university department needs to do is to specify the grades it will accept as an entry qualification.

Information from the school

Students choose their university course and apply to several (5 or 6), putting their choices in order of preference. They will use a special form to describe themselves and their (non-academic) achievements and interests, and there is also a confidential letter from the head of the school. There is a complex 'clearing house' system to cope with this freedom of choice. Most students will be asked to attend their first or second choice universities to be interviewed by a member of the physics department. This is not likely to be a formal 'oral' about physics, but will assess the candidates' maturity and ability to fit into the university. This is a very important part of the selection process for the most popular universities which attract more candidates than they can accept.

Examination Boards

A level examinations are set by 8 different 'Examination Boards', one each for Wales and Northern Ireland, and six for England. Historically these Boards were set up by Universities or groups of Universities to enable them to select candidates for degree courses. They are independent organisations, but most have strong links with Universities.

The Boards charge fees which are usually paid by the candidate's school, out of public funds. By agreement the examination fees for a given subject are the same for all Boards. They provide the main income for the running of the Boards. The Boards are not meant to be profit-making. However, if they do not attract enough candidates they will have to close down, as indeed happened with one Board in 1990.

The chief examiners, who set the papers, and their assistant examiners, who mark them, work part time. They are usually teachers, at secondary school or university level. The payment is quite small for the time and expertise required.

Keeping up standards

It is assumed that the different A level Physics examinations are all of the same standard, so that a grade B from one course is equivalent to a grade B from any other course. From time to time statistical analyses are done to confirm this. There is an increasing tendency for the state to control examinations. This is done by the Schools Examinations and Assessment Council (SEAC), a body set up by the Secretary of State for Education. This body monitors standards and has the power to withhold recognition of a particular examination syllabus. Any new syllabus - and any significant changes to an existing one - have to be approved by SEAC who will lay down strict criteria for all A levels.

The Form of the Examination

General Outline

The result of a candidate is awarded as a single grade. However, this is worked out from performance on several separate components, usually called 'papers'. The Nuffield Physics examination consists of 6 such components, and is more complex and innovative than the alternative A-levels. The account below concentrates on this examination.

The designers of the Nuffield Advanced Physics course believed that students should be given an opportunity to show their Physics skills, knowledge and understanding in a variety of ways. Some are good at doing this practically, others in problem solving, yet others may show themselves to best advantage by writing explanations and theoretical arguments. The 'complete physicist' should be good at all these.

The examination is designed to reflect the main aims of the course: Learning in the Future, Understanding Physics, Understanding the Nature of Physics, Learning to Enquire, Awareness of the Role of Physics in the World - and Enjoyment of Physics.

From 1992 the examination will have the six different components, four of these being timed tests - three written, one practical - and two being based on teacher assessment of pieces of work done during normal teaching.

Awarding a grade

The candidate's marks for each component are added to give a total, which determines the final letter grade awarded. Table 4 shows the maximum marks for each component, and its percentage 'weighting' in the total.

Table 4 : Nuffield Advanced Physics - Paper Weightings

Paper	1	2	3	4	5	6
Marks	60	60	60	45	30	30
% Weight	21	21	21	16	10.5	10.5

External Tests

Paper 1 is called the "Coded Answer " paper; 40 multiple choice questions have to be attempted in 1.5 hours. Multiple choice questions are widely used at A-level because they are easy to mark (by machine) and can assess most of the topics in the syllabus in a very short time. Example 1 shows two types of these questions.

In paper 2, the "Short Answer" paper, pupils have 1.5 hours in which to do 7 or 8 short questions of the problem solving type. This paper uses problem-solving types of question. They are 'structured' to lead the candidate through a problem, often getting more difficult towards the end. They can be very searching tests of understanding, analysis and the ability to make calculations with accuracy. A problem with such questions is that if candidates get the first part wrong, they are then unable to gain credit for later work. Examiners try to avoid this by, for example, telling candidates the correct (numerical) answer and asking them to justify it. Example 2 is a typical question. Example 3 is also taken from this paper - it asks candidates to make sensible estimates of everyday quantities and to use these to make relevant calculations; a question of this type is included almost every year.

In paper 3, the questions are usually strongly related to applications of physics in technology or everyday life - but research physics may also appear. Recent topics have included: how buildings are protected against earthquakes, using microwaves in radar and in cooking, drag coefficients in car design, accelerating particles in the CERN system, optical fibre transmission, why a gust of air can knock a person down, light bulbs, batteries, how helicopters work. The paper is called the "Comprehension and Long Answer" paper, and pupils have 2.25 hours in which to attempt questions in three main sections.

In the first section, the "comprehension paper" candidates have to read about a topic that is new to them, and are given 4 or 5 questions which require them to understand and apply their knowledge and skills in physics to, say, check the meaning or accuracy of the statements made. It is hoped that such a component in an examination will encourage students to read physics magazines for themselves. Example 4 gives in full this first section from a typical paper.

The second section is a "data analysis" question which tests candidates' ability to select and use the appropriate data from an unstructured data set. The question is usually structured, beginning with an easy task. The data may be numerical, graphical or diagrammatic - preferably all three (see Example 5).

In the third section, candidates choose 3 from a set of 5 short paragraphs which outline an effect, a device or a phenomenon and must give a short analysis or set of comments relating these to the underlying physics. Any

sensible answer based on the physics of the situation will be rewarded - some paragraphs are very open ended, others focus quite closely on a simple effect. Example 6 shows a question of this type.

In paper 4 - "Practical Problems" - pupils have 1.5 hours in which to attempt 8 short 'questions with apparatus'. The aim is not to test the ability to design an experiment, or to take very precise and accurate readings. Sometimes the observations to be made are very simple - e.g. tearing a sheet of paper in two different directions. Others require a set of readings from electric meters, stop watches or cathode ray oscilloscopes. But all will require the candidates to think about the significance of the observations, in the context of a problem, and where they can see, handle and change the physical effects involved. The right hemisphere of the brain is in play! Example 7 shows some questions from this type of paper.

Internal Assessments

Papers 5 and 6 require students to think, plan, test, check, reflect and review. They choose their own resources and areas of interest. They can make mistakes, change their minds, try again. This takes time, and is better done in school than in an examination hall. The aim is to encourage original thinking, and the abilities make and carry out plans. Practical skills are important in Paper 5 which is entitled "Practical Investigation" : candidates spend about two weeks of school Physics time in carrying out an extended investigation into a topic of their own choice. They write a 'diary style' account of their work and conclusions.

For paper 6 - "Research and Analysis" - candidates spend about two weeks in reading and collecting information about a problematic topic or issue of their own choice.

For both of these papers, the pupils work is marked by their teacher using criteria supplied by the Board - example 8 is the list of criteria specified for paper 5. Teachers have to send 5 marked samples to the Board so that standards of marking can be checked. If discrepancies are found, further samples may be called for and marks may be adjusted.

Preparation

Papers are set by Chief Examiners : there is one per paper, but he or she may have one or two assistants to help draft or comment upon questions. The visible process begins in the summer, two years before candidates will sit the papers. When the examiners meet to decide on the pass marks and grade boundaries for the current examination, they also discuss the draft questions for 2 years ahead. Some questions are rejected, others may be radically amended but are a basis for further work. About 2 to 3 months later, there is a further meeting to look at second drafts of complete papers. These are checked to ensure that they adequately meet the detailed examination <u>objectives</u> laid down in the syllabus, as shown in Table 5.

This meeting may result in further changes. In the later stages, two independent "Revisers", who are teachers of the course, are involved, as critical evaluators who have to be satisfied that the papers are clear and fair. There are further postal circulations followed by a further meeting to make a final check through the papers, which are then ready for printing. By this time, the examiners are already drafting questions for the following year.

Table 5 : Objectives of the Nuffield Physics Examination

The assessment objectives are set out in three groups.

3.1 Knowledge

In the context of the defined syllabus content, candidates will be expected to demonstrate knowledge of:

(a) terms, concepts, units, models, laws and principles;
(b) standard experimental and investigative procedures
(c) appropriate computational, algebraic and graphical techniques

3.2 Application of knowledge to show understanding

Candidates will be expected to show their understanding of the knowledge defined in the syllabus by using it to:

(d) formulate hypotheses and plan inquiries to test them;
(e) choose and/or apply known laws and procedures to routine problems;
(f) analyse and evaluate data, evidence or arguments;
(g) give explanations of familiar phenomena;
(h) solve problems which are unfamiliar or presented in a novel manner;
(i) discuss appropriate technological applications of physics and the social, economic and environmental implications of physics-related applications, developments or phenomena.

3.3 Skills and processes

Candidates will be expected to:

(j) translate data and information from one form to another;
(k) argue, describe, analyse and evaluate in coherent, extended prose;
(l) demonstrate appropriate laboratory skills in investigatory activities;
(m) plan and carry out investigations.

4. SCHEME OF ASSESSMENT

The relationship between the Assessment Objectives, the components of the Scheme of Assessment and the subject content is shown in the following grid.

Component Objectives	Paper 1	Paper 2	Paper 3	Paper 4	Paper 5	Paper 6
Knowledge	**	**	**	*	*	*
Application of Knowledge	***	***	***	***	**	**
Skills and Processes	*	*	*	***	***	***
Units Tested	All Compulsory Units	All Compulsory Units	All Compulsory Units	All Compulsory Units	Makes use of Principles of Physics	Option Units Only

The asterisks* indicate the relative weighting of the grouped Assessment Objectives for each component of the Scheme of Assessment

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Marking

The mark schemes are produced at the same time as the examination papers are written. Each scheme gives one or more marks for every correct part of an answer, as shown in the scheme given with Example 3. These schemes will be modified, at a meeting of markers held very soon after candidates have taken the paper, in the light of experience gained in marking samples. After this, each marker has to mark some 200 or 300 scripts in about 3 weeks. Samples of marked scripts are monitored by experienced examiners to check for errors and consistency of standards.

The marks gained by each candidate are entered on a computer readable form and sent to the Board's offices. When the marking has been completed, and the computer can produce summaries of the statistics, the chief examiners and their assistants (12 people in all) meet to 'award' the grades to candidates. The first stage in this process is to reach a collective decision about the pass mark - between grades E and N - and the boundary mark between grades B and C. This is done by starting from an agreed proposal based on impressions gained from the marking and checking this by reading and discussing samples for candidates on and close to the proposed borderlines. The effect of these decisions on the overall success rates is then compared with statistics for previous years - significant deviations can be approved if they can be justified by the qualitative evidence.

The second stage involves remarking of the scripts of ALL the candidates who are within two marks or so of these boundary marks. The statistical data are also used to pick out any markers who have been too generous or too severe. Standard corrections can be fed into the computer to remedy this. After this, the other grades are awarded by computer. All decisions are taken on the basis of the sum of the marks on the eight components ; there are no separate conditions, i.e. there is no requirement to gain above a specified minimum on any one component.

In the third stage, the examiners review the examination as a whole, suggest future changes, write reports on their markers and on how the candidates have tackled their papers (for the benefit of their teachers) and consider draft questions for future examinations.

Analysis of the Results

Computer analyses of the data give the examiners comparisons of mark distributions between papers, between successive years, and between different markers on the same paper. The spreads and symmetries of the mark distributions can also be checked.

Each component of the examination should contribute fairly to candidates' final scores, according to its weighting. This will only be the case if : -

*good performance on the paper has a reasonable correlation with good performance on the whole examination

* each paper discriminates, i.e. has a good spread of marks between good candidates and weak candidates; discrimination is sampled as follows.

Two groups of 200 candidates, whose total marks place them on the B/C and E/N grade borderlines respectively, are selected from the print-out at random. The average marks for the two groups are calculated for each separate paper. The spread for each paper, which is the difference between the average marks on that paper for the strong and the weak groups, is expressed as a percentage of the total mark. Table 6 gives these results for four years (in these years Comprehension and Long Answer were separate papers and the Research and Analysis paper had not been introduced). A reasonable target is 25%. It is interesting to note that the lowest spreads are in the practical aspects of the examination.

Table 6 : Spread (as a %) Between Strong and Weak Candidates

	1988	1989	1990	1991
Paper 1 (Coded)	23.5	24	26	24
Paper 2 (Short)	25	27	27	26
Paper 3 (Comprehension)	23.5	26	28.5	30
Paper 4 (Long Answer)	20	20	22	24
Paper 5 (Practical Paper)	22	18	22	19
Paper 6 (Investigation)	18	15	16	15
Whole Subject	23	23	24	24

More detailed data on facility and discrimination for each question are available for the Coded Answer paper. From time to time, questions from previous years are set again in this paper. This has shown that the standard of difficulty of the paper - and by reasonable extrapolation - the examination as a whole has stayed much the same for the last ten years or so.

Checks with Physics examinations of other Boards (e.g. by comparing two groups of candidates who have taken the same mathematics examination but different physics examinations) have shown that all are at about the same sort of difficulty. However, there is some feeling - but little hard evidence - that all the Physics A-level examinations are harder than - for example - English, or Economics, or Biology examinations.

Links With Schools, Teachers and Pupils

Each year, the examiners produce a report, about the examination as a whole and about how candidates performed on each question, emphasising any major areas of common misunderstanding. This is sent to all schools involved, with an invitation to attend one of two meetings, held in different parts of the country in November. Schools are invited to send in queries or items for discussion. Each of these meetings lasts a day. The morning is usually spent on general issues; in the afternoon, individual papers are discussed in sub-groups. Up to 300 teachers attend such meetings each year. Any major changes in the syllabus or examination are first considered at such a meeting. All schools receive a copy of the mark schemes that the examiners use.

