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ABSTRACT

This publication in physics shows the wide diversity that still exists in teaching science at the upper secondary level. One section deals with the teaching aims of physics teachers as actually stated by different countries. These are listed in a table including a total of 53 items. A second table lists the official publications giving programs for teaching physics in the academic secondary school. A summary is presented comparing degrees of freedom of interpretation in the various countries related to structure and content of the syllabus for teaching physics. Detailed summaries of teaching methods are presented in one of the appendices. The terminal examination is discussed, and pertinent data are presented from the various countries. The role of physics in the curriculum and future trends are presented. An extensive bibliography is included, and sample examination questions from various countries are found in an appendix to the booklet. (EB)

EUROPEAN CURRICULUM STUDIES

(in the Academic Secondary School)

N° 6 - PHYSICS

by

W.D. HALLS
P. FIGUEROA
R.J. GRIGGS
Oxford University
Department of Educational Studies
15 Norham Gardens - Oxford

Council for Cultural Co-operation
Council of Europe
Strasbourg
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The Council for Cultural Co-operation was set up by the Committee of Ministers of the Council of Europe on 1 January 1962 to draw up proposals for the cultural policy of the Council of Europe, to co-ordinate and give effect to the overall cultural programme of the organisation and to allocate the resources of the Cultural Fund. It is assisted by three permanent committees of senior officials: for higher education and research, for general and technical education and for out-of-school education. All the member governments of the Council of Europe, together with Greece, Finland, Spain and the Holy See are represented on these bodies [1].

In educational matters, the aim of the Council for Cultural Co-operation (CCC) is to help to create conditions in which the right educational opportunities are available to young Europeans whatever their background or level of academic accomplishment, and to facilitate their adjustment to changing political and social conditions. This entails in particular a greater rationalisation of the complex educational process. Attention is paid to all influences bearing on the acquisition of knowledge, from home television to advanced research; from the organisation of youth centres to the improvement of teacher training. The countries concerned will thereby be able to benefit from the experience of their neighbours in the planning and reform of structures, curricula and methods in all branches of education.

Since 1963 the CCC has been publishing, in English and French, a series of works of general interest entitled "Education in Europe", which records the results of expert studies and intergovernmental investigations conducted within the framework of its programme. A list of these publications will be found at the end of the volume.

Some of the volumes in this series have been published in French by Armand Colin of Paris and in English by Harraps of London.

These works are being supplemented by a series of "companion volumes" of a more specialised nature to which the present study belongs.

General Editor:

The Director of Education and of Cultural and Scientific Affairs, Council of Europe, Strasbourg (France).

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1. For complete list, see back of cover.

FOREWORD

The Council of Europe, working through the Committee for General and Technical Education of the Council for Cultural Co-operation, has in recent years become increasingly interested in the field of curriculum development. One manifestation of this interest is the continuing support it has given to what has become known as the OCESCE Study (Oxford/Council of Europe Study for the Evaluation of the Curriculum and Examinations) of which this present study of physics forms part. Thus several publications of the results of the Study, in mathematics, Latin and modern languages have already been published either under the auspices of the Council for Cultural Co-operation or commercially. [1]

The OCESCE Study, which is also partially financed through the generosity of the Gulbenkian Foundation, of course represents no more than the opinions of those specialists engaged in it : any judgements made are theirs, and do not commit the responsibility of the Council of Europe in any way At the same time, as the one appointed to direct the Study , I should like to express gratitude to the Council of Europe for the help and encouragement it continues, through its Secretariat, to give us.

The OCESCE Study, which is carried out at Oxford in the University Department of Educational Studies, aims at being European - rather than national-oriented - and is concerned with the aims and objectives, the programme content, teaching methods, evaluation and assessment and future trends in the development of curricula for the gifted at the upper academic secondary level. Through a study of the official and semi-official publications of the member countries of the Council of Europe it has arrived at an overall evaluation which represents the state of a number of subjects about the beginning of the new decade. It shows a clear tendency towards increasing rigour in the delimitation of curriculum goals, the subject matter taught and in the use of assessment techniques.

From the Study is emerging valuable data concerning curriculum theory in the member countries, which should be useful in arriving at pedagogical agreements on equivalence between the various European countries. To some extent this is a function of what might be termed the congruence problem : How far do terminal school courses in one country "fit" with initial courses in higher education in another ? What the Study seeks to provide is the raw material upon which pedagogical decisions made by educational experts at international conferences could be based.

The present publication in physics exemplifies the wide diversity that still exists in teaching programmes in this subject at the upper secondary level. On the other hand, current trends towards the harmonising, if not the unification, of programmes can be discerned.

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1. W.D. Halls and Humphreys, European Cuuriculum Studies
   n° 1 : Mathematics, Council for Cultural Co-operation, Strasbourg 1968

   P. Story, European Curriculum Studies
   n° 2 : Latin, Council for Cultural Co-operation, Strasbourg 1969

   W.D. Halls, Modern Languages and Education in Western Europe, George Harrap, London, 1970

Further studies which are in the press include those on biology and chemistry. One on the teaching of economics is in preparation. The series will be completed by comparative studies of the mother tongue, civic and social education, history and geography. It is hoped that by 1972 the main subjects of the academic secondary curriculum will have been covered in this way. A synthesis of the whole series of subject studies will then be made in relation to such questions as the overall balance of the curriculum, the various alternatives to traditional examinations that are emerging and the increasingly blurred distinction between general and vocational education, as well as other related issues.

OXFORD

W.D. HALLS

INTRODUCTION

As a subject in the school curriculum physics may not have quite the foundation-stone status of mathematics but it is nevertheless assured of an important place. It is the most exact and fundamental of the sciences and its historical development has played a vital part in shaping many aspects of philosophical thought. A ready example of this is furnished by consideration of the grip that Aristotelian physics had on men's minds for something like 2000 years and the subsequent freeing of these shackles by Galileo and Newton. The quantum and relativity theories provide more recent examples of a further revolution in man's thinking stimulated by discoveries in physics. Even an elementary course, say from 11 - 16 years, may be designed to bring out this aspect of the subject.

Physics has made the greatest contribution to technological development and has shown an intellectual structure that has given a rational and quantitative interpretation to natural phenomena. By virtue of this it has freed man from a fear of much that had been given a supernatural explanation as well as enabling him to make the greatest use of natural resources. This facet of the subject must be apparent to the pupil in any worthwhile physics course. In addition he should become aware of the technique of physical experiments and how they may lead to the formulation of laws and their expression in mathematical form. This should develop into the need for theories, models and abstract ideas.

Mathematics, in some form or other, is seldom far away in the teaching of physics, and chemical phenomena are at times included. This may perhaps be regarded as a contribution towards the criticism of the tendency to departmentalise learning although of course it must be recognised that today the corpus of knowledge is so great that it is impossible to return to the full mediaeval concept of knowledge being one and indivisible.

The points touched upon in this introduction will be found elaborated in the subsequent chapters of this book.

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ABBREVIATIONS

The following abbreviations have been used throughout the text.

A	Austria	
B	Belgium	
CH	Switzerland	
CY	Cyprus	
D	Federal Republic of Germany	
	(Ber)	Berlin
	(Hes)	Hessen
	(NRW)	Nordrhein-Westfalen
DK	Denmark	
E	Spain	
EIR	Ireland	
F	France	
GB	England and Wales	
GR	Greece	
I	Italy	
L	Luxembourg	
M	Malta	
N	Norway	
NL	Netherlands	
S	Sweden	
SL	Scotland	
TR	Turkey	

CHAPTER I

THE AIMS OF TEACHING PHYSICS

A great variety of physics teaching aims are expressed in the official and semi-official publications [1] of the member countries of the Council of Europe. These aims might conveniently be summarised as : discipline (that is to say, subject-matter) centred ; pupil centred ; society centred ; and those which are concerned with philosophical aspects. The discipline centred aims can further be subdivided into those dealing specifically with physics and those dealing with science in general. They are concerned with the nature, history and applications of physics and of science in general and also with the way of thinking (the scientific spirit), the methods and skills involved. The pupil centred aims may be divided into general aims (such as 'education for life'), those dealing with intellectual training and those dealing with character and moral formation. By society centred aims are meant those which are explicitly concerned with furthering the smooth functioning of society and with fulfilling its needs. The philosophically oriented aims are concerned with the philosophical (the 'reflective') method, with the basis and validity of knowledge and with broader questions, such as the moral, social, political, aesthetic and cultural issues involved. Although most countries would probably subscribe to most of the aims listed throughout member countries of the Council of Europe, the emphases vary. All give a good deal of importance to the discipline centred aims, especially to those dealing specifically with physics, though most also mention the wider scientific aspects. Thus all are concerned with physical laws and phenomena - although many state that the aim is not merely to imbibe facts. Virtually all refer to physical methods, in particular to the experimental approach.

Only Spain does not explicitly mention experiments or scientific methods of study [2]. At least half of the countries subscribe to : a deepening in physics ; a consideration of contemporary methods, discoveries, advances or problems ; treatment of the history of physics ; and awareness of the coherence of physics and other disciplines - the use of mathematics especially is often mentioned.

Most countries also give a good deal of importance to the pupil-centred aims - though the available publications for Denmark, Ireland, Italy, Netherlands and Spain do not refer to these sorts of aims at all[2]. Eleven countries named different aspects of intellectual training and of character and moral education. The sorts of things mentioned here are : preparation of the pupil for further education or for independent research ; pursuit of knowledge ; a training in critical thought and expression ; modesty, honesty ; tenacity; inventiveness ; faith in oneself, and a strengthening of a religious feeling. Those countries which seem to stress the intellectual and character formation of the pupils are : France, Germany, Belgium, Austria and the United Kingdom.

Even those countries which give importance to character formation seem on the whole to think more in terms of an <u>individual</u> and his qualities than of a person in society. However, Belgium does mention the ability to work as a member of a team. Apart from this only Germany, France and the United Kingdom mention any society-centred aims as such, although most countries are concerned at one level or another with the technological applications of science and some with the influence of science on social development. However, Germany alone speaks expressly of a sense of social responsibility. Germany also aims at producing leaders, men of high technical, moral and intellectual qualities ; while France stresses the formation of the men of tomorrow, of the élite, men of generous not egotistical action, men of impartiality, integrity and creativeness. The United Kingdom speaks of preparing the specialists needed by society.

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1. See Appendix for a list of these publications.
2. The available information on Spain, Italy and Ireland was rather limited.

Nine countries also mention the philosophical aspects; but it is Germany which stresses these most. The two topics referred to by most of these countries are : the discussion of moral, social aesthetic, political questions concerning, for instance, technological applications of science ; and an appreciation of the influence of science on the history of ideas. Belgium subscribes implicitly to the last mentioned ; but insists strongly elsewhere that "it is necessary for the teacher to stick to the purely scientific domain, without diverging into philosophical speculations "[3].

A number of the aims seem to involve the assumption of transfer of learning - particularly the aims concerning the intellectual, character and moral formation of the pupil. It is, however, not often clear to what extent the desired results are expected to come about automatically from the teaching of physics or to what extent the physics lesson is simply considered a good occasion to inculcate these qualities. It does often seem that it is the method of the teaching rather than the actual syllabus that is supposed to ensure the attainment of these aims. It is therefore much to be regretted that this study cannot report on what actually happens in the schools. The section on assessment does, however, indirectly throw some light on this matter[4].

Table I summarises the teaching aims in the different countries.

In concluding this section on the teaching aims as actually stated by the different countries, it might be remarked that many of these aims are couched in rather general and even vague terms. Also, on the whole, the aims do not seem to be systematically set out. One indication of this is that, taking together all the aims expressed by the different countries and listing them as in Table I, we find that there are a total of 53 items, including any general ones that were expressly named as such : yet only one country, France, mentions as many as half of these items. The aims given by fewest countries were those concerning character and moral formation, the society centred aims, and those referring to the philosophic aspects and intellectual training.

There would be many advantages in having a systematic list of aims and objectives. It would help one to clarify, to make specific, to disentangle and to express rigorously the educational aims to be achieved thus making it easier to apply them in practice to curriculum development and in actual teaching. It could also facilitate the study and comparison of educational programmes. Not least, in the general context of the present discussion, it could prove a very useful tool for planning assessment : for ordering and describing test items ; for clarifying just what is actually being measured by any given test item, and hence for ensuring that the achievement of all education aims is being tested to the extent that is possible and desired ; and, finally, for establishing appropriate examination techniques in any given case.

Bloom's and Krathwohl's taxonomies represent one of the most complete attempts in this field of defining and systematising education aims and objectives[5]. They attempt a thorough analysis, listing the objectives in hierarchical order, so that each classification in each of the two taxonomies demands the skills and abilities which are lower in the classification order. Being, however, taxonomies of education aims in general, they do not immediately apply to physics.

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3. Instructions concernant la réforme de l'enseignement moyen : Physique, Chimie, Biologie, p.26.

4. See below, chapter IV.

5. B.S. Bloom (ed) Taxonomy of Educational Objectives - The classification of education goals, Handbook I : Cognitive domain, Longmans, Green & Co. Ltd., London 1956 (Reprinted 1964)
D.R. Krathwohl (ed), Taxonomy, etc., Handbook II : Affective domain.