Comments on Quality and Effects

It is felt that the Nuffield examination is more successful than most in matching the demands of the examination to good practice in teaching and learning. Thus the two teacher based assessments are linked closely to normal good classroom work, whilst the fact that the Comprehension passage leads pupils to prepare by practising the reading of general articles on uses of Physics is a good feedback effect of the examination pressure.

More generally, A-level examinations are held to be useful in selecting degree students, although the correlations between degree results and A-level results are not high. One concern is that overloaded syllabuses and dependence by students on memorised work and routine problem-solving may lead to reward for students who are hard-working and consistent but who might lack originality. The use of a varied range of assessments and inclusion of such elements as investigations are important in reducing this concern.

However, there is serious general concern about the A level system. Most institutions of higher education agree with representative business and industrial organisation that A levels are 'out of date' and no longer serve national needs. In particular, they criticise them because they

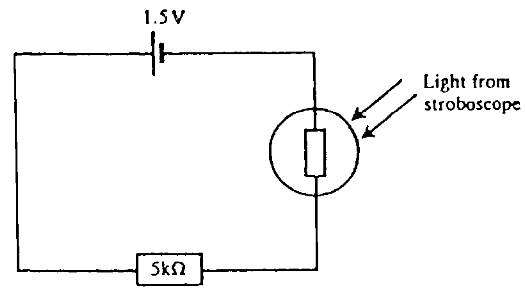
* are 'narrow' (over specialised)
* divide able 16-18 year olds with 'Arts' and 'Science' specialists
* are too academic and support the traditional anti-industry bias of higher education
* do not attract students from poor families or disadvantaged backgrounds
* give no reward at all to students (25%) who fail to get a pass grade
* do not link with other qualifications (e.g. technical/vocational)
* do not follow or build as the new GCSE course particularly well.

Attempts to change the system are currently meeting strong opposition from the government. The controversy is inhibiting curriculum development in Physics - people are uncertain if and when change will occur, and about the scale of any changes.

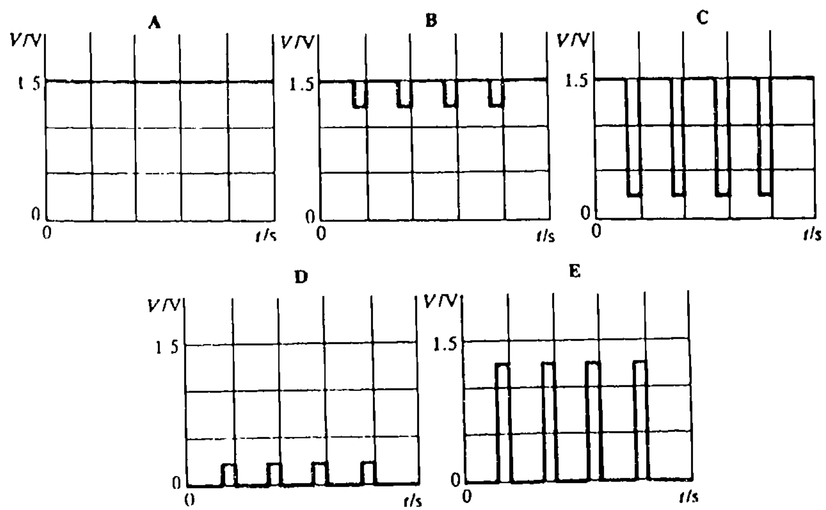
Of course, not everyone agrees with the criticisms listed above: teachers of very able students (often in independent education) are concerned that A levels might become 'watered down' and so not stretch their students fully. But even in these schools Physics is seen as 'too hard' for average A level students.

Example 1 : Questions From the Coded Answer Paper - Paper 1

3, 4 A light dependent resistor is illuminated in an otherwise dark room by a stroboscope flashing at a slow rate. The LDR has a resistance of about 1 MΩ in dark conditions and about 1 kΩ when illuminated. It is connected in series with a 5 kΩ fixed resistor to a cell of negligible resistance, as shown below.



Below are five graphs of what might be seen on the screen of an oscilloscope connected across part of the circuit



3 Which graph best shows the voltage variation across the LDR?

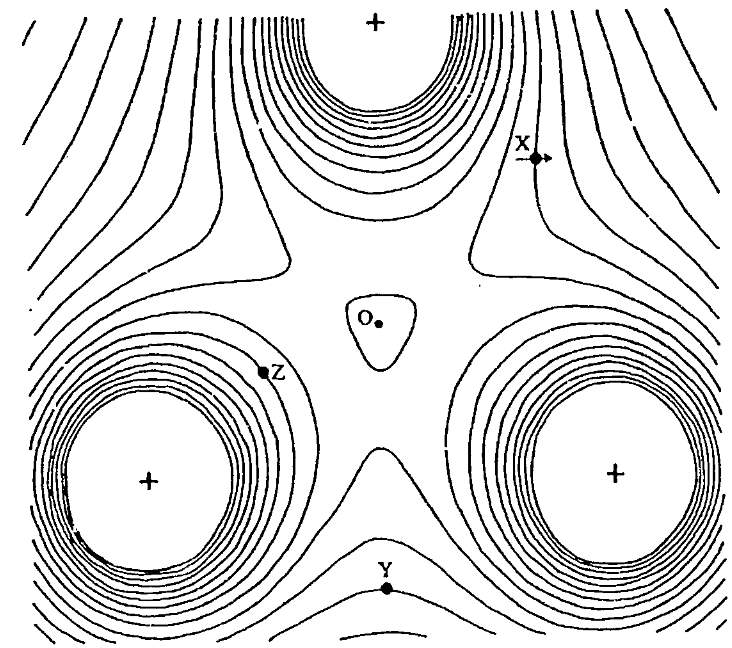
4 Which graph best shows the voltage variation across the 5 kΩ fixed resistor?

33 Which of the following would be useful features to look for in a material which you wished to use to carry sound waves at as high a speed as possible?

1 low frequency of atomic vibration
2 strongly bonded atoms (large restoring force for a deformation)
3 small atomic mass

A 1 only B 2 only C 1 and 3 only D 2 and 3 only E 1, 2 and 3

34 The map shows computer predictions for some equipotentials near to three equal positive charges.



Which of the following statements is/are true?

1 The potential at O is the same as the potential a long way from the three charges.
2 The electric field at X is in the direction shown by the arrow in the diagram.
3 The magnitude of the electric field at Z is bigger than that at Y.

A 1 only B 2 only C 1 and 3 only D 2 and 3 only E 1, 2 and 3

35 When a nucleus disintegrates, which of the following quantities is/are conserved?

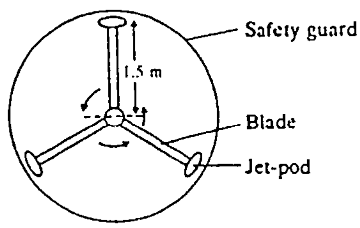
1 The total momentum of the particles involved.
2 The total potential energy of the particles involved
3 The total (net) electric charge of the particles involved

A 1 only B 2 only C 1 and 3 only D 2 and 3 only E 1, 2 and 3

Example 2 : A Typical Question From the Short Answer Paper - Paper 2

3 A lift fan for a hovercraft, shown as seen from below in Fig. 3, consists of three light glass-reinforced-plastic blades, each 1.5 m long and having a uniform cross-sectional area of 1.6×10^{-4} m^2.

The fan is driven by jet-pods, each of mass 5.0 kg, attached to the ends of the blades. A safety guard encloses the fan.



Data for glass-reinforced-plastic:

Young modulus	6.0×10^9 N m^{-2}
tensile strength	5.0×10^8 N m^{-2}

Fig. 3

(*a*) (i) Show that each blade exerts a force of about 3.0×10^4 N on a jet-pod when the fan rotates at 10 revolutions per second.

(ii) What is the direction of the force exerted by the blade on the jet-pod?

[2]

(*b*) Calculate

(i) the longitudinal stress in a blade at this speed.

(ii) the consequent extension

[3]

(*c*) The designer says that the maximum safe speed of rotation is 15 revolutions per second.

Explain why there is such a limit.

[2]

Example 3 : Estimates Question From the Short Answer Paper - Paper 2

With the Mark Scheme

4 This question is about the forces involved in supporting books on a bookshelf.

(a) In answering this question you will need to estimate various quantities and then combine them in order to obtain the required answer.

Show clearly your estimates and all the steps in your calculation. Remember to include the units in estimates as well as in the answer, and to work throughout to an appropriate number of significant figures.

(i) Estimate the weight of books which fill a bookshelf 1.5 m long.

Estimates	*Calculation*

(ii) Calculate the minimum cross-sectional area of steel wire which can support this weight. [Breaking stress of steel = 4.0×10^8 N m^{-2}]

(b) One way to support the loaded bookshelf with a single steel wire is shown in Fig. 4.1. On the inner edge, the shelf rests on a strip of wood fixed to the wall.

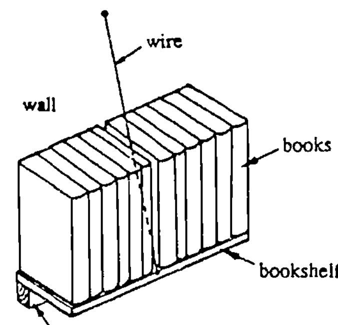


Fig. 4.1

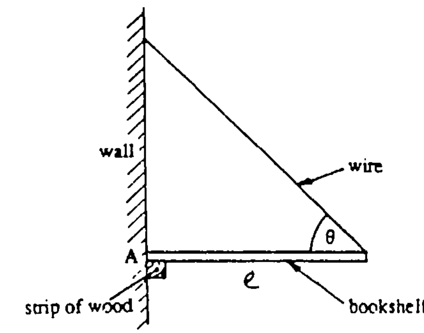


Fig. 4.2

(i) On Fig. 4.2 draw three arrows to represent the three forces acting on the loaded bookshelf, including the force acting at A. Be precise with the directions of your arrows.

(ii) The tension in the wire is equal to the total weight supported. Calculate the angle θ.

Example 3 : Estimates Question - continued. Mark Scheme.

			Marks
(a)	(i)	Sufficient relevant quantities estimated (1) Properly combined (1) Correctly calculated weight, rounded (1)	3
	(ii)	Area = Force -- Stress = answer to (i) -- 4 . 10	2
(b)	(i)	weight and tension arrows (1) reaction through meeting point (1)	2
	(ii)	sensible method (e.g. vector diagram) -- 0 = 30	2
		Total for Question	9

Example 4 : The "Comprehension" Section of Paper 3
The Passage for Analysis

Section A (25 marks)

Read the following passage carefully and then answer **all** *the questions printed after it.*

Adapted from 'The Year of Optical Fibres', by John Midwinter (*National Electronics Review*, 1980, S1)

The weather conditions in Britain often prevent one seeing very far, therefore direct line-of-sight transmission of light is unreliable. Hence the use of very thin fibres of glass to guide signals is a more reliable alternative. In the future there is every prospect that there will be a telecommunications trunk network based on optical fibres

Structure of fibres

A typical optical fibre consists of a cylindrical inner core with a diameter of about 0.05 mm and an outer concentric cladding, so that the overall diameter of the core and cladding is about 0.125 mm.

The refractive index of the transparent, pure glass at the centre of the core is typically 1.47, and this means that the speed of light directly along the axis of the fibre is c/1.47. The transparent glass cladding has a refractive index about 1% lower than the core. The difference in the refractive indices of core and cladding causes light, which has entered the core at one end of the fibre, to be totally internally reflected at the core/cladding interface until it emerges from the other end of the fibre (see Fig 1)

The refractive index of the core is not necessarily constant. Some fibres have a refractive index which varies with distance from the centre of the core (see Fig 2), and these fibres are called 'graded index' fibres. A 'step index' fibre has a constant refractive index throughout the core.

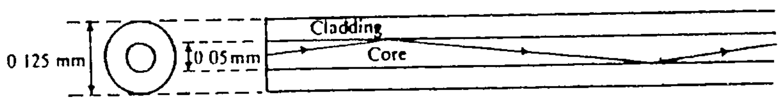


Fig 1

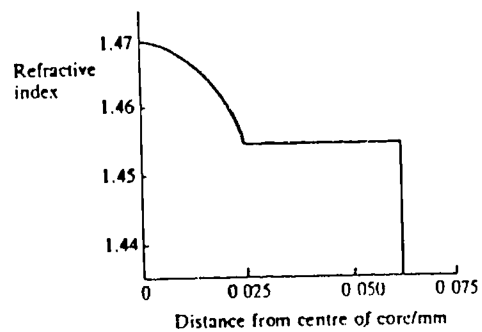


Fig. 2

Attenuation

The first fibre systems used lasers as their source of light and a typical wavelength was in the range 850 to 900 nm when measured in air. When these lasers were used with fibres free from impurities, the attenuation (power loss) was only produced by 'Rayleigh' scattering. This scattering was a result of unavoidable density and structural variations within the glass.

Attenuation (A) is usually given in decibels (dB) and is calculated by using the expression

$$A = -10\log_{10}(P_2/P_1),$$

where P_1 is the power input and P_2 is the power output. A typical attenuation produced by Rayleigh scattering was about 2 dB per kilometre for the first fibre systems.