At an international meeting of physics experts convened in Strasbourg by OCESCE, an attempt was made to adapt Bloom's taxonomy. It was, however, felt to be too detailed for the purpose. Besides, the third of the three taxonomies proposed, that dealing with the psycho-motor domain, has not yet been published. Hence, the skills which come under that heading have not yet been taken into account. The following 'taxonomy', which makes use of certain of Bloom's concepts, was suggested at the meeting of experts as a more immediately useful alternative :

1. Facility in recalling knowledge concerning :

   a) terminology
   b) facts
   c) methods
   d) principles and generalisations
   e) theories and structures.

2. Skill in manipulating apparatus, carrying out instructions for experiments and making accurate observations and measurements.

3. Skill in classifying and processing data, including mathematical formulation.

4. Ability to show understanding by :

   a) translation
   b) interpretation
   c) extrapolation.

5. Ability to assess or recognise the limits of accuracy and suitability of our experimental or theoretical method.

6. Ability to apply previous understanding and mathematical technique to new situations.

The terminology under point 4 is taken from Bloom and, after him, may be defined as follows : translation means roughly the ability to put a communication ; interpretation involves the ability to deal with a more or less complex set of ideas as such, including the ability to think about the interrelationships between the ideas ; roughly, extrapolation is equivalent to drawing out the implications contained in the original communication.

TABLE I - PHYSICS TEACHING AIMS

A. Discipline Centred Aims

I. Understanding of and training in Physics	A	B	CY	DK	D			F	EIR°	I°	L	M	NL	N	E°	S	GB
					Ber.	Hes.	NRW										
1. Understanding of the nature, structure, systematics purposes, value of Physics (a)	x		x		x		x	x									x
2. Understanding of the nature of the world and the fundamental problems which nature poses ; the position of man in nature			x		x		x	x			x					x	x
3. Knowledge of and ability to apply methods of research : use of experiments (b)	x	x	x	x	x	x	x	x		x	x	x	x			x	x
4. A knowledge of physical laws and phenomena (c)	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x
5. Contemporary methods, advances, problems in Physics (d)	x			x	x		x	x		x	x	x				x	x
6. Physics seen as a way of conquering natural forces to the service of man ; technological, practical, everyday applications and importance of Physics (incl. recent technical developments)	x		x	x	x	x	x	x		x						x	x
7. A deepened grasp of the physical way of enquiry (e)	x		x			x	x	x			x	x	x		x	x	x
8. An awareness of the coherence of Physics and other disciplines (incl. use of mathematics in Physics) (f)	x							x	x	x		x	x			x	x
9. History of Physics (g)	x		x	x	x		x	x			x		x				x
10. Humanist elements of history of Physics (Physicists) (incl. role of national Physicists in the development of Physics) (h)	x		x	x	x		x										

II. Understanding of and training in Science	A	B	CY	DK	D			F	EIR°	I°	L	M	NL	N	E°	S	GB
					Ber.	Hes.	NRW										
1. Development of objective attitude			x			x		x		x							
2. An understanding of the scientific way of thinking (i)					x			x	x								
3. Appreciation of the quantitative nature of science													x				
4. A grasp of the scientific method (b)	x				x	x	x				x		x				x
5. Ability to handle scientific knowledge													x				
6. Appreciation of the limitations of science		x	x		x	x	x				x					x	
7. A realisation that the sciences are the task and achievement of all mankind						x											
8. Importance of science for modern society (j)	x	x	x			x							x				

B. Pupil centred aims

	A	B	CY	DK	D			F	EIR°	I°	L	M	NL	N	E°	S	GB
					Ber.	Hes.	NRW										
1. Preparation for life (k)							x										x
2. A general education (l)					x			x									x
3. Preparation for employment																x	x
4. Preparation for further education							x	x								x	x
5. An intellectual training (m) (n)		x			x			x									
6. Disinterested pursuit of knowledge (o)	x				x	x		x			x						x
7. Capacity of seeing analogies of generalisation								x									
8. Impartiality (objectivity in thought) (p) (q)			x		x			x				x					
9. Development of critical faculties (p) (r)	x	x				x	x	x			x						
10. Development of judgement ; intellectual independence (r)	x				x		x	x									
11. Clear thinking ; exact formulation of concepts ; clear expression	x	x			x	x	x	x			x	x					x
12. Exact observation and measurement (s)			x		x			x			x						x
13. Development of imagination			x		x			x									
14. Development of memory								x									

	A	B	CY	DK	D			F	EIR°	I°	L	M	NL	N	E	S	GB
					Ber.	Hes.	NRW										
15. Character and moral training					x			x									
16. Awareness and development of the spiritual values								x									
17. Honesty, truthfulness (including intellectual honesty)	x				x												
18. Modesty. Awareness of complexity of nature	x				x						x						
19. Thoroughness	x																
20. Will-power, courage, tenacity, dedication (t)					x												
21. Inventiveness, creativeness (q)			x					x									
22. Sense of achievement, faith in oneself					x												
23. Spirit of cooperation, team spirit																	
24. Strengthening of a religious feeling (u)			x														

C. Society centred aims

	A	B	CY	DK	D			F	EIR	I°	L	M	NL	N	E°	S	GB
					Ber.	Hes.	NRW										
1. Development of a sense of social responsibility						x											
2. To produce men who can be leaders : men of high technical, moral and intellectual qualities (q)						x		x									
3. To prepare the specialists needed by society																	x

D. Philosophical aspects

	A	B	CY	DK	D			F	EIR	I	L	M	NL	N	E	S	GB
					Ber.	Hes.	NRW										
1. To contribute to an understanding of contemporary civilisation											x						
2. A better understanding by man of himself							x										
3. An appreciation of the influence of physics (of science) on the history of ideas (s)		x			x		x									x	
4. An awarenessof the philosophical background	x																
5 Introduction to the reflective method (reflektierende-Haltung) (v)																	
6. Epistemological questions							x										
7. Moral, social, aesthetic, political questions (the human implications of Physics/Sciences)	x				x	x	x										

TABLE 1 - AIMS OF PHYSICS TEACHING : NOTES

° : Limited data

(a) The aim Cyprus put forward was to indicate to the pupils the necessity of the study of nature. United Kingdom speaks of the purposes and structure of physics.

(b) United Kingdom (Science in Secondary Schools, p.129) stresses the experimental nature of physics and says : "The nature of an argument in physics needs to be clearly appreciated". The deductive element must not be concentrated on to the neglect of the rest. "The main job to be done in physics is to test and establish the premises from which deductive reasoning can proceed".

(c) Nordrhein-Westfalen also mentions : the handing on of knowledge. Berlin also mentions : the setting right of the popular notions of the pupils.

(d) France mentions : touching on contemporary questions of interest to the pupils.

(e) Nordrhein-Westfalen also mentions : a scientific and theoretical deepening.

United Kingdom also mentions the need to clarify the logical status of certain laws and concepts. (Ministry of Education, Science in Secondary Schools 1960, p. 130).

(f) Austria also gives as an aim : a deepened treatment of problems common to a number of fields of knowledge. (The Netherlands also speaks of the influence of scientific thought and method on other branches of knowledge).

(g) The Netherlands refers to the historical development of scientific thought and method.

United Kingdom speaks of "time for the pursuit of special interests such as ... in the history of science". (p. 132)

(h) Luxembourg mentions : wonder at the great achievements of the human race.

(i) Berlin : An appreciation of the value and range of causal thought.

(j) Belgium refers to : the present influence of science and of technical advances on human life and thought ; ... the connection between the practical aspects of different techniques and their value as agents of civilisation. (Instructions concernant la réforme de l'enseignement moyen : Physique - Chimie - Biologie, p. 11) However, the instructions also stress that : "it is necessary for the teacher to stick to the purely scientific domain, without diverging into philosophic speculations". (p.26)

(k) Nordrhein-Westfalen : to help the maturing men and women to lead their lives responsibly and with an awarencess of reality. (Richtlinien : Physik, p. 1)

United Kingdom : "preparation for life in an increasingly technological age" (Nuffield Progress Report, 1965, p.16).

" to enable them (the pupils) to keep some measure of control over their own destinies." (Ministry of Education, Science in Secondary Schools, 1960, p.1).

(l) Berlin : experiencing the educational value of physics ; appreciation of the struggle of the human intelligence for order, knowledge, unity.

On the whole, France stresses : formation of the person and also speaks about : the formation of the man of today.

Sweden mentions : the personal development of the pupil.

(m) France stresses that, rather than being given knowledge, the pupil should be made capable of acquiring knowledge for himself.

(n) Berlin : The first task of the science lesson has to do with a training in the acquisition of knowledge (erkenntnismässig).

(o) Berlin : a respect for intellectual work.

(p) Berlin : General problems from the science can show the value of objective, critical thought.

(q) France stresses the intellectual and moral formation of the men of tomorrow, of the elite, who must be men of action - generous, not egotistical, action. They must have the spirit of impartiality, integrity and creativeness.

(r) Sweden : independent and critical attitude.

(s) Berlin also mentions : a regard for natural phenomena.

(t) Berlin : "Patient painstaking trains one's will power" - Entwurf, p. 60.

(u) Berlin : General problems from the sciences can awaken philosophical reflection.

CHAPTER II

STRUCTURE AND CONTENT OF THE SYLLABUS

a) - Official Directives

Table II lists the official publications giving programmes for teaching physics in the academic secondary school. It is apparent that although most countries allow the teacher varying degrees of freedom of interpretation, only in the Federal Republic of Germany, Switzerland and the United Kingdom is control decentralised to any great extent. Although in the Netherlands teachers have considerable say in the individual items taught, outlines for the programmes are officially prescribed. In both Germany and Switzerland each of the eleven Länder, or twenty-two Cantons is free to devise its own programme, although official regulations circulated by the central authorities give some guidance as to the overall plan of study. In the United Kingdom, programmes are determined by the requirements of the eight regional examining boards. These boards, although operating under the aegis of a university or group of universities, are virtually autonomous and devise programmes by consultation with school and university teachers. The central authority, the Department of Education and Science, issues no official directives on syllabus content.

In spite of decentralised control programmes for the different German Länder and Swiss cantons, and for the various examining boards in the United Kingdom are fairly uniform in content and structure. This similarity is particularly evident in physics, where, unlike the social sciences, there is an internationally accepted corpus of knowledge.

TABLE II - OFFICIAL PUBLICATIONS OF PHYSICS TEACHING PROGRAMMES

Austria	Verordnungsblatt für den Dienst bereich des Bundesministeriums für Unterricht. Osterreichischer Bundesverlag especially Stück 10a/1955. Neuverlautbarung der provisorischen Lehrpläne für die Mittelschule
Belgium	Ministère de l'Education Nationale - Programme de Physique avec directions méthodologiques.
Cyprus	a) Programmata Analytica kai Orologia (I-V) New syllabuses following educational reform 1964 b) Programmata Analytica kai Orologia didacteas Ylis 1959 In force for VI form only
France	Brochure No. 63 de l'Institut Pédagogique National Directives are set out in Brochure No. 110 of IPN (Guy Lazerges) : L'Enseignement des Sciences Physiques dans le second degré.
Federal Republic of Germany	Bildungspläne für die allgemeinbildenden Schulen Amtsblatt des Hessischen Ministers für Erziehung und Volksbildung No. 6 June 1962. Amtsblatt No. 4 March 1957 pp 566-585

Greece	Official curriculum is issued by the Ministry of Education
Ireland	'Rules and programmes for Secondary Schools'
Italy	These are issued by the Ministry with analytical presentation.
Luxembourg	'Horaires et Programmes' are published each year - up to 1962 les directives were included as well.
Netherlands	There are no official publications besides the laws on education in which only a few remarks are made. Programmes for government schools contain a short list of subjects and only give directives for the classes in which these subjects must be taught. The official programmes for the final examinations give no details. The semi-official programme for the final examination in physics is far more extensive and modern - it has a greater influence on what is done in the physics lessons than the official programme has.
Norway	There are official syllabuses
Spain	a) Secondary school teaching law (Feb. 1953) Ley de Ordinación de la Enseñanza Media b) Plan de Estudios del Bachillerato c) 1st - 6th year curricula and pre-university curricula.
Sweden	Lüroplan för gymnasiet edited by National Board of Education contains the curricula of all subjects for the new gymnasia.
Switzerland	a) Règlement fédéral pour les examens de maturité Verordnung über die Anerkennung von Maturitäts - anweisen durch den Schweizerischen Bundesrat b) Regulativ für die Aufnahme von Studierenden der Eidgenossischen Technischen Hochschule 25.3.61 c) Bericht der Eidgenossschen Expertenkommision für die revision der Maturitäts - Anerkennungs - verordnung 1964
Turkey	There is one publication from the Ministry indicating the aims of the syllabus - it is official and was accepted in 1957
United Kingdom	Examination regulations of the 8 Boards 1. University of London Entrance and Schools Exam. Council, Senate House, London. W.C.1 2. Oxford and Cambridge Schools Examinations Board 10 Trumpington St. Cambridge.

United Kingdom	3. University of Cambridge Local Examinations Syndicate Syndicate Buildings, Cambridge. 4. Southern Universities Joint Board for Schools Examinations, 22 Berkeley Sq. Bristol 8. 5. Associated Examining Board for GCE, Wellington House, Station Rd. Aldershot. 6. Joint Matriculation Board, Manchester 15. 7. Oxford Delegacy of Local Examinations, Summertown, Oxford. 8. Welsh Joint Education committee, 30 Cathedral Rd. Cardiff.
Scotland	Scottish Certificate of Education Examinations Board, Broomhouse Drive, Saughton, Edinburgh. 11.

b) - Organisation of Syllabus Analysis

In order to compare the content of European programmes for physics, a complete list was made of all items studied by the member countries of the C.C.C., classified according to a modified version of the Universal Decimal Classification System. Items were classified in ten major sections :

530 : General Principles of Physics

531 : General Mechanics

532 : Mechanics of Fluids

533 : Mechanics of Gases : Aerodynamics

534 : Acoustics : Vibrations

535 : Optics

536 : Heat : Thermodynamics

537 : Electricity

538 : Magnetism : Electromagnetism

539 : Molecular and Atomic Physics

(This list appears in Appendix I)

This item analysis was then circulated to a representative of each member country, who was requested to indicate which topics were studied in their country, and to give an estimate of the depth to which each one was taught. Answers to this survey can be found in complete form in Appendix II. A summary of the results can be found in Tables III and IV. Table V shows in graph form the percentage of the total syllabus covered by each country.

TABLE III - NUMBER OF ITEMS STUDIED BY EACH COUNTRY IN EACH OF THE TEN SECTIONS OF THE PHYSICS SYLLABUS

	Extent studied	A	B	CY	F	D Hes.	L	EIR	I	NL	N	SL	S	E	CH	TR
530. General principles.	v. great	2	10	5	5	9	0	7	0	10	4	4	1	3	1	1
	Moderate	12	6	12	6	9	9	5	2	8	4	10	13	10	15	11
	Superficial	5	5	2	5	4	4	2	2	2	8	2	7	4	3	4
	Not at all	4	2	4	7	1	10	9	19	3	7	7	2	6	4	7
Total items : 23	Total studied	19	21	19	16	22	13	14	4	20	16	16	21	17	19	15
531. General mechanics ; Mechanics of solid and rigid bodies.	v. great	2	36½	55	26	27	24	55	52	20	31½	26	29	15	20	1
	Moderate	37	16	11	19	16	12	4	17	33	23½	20	15	47	36	34
	Superficial	18	5½	0	14	13	12	1	0	14	10	12	11	3	7	22
	Not at all	20	19	11	18	21	29	17	8	10	12	19	22	12	14	20
Total items : 77	Total studied	57	58	66	59	56	48	60	69	67	65	58	55	65	63	57
532. Mechanics of fluids.	v. great	0	6	6	1	2	6	5	6	0	4	0	1	0	0	0
	Moderate	8	1	3	5	0	0	0	0	1	2	1	1	7	4	2
	Superficial	0	1	0	0	2	1	0	1	8	1	2	1	2	1	3
	Not at all	1	1	0	3	5	2	4	2	0	2	6	6	0	4	4
Total items : 9	Total studied	8	8	9	6	4	7	5	7	9	7	3	3	9	5	5
533. Mechanics of gases ; Aero-dynamics.	v. great	0	2	2	0	1	2	0	1	0	0	0	0	0	0	0
	Moderate	1	0	0	2	1	0	1	0	0	1	2	1	2	1	0
	Superficial	1	0	0	0	0	0	1	0	2	0	0	1	0	1	1
	Not at all	0	0	0	0	0	0	0	1	0	1	0	0	0	0	1
Total items : 2	Total studied	2	2	2	2	2	2	2	1	2	1	2	2	2	2	1

	Extent studied	A	B	CY	F	D Hes.	L	EIR	I	NL	N	SL	S	E	CH	TR
534.																
Acoustics ;	v. great	1	1	3	2	3	0	2	6	3	2	1	1	0	2	2
Vibrations.	Moderate	8	9	6	3	3	2	8	5	9	6	11	6	1	9	9
	Superficial	5	5	3	6	2	1	2	0	3	4	3	7	10	2	5
	Not at all	2	1	4	5	8	13	4	5	1	4	1	2	5	3	0
	Total studied	14	15	12	11	8	3	12	11	15	12	15	14	11	13	16
Total items : 16																
535.																
Optics.	v. great	4	14	13½	8	7	5	12	15	2	1	0	15	14	5	0
	Moderate	18	12	9½	7	4	3	2	6	19	21	25	9	15	14	19
	Superficial	8	4	2	7	1	8	6	4	8	4	4	6	0	2	7
	Not at all	3	3	8	11	21	17	13	8	4	7	4	3	4	12	7
	Total studied	30	30	25	22	12	16	20	25	29	26	29	30	29	21	26
Total items : 33																
536.																
Heat ;	v. great	0	13½	19	1	1	9	14	16	6½	11	3	11	1	1	0
Thermo-dynamics.	Moderate	16	3½	1	9	2	7	5	3	15½	9	11	4	20	13	11
	Superficial	8	5	0	10	1	6	0	2	2	1	7	8	2	4	6
	Not at all	2	4	6	6	22	4	7	5	2	5	5	3	3	8	9
	Total studied	24	19	20	20	4	22	19	21	24	21	21	23	23	18	17
Total items : 26																
537.																
Electricity.	v. great	2	27	50	17	25	13	30	35	8	11	6	14	14	14	0
	Moderate	34	22	1	16	6	18	20	16	43	30	31	32	40	17	18
	Superficial	18	7	0	7	7	12	3	4	6	7	18	13	0	7	28
	Not at all	6	4	9	20	22	17	7	5	3	12	5	1	6	22	14
	Total studied	54	55	51	40	38	43	53	55	57	48	55	59	54	38	46
Total items : 60																

	Extent studied	A	B	CY	F	D Hes.	L	EIR	I	NL	N	SL	S	E	CH	TR
538.																
Magnetism ;	v. great	0	17	23	10	4	8	12	12	2	8	1	2	5	9	0
Electromagnetism	Moderate	23	8	6	6	3	7	12	6	14	9	16	11	18	10	7
	Superficial	4	5	0	4	2	9	2	12	7	6	12	13	3	0	17
	Not at all	3	0	1	10	21	6	4	0	7	7	1	4	4	11	6
	Total studied	27	30	29	20	9	24	26	30	23	23	29	26	26	19	24
Total items : 30																
539.																
Molecular and	v. great	0	6	$2\frac{1}{2}$	2	$11\frac{1}{2}$	0	0	0	1	0	2	4	0	3	0
Atomic physics.	Moderate	6	9	$18\frac{1}{2}$	$7\frac{1}{2}$	8	3	18	2	$17\frac{1}{2}$	1	12	14	17	3	0
	Superficial	12	7	0	$3\frac{1}{2}$	$1\frac{1}{2}$	8	2	11	$2\frac{1}{2}$	12	4	4	0	10	8
	Not at all	4	0	1	9	1	11	2	9	1	9	4	0	5	6	14
	Total studied	18	22	21	13	21	11	20	13	21	13	18	22	17	16	8
Total items : 22																
Totals	v. great	11	133	179	72	$90\frac{1}{2}$	67	137	143	$52\frac{1}{2}$	$72\frac{1}{2}$	43	78	52	55	4
	Moderate	163	$86\frac{1}{2}$	68	$80\frac{1}{2}$	52	61	75	57	160	$106\frac{1}{2}$	139	106	177	122	111
	Superficial	79	$44\frac{1}{2}$	7	$56\frac{1}{2}$	$33\frac{1}{2}$	61	19	36	$54\frac{1}{2}$	53	64	71	24	37	101
	Not at all	45	34	44	89	122	109	67	62	31	66	52	43	45	84	82
	Total studied	253	264	254	209	176	189	231	236	267	232	246	255	253	214	216
Total items : 298																

TABLE IV - EMPHASIS PLACED ON EACH SECTION OF TOTAL SYLLABUS BY EACH COUNTRY

Section	Total no. of items in each section	No. of items as % of total syllabus	A	B	CY	F	D	L	EIR	I	NL	N	S	E	CH	TR	SL
530	23	8 %	7 %	8 %	7 %	8 %	12 %	7 %	6 %	2 %	7 %	7 %	8 %	7 %	9 %	7 %	6 %
531	77	26 %	22 %	22 %	25 %	27 %	32 %	25 %	26 %	29 %	25 %	28 %	21 %	25 %	29 %	26 %	23 %
532	9	3 %	3 %	3 %	4 %	3 %	3 %	4 %	2 %	3 %	3 %	3 %	1 %	4 %	2 %	2 %	1 %
533	2	1 %	1 %	1 %	1 %	1 %	1 %	1 %	1 %	0 %	1 %	0 %	1 %	1 %	1 %	0 %	1 %
534	16	5 %	6 %	6 %	5 %	5 %	5 %	2 %	5 %	5 %	6 %	5 %	5 %	4 %	6 %	7 %	6 %
535	33	11 %	12 %	11 %	10 %	10 %	7 %	8 %	8 %	11 %	11 %	11 %	12 %	11 %	0 %	12 %	12 %
536	26	9 %	10 %	9 %	9 %	10 %	3 %	13 %	9 %	9 %	10 %	10 %	10 %	10 %	9 %	9 %	9 %
537	60	20 %	21 %	21 %	20 %	19 %	22 %	23 %	23 %	23 %	21 %	21 %	23 %	21 %	18 %	21 %	22 %
538	30	10 %	11 %	12 %	11 %	10 %	6 %	13 %	11 %	13 %	9 %	9 %	10 %	10 %	9 %	11 %	12 %
539	22	7 %	7 %	8 %	8 %	6 %	12 %	6 %	9 %	6 %	8 %	6 %	9 %	7 %	7 %	4 %	7 %

TABLE V

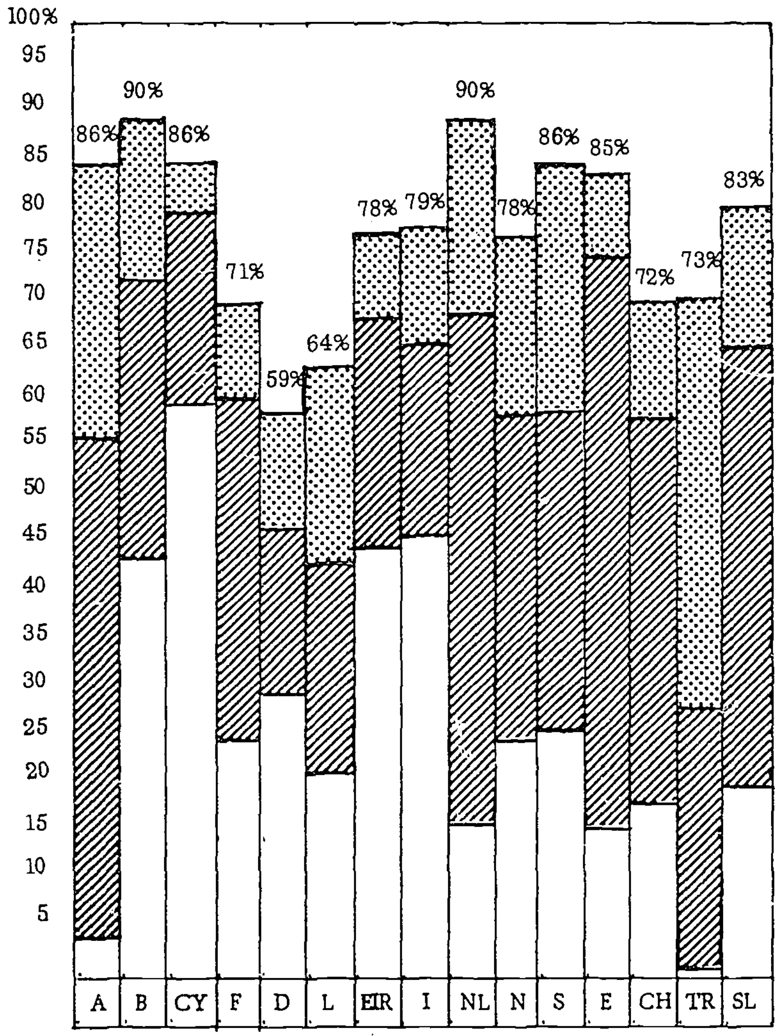
THE APPROXIMATE PERCENTAGE OF THE TOTAL SYLLABUS COVERED BY EACH COUNTRY

COUNTRY	Percentage	Total no. of items
1. Netherlands	90	267
2. Belgium	90	264
3. Sweden	85	255
4. Cyprus	85	254
5. Austria	85	253
6. Spain	85	253
7. Scotland	85	246
8. Italy	80	236
9. Ireland	80	231
10. Norway	80	232
11. Turkey	70	216
12. Switzerland	70	214
13. France	70	209
14. Luxembourg	65	189
15. Fed. Rep. of Germany	60	176

Total number of items on total syllabus : 298

PERCENTAGE OF TOTAL SYLLABUS COVERED BY EACH COUNTRY

Total no. of items = 298



A to a great extent B to a moderate extent C to a superficial extent

c) - Results of analysis

It is clear that the indications of the extent of study are not capable of a rigid interpretation. For example, Belgium studies 264 topics and of these 133 are deemed to be to a very great extent. The corresponding figures for Sweden are 255 topics but only 78 to a very great extent. This is despite the fact that in the last two years Sweden devotes 220 hours to the teaching of physics while Belgium only devotes 100 hours (see Table VI "Allocation of Teaching Time" and accompanying graph). More detailed research would help to standardise the assessment of the extent of study.