At greater wavelengths the Rayleigh scattering attenuation would be lower because Rayleigh scattering varies as λ^{-4}, where λ is the wavelength.

When using lasers emitting longer wavelengths another mechanism comes into play. The signals can now be absorbed as a result of infra-red absorption by atoms in the glass, as the atoms are forced into oscillation. The maximum absorption occurs at laser wavelengths of 9000 nm. This type of absorption is present at shorter wavelengths but at a much reduced level.

The effect of these two mechanisms is that fibres based on silica glass have a minimum level of attenuation in the region of 1550 nm of about 0.2 dB per kilometre.

Transmission

All the fibre systems that will be operating in the telecommunications trunk network will use a digital system. The binary digital data are transmitted by signalling a 'one' as a flash of light and a 'zero' as darkness. Since on average, there would be approximately the same number of one's and zero's in a message 'stream', a 140 Mbit/s optical fibre transmission system would transmit seventy million flashes of light per second intermixed with seventy million blanks. The duration of each pulse of light from the laser needs to be very much less than 7 ns and also the transmission process must not allow pulses to become longer than this value. If pulses were allowed to become longer than 7 ns everything would become hopelessly confused.

Unfortunately, if the fibre core is made of a single uniform material of the 'step index' type, considerable pulse spreading takes place. For fibres of the diameter and refractive index already described the pulse spreading could be as much as 40 ns per kilometre, since in all fibres light travels by internal reflection along zig-zag paths of different lengths. Light which crosses the axis of a fibre at a small angle will travel by a shorter physical path than that which crosses the axis at a greater angle.

The 'graded index' type of fibre is a way of limiting pulse spreading. Light travels more slowly in the centre of the core than near the core/cladding interface. As a result of this it is possible for pulse spreading to be reduced to 0.01 ns per kilometre or even less.

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Example 4 : The "Comprehension" Section of Paper 3 - continued Questions on the Passage

Questions

1 (*a*) Explain why direct line-of-sight transmission is unreliable in rain or mist (lines 1-2).

(*b*) Calculate the minimum time a pulse of light would take to travel along 10 km of a 'step index' fibre which has a core of refractive index 1.47 ($c = 3.00 \times 10^8$ m s^{-1}.)

(*c*) With the help of a labelled diagram, illustrate and explain the meaning of the sentence 'Light which crosses the axis of a fibre at a small angle will travel by a shorter physical path than that which crosses the axis at a greater angle' (lines 46-7). [5]

2 (*a*) Assuming that the attenuation due to Rayleigh scattering varies as λ^{-4}, show that if this attenuation is approximately 2 dB per kilometre at a wavelength of 880 nm, the expected Rayleigh attenuation at 1550 nm would be 0.2 dB per kilometre.

(*b*) A laser transfers a power of 100 mW into an optical fibre which has an attenuation of 6 dB per kilometre. Using the formula in line 23, calculate the power received at the end of 1 kilometre of the fibre [4]

3 Summarise the reasons given in the passage for the statement that 'fibres based on silica glass have a minimum level of attenuation in the region of 1550 nm' (lines 32-3). [4]

4 On graph paper draw two labelled graphs, with suitable time and relative intensity axes, to represent:

(*a*) pulses which have not been spread, but are part of a 140 Mbit/s message stream of digital light signals (lines 35-41);

(*b*) the same pulses after they have been transmitted along a fibre and subjected to *attenuation* and *pulse spreading*. [6]

5 (*a*) Explain how a 'graded index' type of fibre produces less pulse spreading than the 'step index' type.

(*b*) When a telephone conversation is transmitted along an optical fibre, the conversation is sampled 8 000 times a second and each sampling is encoded as an 8-bit binary number.

Calculate the theoretical maximum number of telephone conversations that can be transmitted at the same time along one fibre using a 140 Mbit/s system.

(*c*) In the near future it is hoped that 2 400 Mbit/s optical line systems will be used and hence more telephone calls will be able to be transmitted in one stream of pulses. Why is pulse spreading likely to be more of a problem at this high rate of transmission? [6]

Example 5: A "Data Analysis" Question From Paper 3

Section B (20 marks)

6 In this question you are asked to make calculations concerning the design of a conveyor belt which is in continuous operation lifting coal from a stockpile to the furnace of a small coal-fired power station.

Relevant data are given on the facing page.

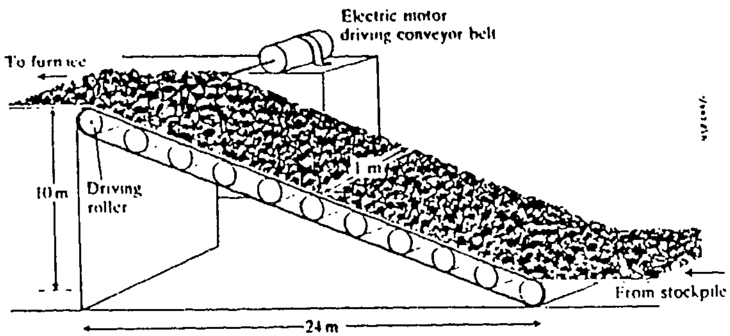


Fig 1

(a) For a 300 MW output from the power station use the data given to verify that:

about 36 kg of coal must be delivered to the furnace each second.

for a depth of coal on the belt of 0.5 m, the belt must move at a speed of about 0.07 m s^{-1}.

the total mass of coal on the belt at any moment is about 13 tonnes. [6]

(b) The belt is driven by an electric motor with an output power of more than 5 kW. As can be seen from the graph in the data, the frictional force in the conveyor belt system is about 2.4×10^4 N with 13 tonnes of coal on the belt.

(i) Calculate:

the power needed to lift the coal, ignoring friction.

the power needed to overcome the friction in the conveyor belt system.

(ii) Show that the power required to give kinetic energy to the coal moving on the belt is negligible compared with the values calculated in (b) (i)

(iii) Hence find the total power output from the motor.

(iv) Using the data and your calculated power for the motor, show that

the tension required in the belt is of the order of 10^5 N.

a belt 10 mm thick is adequate to carry the load without breaking [8]

(c) The designers wish to consider the effect on the power required from the motor of changing the depth of coal on the belt (keeping the power station output constant.)

If the depth of coal on the belt is *halved*, discuss quantitatively the effect on:

the belt speed,

the total mass of coal on the belt,

the frictional force in the conveyor belt system,

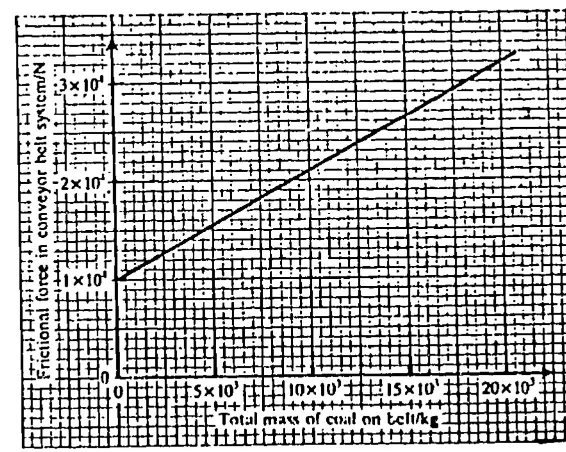
the power output required from the electric motor. [6]

DATA

Power Station: Output power 300 MW
Thermal efficiency 30%

Coal: Energy content of coal 2.8×10^7 J kg^{-1}
Effective density: 1000 kg m^{-3}
1 tonne = 10^3 kg

Conveyor Belt: (see also Fig. 1)
Width 1 m
Height through which coal is raised 10 m
Horizontal distance from stockpile to furnace 24 m
Tensile strength of belt material 2×10^7 N m^{-2}



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Example 6 : A "Paragraphs" Question From Paper 3

Section C (*15 marks*)

7 Choose **three** of the statements (*a*) to (*e*) below. Write a few paragraphs about each of the three statements.

For each statement you select:

show how physical principles apply to the situation described;

make calculations and/or give equations wherever possible to show the relationships between the quantities involved.

Spend not more than about 10 minutes on each statement. It should be unnecessary to write more than about one page on each answer. A suggested approach is given in italics after the statement.

(*a*) Air is about a thousand times less dense than a human body yet a 30 m s^{-1} gust of wind can knock a person over.

(Density of air $\approx$ 1.0 kg m^{-3}.)

(You might begin by estimating the dimensions of a human body and hence calculate the force which such a gust might exert.)

(*b*) When a 100 W, 240 V domestic light bulb is switched off, the light fades almost immediately. However, a 12 V car headlight bulb of the same power takes much longer to dim despite having a filament of only half the length and being made from the same material.

(You could start by comparing the electrical resistances of the bulbs and then go on to compare the dimensions of the filaments.)

(*c*) In one important experiment which led physicists to revise their ideas about the structure of the atom, a beam of alpha particles was directed at a thin metal foil. Some alpha particles were scattered in the metal, and a few were deflected through large angles.

Your discussion might describe briefly the results of the experiment, and outline some of the deductions made from them. A detailed account of the experiment is not required.

(*d*) Surface features on the Moon can be seen by the naked eye, but small dark patches cannot be distinguished from their brighter surroundings if they are less than about 40 km in diameter. Distant stars, however, are clearly visible, despite having an angular size much smaller than that of the dark lunar patch.

(Distance from the Earth to the Moon = 3.56×10^{8} m; mean wavelength of light = 5.0×10^{-7} m.)

(You might start by estimating the diameter of the pupil when looking at the Moon, and hence determine the resolving power of the eye.)

(*e*) A student incorrectly suggests that the storage of energy in a rechargeable pocket torch is by means of capacitors. The bulb of such a torch is marked 2.5 V 0.3 A, but the rest of the torch casing is sealed, and its contents may not be examined.

You could start by estimating the capacitance value needed, or by considering differences between capacitors and batteries.

Example 7: Two "Practical Problems" Questions From Paper 4

The diagram in the first question shows primary and secondary coils, placed around a core made by clipping together two C-shaped iron bars

5 This question is about magnetic circuits.

The apparatus shown in the diagram below is set up on the bench. There is also a pile of postcards (taped together) and an aluminium plate.

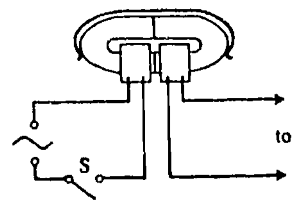

Fig. 6

Close the switch S and observe the voltage waveform on the CRO. You may wish to centralise the trace on the screen but **do not** change any of the other settings.

The Y-plates are set at a sensitivity of 0.5 V cm^{-1}.

(*a*) Use the CRO to measure

V_1, the peak to peak voltage across the secondary coil.

V_1 = ...

Now remove the clip holding the C-cores together. Insert the stack of cards across both ends of the C-cores and replace the clip.

(*b*) Use the CRO to measure

V_2, the peak to peak voltage across the secondary coil with the cards in place.

V_2 = ...

By considering the reluctance of the system, explain why V_2 is different from V_1.

[3]

8 This question is about the physical properties of biscuits and of the packaging in which they are sold.

(*a*) (i) Break each biscuit in half, observing carefully what happens as you do so. Describe the behaviour of each biscuit, by comparing the forces required and the manner in which it breaks. Your answer should use appropriate scientific terms.

(ii) Look at the broken edges (a hand lens is provided). How does the structure of the biscuits relate to the way they break?

[3]

(*b*) Now attempt to crush each biscuit by squeezing a fragment between finger and thumb. Describe what happens and explain it in terms of the physical properties of the biscuit.

[2]

(*c*) Biscuit A is usually supplied in a cardboard container whereas biscuit B is often just wrapped in cellophane. From your observations, justify this choice of packaging.

[1]

Example 8 : Pupils' "Investigations" - Paper 5
Notes and Instructions to Teachers for Assessment

General

A period of two weeks of lesson time together with the usual homework or preparation time is intended as the norm for the Investigation – up to say 20 hours for A Physics (Nuffield). It is unlikely that work of adequate quality can be done in much less than these times.

It is desirable that candidates should as far as possible choose their own topics for the Investigation and these must be concerned with a practical problem related to physics or its applications. They should be discouraged from undertaking routine exercises which would offer little scope for ideas and inventiveness. Some preliminary discussion with candidates about the feasibility of their plans and the implications of their choice of topic is advisable.

All experimental work for the Investigation must be carried out in the school/college so that the Internal Assessor is familiar with each candidate's work at all stages.

Although as a general rule unsolicited help should not be given, tactful guidance of candidates into more practicable paths may sometimes be needed. If help is asked for it should be given, as far as possible in a way which allows candidates to gain credit for using such advice in their own way.

Joint Investigations

A school wishing candidates to undertake a joint Investigation and to provide individual assessments based on such an Investigation must seek the approval of the Board in advance. Joint Investigations are not encouraged.

Paired or group work would only be deemed satisfactory if each member of the group has an individual task and would be working sufficiently independently of the others for the merits of the individual contributions to be distinguished.

Notes to Candidates

The attached 'Notes to Candidates' should be read by all candidates. They may be displayed, or copies made and given to candidates. All teachers involved in assessing Investigations should also read these notes.

Title and Rating Sheet

The attached form of Title and Rating sheet must be used on moderation sample reports. It is suggested that the same form be copied by the school for use by all candidates.

Internal Assessment

The Investigations must be assessed by the person responsible for teaching the candidates. Where several teachers in a school are involved, it is expected that arrangements will be made to ensure that they are all interpreting the rating criteria in the same way.

The assessment should be based on observation of the actual work done, and on discussion with the candidate, as well as on information revealed in the written report. Ratings must be based on the work actually done, and must NOT be influenced by impressions of what the candidate might have been expected to achieve, whether this is less or more than is actually achieved.

Errors in Physics must be marked on the report.

It is inevitable and indeed often sensible that candidates should seek help or advice from outside sources and it is important that teachers find out about the nature and extent of this assistance so that in making their assessments they can make due allowance for it. Credit should only be given for the way in which the candidate makes use of the help or advice received. Teachers must insist that printed or other sources used be acknowledged, e.g. in a bibliography.

The fact of having spend a longer time on an Investigation should not in itself earn for the candidate concerned a higher assessment. The work should be judged on its quality with respect to the total time spent on the Investigation. Candidates who work effectively for the normal allotted time must not be put at a disadvantage. On the other hand, candidates who spend little time must not be awarded a high rating.

In order to minimise the effect of good or ill luck in the choice of topic or while the work is in progress, an Investigation which fails in its initial objective should be rated equally with one which happens to succeed, provided that they are performed equally well.

Reports should be legible but the candidate's linguistic competence should not influence the assessment except when the report is unintelligible to the assessor. Excessive length of reports should be strongly discouraged.

Investigations are to be rated 0, 1, 2 or 3, under each of the five headings:

(i) interest and independence
(ii) range, variety and relevance of experiments
(iii) quality of experimentation
(iv) analysis and interpretation
(v) communication (the report)

Ratings 0 to 3 are defined on pages 4 and 5 for each heading. Rating 0 should be given where the work falls below the criteria for rating 1. Ratings are to be added, to obtain a rating total. An adjustment, at most ±2, may be made to the rating total, but only where the special nature of an Investigation or the circumstances requires such special consideration. This adjustment is not a bonus mark, but is intended to cover rare cases where the criteria are not appropriate to the nature of the Investigation. The rating total after adjustment must not exceed 15.

Investigations in which there is <u>no use of ideas in physics</u> should have total ratings not exceeding 10. This is NOT intended to exclude Investigations of non-physics topics, provided that they offer opportunities to use physical reasoning (e.g. in analysis or in design).

The general level of ratings 0 to 3 is intended to be:

Rating 0 : falls below rating 1
Rating 1 : some attempt made, limited in important respects
Rating 2 : work of substance, despite some limitations
Rating 3 : work meeting all reasonable expectations.

Work getting rating 1 on all headings would be around a pass/fail borderline.
Work getting rating 2 on all headings would be very creditable.
Work getting rating 3 on all headings would be outstanding.

The rating which is the best fit to the criterion description, bearing in mind the general intention, should be given under each heading. Half ratings must not be given; adjustments should be made by avoiding erring twice in the same direction in choosing ratings.

Amongst the Investigations given the highest possible total rating (15) there may be some which show very special flair and originality, or other qualities quite exceeding normal expectations. Such Investigations should be given the special merit endorsement M.

The Board will scale rating totals suitably to convert them to marks. The Board may award a bonus mark for Investigations endorsed M.

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Example 8: Pupils' "Investigations" - Paper 5 Notes and Instructions - continued

CRITERIA FOR RATINGS

(i) **Interest and independence** Is it a sensible topic? Is there point in pursuing it? Did the student contribute ideas of his/her own? Does the work show imagination, flair, ingenuity, elegance? Were help, advice or sources constructively used/ Did the student work independently, taking responsibility for decisions? Is the physics involved of A level standard?

Rating 0 falls below Rating 1

Rating 1 A definite topic was chosen, and appropriate choice made of what to study. Help given was acted on. Simple physical ideas were used.

Rating 2 The topic has interest and potential, and some of this was developed. Some independent decisions were made. The work has some plan, or development. There is some improvisation of ideas, methods or apparatus. Help given or sources used were considered and acted on appropriately.

Rating 3 The investigation is interesting, achieving results new to the student. Personal responsibility was taken for plans and decisions. Advice and sources were well used. The student's own ideas played a significant role. The investigation as a whole is a sustained attentive, and worthwhile study.

(ii) **Range, variety and relevance of experiments** Is there plenty of good, varied and relevant practical work? Do experiments bear upon the topic? Do experiments develop and relate to one another? Are different possibilities considered and acted on? Are difficulties dealt with or followed up?

Rating 0 Falls below rating 1.

Rating 1 At least one experiment is carried through, or two or three elementary tests or comparisons are made. Variety may extend to trying effects of a few different parameters on some property, of which at least some are sensibly chosen.

Rating 2 Either a collection of related experiments, or one longer experiment including tests of, or development of, certain aspects. Some alternatives were tried. Attempts are made to identify and deal with difficulties. The time is usefully filled.

Rating 3 A good rang: of vari and relevant experiments, showing progression and development. Alternatives are tested and fol :d up. Difficulties are dealt with, and influence the course of the work. Work done is often lim . by the time available.

(iii) **Quality of experimentation** Are experiments well, carefully and thoughtfully done? Are anomalies or discrepancies followed up? Is the level of precision appropriate? Are suitable precautions taken? Are ways sought of making results reliable and accurate? Are methods (often simple) well selected or suitably invented? If apparatus is designed or constructed, how skillfully and effectively was this done? Was there effective improvisation of methods or equipment?

Ratings should be judged in relation to the candidate making good use of available resources.

Rating 0 Falls below rating 1.

Rating 1 Data may be mainly qualitative. Observations, qualitative or quantitative, are made but not usually repeated or checked Simple, often commonly available, apparatus is used in a direct way.

Rating 2 Some measurements are repeated or checked. Discrepancies are noticed. Some thought is given to precision, or to ways of improving it. Methods used are chosen with some care and thought, perhaps after rough trials. Qualitative observations are made with some care, and with some attention to detail and to relevance. Useful methods may have been improvised. Equipment may have been constructed. Major defects in apparatus may have been rectified.

Rating 3 Measurements are made and checked with care, being repeated where appropriate. Discrepancies are noted and investigated. Rough trials or preliminary tests inform later decisions. Methods show ingenuity and skill. Relevant variables are controlled. Qualitative observations are relevant, detailed, and well chosen with insight into what they may reveal. There is evidence of experimental design. Equipment constructed shows some ingenuity, and does more than follow a recipe.

(iv) **Analysis and interpretation** Is an attempt made to make sense of the results, which may be qualitative or quantitative? Does the work go beyond descriptive reporting? Are explanations proposed or criticised? Is any theory developed or considered? Are meaningful relations between results or observations sought?

Rating 0 Falls below rating 1.

Rating 1 Results are usually presented directly. Expected relations are assumed to be present. Discrepancies are simply noted. Work is mainly empirical in nature.

Rating 2 There is some analysis of results, perhaps fitting data to formal relationships (e.g. finding a power law). Some understanding of the underlying physics is in evidence, in both qualitative or quantitative work. Results are given some physical interpretation (even if this reveals certain misunderstandings).

Rating 3 The work is guided by a concern to explain, interpret or understand results (even if not always successful). Knowledge of physics is used to account for or predict results. Experiments are designed or chosen with a view to what they will suggest or test. Qualitative results are interpreted with care and insight. Basic errors in physics are avoided.

(v) **Communication (the report)** Is the report interesting, concise, clear and well argued? Does the report provide evidence of thought? Does it effectively communicate the work done? Are data well presented, usually graphically, and are methods clearly described? Does the report show a view of the whole investigation? Does the report add value, by its quality, to the other work done?

Reports in diary form are as acceptable as more formal reports. See Notes to Candidates.

Rating 0 Falls below rating 1.

Rating 1 The report is likely to be a factual account of work done. Conclusions may be limited, and may focus on the more obvious results. Tables and graphs are presented, perhaps without much comment.

Rating 2 The report has some interest, but may be largely factual, though with some comment and interpretation. The report has some structure and continuity. It may be substantial in length, perhaps lacking conciseness. Graphs and tables are generally adequately presented.

Rating 3 The report shows evidence of critical and connected thought. It will be thorough, but will also be concise. Work is presented as developing, with relationships between experiments brought out. Conclusions, qualified as necessary, are clearly drawn. The report makes interesting reading and by its general quality adds value of its own to the work.

Note Rating 3 is not to be given to excessively long or verbose reports.

Example 8: Pupils' "Investigations" - Paper 5 Notes and Instructions - continued

If there are any circumstances such as illness, injury or irretrievable damage to apparatus at a crucial stage, which present irremediable difficulties to a candidate in this part of the examination, the Head should communicate with The Secretary, Oxford and Cambridge Schools Examination Board before the time set aside for Investigations is over, giving as full details as possible, so that the Awarders may be able to assess a possible allowance.

In such special circumstances the Internal Assessor should award an estimated rating total based on performance in laboratory work throughout the course. Such an award MUST be endorsed with the letter E.

A candidate who makes a worthless attempt or no attempt at all, for which there is no reasonable excuse, should not be awarded a rating. A full report of the circumstances should be sent to The Secretary, Oxford and Cambridge Schools Examination Board, Purbeck House, Purbeck Road, Cambridge, CB2 2PU, no later than 29th April in the year of the examination. The candidate's name must be shown on the assessment sheet and the words 'no assessment' entered against it.

Candidates Re-taking the Examination

If a candidate has undertaken an Investigation which has been assessed in a previous year's Physics (Nuffield) examination, permission may be granted by the Board to carry forward this previous assessment to the coming examination. Application for permission to carry forward an assessment MUST be made to The Secretary, Oxford and Cambridge Schools Examination Board well in advance of the time set aside by the school/college for the Investigations. The application should give the name of the candidate, the school where the previous assessment was made and the topic investigated and the year in which the examination was taken.

A candidate retaking the examination may carry out another Investigation but it is the responsibility of the school to ensure that the topic is entirely different from that investigated for either the previous examination or for practice during the course. When submitting the sample reports a note should be included confirming that the topic is a new one and stating when and where the examination was previously taken if at a different school.

General Directions

1 Internal assessors must enter the appropriate details on the assessment sheets provided. Candidates should be listed by surname and initials (forename(s) should be given in cases of identical surname), in the same order in which names are submitted to the Board for the whole Examination.

2 The total rating assigned to each candidate's work should be clearly shown, together with any endorsement (M or E).

3 Sample Reports. Six Sample Reports as specified below (letters a–f) must be submitted to the Board for external assessment.

Sample Specification

(*a*) The best report with rating total 15
(*b*) The best report with rating total 13
(*c*) The best report with rating total 11
(*d*) The best report with rating total 9
(*e*) The best report with rating total 7
(*f*) The best report with rating total 5

If no Investigation has been given a rating total required for the sample, then the sample should be completed by submitting a report rated as closely as possible to the required rating total, so that six reports are sent.

If there are six or fewer candidates then all reports should be submitted to the Board.

All reports given the special merit endorsement M should be submitted *in addition* to the sample for moderation. They should NOT form part of the sample.

Any report for which an estimated rating total was assigned or for which the ratings given depended heavily on special circumstances noted by the internal assessor while the Investigation was in progress, must be sent to the Board *in addition to* the sample for moderation. It should not form part of the sample.

4 Submission of Sample Reports

(*a*) Each sample report must have attached as the front page a completed Title and Rating sheet, showing and explaining the ratings given (copy attached).

(*b*) Assessment sheets should be enclosed with the sample reports. Keep a copy in case any difficulty arises.

(*c*) On the Moderation Sheet (copy attached), Teachers are asked:

(i) to complete the Distribution, recording the number of candidates allotted to each rating total, but excluding those carrying forward marks from a previous year;

(ii) to record details of the sample Investigations. Candidates should be entered on this list *in rank order* (a) – (f) not alphabetical order.

(*d*) Sample Reports should be sent with the Moderation and Assessment sheets to:

The Secretary,
Oxford and Cambridge Schools Examination Board,
Purbeck House
Purbeck Road
Cambridge
CB2 2PU

as soon as they are ready and MUST arrive no later than 1st May in the year of the examination.

(*e*) The envelope should show clearly the name of the school and the words INVESTIGATION SAMPLE.

(*f*) The number of schools is now so large that dealing with the bulk of sample Investigations is a serious problem. Teachers are therefore asked to ensure that the reports are kept to A4 size paper and to send the samples without enclosing each one in a file cover. Exercise or other books must not be used.

5 The External Assessors may wish to see, in addition to the samples submitted, other Investigations reports from a school and so they should not be returned to candidates until the end of the Summer term.

6 Return of Sample Reports. Schools wishing to have their sample reports returned should attach to the assessment sheet/s, a stamped addressed envelope. Please ensure that the envelope is the appropriate size for the school sample and that the stamps on the envelope are sufficient for the cost of returning the reports.