However, much interesting and useful information is obtained from analyses of the data. Table IV shows the emphasis that the various countries place on each of the ten main sections of the total syllabus. The similarity in the pattern of emphasis suggests a fair degree of common ground in the separate syllabuses. Table VIIA (Tables VIIA-D appear at the end of the chapter) takes the analysis still further and shows the list of common core topics, that is those studied by all the countries. This amounts to 52 out of the total of 298 or just over 17 %. If we consider each country's separate syllabus, common core topics form about 20 % of their total although Germany shows an exceptionally high figure of 30 %. By themselves these may not appear very impressive figures but if one adds Table VIIB showing the additional common core topics, that is topics common to all but two countries, the total number of topics rises to about 50 % of the total syllabus and this would seem a significant figure. The point which comes over most strongly is the great and common emphasis on General Mechanics (531). Electricity (537) and its kindred item Magnetism and Electromagnetism (538) also show a strong common emphasis.

The suggestion that the separate syllabuses show a useful measure of agreement is supported, in a negative way, by the relatively short (compared with common core plus additional common core) list of unusual topics, that is those dealt with by seven countries or less as in Table VIIC. Further support is given by the fact that few of these unusual topics are studied beyond the moderate extent stage. If there are any surprises in the list of unusual topics the greatest one must surely be 537.54, Transistors. One would suppose that is going, or perhaps has already gone, to the list of common core topics.

Thus the overall picture of the syllabus content would appear to show a useful amount of common ground, and, if it is felt desirable, this could no doubt be increased. But even identical paper syllabuses would leave open the question of interpretation, teaching skill and resources, and the stimulus provided by the standard of the examination.

A closer analysis of each country's syllabus shows important differences that have been somewhat masked by the broader overall picture so far considered. Appendix II, on Methods, gives fuller details of these syllabuses but some points from them are relevant here. Few countries dictate a rigid order in which the syllabus must be followed but rather produce a list of topics which should be covered before the final examination. Sweden is now an exception to this as she has replaced the final examination by a system of continuous assessment. This requires certain topics to be completed for each test although the whole syllabus has an atomistic approach. There are restrictions on the methods of teaching and often standardised directions on the method to be adopted. This follows from the strong centralisation of education in Sweden. To achieve the depth of study required, the system necessitates and gets a high quality teaching and arduous work from the pupil.

In the Federal Republic of Germany the Hessen and Nordrhein-Westfalen syllabuses indicate an advanced nature of the study undertaken with a strong mathematical bias. But the teacher is not required to adhere to the content of the syllabus as much as is found in teaching in England. This is shown by the Hessen introduction which includes the following, "Only selected sections of the Outline Plan ('Rahmenplan') need be treated fully" so that sufficient time remains to go into some of those aspects in the voluntary part of the syllabus making pupils "increasingly aware of the meaning of establishing theories in physics and the paradigmatic nature of physical knowledge". However the syllabus also includes "Hints on Method" so there is some limitation on the presentation of content. Both syllabuses mentioned recognise that the scope is too large for a full treatment in all topics. Hessen solves the problem by having a compulsory (outline plan) and a voluntary part. Nordrhein-Westfalen allows a choice of one of three basic themes

a) the atomic model and its development,

b) wave and corpuscle dualism or

c) electromagnetic waves.

The result is a high academic standard on a par with the English 'A' levels. This is particularly interesting as the students taking the equivalent examination (Abitur) do so in anything up to eight subjects.

The United Kingdom has a greater degree of specialisation than any other member country (see Table V). The syllabuses are set by the seven English Boards, one Welsh and one Scottish Board listed in Table II. All are geared to the entrance demands of the universities and show greater detail than those of other countries. As already mentioned, the differences in the various syllabuses are relatively small although there may be different emphases. The London syllabus for example requires a stronger emphasis on the mathematical aspects of the physics teaching than that of the Northern Board. But it is probably true to say that a good pupil prepared for one Board would make at least a reasonable showing on the papers of any other Board. Another interesting difference between the United Kingdom and other countries is the importance attached to practical work (see Table IX, Chapter III). This table shows that the United Kingdom devotes a greater proportion of its relatively high teaching time to practical work than any other country. All this amounts to a high academic standard to meet the university entrance requirements.

The French syllabus shows a strong mathematical bias although it has neither the detail nor the content of any United Kingdom syllabus. Only three hours per week are allowed for physics teaching so that the depth of study does not reach that of Germany, Sweden or the United Kingdom. The intention of the "Baccalauréat" is to give "a broad test of knowledge and the ability to think" which officially serves as a "school leaving certificate rather than a university entrance requirements". France is the only country to link physics and chemistry in the subject 'physical sciences'.

Three hours per week and a relatively short syllabus also characterises the Austrian syllabus so that again the teaching is of a broad nature. The teacher must cover a set number of topics in each grade though the syllabus adds, "the large quantity of matter to be taught may make it necessary to omit material which is concerned with isolated occurrences rather than with basic phenomena" - in other words the paradigmatic approach. The depth of understanding is not comparable to that in the United Kingdom although the official attitude places greater store on understanding rather than the storing of facts. The United Kingdom system has sometimes been criticised for encouraging the opposite attitude.

Without going into any detail for the remaining countries, one may say that there is a wide variation in standards required both from teacher and pupil. The net result of content of syllabus, interpretation, method of teaching, time available and the stimulus of the demands of the terminal examination shows that the United Kingdom, Norway, Cyprus and the Netherlands (HBS) devote the greatest amount of time and undertake the most detailed study of physics, where Sweden and France spend rather less time studying a smaller range of topics. The Federal Republic of Germany is something of an exception, studying less topics than any other country, but having a very generous time allowance. Belgium and Austria, on the other hand, study a wide range of topics in a comparatively limited time.

TABLE VI

ALLOCATION OF TEACHING TIME

Approximate amount of time devoted to physics in the most specialised section of the most specialised academic secondary school in the last two years

		(in 60 minute hours) (1)
1.	United Kingdom	375
2.	Norway	340
3.	Cyprus	315
4.	Netherlands (h.b.s.)	290
5.	Denmark (2)	270
6.	France (3)	260
7.	Fed. Rep. of Germany (Hes)	240
8.	Spain	225
9.	Sweden	220
10.	Italy	205
11.	Luxembourg	205
12.	Greece	200
13.	Netherlands (gymnasium)	195
14.	Ireland	190
15.	Turkey	190
16.	Switzerland	180
17.	Austria	140
18.	Belgium	100

The median was about 210 hours and the mean about 230 hours.

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(1) This information was obtained from answers to a questionnaire which was completed by physics experts from each of the countries concerned.

(2) Assuming a 40 week year.

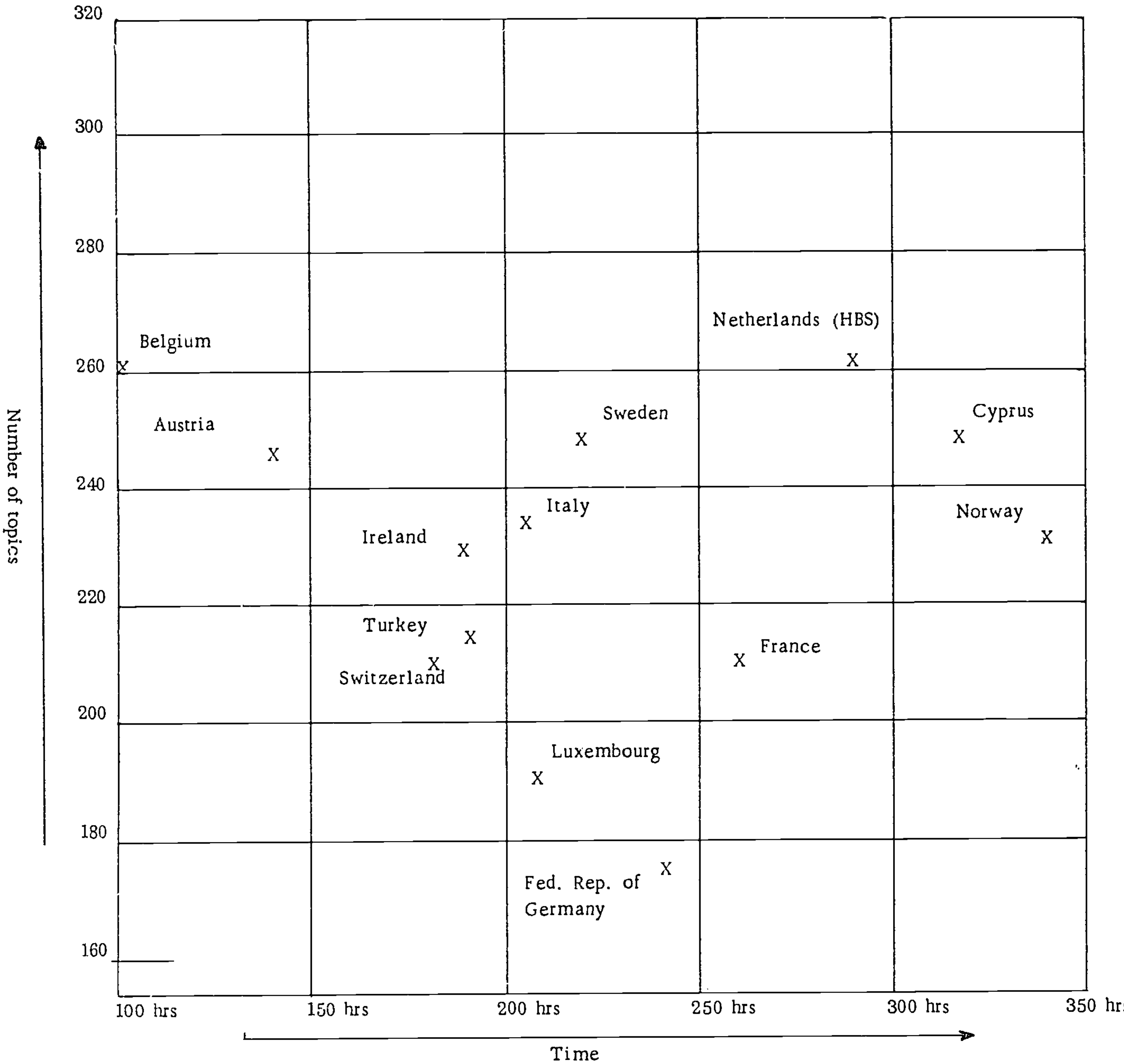
(3) This time allocation is for les sciences physiques, which includes chemistry. With the 1968 baccalauréat reforms the amount of time spent on les sciences physiques in section C has increased. The total number of hours for the last two years is now about 340.

TABLE VII A

PHYSICS COMMON CORE TOPICS

531.11	Uniform motion in a straight line
531.13	Uniformly accelerated motion in a straight line
531.14	Velocity and acceleration as scalars and vectors
531.17	Linear momentum. Law of conservation
531.21	Parallelogram and triangle of forces
	Principle of moments ; parallel forces and couples
531.23	Concept of force
	Couples and moments
531.31	Motion of a particle in a straight line
	Motion of a particle under gravity : projectiles
531.35	Newton's laws of motion. Inertia
	Laws of action and reaction
531.36	Composition and resolution of velocities
531.37	Impulse
531.38	Simple Kinetic theory
531.42	Work and efficiency
	Power
531.51	Simple harmonic motion
531.52	Free fall
	Mass and weight
531.53	Newton's law of gravitation
531.61	Conservation of momentum and energy
	Energy : conservation, potential, kinetic energy
531.72	Units CGS and MKS
534.51	Interference of sound
535.11	Light as a wave motion
535.12	Wavelength
535.21	Velocity of light
535.41	Interference of waves
536.72	Kinetic theory of gases : elementary interpretation
537.11	Electronic charge
	Electronic mass
	Electric field and lines of force
	Electric field intensity
	Work in an electric field
537.22	Capacitance and capacitors
	Parallel plate condensor
537.24	Potential
537.51	Cathode rays
	Cathode ray tube
537.71	Units (current, potential difference)
538.31	Electromagnetic waves, electromagnetic spectrum radio waves
538.51	Electromagnetic induction
	Self induction

GRAPH INDICATING AMOUNT OF TIME DEVOTED TO STUDY OF PHYSICS AND NUMBER OF TOPICS INCLUDED



538.52 Alternating currents
Instantaneous and effective values of current, voltage
Resistor, capacitor and inductor in alternating current : elementary and advanced
539.13 Isotopes
539.14 Natural radioactivity and radiation
Natural and artificial nuclear transformations
Radioactive half-life and range
539.15 Atomic models

The common core items expressed as a percentage of each country's syllabus : - (e.g. Austria covers 255 items : common core items, 52)

Austria	20 %
Belgium	19 %
Cyprus	20 %
France	25 %
Fed. Rep. of Germany	30 %
Luxembourg	27 %
Ireland	23 %
Italy	22 %
Netherlands	19 %
Norway	22 %
Sweden	20 %
Spain	20 %
Switzerland	24 %
Turkey	24 %
Scotland	21 %

TABLE VII B

ADDITIONAL COMMON CORE TOPICS

The common core topics can be expanded if we also include topics which were common to all but two countries

530.13	Wave as a propagation of a disturbance and as a form of energy
	Propagation of waves in elastic media
	Wave length, period, frequency
	Longitudinal waves
	Wave velocity
	Phase difference
	Graphical representation of waves
530.14	Reflection of waves
	Refraction of waves
530.15	Interference of waves
	Standing waves
531.12	Irregular motion in a straight line
531.13	Acceleration
531.15	Uniform motion in circle
531.16	Angular acceleration
531.18	Angular momentum. Law of conservation
531.21	Equilibrium of a particle
	General conditions of equilibrium as coplanar forces
531.23	Composition and resolution of forces
531.25	Centre of mass
531.31	Motion in a circle
531.34	Projectiles
531.36	Composition and resolution of acceleration
531.37	Relative velocity
531.41	Inclined plane
531.51	Hooke's law
	Superposition of oscillations
	Simple pendulum
	Vibrating spring
531.53	Relation between G and g
	Earth's gravitational field
532.12	Fluid pressure
532.41	Specific gravity
533.41	Atmospheric pressure. Variation in time and space
533.42	Manometers and pressure gauge. Barometers
534.11	Sound as a wave motion
534.21	Propagation of sound in a gas
	Propagation of sound in a liquid, solid
534.22	Velocity of sound
	Measurement of velocity of sound (air or Kundt's tube)
534.51	Standing waves
534.52	Resonance
535.21	Determination of velocity of light
535.31	Plane and curved mirrors

535.32 Convergent, divergent, thin lenses (formulae)
535.33 Prism (and dispersion)
Deviation
535.35 Rectilinear propagation
535.36 Laws of reflection, refraction (index of refraction)
Total internal reflection, critical angle
535.41 Interference by division of wave front (Young's slits etc.)
535.61 Spectrometer. Analysis of spectra
535.62 Infra-red and ultra-violet radiation
536.21 Transfer of heat ; conduction, convection, radiation
536.41 Thermal expansion of solids, liquids
Definition of coefficients of expansion
536.43 Changes of state, melting, freezing
boiling, solidification
liquefaction
536.51 Temperature : its measurement, thermometers, centigrade, absolute
536.61 Units of heat
536.62 Calorimetry : elementary
Specific heats (liquids, solids)
536.63 Specific heats of gases
536.71 The ideal gas, laws, equation of state
536.73 First law of thermodynamics
536.81 Mechanical equivalent of heat
537.11 Deflection of electron beam in electric and magnetic fields
537.12 Current as a moving charge
537.21 Concepts of charge (positive and negative)
Elementary electrostatics - basic ideas
537.22 Induction (including Faraday's experiment)
Linking of capacitors
Energy of charged capacitor
Dielectric constant
Effect of dielectric on field, capacitance
537.23 Inverse square law
537.31 Electrolysis
Faraday's laws
Simple ionic theory
Polarisation
Voltaic cell, lead accumulator
537.51 Passage of current through gases at normal and reduced pressure
Cathode ray oscilloscope, television
537.52 Thermionic emission
Thermionic diode
537.53 X-ray
537.71 Measurement
537.72 Resistance
Resistivity
Ohm's law
Wheatstone bridge
537.73 Heating effects of a current
Kirchoff's laws
Electromotive force

537.74 Moving coil galvanometer
538.11 Magnetic materials (lodestone etc.)
538.12 Magnetic effects of a current
Field due to a long straight conductor
Field at centre of a plain circular coil carrying a current
Field inside a long solenoid
538.13 Magnetic field
538.32 Force between current carrying conductors
Force on conductor carrying current in magnetic field
538.62 Magnetic flux density (D)
539.11 Particle aspect of radiations, photons
Photoelectric effect
539.12 Planck's constant
539.14 Elementary particles and nuclear structure
539.15 Atomic number

TABLE VII C - SOME UNUSUAL TOPICS IN THE SYLLABUS DEALT WITH BY 7 COUNTRIES OR LESS

A = to a very great extent ; b = to a moderate extent ; c = to a superficial extent

		A	B	CY	F	D Hes.	L	EIR	I	NL	N	S	E	CH	TR	SL
530. 11	Principle of relativity		c		c							c		b		
530. 12	Wave mechanical model of atom		c	c		b						c	b	b		
530. 13	Group velocity, phase velocity		c			c				A						
530. 16	Doppler effect	b	A			b				b		c		b	b	
531. 21	Graphical statics			b		c			A				c	c		c
	Bending moments and shearing forces								b				c			
	Bows notation. Framework								b							
	Fundamental theorem, plane statics			A					A	b			c	b		b
531. 25	System of particles ; internal & external forces			A	c				A		b	c	b			
	Particle model		A	A		c					c					A
531. 31	Motion of a particle in a smooth curve		b	A						b	c			b		
531. 33	Rigid body free to move in a plane			A				b	A	c						
531. 51	Torsional oscillations. Torsional pendulum			b	b			A	b		c		b	c		
531. 55	History of the view of the universe	b	c			b					b	c				
531. 56	Gyroscope	c														
531. 61	Oblique contact		c		c	c				b					c	b
531. 72	Modulus of elasticity	c		b					b	b	b			b	c	
534. 23	Doppler effect (sound)	b	b			c				b		c		b	b	
534. 81	Ultrasonics		c			c						b			c	b
535. 13	Doppler effect (optics)	c	b			b				c	c	b				
535. 32	Thick lenses			b					b				A			
535. 36	Reflection and refraction waves		b	A	b								A			
535. 41	Interference by division of amplitudes e. g. thin films		b	b						b	b	A			b	b
536. 43	Latent heats	b	A	A	b					A		c	b			
536. 72	Advanced interpretation of kinetic theory of gases									b		A				
536. 74	2nd law of thermodynamics	c					c	A	b	b			c			c
	Technological application						c						c			c
537. 11	Thomson's experiment	c	b					A	b	b		b				b

No.	Topic	A	B	CY	F	D Hes.	L	EIR	I	NL	N	S	E	CH	TR	SL
537.24	Gauss' theorem			A		c		A	b	b			A			
537.52	Use of diode as amplifier			A		A					b	b			c	
537.53	X-ray spectra		c			c			b	c		b	b			
537.54	Transistors		c			c						b				c
538.31	Constants of electric and magnetic field and their relation to the speed of light		b			A		A	c				b	b		
538.33	Applications : telephone, telegraph (force between current carrying conductors)	b	c	b					A		c					c
538.51	Mutual inductance															
539.12	Balmer lines		b	b		A				b		b	c	c		
	Franck Hertz experiment		A	b		A		c	b	c		c				
539.14	Cosmic radiation		c									c				

TABLE VII D - PERCENTAGES OF RARE AND COMMON TOPICS IN EACH SECTION OF THE SYLLABUS

	Total no. of items in section	Common core items		Additional common core items		Rare topics		Other°	
		No.	%	No.	%	No.	%	No.	%
530. General principles of Physics	23	0	0%	11	48%	4	17%	8	34%
531. General mechanics. Mechanics of solids and Rigid Bodies	77	24	31%	18	23%	13	19%	22	37%
532. Mechanics of fluids	9	0	0%	2	22%	0	0%	7	78%
533. Mechanics of gases : Aerodynamics	2	0	0%	2	100%	0	0%	0	0%
534. Acoustics : Vibrations	16	1	6%	7	45%	2	12%	6	37%
535. Optics	33	4	12%	11	33%	4	12%	14	43%
536. Heat : Thermodynamics	26	1	4%	13	50%	4	15%	8	31%
537. Electricity	60	11	18%	28	46%	5	8%	16	27%
538. Magnetism : Electro-magnetism	30	6	20%	10	33%	3	10%	11	37%
539. Molecular and Atomic Physics	22	5	23%	7	31%	3	14%	7	31%
Total	298	52	17%	89	30%	38	13%	103	40%

Additional common core topics are studied by 14-16 countries.

° These topics are studied by more than 7 and less than 14 countries.

CHAPTER III

PHYSICS TEACHING METHODS

(Detailed summaries of teaching methods in each country appear in Appendix II)

After defining the goals to be achieved by teaching any given subject and expressing them operationally in a list of topics to be taught, the next step must surely be to establish how the teacher must proceed in order to attain the desired objective. It is, of course, not possible to draw rigid distinctions between these three interdependent processes, determination of aims, subject-matter and method, as so many variables may influence both those designing courses and those teaching them. The force of tradition in syllabuses, the school facilities available or the demands of society and the professional world are but a few factors which play an important part in determining the curriculum.

Subject matter and method of instruction have a particularly close relationship one to the other, for the way in which pupils are taught has a direct bearing on their comprehension of a subject. The introduction of an increasing proportion of practical work into school physics courses is designed to demonstrate physical laws in direct application to the environment and not merely as a set of abstract principles. There are indications however that there is an optimum proportion of practical work that might be included in the curriculum, and that too much time devoted to experiments performed by pupils might be too time-consuming. While most countries include a certain amount of practical work in their programmes, the United Kingdom is the only country in which it may take up as much as 50 % of the total time given to physics. (See Table VIII).

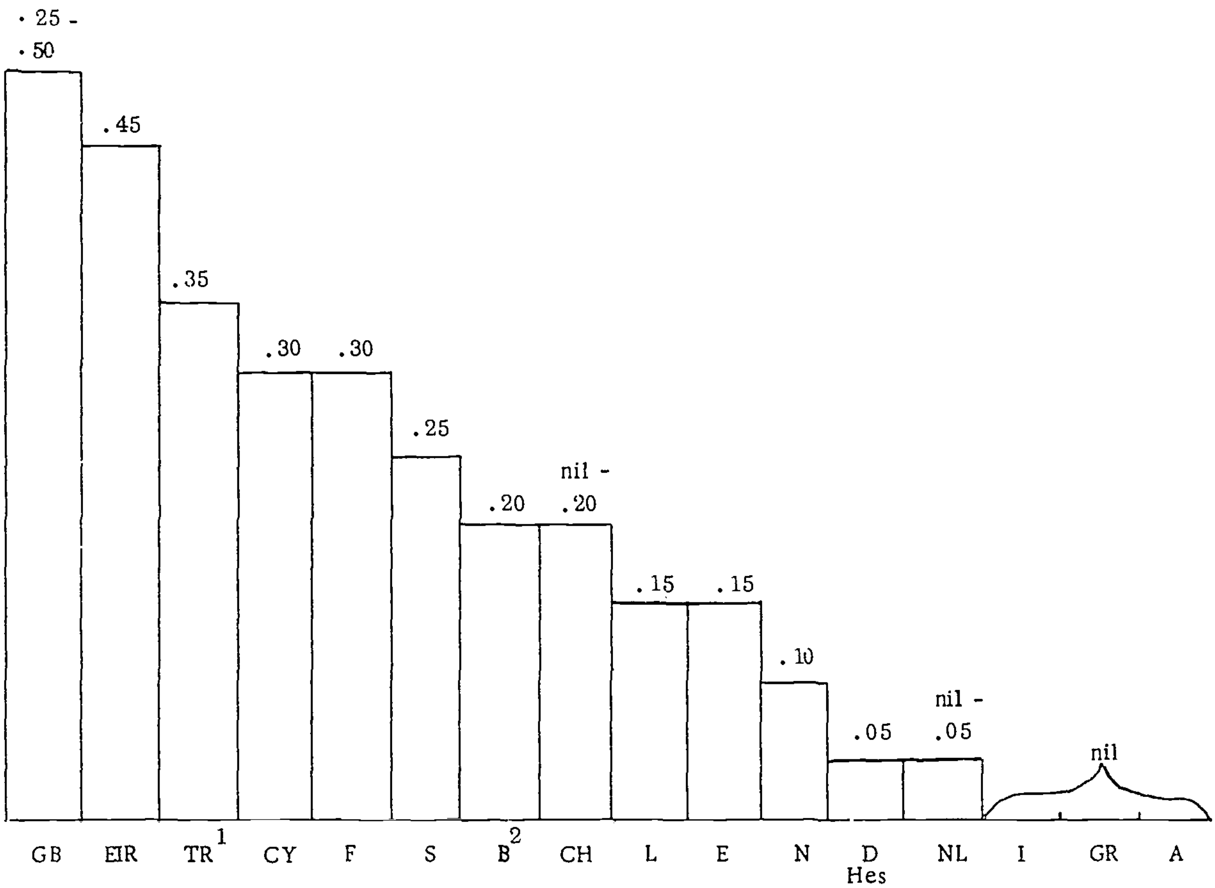
In the United Kingdom, moreover, a large proportion of the time devoted to practical work is set aside for experiments done by the pupils themselves, where in the other European countries, greater emphasis is laid on demonstrations performed by the teacher.

It would be an interesting investigation to examine the experiments performed as part of the examination syllabus by each country and then to assess whether their inclusion is justifiable. The United Kingdom is indeed the only country that gives a practical examination for candidates at this level. And even here, much discussion is going on as to the usefulness of practical work at this stage. There are serious doubts as to whether much of the new apparatus on structure and properties of matter may not be too expensive, and whether too much time is wasted by getting pupils to perform for themselves experiments which might just as well have been demonstrated by the teacher. French semi-official instructions lay down that too much time must not be spent on repetition by pupils of experiments which have been successfully demonstrated. For some experiments, demonstration may well be the most suitable method, particularly now that closed circuit TV is becoming more widespread.

Connected with the proportion of time given over to practical work is the question of the use of the time available for physics. The Federal Republic of Germany and Sweden in particular make use of the idea of 'Epochalenunterricht' or concentration. This means that instead of spreading the physics teaching time evenly over the whole course, more time - often double or treble periods - is given to physics at one time, and less, or none at another. More controlled experimentation needs to be done with the various ways of utilising the time available.

Another matter that is basic to method is the order in which the syllabus is taught. Table IX was also drawn up on the basis of the questionnaire completed by the physics experts.