Chapter 12 : School Grades and Standard Tests - Diversity in the U.S.A. System

Professor E. Leonard Jossem

General Features

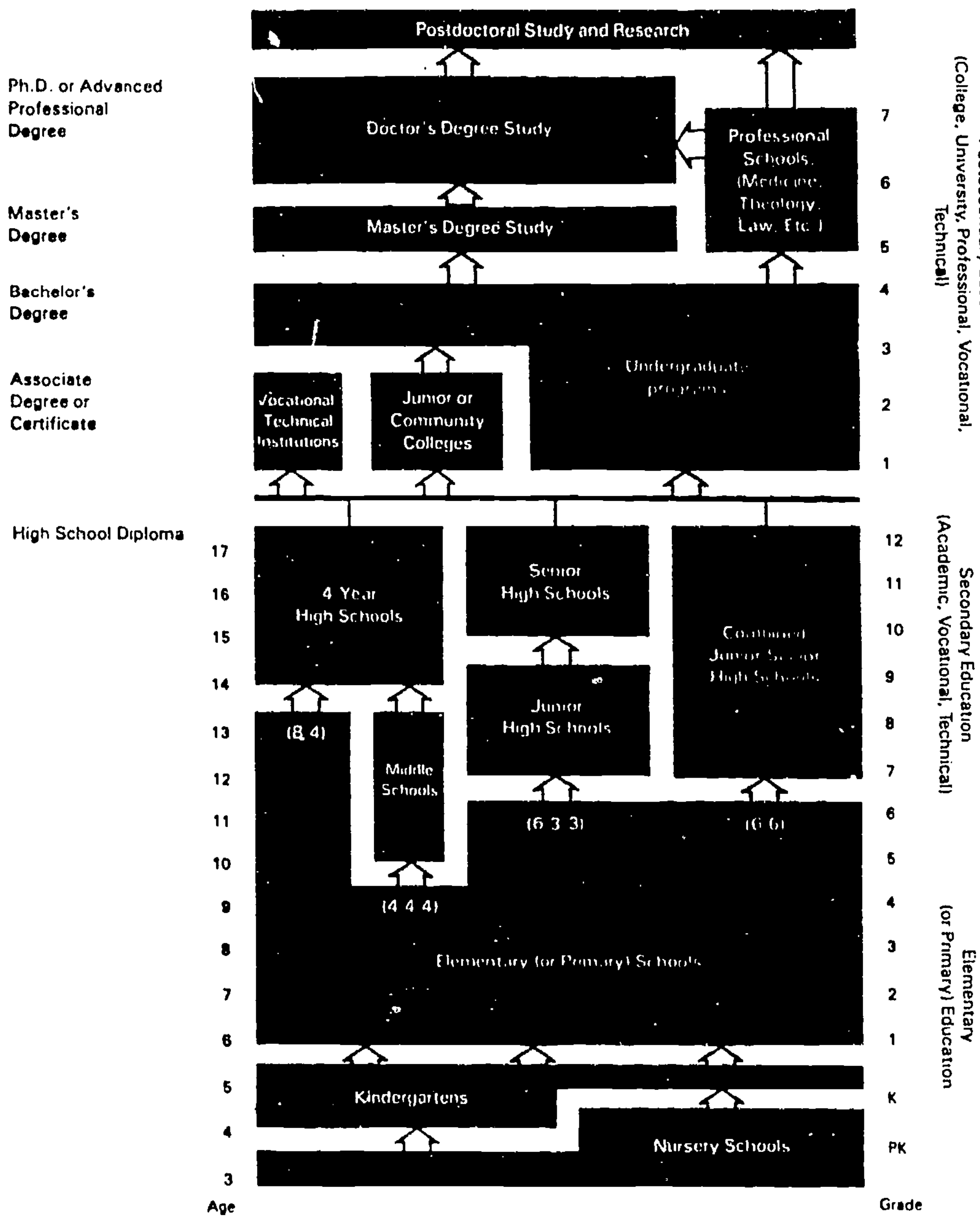
A diagrammatic overview of the structure of the educational system in the U.S.A. is shown in Figure 1. It is a system characterized by its great diversity. There is no single governmental body that determines educational policy or curricula or examinations for the country, and at all levels there is a mix of public, private, and parochial educational institutions which are autonomous in almost all aspects of their operations. There is also considerable diversity in the population of the U.S.A. It is much more heterogeneous in character than that of many other countries. Table 1 provides some current data on the population and levels of educational achievement (see reference 1).

Table 1 : U.S.A. Data for High School and University Numbers

Number in the age 17 cohort (1988/89)	3 822 000
Percentage in high schools (ages 14 to 17)	92%
Percentage of high school students who have taken courses in both physics and chemistry	15%
Percentage of high school students who have taken courses in one of either physics and chemistry	25%
Percentage of the age cohort graduating from High School	74%
Total numbers in higher education (1989)	13 419 000
Percentage of these in 4-year courses	62%
Approximate number in each year of a 4-year course	2 080 000 *
Number gaining bachelors degrees in physics (1990)	5111

* Drop-out would affect this estimate. Informal estimates of the drop-out rate are that it is between 30% and 50%

Figure 1 : The Structure of Education in the United States



NOTE.—Adult education programs, while not separately delineated above, may provide instruction at the elementary, secondary, or higher education level. Chart reflects typical patterns of progression rather than all possible variations

SOURCE: U.S. Department of Education, National Center for Education Statistics

Elementary and Secondary Education

Elementary and secondary education is supervised by local school boards whose members are elected by the voters of the local school district. There are over 15 000 local school districts in the USA, supervising about 84 000 public schools, of which about 61 000 are elementary schools and 23K are secondary schools. In addition, there are about 27 000 private elementary and secondary schools, which enrol about 12% of the students in this age group. The ages for compulsory school attendance vary somewhat among the various states. On average, children start elementary school at age 6 or 7 and have between 8 and 12 years of compulsory schooling.

Pre-College Physics Education

At the high school level the requirements for graduation vary considerably from state to state, but the majority of states have minimum requirements for course work in English, Social Studies, Mathematics, and Science. Almost all states require at least two science courses, but only three require more than two; the total requirement ranges from 13 to 24. The average requirement in private schools is about 2.5 courses, compared with a 1.8 average in the public schools. The Science requirement for graduation can be fulfilled by courses in biology, earth science, chemistry, or physics. The per-pupil expenditure and the quality of education in the schools varies markedly with geographical location and with the socio-economic status of the residents of the individual local school districts.

Physics is not a required subject at the secondary school level. Fewer than 75% of all public secondary schools offer a course in physics every year, and a large fraction of the private schools rarely, or never, offer a course in physics. The probability of attending a secondary school that offers a course in physics depends greatly on the type of school and the state in which the school is located. Physics is usually a one year course taken in the last year of secondary school (reference 2) but, overall, fewer than 20% of all secondary school seniors have taken a course in physics (reference 3).

Admission to University Courses

In 1989, about 60% of secondary school graduates continued on to post-secondary education, but there is no single examination system through which students must pass in making the transition. Admission requirements for institutions of higher education are as diverse at the institutions themselves. Many colleges and universities have essentially an"open admissions" policy under which secondary school graduates and other adults with equivalent credentials are admitted without regard to

grades or other measures of academic achievement.

It should be noted also that, in general, a student is not required to specify a major field of study before entrance to a college or university, and in many cases the student may postpone such a decision for a year or more. The admission process is almost entirely in the hands of professional administrators, who rely on recorded data rather than knowledge of particular subjects.

In the last decade there has been much public discussion concerning the degree of science and mathematics illiteracy in both the student population and among adults. There has also been much discussion about the need for national norms for achievement testing, but the subject remains controversial (reference 4). Entrance requirements to colleges and universities remain in the control of the individual colleges and universities and vary widely in character.

Entrance Requirements

There are about 3 200 post-secondary institutions in the U.S.A.(reference 5). Each institution has its own criteria which it uses in making decisions concerning admissions. Approximately 840 two-year colleges and approximately 140 four-year colleges and universities have an "open admissions" policy. For the majority that do have selective admissions policies, among the most common selection criteria are: high school achievement record, test scores, school and community activities, letters of recommendation, personal essay, personal interviews, and for certain private schools, religious affiliation. Where test scores are required, the SAT or ACT scores (see section below) are specified. Some state universities require such scores only for applicants from outside the state.

The Standard Tests

As noted above, there is no single national examination which secondary school students must take to gain admission to a college or university. There are, however, achievement tests which are available nationally, and which are used by post-secondary institutions which have selective admissions policies as one of the factors taken into account in making decisions about student admissions. Among the more widely used of such tests are the Scholastic Aptitude Test (SAT) and the American College Testing Program (ACT) tests.

The SAT is organised by the College Board, for whom tests are supplied by the Educational Testing Service. Between them these two, which are both

private non-profit organisations, employ over 3 200 staff. The S.A.T. includes tests of verbal and of quantitative skills and is taken by about 40% of the high school graduates. The ACT employs about 900 staff, and provides tests in subject matter areas: English, Mathematics, Social Studies, and Natural Sciences (including physics). These are taken by about 30% of the high school graduates.

In addition, there are three types of tests specific to physics provided by The College Board: the Physics Achievement Test, the Advanced Placement Physics B test, and the Advanced Placement Physics C test. The latter two tests are used primarily to assist colleges and universities in awarding credit to incoming students who have studied college level physics in secondary school, and in placing such students at the appropriate level in a college physics curriculum. In 1989-90, 18 733 attempted the Physics Achievement test, 76.4% of these being male. Numbers for the Advanced Placement Physics C tests, designed for those specialising in physics, range from 3 350 to 5 500, with over 80% male (reference 6).

In the physics achievement test, candidates have to attempt 75 multiple choice tests in one hour. The content is meant to reflect the topics commonly covered in a standard one-year high school course. Five main topic areas, mechanics, electricity and magnetism, optics and waves, heat kinetic theory and thermodynamics, and modern physics form the basis of a specified syllabus. There is also a skills specification, set out in Table 2. The proportion of questions demanding factual recall has declined over the years - the test was first administered in 1903.

Table 2 : Skills Specification for Physics Achievement Test

Skills Specification	Approximate Percentage of Test
Recall (generally involves only remembering the desired information)	20 - 33
Single-concept problem (recall and use of a single physical relationship)	50 - 53
Multiple-concept problem (recall and use of two or more physical relationships that must be combined)	20 - 33

A set of 19 questions, published as a sample set by the College Board, is reproduced as Examples 1. Some questions ask for the interpretation of laboratory data. Numerical calculations are limited to the use of simple

arithmetic, but simple algebra, trigonometry, use of graphs and of ratio and proportion are required.

The ACT Assessment includes, as one of its four components, a Science Reasoning Test. A typical test comprises seven short passages, on each of which are based several multiple-choice questions. In total there are 40 questions, to be attempted in 35 minutes. The seven passages will span the main sciences, some being interdisciplinary. The tests appear to contain only one, occasionally two, passages involving physics. Examples 2 and 3 are both published samples of the test.

School Assessments

Whilst university admissions offices look at high school records, these are usually no more than an official statement of the courses a student has taken and the grades received in them. There is enormous diversity in the secondary school system, and most high school physics teachers have a great deal of autonomy in their classrooms. This extends to questions of grading, test composition, homework and so on. Thus it is not possible to give any general report on the methods used by teachers to arrive at student grades.

College admissions offices do keep close track of the success students have in their college work and make correlations with the high schools the students come from. They use this data to set up their own calibrations on their feeder schools.

Analysis of the Results

The testing agencies have the resources and the skills to carry out sophisticated statistical analyses of their test results. Partly because of this, much of the most advanced research in analysis of multiple-choice tests has come from the U.S.A. The questions used are pre-tested, and the facility and discrimination parameters of individual questions and of each test as a whole are carefully tailored for optimum statistical effect. Such matters as the scaling of scores to ensure comparability from one year to the next, and the provision of explanatory statistical data to users, receive much attention.

The College Board (TCB) and the American College Testing Program (ACT), offer research and validation services to colleges and universities. These services collect the admissions data - high school records, SAT verbal and mathematical scores, achievement test scores, and qualitative

information about the background and status of those admitted. They then compares these with performance within the institution's courses. The aim is to determine that combination of the available input data which will give maximum correlation with subsequent performance, so that the institution can use this combination in future admissions work. The analysis can be made separately for different subjects or other sub-groups within the institution.

Links with Schools Teachers and Pupils

Here, as elsewhere, the diversity makes it impossible to generalise. The fact that college subject departments are rarely involved in individual decisions about admissions tends to inhibit the development of links. One example started from the mathematics department at Ohio State University, who grouped the statistics on the performance of their students by the schools from which they entered. They then went around the various schools and presented them with this feedback. Most of the schools were appalled by the poor showing their students had made and asked for help from the university mathematicians. This has led to a programme of interactions, taken up by other universities in the state of Ohio which has helped to raise the performance of students on the mathematics placement examination. However, on a national scale, this example appears to be the exception rather than the rule.

Comments on Quality and Effects

Insofar as the test and assessment methods used are comparable nationally, they are confined almost entirely to the multiple choice paper and pencil format. Whilst these have been developed to a very high level of expertise, the absence of any tests of practical skills and strategies, or the ability to tackle problems presented in an open-ended way, means that responsibility for these important aspects of physics learning are almost entirely in the hands of teachers. There is little national data about them, and little by way of reliable evidence that higher degree institutions can call upon in their decisions. Given the decentralized and highly diversified character of the educational system in the U.S.A., it is hard to see how this system might change. National concern about the educational performance of high school students, particularly in international comparison tests, and concern that creative skills are not being developed because they are not being assessed, is leading to policy re-appraisal by government and by the National Science Foundation.

Footnotes and References

1. Data from Digest of Educational Statistics 1990 U.S. Department of Education, Office of Educational Research and Improvement NCES 91-660 February 1991.