TABLE VIII - APPROXIMATE PROPORTION OF PHYSICS TEACHING TIME ALLOCATED TO PRACTICAL WORK IN FINAL YEAR



median = about .15 - .20

mean = about .20

1. In theory one in three lessons. However, large classes and lack of equipment make this difficult.

2. This refers to time for problems and practicals.

TABLE IX

WHETHER THERE IS A PRESCRIBED ORDER FOR TEACHING THE PHYSICS SYLLABUS

	A	B	CY	DK	D Hes	F	GR	EIR	I	L	NL	N	SL	E	S	CH	TR	GB
Yes			x 1)		x 2)	x 3)	x		x 4)	x	x 5)	x			x		x	
No	x	x		x				x					x	x 6)		x 7)		x

1) It is taken for granted that the order of the official syllabus will be followed.

2) A certain amount of re-ordering is possible.

3) The syllabus is presented in a logical order, which the majority of the teachers follow though it is not imposed for any given class.

4) "The syllabus for each year must be completed"

5) "No order is prescribed other than what is in the syllabus"

6) It is customary, though not obligatory, to follow the order of the textbook. It normally adheres to the order of the official syllabus.

7) Varies from canton to canton and school to school. Often the programme is not prescribed in detail.

It can be seen that in over half of the countries there is a prescribed order for teaching the physics syllabus. In most of these cases the teaching seems to start with mechanics.

In the OECD publication, A Modern Approach to School Physics, it was argued that the introduction to physics should be "through a consideration of atoms, molecules and electrons" because most children today have some acquaintance with and interest in these terms, and above all, because physics should be presented right from the very start in as modern a way as possible. However, (in a later OECD publication) Dr. H. Schoene (Teaching Physics Today, OECD, 1965) criticises this suggestion. The pupil's conception of these entities is often false, and if introduced too early to them, he may end up with a distorted picture.

There is a fair degree of agreement between the various countries that the academic secondary course should not only familiarise the pupil with the subject matter of physics but should also develop in him a favourable attitude towards the subject (cf. Chapter I, The Aims of Teaching Physics). He should become practised in the appropriate modes of thought - "the scientific way of thinking" and should develop an "objective attitude". It is doubtful, however, whether the development of new patterns of thinking can be entirely compatible with the bulk of facts that some countries demand that pupils should retain. The Federal Republic of Germany alone appears to place any great emphasis on the paradigmatic method. In Nordrhein-Westfalen, for example, the pupil of 18 years is offered a choice of three basic themes :

1. The atomic model and its development

2. The wave and corpuscle dualism

3. Electromagnetic waves : the ether problem : space, time and relativity.

Aspects of physics relevant to the particular theme chosen are then selected. The first 'line' of instruction, the atomic model, may, for example, be used to show the value of static methods, to compare the inductive and deductive methods and to show the importance to physics of the concept of the model. Using the atomic model as an example the growth of modern physics can be illustrated, showing the change from speculative Aristotelian thought to an empirically verified view of nature. The second theme, wave and corpuscle dualism can show the ideas of 'dualism' and 'complementarity' as essential to modern scientific thought. The third theme, by showing how a description of sound and certain light phenomena can be systematised by means of one basic concept, can create an awareness of the thought systems of physics and the structural orderliness of nature. Even by the non-physicists, this kind of approach can be appreciated, because it links, by specific examples, fundamental aspects of scientific ways of thinking.

The principle of choosing topics or themes so that they illustrate and link together a whole field is one that is also followed to a certain degree in the Netherlands, where out of 36 topics proposed for the examination syllabus, candidates are required to have studied only 17. In the United Kingdom, the attempt to give complete coverage to all topics may mean that no real understanding of any aspect of the subject is gained. The teacher has little time to follow up developments of proofs.

A major problem is presented for those designing courses in science subjects by the rapid advance of research, which means that the range of topics with which a pupil in the final two years of the academic secondary school might be expected to be familiar is widening at a rate equalled in no other disciplines. The tendency in many countries seems to be to include new material, without modifying in any way already overcrowded programmes. Yet for physics, where every advance on the part of the pupils demands full understanding of the previous step, the ability to master the way of thinking appropriate to the subject seems a pre-requisite.

Table X lists the official, semi-official and recommended books on teaching method.

TABLE X

OFFICIAL, SEMI-OFFICIAL AND RECOMMENDED BOOKS ON TEACHING METHODS

Austria	There are no official books, only a periodical which deals with pedagogical problems. 'Erziehung und Unterricht'
Belgium	There is a catalogue with works allowed by the Conseil de Perfectionnement.
Cyprus	There are no books as the teachers are free to use the methods they deem appropriate. Guidance is provided by the Inspectorate.

France	There are no official or semi- official books
Fed.Rep.of Germany	There are no official books. 'Die pädagogischen der Physik' is recommended. Verlag Georg Westermann.
Greece	The teachers are free to use appropriate methods under the guidance of the Ministry of Education.
Ireland	There are none.
Italy	The teachers are free to use appropriate methods.
Luxembourg	There is no official book. German methodologies are often used. Use also of OECD Enseignement de la Physique and American text books are consulted.
Netherlands	There are none.
Norway	These are contained in the official syllabuses.
Spain	There are few publications about method, the only one to be quoted is the journal 'Enseñanza Media' - it includes some articles about the didactics of sciences. Also used is the translation of the book 'Secondary Modern Science Teaching' published by the Science Masters' Association, London.
Sweden	Recommendations for teaching method are contained in Lüroplan för gymnasiet . The Board of Education will also publish lists of suitable apparatuses to be used and instructions for laboratory work.
Switzerland	Books recommended by many schools are : Lehrbuch der Physik - Seiler-Kardinier Polygraphischer Verlag Zürich Aufgabensammlung - Läuchli-Müller Orell Fussli - Zürich
Turkey	There are no official books on teaching method but a semi-official organisation supported by the government has had the following translated into Turkish : - 1. Physikalischer Experimente - Georg Planer 2. Science Education in British Schools 3. Physik und Chemie Unterricht - Baumann 4. Unesco Source Book for Science Teaching 5. Une conception moderne de l'enseignement de la physique 6. Enseignement actuel de la physique 7. Politique a suivre en matière d'enseignement scientifique

United Kingdom	There are no official books at all. There are semi-official books ; the publications of the Association for Science Education. 1. Modern Physical Science Reports (I and II) 2. School Science and General Education 3. The teaching of modern physics 4. Science teaching techniques (I-XI) 5. Science Teaching aids-physics 6. The teaching of electricity

CHAPTER VI

THE TERMINAL EXAMINATION

The majority of countries conceive of the terminal examination as a proof of the candidate's intellectual maturity and a demonstration of his achievement in a variety of academic disciplines. In all countries except the United Kingdom and Malta, although differentiation will have taken place to a varying degree in the last two or three years of the academic secondary school, the examination is a "certificate" examination, requiring the candidate to be proficient in a group of science, arts and social science subjects. Thus in most countries the terminal examination is regarded as evidence of the candidate's fitness for higher education, while at the same time, giving some indication of suitable fields of specialist study.

In the United Kingdom alone (Malta takes the United Kingdom A-Level examination) the terminal examination is a subject examination, in which the pupil undertakes study in three or four specialised subjects as a preparation for higher study.

With this exception all countries require candidates to take the three 'key' subjects, mathematics, mother tongue and modern languages (Capelle's 'communicators'). Physics does not take its place among these 'key' subjects and is not studied by all pupils in all countries at this level.

Although mathematics is a universal subject, in many countries physics is not usually required by pupils in arts sections for the terminal examination. In the Federal Republic of Germany, physics is not taught during the last two years of the classical and modern languages gymnasia. In Sweden, physics is taught only in the natural sciences and technology lines of the gymnasium, where mathematics, Swedish and modern languages are studied by all. In some countries the emphasis on mathematics is particularly evident ; for example, the Netherlands, where three papers are taken in mathematics, and one in physics.

However, physics is apparently considered to be the major science in many countries. In the Federal Republic of Germany, for example, in the mathematics and science gymnasium, physics is tested by a written examination, where chemistry and biology are examined orally. In section C of the baccalaureat in France, physical sciences alone are examined. There is an examination in biology in one section only, Section D, although candidates opting for this section must still take a paper in physical sciences.

In the United Kingdom, although the three 'key' subjects mentioned above are not compulsory in the terminal examination, mathematics is necessarily studied by all but a very few of those taking physics, and general courses in English are becoming increasingly widespread. Many candidates now take a paper entitled 'Use of English', although this is not yet compulsory. The usual combination of subjects for those taking physics is mathematics, pure and/or applied, physics and chemistry. There is a growing tendency for candidates to substitute another science (or in rare cases an arts) subject for chemistry.

Access to Higher Education

In most countries, as certain core subjects are studied by all pupils, the terminal examination is sufficient qualification for entry to all university faculties. In France, however, a supplementary test has been introduced for those taking Sections A and B of the baccalauréat (philosophy and economics) who wish to enter science faculties of the university. In the United Kingdom, although theoretically candidates are free to take the subject combination of their choice, in practice the universities demand certain subject combinations, and it is doubtful whether a prospective physics student would be accepted without a qualification in mathematics.

Some interesting figures were received on the percentage of drop-out from university physics courses during the first year of study. Unfortunately the figures were received very incomplete, but the divergence between those available indicates that this might be a valuable field for research.

These figures were given :	Belgium	80 %
	France	60 - 80 %
	Netherlands	40 %
	Malta	20 %
	Scotland	20 %
	Fed.Rep. of Germany	20 %

It is obviously impossible to reach any conclusions with such limited data and without considering all the variables which might affect a student's performance, but it is interesting that Belgium and France have such a high rate of drop-out. One possible reason for this might be that there has been up to now only limited differentiation in the latter years of the secondary school. As the tendency in France is now towards greater specialisation, it would be interesting to see if the rate of drop-out is decreasing. The drop-out seems smaller in Scotland and Malta, where there is a greater degree of specialisation in the schools. On the other hand, there is no apparent reason for the low drop-out rate in Germany, unless this can be attributed to the 'weeding out' process which takes place before the Abitur.

Structure of the examination (see tables XI and XII)

Two countries, Austria and Italy, examine physics orally ; alone in France, the Netherlands and Switzerland there is one written paper and an oral, although in the Netherlands only those candidates obtaining less than 70 % in the written paper are examined orally. In Germany, Ireland, Norway and Spain there only are written examinations. Countries with the most generous time allowance for examinations are Belgium, two written papers and an oral, and the United Kingdom, two written papers and a three-hour practical examination.

Sweden is the only country to use a system of continuous assessment. Physics is one of the subjects where marks obtained in central tests (administered annually during the last two years of the course) contribute to the pupil's final grade. Sweden is also the only country to have introduced objective testing methods, although one examining board in the United Kingdom is experimenting with these in the terminal examination for those following Nuffield courses in physics. Sweden has abolished essay questions in favour of problems and multiple choice or short answer questions. Candidates are usually expected to answer fifteen questions.

In the United Kingdom twelve questions and in most other countries three or four questions must be answered. In France, a joint paper in physics and chemistry (called physical sciences) is set and 75 % of the questions are on physics. Only Germany, Sweden and the United Kingdom offer any choice of question.

TABLE XI

THE TERMINAL EXAMINATION IN PHYSICS

The written Examination

	A	B	F	GR	EIR	I	NL	N	E	S	CH	GB
1. No.of written papers	none	two	one [1]	?	one	none	one	one	one	two [2]	one	two [3]
2. Time allowance in written examination	n.a.	2h	3h	3h	2½h	n.a.	3h	5h	2h [4]	3h	3h	3h + 3h [9]
3. No.of questions to be answered	n.a.	4	3-5	3	6	n.a.	5	4	2 [4]	15	4-8	12 [10]
4. Choice of questions	n.a.	none	none	none	6/10	n.a.	none	none	none	none	Yes [5]	12/24 [10]
5. Type of question [6] a - Question de cours b - Problem	n.a.	2 (a) 2 (b)	1 (a) 1 (b) [7]	(a) (b)	(a) (b)	n.a.	(a) (b)	(a) (b)	(a) (b)	10 (a) [8] 5 (b)	(b)	(a) (b)

Notes

1. ± ¼ of the examination paper also deals with Chemistry.
2. All answers in relation to Sweden refer to the system of continuous assessment as practised in the final year.
3. Answers for England refer to the London Matriculation Board.
4. Includes chemistry as well.
5. Usually one or two questions need not be answered.
6. Questions seem to fall into two categories :
   a) Question de cours : the candidate is asked a question which bears directly on a part of the course, a theory, a topic etc.
   b) Problem : the candidate is asked a question in problem form and has to think out for himself what are the relevant portions of the course.
7. The problem involves 2-4 interrelated questions.
8. 10 short-answer questions ; 5 problems.
9. There is in addition a three-hour practical examination.
10. 'Candidates may answer six questions on each paper'.

TABLE XIII - THE TERMINAL EXAMINATION IN PHYSICS

General

		A	B	F	GR	EIR	I	NL	N	E	S	CH	GB	DK
1. The examiners include :														
(i) candidate's teachers	(a)	-	x[2]	-	-	-	-	x	x	-	x	x	-	-
	(b)	-	x[2]	-	-	-	-	x	x	x	-	x	-	x
(ii) teachers from outside	(a)	-	-	x	-	x	-	-	x	-	-	-	x	x
	(b)	-	-	x	-	-	x	-	x	-	-	-	-	-
(iii) university teachers	(a)	-	-	-	x	-	-	-	-	x	-	-	x	-
	(b)	-	-	-	-	-	-	-	-	-	-	-	-	-
(iv) inspectors or official representatives	(a)	-	-	-	-	x	-	x	-	x	x	-	-	x
	(b)	-	-	-	-	-	-	x	-	-	-	-	-	x
(a) written examination (b) oral examination														
2. Is the examination (a) locally prepared [1] (b) centrally prepared		(a) (b)	(a)	(b)	(b)	(b)	(a)	(b)	(b)	(b)	(b)	(a)	(b)	(a) (b)
3. Is the pupil's school record taken into account at all		Yes	Yes	Yes	No	No	No	Yes	No	No	Yes	Yes	No	Yes

Notes

1) By 'locally prepared' is understood the school or immediate local body, an distinct from a more remote, central body.