2. Commonly used textbooks for high school physics courses include, for example:

Physics- Principles & Problems (Fifth Edition)
J.T. Murphy, P.W. Zitzewitz, J. M. Hollon
Charles E. Merrill Publishing Co. Columbus, Ohio 1986
ISBN 0-675-07070-8

Conceptual Physics
P.G. Hewett
Addison-Wesley Publishing Co. Reading, Massachusetts 1987
ISBN 0-201-20729-X

PSSC Physics (Seventh Edition)
U. Haber-Schaim et al.
Kendall-Hunt Publishing Co. Dubuque, Iowa 1991
ISBN 0-8403-6025-8

3. Data from *Who takes Science?* American Institute of Physics Report, Publication number R-345 , December 1989.

4. See, for example, *Should the National Assessment of Educational Progress Be Used to Compare the States?* Educational Researcher Vol. 20, April 1991, pp.17-21.

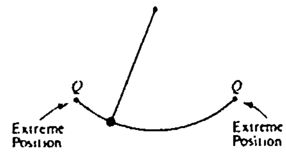
5. For data on these colleges and universities see, for example:
The College Handbook (Twenty-ninth Edition),
The College Entrance Examination Board, New York, N.Y. 1991
ISBN 0-87447-408-6

6. *Testing Physics Achievement: Trends over Time and Place.* W. Pfeiffenberger, Ann Marie Zolandz and Lee Jones, Physics Today, Vol. 44, No.9, pp. 31-37 September 1991.

Example 1 : Samples of Physics Achievement Test Questions As Published by the College Board

Directions Each set of lettered choices below refers to the numbered questions or statements immediately following it Select the one lettered choice that best answers each question or best fits each statement and then fill in the corresponding oval on the answer sheet A choice may be used once, more than once, or not at all in each set.

Questions 1-2



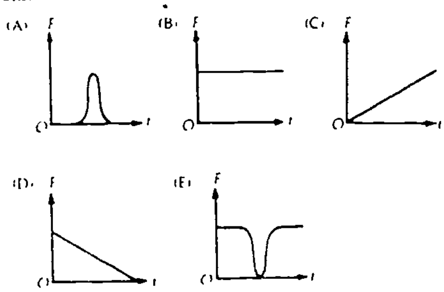
A small sphere attached to the end of a string swings as a simple pendulum. The sphere moves along the arc shown above. Consider the following properties of the sphere.

(A) Acceleration
(B) Kinetic energy
(C) Mass
(D) Potential energy
(E) Velocity

1. Which property remains constant throughout the motion of the sphere?

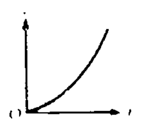
2. Which property goes to zero and changes direction at each extreme position Q?

Questions 3-4 relate to the following graphs of the net force F on a body versus time t, for the body in straight-line motion in different situations.

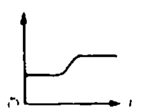


For each of the following speed v versus time t graphs for the body, choose the graph above with which it is consistent

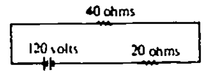
3



4



Directions Each of the questions or incomplete statements below is followed by five suggested answers or completions Select the one that is best in each case and then fill in the corresponding oval on the answer sheet.



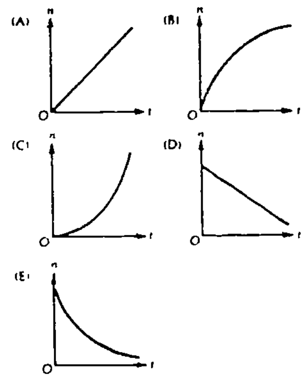
5. If the internal resistance of the 120-volt battery in the circuit shown above is negligible, the current in the wire is

(A) 0 A (B) 2 A (C) 3 A (D) 6 A (E) 9 A

6. All of the following are vector quantities EXCEPT

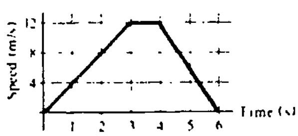
(A) force (B) velocity (C) acceleration
(D) power (E) momentum

7. Which of the following graphs best represents the number n of radioactive atoms remaining in a sample as a function of time t?



Questions 8-9

In the following graph, the speed of a small object as it moves along a horizontal straight line is plotted against time



8. The magnitude of the acceleration of the object during the first 3 seconds is

(A) 3 m/s² (B) 4 m/s² (C) 6 m/s²
(D) 12 m/s² (E) 36 m/s²

9 The average speed of the object during the first 4 seconds is

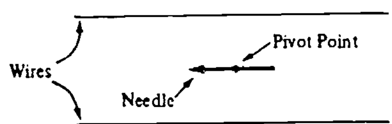
(A) 1.9 m/s (B) 3.0 m/s (C) 4.0 m/s
(D) 6.0 m/s (E) 7.5 m/s

Example 1 :Samples of Physics Achievement Test Questions (continued)

10. A ball is thrown vertically upward Air resistance is negligible After leaving the hand the acceleration of the ball is downward under which of the following conditions?

    I On the way up
    II On the way down
    III. At the top of its rise

    (A) I only
    (B) III only
    (C) I and II only
    (D) II and III only
    (E) I, II, and III



11. A magnetized needle midway between two parallel wires in a vertical plane, as shown above, is free to turn in any direction When there is no current in the wires, the needle is parallel to the wires. If equal currents to the right are produced in both the top and the bottom wires, the needle will

    (A) remain parallel to the two wires
    (B) turn and point toward the top wire
    (C) turn and point toward the bottom wire
    (D) turn and point out of the page
    (E) turn and point into the page

12. To keep a ball of mass m moving in a circle of radius r at constant speed v requires a force on the ball that is

    (A) directed toward the center of the circle and equal to mv^2/r
    (B) directed toward the center of the circle and equal to $mv^2/2r$
    (C) directed away from the center of the circle and equal to mv^2/r
    (D) directed away from the center of the circle and equal to $mv^2/2r$
    (E) zero because the velocity is constant

13. If the pressure on a gas is doubled at the same time that its absolute temperature is doubled its volume will be

    (A) one-fourth as great
    (B) half as great
    (C) twice as great
    (D) four times as great
    (E) unchanged

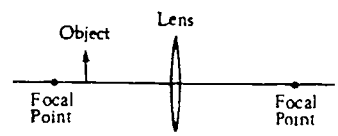
14. In an experiment, a belt is rubbed against the outside of a can containing water. To calculate the mechanical equivalent of heat, one must measure the work done by the frictional force between the belt and the can and must also measure which of the following?

    I. Quantity of water in the can
    II. Initial and final temperature of the water
    III. Coefficient of friction between the belt and the can

    (A) I only (B) III only (C) I and II only
    (D) II and III only (E) I, II, and III

15 The existence of two kinds of electric charges — positive and negative — may be demonstrated by all of the following EXCEPT

    (A) cloud chamber tracks in a magnetic field
    (B) the paths of charged particles moving in electric fields
    (C) the existence of isotopes
    (D) electrolysis
    (E) electrostatic experiments



16. A converging lens placed in relation to an object as shown above would produce an image that is

    (A) real and inverted
    (B) real and erect
    (C) virtual and inverted
    (D) virtual and erect
    (E) none of the above

17. All of the following statements are true of light waves, sound waves, and radio waves EXCEPT

    (A) Their wavelengths depend upon the medium in which they are traveling
    (B) They belong to the electromagnetic spectrum
    (C) They undergo refraction in accordance with Snell's law
    (D) For point sources, they obey the inverse-square law of intensity.
    (E) They can produce interference patterns.

18. The critical angle for light passing from crown glass to air is 42°. Total internal reflection would occur at a glass-air interface if light approached the interface from the

    (A) air at an angle of incidence of less than 42°
    (B) air at an angle of incidence of precisely 42°
    (C) air at an angle of incidence of greater than 42°
    (D) glass at an angle of incidence of less than 42°
    (E) glass at an angle of incidence of greater than 42°

19. As compared with the nucleus of a lead atom with atomic mass 207, the nucleus of a lead atom with atomic mass 206 has one

    (A) more proton (B) less proton (C) more neutron
    (D) less neutron (E) more electron

Answers to the Physics Achievement Test questions

1. C	5. B	9. E	13. E	17. B
2. E	6. D	10. E	14. C	18. E
3. C	7. E	11. A	15. C	19. D
4. A	8. B	12. A	16. D	

Example 2 : First Sample Question from an ACT Science Reasoning Test

Passage II

Cosmic radiation (electromagnetic) of all wavelengths falls on Earth's atmosphere. Radiation at some wavelengths is absorbed by thin gases 100 kilometers or more above Earth's surface. At other wavelengths, radiation penetrates deeper into the atmosphere before being totally absorbed. At still other wavelengths, radiation passes completely through the atmosphere to the ground. The figure below shows the height above Earth's surface to which cosmic radiation of different wavelengths can penetrate before being totally absorbed. The figure also shows the heights at which balloons, rockets, and satellites can be used.

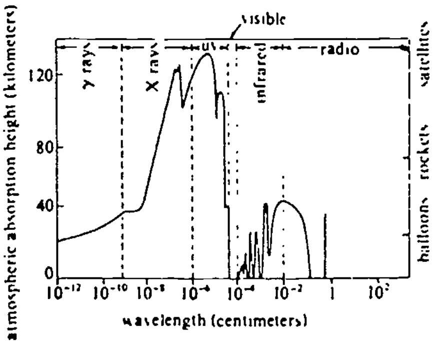


Figure adapted from Hannes Alfvén, "The Plasma Universe" ©1986 by the American Institute of Physics

6. At about what height is radiation of wavelength 10^{-9} centimeter completely absorbed?
   F. 22 kilometers
   G. 38 kilometers
   H. 80 kilometers
   J. 100 kilometers

7. Which of the following types of cosmic radiation are completely absorbed in the atmosphere at the highest altitude?
   A. γ rays and X rays
   B. X rays and uv
   C. Visible and radio
   D. Visible and infrared

8. Which of the following types of cosmic radiation can each be measured fully from a satellite, but not from a rocket?
   F. X rays and uv
   G. X rays, uv, and infrared
   H. Visible and infrared
   J. Visible, infrared, and radio

9. Which of the following types of electromagnetic radiation is LEAST absorbed by Earth's atmosphere?
   A. γ rays
   B. X rays
   C. Visible
   D. uv

10. To observe the full radio spectrum of cosmic radiation, one could locate a receiver at:
    F. ground level.
    G. an altitude of 25 kilometers.
    H. an altitude of 35 kilometers.
    J. an altitude of 45 kilometers.

Example 3: Second Sample Question from an ACT Science Reasoning Test

Passage IV

Neutrinos are particles produced inside stars by the process that fuses hydrogen into helium. Neutrinos move at the speed of light and pass easily through matter, rarely interacting with it Enormous numbers of neutrinos, many of them produced in the Sun, pass through Earth each second One of the few elements that reacts strongly with neutrinos is chlorine (Cl). Dr. Raymond Davis, Jr., built a neutrino detector at a depth of 4,850 feet in a gold mine. The detector is a closed, gas-tight tank containing 100,000 gallons of C_2Cl_4. When neutrinos interact with individual chlorine atoms, those atoms are converted to atoms of radioactive argon (Ar). From time to time, these argon atoms are collected and counted. The number of argon atoms collected is used to determine the rate at which argon atoms are produced in the tank. The tank was placed far underground so that the overlying rock would shield it from cosmic rays, which are also capable of producing argon from chlorine. Theoretical calculations of the rate of neutrino production in the Sun lead to the prediction that 1 argon atom per day should be created in the tank.

Experiment 1

The tank was set up as described above and several experimental runs were conducted. The results of two of the runs are given below:

Trial	Argon atoms/day
1	0.60 ±0.26
2	0.82 ±0.52

Experiment 2

The tank was submerged completely in a pool of water in order to shield the tank from locally produced particles capable of producing argon from chlorine. Some production rates obtained from shielded runs are given in the table below:

Trial	Argon atoms/day
1	0.11 ±0.36
2	0.21 ±0.20
3	1.19 ±0.40
4	0.40 ±0.40
5	0.25 ±0.38
6	0.17 ±0.23

18. During the next 5 billion years, the Sun will gradually become more luminous as it fuses hydrogen more rapidly As the Sun's energy output increases, which of the following is most likely to happen to the argon production rate in experiments similar to those described in the passage?
    F. It should gradually decline to zero
    G. It should gradually increase.
    H. It should remain the same for about 2 billion years and then abruptly increase significantly.
    J. It should decline for about 2 billion years and then increase for about 3 billion years.

19. Using 200,000 gallons of C_2Cl_4 instead of 100,000 gallons would most likely do which of the following to the rate at which argon atoms are produced in the tank by solar neutrinos?
    A. Reduce the rate by approximately one-half
    B. Increase the rate by approximately a factor of 4
    C. Approximately double the rate
    D. Reduce the rate by approximately a factor of 4

20. Which of the following procedures should Davis follow to obtain the most accurate value for the argon production rate?
    F. Adding a known amount of argon to his experiment each day
    G. Adding a known amount of water to his experiment each day
    H. Carrying out a very great number of experimental trials and finding their average
    J. Adding a new argon atom for every argon atom detected

21. To study the rate at which cosmic rays produce argon from chlorine, Davis would learn most by doing which of the following?
    A. Setting up another detector on the surface of Earth
    B. Surrounding the water jacket with lead
    C. Placing radioactive materials near the present experiment
    D. Reducing the amount of C_2Cl_4 in the experiment by half

22. Which of the following assumptions did Davis probably make in choosing C_2Cl_4?
    F. Being in a compound does not significantly affect how chlorine atoms interact with the neutrinos.
    G. Carbon atoms interact with neutrinos as much as chlorine atoms do.
    H. Carbon atoms interact with neutrinos more than chlorine atoms do.
    J. Chlorine atoms do not interact with neutrinos.