2) Belgium : the candidate's teacher also prepares the question and corrects the scripts.

It is difficult to assess how complete a sampling of candidates' knowledge is made in each country without making a detailed analysis of examination papers. In Sweden during the two central tests, pupils must answer a total of thirty questions. The only country which compares with Sweden in the number of questions to be answered is the United Kingdom. Half an hour is allowed for each answer, which indicates that a fair degree of sophistication is required. In other countries, where as much as an hour is allowed for answers, questions asked are usually complex, drawing on many areas of knowledge and may ask the candidate to perform a variety of exercises. (Sample examination questions appear in Appendix III).

Papers are set externally in most countries, although in Denmark the class teacher is consulted (see Table XIII). Papers are set and corrected internally only in Belgium and Switzerland. One interesting point which emerges from a study of the structure of examinations is that although practical work is stressed in varying degrees throughout Europe (see chapter III, table VIII) practical examinations are held only in the United Kingdom. For Biology also, for which the role of practical work might be considered even more an integral part of the subject, three countries only - the United Kingdom, Malta and Norway - hold a practical examination. An example of the type of exercise candidates are required to perform in the practical paper of the terminal examination for physics in the United Kingdom appears in Appendix III. (Detailed studies of the terminal examination in a few countries appears in Table XIV).

TABLE XII - THE ORAL EXAMINATION

	A	B	F	D	EIR	I	NL	N	E	S	CH	GB
1. Is there a compulsory oral examination ?	Yes[1]	Yes	Yes	No	No	Yes[2]	Yes[3]	Yes	No	No	Yes[4]	No
2. Length of oral examination	15-30 min.	30 min.	15-20 min.	n. a.	n. a.	30 min.	20 min.	30-45 min.	n. a.	n. a.	10-15 min.	n. a.
3. Time allowed for preparation	30 min.	not given	12 20 min.	n. a.	n. a.	none	none	?	n. a.	n. a.	none	n. a.

Notes

1. Austria : A pupil selects three subjects in which to be orally examined, of which one may be physics.

2. Italy : There is no writen examination, but only an oral one.

3. Netherlands : Only if the writen mark is below 7-out of 10. In recent years, because of the shortage of examiners, itshas only been possible to examine orally either physics or chemistry.

4. Switzerland : The oral may be alternative to a writen examination.

TABLE XIV

NATURE OF THE ACADEMIC SECONDARY LEAVING EXAMINATION WITH SPECIAL REFERENCE TO PHYSICS

FRANCE

1. Can you list the subjects which are studied in the last two years of the secondary school ?

French, History, Geography, Civic Instruction, 1st Foreign Language, Maths, Physics, Physical Education

Terminal class only : Philosophy, Natural Sciences

In addition : 2 optional subjects, voluntary additional subjects. (This applies to Section C which undertakes the most detailed study of physics)

2. Can you list the subjects which are examined by a written paper and form a part of the terminal examination ?

Baccalauréat C	Coefficient *
French or Philosophy	2
1st Foreign Language	1
Mathematics	4
Physics	3

* The coefficient represents the number by which the candidate's marks are multiplied to give the final result.

3. How many written papers are there in physics ? - in other examinable subjects ?

1 paper concentrating mainly on Physics ($\frac{3}{4}$ or $\frac{2}{3}$) and in addition Chemistry ($\frac{1}{4}$ or $\frac{1}{3}$)

4. How much time is allowed for the physics examination ?

3 hours.

5. How many questions are there in the physics examination paper or papers ?

1 problem (2 to 4 questions) and generally 1 'question de cours'.

6. Is there any choice ? If so, how many questions must the pupil do ?

No choice.

7. What sort of questions are set ? e.g. 'questions de cours', 'problems' ?

1 problem with 2, 3 or 4 questions and in general 1 'question de cours'.

8. Is there an oral examination ? Is it compulsory or does it depend on the pupil's performance in the written examination ?

Yes. It is compulsory for all candidates who attain an overall average of between 8 and 12 out of 20 in their 4 written papers. Those who gain an average mark of more than 12 gain an unconditional pass, where those obtaining an average of less tham 8 are failed. Six oral tests are used to examine the less weighted subjects. Oral and written tests contribute equally in total to the final mark for the entire examination.

9. How long is the oral examination ? Is any time allowed for preparation ?

15 to 20 minutes. Sometimes the candidate is given 12 to 20 for preparation but this is not compulsory.

10. Who are the examiners ? a) for the written examination
b) for the oral examination

The same examiner is used for both the written and the oral examination. The examiners are teachers from a lycée other than the one the candidate attends.

11. Who prepares the examination ?

The Ministry of Education or heads of universities choose the topics.

12. Is the pupil's school record taken into account at all ?

Yes, in part. A baccalauréat candidate cannot be failed until the committee has examined his school reports.

1. Can you list the subjects which are studied in the last two years of the secondary school ?

At least five of the following, one of which must be Irish : - Irish, English, Latin, Greek, Hebrew, French, German, Italian, Spanish, History, Geography, Maths, Applied Maths, Physics, Agricultural Science, Botany, Physiology and Hygiene, Domestic Science, Art, Drawing, Music, Commerce.

2. Can you list the subjects which are examined by a written paper and form part of the terminal examination ?

All of the above : Art and Drawing do not require "writing" other than drawing and painting.

3. How many written papers are there in physics ? - in the other examinable subjects ?

One. Most subjects have only one paper, except Irish and English, which have two each. (Art and drawing have a number of options).

4. How much time is allowed for the physics examination ?

$2\frac{1}{2}$ hours.

5 How many questions are there in the physics examination paper or papers ?

10.

6. Is there any choice ? If so, how many questions must the pupil do ?

Yes. 6 out of 10.

7. What sort of questions are set ? e.g. 'questions de cours' 'problems'?

Questions requiring descriptive type answers. Also problems where appropriate.

8. Is there an oral examination ? Is it compulsory or does it depend on the pupil's performance in the written examination ?

No. (Pupils taking Applied Maths or any Science subject may be required to undergo a qualifying practical examination.)

9. How long is the oral examination ? Is any time allowed for preparation ?

———————

10. Who are the examiners ? a) for the written examination
b) for the oral examination

a) The candidates' work is examined by specialist teachers under the supervision of an inspector.

b) None.

11. Who prepares the examination ?

Inspectors of the Ministry for Education in consultation with Professors of the National University of Ireland.

12. Is the pupil's school record taken into account at all ?

No.

NETHERLANDS

1. Can you list the subjects which are studied in the last two years of the secondary school ?

In the last two years of the secondary school which undertake the most detailed study of physics the subjects are : Dutch, French, English, German, History, Geography, Maths, Physics, Chemistry, Biology, Economics, Astronomy, either Drawing or Book-keeping, Physical Education.

2. Can you list the subjects which are examined by a written paper and form part of the terminal examination ?

The following subjects are examined by a written paper in the terminal examination : Dutch (2 papers), French, English, German, Maths (3 papers), Physics, Chemistry.

3. How many written papers are there in physics ? - in the other examinable subjects ?

One paper in physics. Three papers in mathematics. One paper in Chemistry. Two papers in Dutch. One paper in French. One paper in English. One paper in German.

4. How much time is allowed for the physics examination ?

Three hours for the written examination + 20 minutes of oral examination. If a pupil gets 7, 8, 9, or 10 for the written paper, he is not obliged to do the oral examination. In some cases pupils gaining more than 7 marks still ask for an oral examination.

5. How many questions are there in the physics examination paper or papers ?

5 questions.

6. Is there any choice ? If so, how many questions must the pupil do ?

There is no choice.

7. What sort of questions are set ? e.g.'questions de cours' 'problems'?

See examples.

8. Is there an oral examination ? Is it compulsory or does it depend on the pupil's performance in the written examination ?

There is an oral examination for all pupils who have a mark below 7 for their written paper. (See also question 12)

9. How long is the oral examination ? Is any time allowed for preparation ?

The oral examination lasts 20 minutes. There is no preparation.

10. Who are the examiners ? a) for the written examination
b) for the oral examination

The teacher is the examiner for the written and the oral examination. A specialist in physics, chemistry and/or biology joins him for the final examination. He is sent to the school by the

Ministry of Education, together with specialists for the other disciplines. The teacher and the specialist mark the written paper and preside together for the oral examination. Together they allot the final mark.

11. Who prepares the examination ?

Two inspectors, specialised in physics, consulting some teachers, set the written examination paper for the schools all over the country.

12. Is the pupil's school record taken into account at all ?

For the last 5 years, because of the lack of specialists which can be sent to the schools, either physics or chemistry is examined in the oral examination. Biology is always examined orally, for there is not a written examination. For the discipline that is not examined orally the mark for the oral examination is replaced by the mean school record of the pupil in the 5 th class and this record, together with the mark for the written paper, is taken into account for stating the final mark for the discipline.
(this system will be changed in 1974).

NORWAY

1. Can you list the subjects which are studied in the last two years of the secondary school ?

Religion, Norwegian, English, French, History, Physics, Mathematics, Physical Education, Music.

2. Can you list the subjects which are examined by a written paper and form part of the terminal examination ?

Norwegian, English, Physics, Mathematics.

3. How many written papers are there in physics ? - in the other examinable subjects ?

One.

4. How much time is allowed for the physics examination ?

5 hours (300 minutes)

5. How many questions are there in the physics examination paper or papers ?

The examination paper comprises 4 principal parts, two of which are of a theoretical nature.

6. Is there any choice ? If so how many questions must the pupil do ?

No.

7. What sort of questions are set ? e.g. 'questions de cours''problems'?

Mixed.

8. Is there an oral examination ? Is it compulsory or does it depend on the pupil's performance in the written examination ?

The oral examination is compulsory.

9. How long is the oral examination ? Is any time allowed for preparation ?

30 -45 minutes.

10. Who are the examiners ? a) for the written examination
b) for the oral examination

a) The Council of the Gymnasium (Governmental central board) nominate the examiners among the physics teachers
b) The Council nominate one teacher from another school. Class teacher examines.

11. Who prepares the examination ?

The Council of the Gymnasium.

12. Is the pupil's school record taken into account at all ?

So far school record is not listed. From 1970 the school record will be included in the final assessment.

SPAIN

1. Can you list the subjects which are studied in the last two years of the secondary school ?

   For students who choose the Science branch, these are : Religion, Spanish, History, Philosophy Natural Science, Modern Languages (French, English, German, or Italian), Civics and Political Education, Physical Education, Mathematics, Physics, Chemistry.

2. Can you list the subjects which are examined by a written paper and form part of the terminal examination ?

   There are two kinds of tests, i.e. the Common test which is the same for students of both sections plus the Specific Test.

   Common Test : a) a written paper (1 hour) of one of the following subjects : History, Spanish Literature, Biology, Geography of Spain, Religion
   b) a written report (1 hour) of a talk given by one of the examiners about one theme of one of the subjects listed above.
   c) one oral examination on a modern languages.

   Specific Test : a) a written paper on Chemistry and Physics.
   b) a written paper on Mathematics

3. How many written papers are there in physics ? - in the other examinable subjects ?

   Only one in Physics. - In the other examinable subjects there are four more.

4. How much time is allowed for the physics examination ?

   Two hours with Chemistry.

5. How many questions are there in the physics examination paper or paper ?

   One essay, plus one problem, but the candidate can take the Physics problem or one problem of chemistry.

6. Is there any choice ? If so, how many questions must the pupil do ?

   Yes. - One question or theme involving several questions. There is a choice about the problem as explained above.

7. What sort of questions are set ? e.g. 'questions de cours''problems'?

   "Questions de cours" (compulsory) plus one problem of Physics or Chemistry.

8. Is there an oral examination ? Is it compulsory or does it depend on the pupil's performance in the written examination ?

   No.

9. How long is the oral examination ? Is any time allowed for preparation ?

10. Who are the examiners ? a) for the written examination
b) for the oral examination

Any of the three members of the Board, two of which are Professors at the University and the other is a High School teacher or a Secondary School Teaching Inspector.

11. Who prepares the examination ?

The "Jefatura de Examenes" - Inspección Central de Enseñanza Media - Dirección General de Enseñanza Media - Ministerio de Educación y Ciencia (Address: Guzman el Bueno, 94 - Madrid - 3).

12. Is the pupil's school record taken into account at all ?

No.

SWEDEN

1. Can you list the subjects which are studied in the last two years of the secondary school ?

The new gymnasium is divided into 5 lines : Humanities, Social Sciences, Economics, Natural Sciences, Technology. Physics is studied only in the two last mentioned lines, the same curriculum in both. The other subjects in the last two years of the Natural Sciences line are : Swedish, English, French or German (in grade 2, one of these or English in grade 3), History (finished in grade 2), civics (in grade 3), Philosophy (only in grade 3), Religion (only in grade 3), Mathematics, Physics, Chemistry, Biology.