23. Do the results of the experiments support the theoretical prediction of the rate of neutrino production in the Sun?
    A. Yes, because the measured Ar production rates for Experiment 2 correspond to the rate predicted from theory.
    B. Yes, because the measured Ar production rates for Experiment 1 correspond to the rate predicted from theory.
    C. No, because the measured Ar production rates for all trials are greater than the rate predicted from theory.
    D. No, because the measured Ar production rates for Experiment 2 are less than the rate predicted from theory.

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Chapter 13 : Issues and Comparisons

Paul Black

A Personal View

The purpose of this chapter is to bring together ideas and information about issues which are illustrated in a variety of ways in the preceding chapters. However, this chapter is not an attempt at a neutral synthesis. This would be very difficult to achieve, and I judge that at this point it might be more useful to present a personal synthesis, including personal criticisms and recommendations. In so doing, I have to emphasise that the views in this chapter are my own, and do not commit the other authors, the International Commission or UNESCO. However, my experiences with the correspondence and with the discussions at the Torun workshop make me fairly confident in asserting that most of the chapter authors, with their wealth of responsibility and experience in their different countries, would be in agreement with most of what is said below.

Whilst many of the issues raised apply to assessment and examinations in general, it is not appropriate here to attempt a comprehensive review of this field. A broad review of this type for examining in science, with references to the wider literature, has been published recently (Black 1990)

General Features of Country Systems

The eleven countries show a wide variety of systems. The numerical data show that comparisons between the different countries have to be made with great care. Although the difficulties of obtaining strictly comparable data across the different countries have not been overcome, the chapters show many of the important differences. For example, the time spent in studying physics at the top secondary school level may vary between 25% in the U.K. or 17% in Egypt, down to 6% in Japan or 8% in Poland or Hungary. The proportion of an age group studying physics at this stage may be as high as 40 %, as in Hungary, or as low as 6 to 7%, as in Sweden and the U.K.

In some countries, such as Egypt and China, there is central control, both of examinations and of admission procedures. In others, there is local control over examinations, as in France, or there is indirect government control over competing agencies which are in principle independent of government, as in England. All these may be distinguished from countries where the examinations are set and controlled by universities, who act either individually, or in various types of collaboration, as in Japan and Brasil. Where there is no established system, the vacuum is sure to be

filled as universities must have some system for selection; typically, it is private agencies that undertake the role of entrance examiners, as in the U.S.A. There are also countries in which there is a mixed system, with access determined by a combination of central government and local university procedures - Sweden, Hungary and Poland are all examples here.

If the concern is for the fairness and quality of the examination system, the primary criteria may not be the type of system, but the various characteristics of quality which can vary a great deal within any one type.

One of these characteristics is the size of the system. Where a single examination deals with many entrants, there is more chance of employing high quality people and of having resources to review policy and methods because resources are concentrated on the one examination rather than divided between many alternatives. The discussion of recent changes in Poland reflects concern about how de-centralisation may lower quality for this reason.

On the other hand, with a single system in a large country, the chains of command are inevitably extended and the gaps between users and those in charge are inevitably wider. Thus for example, the Nuffield examiners, with about 7 500 entrants in a relatively small country can arrange that all school-teachers have an opportunity, once every year, to meet those in charge of the examination and question them about their work. Such events provide important opportunities for communication, in both directions, between examiners and teachers.

The element of competition is another aspect. Where there is more than one agency and schools have a choice, then there can be genuine alternatives, and there is extra motivation to produce examinations which reflect and reinforce what teachers think they ought to achieve in their teaching. The two alternative agencies in the U.S.A., and the competing examination boards in the U.K. are examples here. Where examinations are run by or for different universities, there does seem to be limited variety, for example between the different institutions in Japan or Poland. However, a candidate's choice may then be limited to the university in which he or she is interested. At the other end of this particular spectrum, for the single national examination, improvement of quality depends entirely on the commitment of those responsible, and to the degree to which they can know about possible alternatives and have access to informed criticism of their own methods.

A third variable is that of power and accountability. This is clearly related to both size and competition. Systems may be accountable to a state planning authority, which tries to balance the interests of schools, of universities, and of national manpower needs, or to universities alone, or mainly to schools. Each of these creates different pressures on the examiners, both in respect of methods and of standards. An ideal might be

a system in which physicists in school and in universities, together with some to represent the national interests in recruitment and in school and university resources, shared power and could debate the effects of their examinations on teaching and learning at both levels. This ideal is hard to achieve. A desire to preserve integrity which leads to making even the identity of examiners a matter of secrecy clearly has a serious disadvantage in this respect.

The Results and Use for University Admission

The nature of an examination system, the ways in which examiners operate it, and the standards that it sets, are all strongly influenced by the use to be made of the results. The pressures arise because the systems are for selection, and also, therefore, for exclusion. Even in countries where there is said to be open access to higher education, this always means that some minimum standard has to be obtained, and can mean that access is fiercely competitive for the high prestige institutions. This is evident in the U.S.A, and in the special hurdles for the high prestige institutions in France. A genuinely open access system is hard to find; it cannot be achieved without radical changes to higher education - the dilemmas presented by the 1990 changes in Poland are an example of the difficulties.

Where the admission hurdles are very high, as for example in the high prestige universities in Japan, the examiners can set very difficult problems, reflecting a belief that the ability to tackle these under examination pressure is the best evidence of potential as a physicist. Where there is such a shortage of qualified candidates that the admission hurdle is almost non-existent, as in Brasil, the questions have to be oriented towards minimum competence. Indeed, if the school system lacks qualified teachers or other resources, the feedback effects of an examination cease to operate and there is little that the examiners can do.

What is surprising is that there seem to be few countries where the effectiveness of the selection system is a matter for research. The reports for Botswana, for the U.S.A., and for one university in Poland, do mention studies of the correlation between the entry indicators and subsequent performance in degree courses, where the aim is to optimise the balance between entry indicators - e.g the external component and the high school's internal grading - in order to increase the correlation. There are difficulties here. In a highly selective regime, an efficient system might show a poor correlation if - as is bound to happen - only the small proportion who do really well are admitted. In any correlation exercise, a drastic attenuation of the range of one of the variables is bound to reduce the calculated correlation, so that one cannot know what correlation the full range would have given. Table 4 in the chapter from Hungary illustrates this effect; here the correlation studied is between high school record and the external examination.

In most university procedures, performance in several subjects, rather than in physics alone, is taken into account even for admission to specialised physics courses. Where there is a broad range of subjects taken at the top end of secondary school, there can be rules of aggregation which so operate that a student can be admitted to study in physics when the physics performance has been very low - Brasil provides a striking example of this effect. Where the entry examination is based on only a few subjects - the U.K. with a norm of three is the extreme case here - it is possible to place great weight on the physics result, partly because this can be examined by an extensive exercise which would be impracticable for candidates taking more subjects. Some systems use a combination of a general overall score,together with requirements about a specific component ,such as physics. The Swedish procedure is of this type, whilst moves to enhance the importance of the specialist subject are mentioned in Egypt and China.

There is some advantage in combining data over several subjects. An aggregated result may be more reliable partly because it is less subject to the variations associated with variations in teaching or with the inevitable unreliability of any one examination. In addition, a university course is bound to be different from a school one and general ability, measured over several subjects, may be a better indicator of the power to adapt. However, this is only a speculation -the surprise is that there have been few studies of these issues by universities themselves, even although the data are readily available to them and they should have a strong interest in optimising their selection procedures.

A further feature here is that most competitive systems put the onus on the candidate to gamble in that he or she has to decide between the low chance of success with the high prestige institution and the high chance with a less attractive one. The private agencies which provide statistically based advice on this in Japan are an extraordinary evidence of the pressure this can create, pressure which partly arises from secretiveness in the system. However, such pressures arise elsewhere, and are only absent when the national system assigns students to universities, as in China or Egypt, a procedure which some societies would not find easy to accept.

The example of Botswana seems unique in this respect, in that there is a low hurdle for entry into a course which is run within the university for subsequent selection into the main course. In a small country short of resources for the highest level of school teaching, this system has much to commend it. In larger countries, a combination of open access, large numbers in first year courses, and high drop-out rates, may produce a similar outcome, but perhaps in a less well designed way.

The Examination Methods Used

The range of methods used is very varied in some countries and very restricted in others. At one extreme is the exclusive use of multiple choice questions, as in the U.S.A. for those using one of the testing agencies, whilst at the other is the spectrum of eight types of task included in the Nuffield examination in the United Kingdom. If there is a most popular pattern, it seems to be a mixture of multiple choice questions and short problems. The existence of this variety raises two questions. First, what are the reasons for the differences in practice? Secondly, do they matter, or, to put it another way, are some methods or combinations of methods much better than others ?

In general terms, answers to the first question can easily be provided. Familiarity with certain methods and a tradition of using them can inhibit the possibility at looking seriously at other methods. For example, there is a tradition in some countries that the mathematical theoretical question is the most significant test of ability as a physicist, so these are given far greater prominence than, say, ability to tackle problems experimentally or to write critically about the subject.

Another reason may be a belief that some methods cannot give reliable results : some think that multiple choice questions, with their objective marking, pre-testing checks, and possibilities of statistical analyses of large numbers of questions, give results which are so much more reliable than other types that they should be the only method used. Others, to quote the commentary from Brasil, believe that multiple choice tests are "the mother of all evils" because of their feedback effects on school work, exacerbated by the poor quality of such questions when inexperienced teachers compose their own. It does seem now as if very few countries would be happy with exclusive use of multiple choice, but that most would use them as one of several components.

A third reason may be cost. For examinations with a large entry, the expense of preparing good multiple choice questions is justified by the possibility of securing reliable marking at low cost. To set and mark several other types of question makes heavy demands on the time and expertise of examiners. In particular, assessment of practical work is usually ruled out on grounds of cost and practicability.

Reliability and Validity

The question of whether or not the range of types of questions really matters is a more complex one to address. The main factors involved are reliability, validity and feedback. Reliability is the simplest to tackle. An examination can be reliable if one can have confidence that the same results would be obtained with a parallel examination, i.e. one set and marked according to the same aims and methods. It is possible to obtain a measure of reliability by testing the internal consistency of response, but

this is only appropriate where there is a reasonably large number of questions and where it can be assumed that they should give homogeneous results because they are all testing the same type of performance. A more strict test is to set parallel forms to the same students, or at least to give some students large numbers of questions in the same domain of testing and to determine from the results the minimum number of questions needed to reduce the error below a given limit. None of the country reports gives prominence to any test of reliability. The faith of university and school examiners in the reliability of short external test papers is probably misplaced; it is certainly unjustified in that it is not based on systematic evidence. The low correlations between scores in school tests and in a national tests, reported in Figure 1 for Sweden and in Table 4 for Hungary, may be relevant data here, although the reliability of both of the measures being correlated has to be considered here.

Validity is a more subtle and yet more important issue. It relates to whether or not an examination measures the performance that it is designed to measure. Here again, remarkably little is said about the issue in the various country reports. Ideally, there should be scheme attempting to set out the objectives of an examination, and then a method found of auditing and correcting the set of questions to ensure that they reflect these aims with the intended emphasis and balance. Formal attention to such issues is reported in some cases, notably in the Nuffield examination, in the French baccalaureat,in the specified weights for memory, problems and applications, and accounts of experiments laid down in China and in the specification for the College Board test in the U.S.A. Even in such cases, it is notoriously difficult to be sure that a given question makes those demands on the student which were intended by those who set it - the variations in marks between questions intended to test the same thing are evidence of this, and here issues of reliability and validity overlap.

It is possible to infer, from sample questions, the intentions of the examiners. Thus, it is striking that the examples given in the various country chapters contain, in most cases (e.g. Japan, Sweden,the written papers in Hungary) almost none that can be answered solely by memory of standard definitions, explanations or experimental details. The French baccalaureat questions are remarkably homogeneous in setting structured problems. In others, e.g. the Polish and Egyptian examinations, there is a range of questions including some testing knowledge and ability to explain principles and other ideas in the students own words. The two private agency tests reported from the U.S.A. show striking differences, one - the A.C.T. - being unusual in giving emphasis to thinking skills in its design of questions. If the examination questions really represent considered opinion on the performance that represents potential to succeed in a physics degree course, then there only a limited consensus across the different countries.

Finally, in this discussion of reliability and validity, one simple principle is worth re-stating. The longer the time spent on performance measures, the more different questions that are used, the greater the number of occasions on which assessment takes place, and the wider the variety of methods and instruments employed, the greater the reliability and validity of the examination result can be. If time and range for the methods are limited, then there will be a corresponding limit to the confidence that can be placed in the results.

One particular aspect of assessment which stands out because it receives attention in only one or two countries is the choice between norm-referenced and criterion-referenced approaches. The Swedish report is the only one to discuss a national policy to change to a criterion referenced approach, although it is also being discussed in the U.K. This has great advantages in the guidance of students, but it requires considerable expertise from examiners faced with implementing such a change for the first-time.Such a change directly confronts the issue of validity.

Orals and Practicals

Oral examinations are used in Poland and Hungary and are open to all candidates; there is a limited use in France - for resolving marginal cases. It is notable that in these countries the examples suggest that they are used to assess abilities not tested in the written papers. In many countries orals are ruled out because of time and expense, and where they are used, they are used by individual universities for their own applicants and only at a late stage in selection. Again, whilst concern about the reliability of orals is expressed, there is little evidence.

The assessment of practical workappears to be neglected altogether in some countries, e.g. in China because many schools are not equipped to do significant work. In many others, an attempt is made through questions in written examinations about the methods of experimental work and about analysis of results. There is no direct evidence that these reflect experimental skills, or even that they encourage anything more than direct preparation of pupils to answer such written questions. There is evidence that the performance of pupils with practical questions using actual equipment is very different from their performance with written question "equivalents". Thus, whilst it may be useful that some attempt is made to reflect the importance of experimental work in physics, there is a prima facie case that such attempts cannot achieve their aim.

The only cases, out of the eleven reported here, where practical work is tested directly, are Botswana and the United Kingdom. The former operates in the special circumstances of a course and examination which are internal to a single institution. The U.K. Nuffield assessment uses a combination of a timed formal event involving several short tests which have to be set up in schools by teachers, and teacher assessment in informal contexts of pupil investigation. This depends on well equipped

schools and well trained teachers. It also introduces another element into the debate, the use of teachers' own assessment information in the examination system. In Sweden, teachers' assessments of practical work can play a part in the final outcome, but it seems that teachers' don't take full advantage of their freedom here.

Teachers' Assessments

The U.K. seems unique in adding into the total of examination marks some which are decided by the students' own teachers on the basis of work done outside formal examination conditions. For this to be acceptable, in commanding public confidence, there have to be very carefully specified rules, and a system of moderation which, by drawing samples from schools and checking their standards, can ensure the integrity, and comparability between schools, of the results.

Sweden is also unique in a very different and more radical way. There, the teachers' assessments are the foremost element in determining the whole result. The external examination serves to calibrate the schools distribution as a whole, but leaves the teacher free to decide about individual students.

Other systems use the internal results of schools. In France such results are used in resolving borderline cases. However, they are more often used in informal ways that leave students at risk of being calibrated according to the reputation of their school, and which inevitably lead to the external instrument having the prime role in influencing decisions. Of the countries mentioning the use of school reports in an informal way, the nearest to a systematic procedure might be the U.S.A., although the outcome there very much depends how individual colleges weight the schools' grades, and does not seem to lead to serious attention being given to the quality and comparability of teachers own assessments.

Teachers can have a great deal of reliable information about their students. Whether or not their judgements are reliable and valid depends on the ways in which they collect information during their teaching. If they do it only by formal written tests, and if they do not use this information to identify and act on the problems of individual students, then their data may add little to that given by external examinations - indeed it may be less reliable because of technical limitations and lack of comparability of standards. However, the requirements of good teaching, quite apart from any needs for terminal or summative assessment, demand that teachers use a variety of means of assessment for formative purposes. The implication here is that teachers should have policies for formative assessment, leading to a practice of collecting information as an essential guide to improving their own teaching. Such assessment can serve as general feedback, leading to reconsideration of teaching methods, and as feedback about individual students, leading to action to help each with their particular difficulties. This need is recognised by good teachers, but

the techniques needed have not been studied or researched to any significant extent and the bulk of the literature on examinations is about summative rather than formative assessment.

Where teachers have developed their own assessments, they can have far better information about their students than any external system can possibly obtain. This is evident because teachers can assess a student on many occasions, by a wide variety of methods, and with any given piece of work can follow it up with a student to check ambiguities and strange interpretations of the task. Thus, in principle many of the features which constrain the reliability and validity of external examinations can be overcome in internal assessment in schools, without adding unnecessary work, because good assessment is needed as an intrinsic part of good teaching.

The obvious difficulties are the lack of expertise of teachers in assessment, the lack of comparability of standards between different schools, and indeed between teachers in the same school, and the dangers of prejudice, in the case of individuals, and dishonesty for school reports as a whole. The discussion of teachers' assessments in Brasil shows how there can be real national anxiety about this aspect of school teaching. None of these obstacles can be overcome quickly or cheaply. To improve the expertise of teachers in assessment would be justified for improvement in teaching as well as in assessment, but would be a process requiring considerable investment in a long term training programme.

Comparability between schools can be secured by exchange meetings between groups of schools in which criteria are discussed and examples of student work are exchanged. Such meetings have been found to be very valuable for the development of the teachers involved, often revealing how isolated teachers have been in respect of their standards and expectations. There are other methods of moderating standards between schools, notably using external visitors to inspect procedures and samples, the sending in of samples of work. Of particular interest is the use of external tests to calibrate the general standards of a school, whilst acknowledging the superior information that a teacher has about individuals by leaving the teacher to place the individuals within a calibrated envelope. This last method is used in Sweden, and seems to have a great deal to recommend it. In particular, where an external test result is used only to produce an aggregated score over all pupils in a teaching group, that score will be far more reliable than the result for any individual in that group. However, all of these procedures require backing in a policy that commits resources in order to secure the advantages of change. Where teachers are not helped, and are not required to calibrate their efforts against those of others, their assessments can be very variable, in aim and in quality. An example here is the Swedish opinion that the information used in teachers' own assessments in that country is variable in both aspects.

Some teachers would not welcome being given responsibility for determining the final results of their students : they prefer to be the students' allies against the examiner. However, the acceptance of this responsibility would enhance the status of teachers, and lead to a quite new framework of partnership between teachers in school and those in higher education. Certainly it seems clear that unless some such changes are made, experimental work in schools cannot be fairly assessed in the examination system, and, therefore, will never be taken seriously in teaching and in the allocation of resources. This is a very serious conclusion to anyone interested in the improvement of physics education.

Preparation and Marking

Little has been said here about the methods for preparation of examinations, or about the methods of marking. The chapters contain several references to these matters,and the information suggest that, within the limitations of the overall framework and policy of any system, a great deal of care is taken. There is however little reference to pre-testing of questions. This is not uncommon for multiple choice questions, and the reports from Sweden and from the U.K mention pre-testing of other types of question.However, elsewhere there seems to be no such use of pre-testing. Given the difficulty in predicting the many possible misinterpretations that can seriously undermine the validity of any question, it seems strange that the precaution of pretesting is not more widespread.

For marking, variations in standards between different markers is a recognised difficulty, and procedures, such as the double marking reported from Poland, and the group system used in Egypt, show a serious attempt to deal with the difficulty. In some countries, for example Hungary, teachers' marking is checked by inspection of samples. It does not seem however that procedures are designed to provide data on the degree of unreliability arising from this source. Ideally, it should be reduced to a level where it is less serious than other sources of unreliability, but there is difficulty in committing resources to produce evidence of unreliability since this might undermine public confidence. The issue of public perception of all of these matters is of great importance. For example politicians might find it hard to support a system which trusts teacher assessment, and support instead the use of external tests, in ignorance of the serious limitations on the reliability and validity of such tests.

Statistical Analyses of Results

Much of the discussion in the previous section has pointed to the need for technical analysis of results. Appropriate analysis is essential if users are to have some guide as to the reliability of the results that they use to make decisions, and can also be an important part of any study of validity. It seems strange that scientists should be making important decisions on the

basis of examination results whilst making no efforts to obtain data about the degree of error attached to these results.

The use of standard analyses to check on the composition of an examination paper is reported from U.S.A., Brasil and Botswana. Analysis of data on sample marking is used to amend marking schemes as reported from both Sweden and Egypt. As mentioned earlier in this chapter, it is also possible to inform future assessment policy by studying the correlation of various components of a result with the subsequent success of students in a course. This is done in the U.S.A., in Botswana, and in one university in Poland. Suitable analyses can also be used to explore the internal functioning of an examination package - for example, by study of the correlations between the results of various components - as reported from Poland, and between external and school-based assessments - as reported from Hungary. One type of attempt, to compare the functional effects of different examination components, is reported in the U.K. chapter.

None of these studies attempts to estimate an overall error for an examination result. The public perception of examinations is that external tests are trustworthy - free of bias and possible corruption, and that teachers own assessments cannot be trusted. This may be more true in some societies than in others. There may be need here both to check on and publicise the limits of reliability of external tests, and to research the reliability of teachers assessments, with a view to seeing how to improve this aspect.

None of these analyses need be particularly expensive or lengthy. Given this, it is surprising that little is reported about the use of such analysis. Ideally, an entry examination should be regarded as an object of research, which should be directed to improvement of the system. It may be that even where this approach might be welcome, the constraints on a system are such that there is little prospect of using the information because there is little prospect of policy change. Other factors may be size and scale, in that there is less resource to spare, and it is less easy to secure the necessary expertise, in a small scale operation. It may also be the case that where universities are responsible,the task may not be one that carries high prestige within the university hierarchy. Staff may not stay with the task for long enough to build up interest and familiarity with the system's data and so be motivated to pursue analysis, and may feel that there will be little reward if they exert themselves to make improvements, particularly when such efforts must start by making unpopular criticism of existing procedures.

Links with Schools,Teachers and Pupils

In most countries, some attempts to maintain communication between those setting and marking the entrance examinations and the teachers preparing pupils for them are reported. It is clearly in the interests of the universities to make and support such links because they can improve the quality of their students. The effect of the size and scale of a system on the possibility of involving schools has already been mentioned. Where there are many examinations set separately by different universities, it is clearly impossible for any one institution to maintain liaison with more than a small number of its supplying schools. With a national system, there can be better division of effort, but then fewer people would have adequate commitment or knowledge to be able to talk with schools.

The purpose and status of links need definition. One possibility is simply to deliver communication, perhaps in one direction only, in that universities may be explaining what they are looking for, how their entrance system works and how candidates have been performing, so that schools can improve the preparation and presentation of their students. Such feedback is reported from Hungary, from Sweden and from Egypt. It has been taken further in the example of the feedback that Ohio State University gave to the state's schools, reporting the weaknesses that the schools' former students were showing in their university work; this appears to have caused surprise and to have lead to collaborative work to improve important aspects of the schools' teaching.

More usefully, there can be a two way interaction, in that teachers can criticise the suitability of the examinations, and make universities aware of any undesirable feedback effects of their requirements on their own physics teaching. A further stage would be attained if schools and school-teachers were to have a share in the power structure that makes decisions about the examinations. Teachers are so involved in many countries, but this usually takes the form of a few selected experts sitting on committees. Such involvement is very useful, indeed essential. However, it is not a substitute for public occasions when teachers can see, hear, and address questions to the examiners so that a sense of real contact and involvement can be generated.

It is hard to judge from the reports whether teachers have real power in the examination system. If and where they do, the possibility of real conflict of interests may arise. For example, physics teachers have responsibility for groups of students, amongst whom only a minority may be intending to study physics in higher education. The needs of the others for a broad view of the subject may not be supported by university examiners who may be anxious to ensure concentration on the conceptual bases and on the exercise of mathematical skills in their subject. There is little sign that such debates have taken place - the syllabuses and examinations do seem to have a strong orientation towards "basic preparation" rather than "physics for the future citizen".

Underlying these aspects however is the more fundamental issue of the feedback effect of the admission/selection examinations on the orientation and character of school physics teaching. Here serious concern is expressed from several countries. The Polish report expresses worry about the lack of practical skills and the weakness of students in finding out information for themselves. The French opinion is that students are not equipped in the thinking skills needed for scientific work. The worries expressed from China and Hungary are more comprehensive and general, focussing on the opinion that the examinations do not reflect good practice in the learning of physics and so are bound to have a bad feedback effect.

Put briefly, if experimental skills and the development of a student's ability to design and carry out his or her own experiments are an important part of learning physics, then such work must be directly assessed as part of any important external examination. If the ability to read new pieces about physics and to use one's understanding to learn new physics from what is written is important, then there has to be a test of this type of performance in the examination. So the question to be asked of those setting up an examination is a simple one - are you happy that schools should direct their teaching effort to train students to produce the best possible performance on your tests to the neglect of all other aims of physics teaching ? The answer might often be " no, but we haven't the time or other resources to do any better ". This might be inevitable response, but would indicate the need for policy review at a higher level to see whether radical changes in the system could overcome the obstacles. To accept a negative answer and do nothing is to accept that a selection system can only be operated in a way that inhibits, or even damages, good physics teaching.

Opinions on Quality and Effect

The examinations discussed in the book have particular power over the future of physics. They attract - or repel - and select the young people from whom the future physicists will be drawn. By setting the targets and framework within which high school teachers feel they must work, they determine the structure and the image of the subject in the eyes of the young.

Thus they act as a filter in two ways. One is a filter of ability - much thought and effort is devoted to improving this aspect. The other is a filter of motivation : if examinations convey a very narrow image of the subject, if they do not call for or promote activities which are important and attractive to physicists, then they may damage the future.

One conclusion that I draw from this study is that the range of methods used, and the range of abilities assessed, by these physics examinations is too narrow and that they are probably having a seriously narrowing effect

on the development of school physics and on the recruitment of physicists. There are many reasons for this. Shortage of resources, together with other system constraints, may account for the willingness of physics examiners to work with systems which they judge to be,at best, far from ideal and perhaps seriously damaging to the future of physics.. Perhaps this situation is accepted too readily by all of us. Given the importance of these examinations, should we not be prepared to work more vigorously to improve the many aspects of them which are discussed in this chapter ? It is to be hoped that this book will be a stimulus and a resource for debating this question.

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