2. Can you list the subjects which are examined by a written paper and form part of the terminal examination ?

In the new gymnasium there exist no final examination papers. Instead there are 'central tests' given by the National Board of Education, spread out during the last two years. The subjects which are controlled in this way are for the Natural Sciences line Swedish (twice), English, French or German, Mathematics (twice) and Physics (twice).

3. How many written papers are there in physics ? - in the other examinable sub cts ?

See answer to question 2.

4. How much time is allowed for the physics examination ?

3 hours is allowed for the physics examination.

5. How many questions are there in the physics examination paper or papers ?

There are about 15 questions, 10 short answer questions, some with open ended answers, others of multiple choice type, and about 5 problems of about the same type as in the old gymnasium.

6. Is there any choice ? If so, how many questions must the pupil do ?

No choice. The pupil has to do as much as he is able to. By means of a sample among the students the mark scale will be fixed in such a way as is seen by the table below.

Mark	1	2	3	4	5
%	7	24	38	24	7

1 is the lowest mark, 5 the highest; this normal distribution is valid for the whole country. Then the teachers can compare their own results with this mean result in this way finding out on what level their pupils stand.

7. What sort of questions are set ? e.g. "Questions de cours", "problems" ?

See answer to question 5.

8. Is there an oral examination ? Is it compulsory or does it depend on the pupil's performance in the written examination ?

No, there is no longer any oral examination.

9. How long is the oral examination ? Is any time allowed for preparation ?

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10. Who are the examiners ? a) for the written examination
b) for the oral examination

The central tests are settled by the National Board of Education and corrected by the teachers, using directions from the Board of Education. A special corps of inspectors, gymnasium inspectors, visit the schools now and then and control that the marks given by the teachers are reliable.

11. Who prepares the examination ?

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12. Is the pupil's school record taken into account at all ?

When the final marks are set by the teachers they have to take into consideration all the records of the pupils. The certificate gives entrance to the university if the mean mark is 2.3.

SWITZERLAND

1. Can you list the subjects which are studied in the last two years of the secondary school ?

   Mother tongue, second language of Switzerland, History, Geography, Mathematics, Physics, Chemistry, Biology, Drawing.
   In addition for Type A : Latin and Greek
   for Type B : Latin and English or third language of Switzerland
   for Type C : English and Geometry.

2. Can you list the subjects which are examined by a written paper and form part of the terminal examination ?

   The same as under 1. when examinations are carried out by the secondary schools.

3. How many written papers are there in physics ? - in the other examinable subjects ?

   In most subjects there is one written paper. In history, geography, physics, chemistry and biology the examination may be oral only.

4. How much time is allowed for the physics examination ?

   Usually 3 hours.

5. How many questions are there in the physics examination paper or papers ?

   This depends upon the type of questions ; from 4 to 8.

6. Is there any choice ? If so, how many questions must the pupil do ?

   Usually one or two questions must not be answered.

7. What sort of questions are set ? e.g. 'questions de cours''problems'?

   Problems. Example : Calculate the maximum speed and the time of revolution of a satellite having a minimum height of 240km and a maximum height of 400km.

8. Is there an oral examination ? Is it compulsory or does it depend on the pupil's performance in the written examination ?

   Oral examinations may take place instead of written ones. If so, they are compulsory.

9. How long is the oral examination ? Is any time allowed for preparation ?

   Ten to fifteen minutes. No time for preparation.

10. Who are the examiners ? a) for the written examination
    b) for the oral examination

    For students at public schools the student's teacher is also his examiner. Private schools cannot examine their own students. For these, federal examinations are organised twice a year, where physics teachers of public schools examine.

11. Who prepares the examination ?

The examiners themselves.

12. Is the pupil's school record taken into account at all ?

Yes, for students of public schools, but not for private schools.

UNITED KINGDOM

1. Can you list the subjects which are studied in the last two years of the secondary school ?

   Two, three or four main subjects (a wide variety). Most schools add a number of subsidiary or balance subjects up to about $\frac{1}{3}$ of the total timetable.

2. Can you list the subjects which are examined by a written paper and form part of the terminal examination ?

   All the main subjects which, on the science side would probably be a selection from Pure Maths, Applied Maths (or just papers labelled Maths). Physics, Chemistry Biology (or Botany and Zoology). A science candidate might include an Arts subject e.g. English, and it is likely that all candidates would take some such papers as 'Use of English' and/or a 'General Paper'.

3. How many written papers are there in physics ? - in the other examinable subjects ?
4. How much time is allowed for the physics examination ?

   Usually two papers of about $2\frac{1}{2}$ - 3 hours plus a 3-hour practical examination. An 'S' level candidate would have an additional 3-hour paper. Other science subjects would be much the same.

5. How many questions are there in the physics examination paper or papers ?

   About 10 to 12.

6. Is there any choice ? If so, how many questions must the pupil do ?

   Yes - a choice of 5 or 6 questions, perhaps grouped into sections.

7. What sort of questions are set ? e.g. 'questions de cours''problems' ?

   The standard question is part book work and part problem but great variation is possible.

8. Is there an oral examination ? Is it compulsory or does it depend on the pupil's performance in the written examination ?

   No.

9. How long is the oral examination ? Is any time allowed for preparation ?

   ____

10. Who are examiners ? a) for the written examination
    b) for the oral examination

    a) A panel of examiners is appointed by the examination boards and great care is taken to standardise the marking. The examiners are usually teachers in schools or universities.
    b) ______________

11. Who prepares the examination ?

    This is arranged by the Examination Boards.
12. Is the pupil's school record taken into account at all ? No.

CHAPTER V

THE ROLE OF PHYSICS IN THE CURRICULUM OF THE ACADEMIC SECONDARY SCHOOL

In the majority of countries official programmes prescribe a nucleus of obligatory subjects and a variety of optional subjects for study, with a compulsory number of hours to be devoted to each. The United Kingdom is the only country to have total freedom in the choice of subjects taught and in the allocation of time. This autonomy of control means, however, that provision of courses may be uneven, especially in small schools, where centralised control of timetables ensures a greater degree of uniformity throughout the country. Unlike some of the newer social sciences, physics has taken its place as one of the basic subjects of the school curriculum and receives a generous time allowance in all C.C.C. member States.

Length of school course in physics (see Table XV)

Most countries begin instruction in general science when pupils are 11 or 12 years old, and in specialised physics at 14-15 years. An exception to this pattern is Italy, where no specialised physics is taught until pupils are 16 years old. No general science is taught in the Federal Republic of Germany, but instruction in specialised physics begins at 13 years. There are even some experimental courses where physics is taught from the age of 10 or 11.

The duration of courses leading to the terminal examination is usually 3 or 4 years ; exceptions to this are Malta and the Federal Republic of Germany, 6 years, and the United Kingdom and Belgium, 5 years although in the latter country, the total number of teaching hours for the course is very small (see Chapter II).

Allocation of time

Allocation of time for physics is shown in Table XVI. The countries devoting the most time to the subject are Norway and the United Kingdom (six periods per week) ; Cyprus spends seven periods per week on science, but the proportion of physics included is unknown. Another seven periods a week are taken up in Cyprus by mathematics, and six with modern languages. In the United Kingdom, six periods might be given to mathematics, but in most cases none to languages. The Federal Republic of Germany, France and Sweden devote less time per week to physics (4 or 5 periods) but in each of these countries a range of other subjects must be studied in depth : France, 3 hours philosophy, 8 hours mathematics, 2 hours French, and 2 hours modern languages per week ; Germany, 5 hours mathematics 6 hours modern languages, 3 hours Swedish. In addition, a variety of minor subjects are studied ; history, geography, civics and others such as psychology and history of music and art in Sweden.

Range of science subjects

In most countries, the most specialised sections studying science at upper academic secondary level take two or three science subjects, excluding mathematics which is compulsory in all countries except the United Kingdom, Ireland and Malta. (Even here mathematics is almost always taken by intending physicists, see Chapter IV). These sciences are almost invariably physics, chemistry and biology, although Italy and Switzerland list geography as a science. In fact geography is one of the two sciences studied by pupils in the final year of the liceo scientifico. Where two sciences only are studied, physics and chemistry is the usual combination. The increasing difficulty of drawing any rigid distinction between physics and chemistry has brought about the emergence of a new discipline in France ; physical sciences, where these two formerly separate sciences are taught together.

Teachers and pupils

At the time of writing this report, little information was available on the size and composition of classes in physics. Some figures were received on the ratio of boys to girls studying physics at this level, which seem to support the claim that physics is a 'masculine' subject. These figures were :

Belgium	3 - 1
France	3 - 2
Fed. Rep. of Germany	3 - 1
Malta	5 - 1
Netherlands	4 - 1
Switzerland	3 - 1

A further point of interest emerged from information received on the most usual post-university careers chosen by those following the most specialised physics courses in the academic secondary school. These were as follows (listed in descending order of importance) :

Belgium	: Research, teaching
France	: Engineering and technology, teaching, research
Fed.Rep. of Germany	: Industry, teaching and research
Malta	: Engineering, research
Netherlands	: Industry, research, teaching
Norway	: Research, teaching

There appears to be a considerable degree of similarity between the professions taken up by graduate physicists in the various European countries, all of which allow for the continuation of specialised scientific work. All those professions listed permit the science graduate to apply his knowledge directly to his professional life. The same would hardly be the case for a graduate in philosophy or classics.

Subsquent research might investigate whether there is as much similarity between professions chosen by graduates from other disciplines. It might also be interesting to find out whether study of physics provides a more relevant preparation for professional life than study of the arts or the social sciences.

Detailed information is given on the training of science teachers in the companion report on Biology (European Cuuriculum Studies : no. 3 : Biology, A. Saunders, 1970) and it would be purposeless to repeat that here.

Professional associations (see Table XVIII)

In all countries for which information was received (except Cyprus) there is a professional national organisation concerned with the teaching of physics. Most of these organisations publish journals, through which opinion can be expressed, new pedagogical theories discussed and a favourable climate for reform created. It is in most cases informal pressure of this type that helps to bring about modifications in official programmes.

TABLE XV

LENGTH OF COURSE IN PHYSICS

In the academic secondary school from what age are
a) general science,
b) physics taught as separate subjects ?
For how many years is each subject studied ?

Belgium	a) General science begins at 12 years old, b) Physics as a separate subject first taught at 13 years, chemistry and Biology at 14 years, Duration of course in General Science · 1 year Duration of course in Physics : 5 years
Cyprus	a) General Science begins at 11 years b) Physics begins at 14 years Duration of course in General Science : 2 years Duration of course in Physics : 4 years
France	a) General Science begins at 11 years (1st year of secondary education) b) Physics begins at 14 years for modern sections and at 15 years for all other sections Duration of course in General Science : 4 - 5 years Duration of course in Physics : 3 - 4 years
Federal Republic of Germany	a) No General Science taught as yet, but may be introduced in the future b) Instruction in Physics begins at 13 years and the course lasts 6 years Some schools are experimenting with Physics courses beginning at 10 or 11 years.
Italy	a) General Science taught only in scuola media unica. Course begins at 11 years and lasts 4 years b) Physics : Liceo scientifico : course begins at 16 years and lasts 3 years - Liceo classico : course begins at 17 years and lasts 2 years.
Malta	a) General Science : 11 years. Course lasts one year b) Physics : taught as a separate subject from 12 years onwards. Course lasts 6 years.

TABLE XVI

NUMBER OF LESSONS DEVOTED TO THE SYLLABUS IN PREPARATION FOR THE TERMINAL EXAMINATION ?

a) the number of years
b) the number of lessons per week
c) the number of teaching weeks per year
d) the length of lessons, on average, in minutes

Austria	a) 4 years b) 2 or 3 lessons per week c) about 36 weeks per year d) 50 minutes
Belgium	a) terminal class b) 2 lessons per week c) about 30 weeks per year d) 50 minutes
Cyprus	a) the examination syllabus is identical to the syllabus of the final year. b) this varies with subject and section Section — Lessons Classical — 3 Agricultural — 3 Science — 7 Economic — 2 Technical — 4 c) 30 weeks per year d) 45 minutes
France	a) Baccalauréat Physics is studied in 1 year. Questions set in the examination have to be drawn from the syllabus of this class. b) In the last three classes there are 2½ hours of lessons and 1½ hours of practical to be divided between Physics and Chemistry. c) 34-35 weeks per year (last 3 years often 32 weeks). d) 60 minutes for lesson ; 90 minutes for practical
Federal Republic of Germany	a) Mittelstufe 3 years Oberstufe 3 years b) 2 - 3 - 2) / 3 - 4 - 4) lessons per week c) 40 weeks per year d) 45 minutes

Netherlands	a) There is no course in General Science ; instruction in Biology begins at 12 years and the course lasts 4 years. Chemistry is taught from 14 years onwards and the course lasts 4 years. b) Physics is taught as a separate subject from 13 years onwards: the course lasts 5 years
Scotland	a) General Science taught as separate subject from 12 years onwards (i.e. 1st year of secondary education) b) In some Schools General Science is subdivided into Physics, Chemistry and Biology from the beginning, i.e. age 12. In others, the subjects are taken together for the first 2 years. Physics then begins as a separate subject at age 14. It is not possible to give a length of study which applies generally, as pupils have considerable freedom in choosing their subjects of studied, but about 25-30 % of academic pupils continue physics to 'O' grade (3-5 years' study)
Switzerland	a) General Science taught as separate subject from about 12 years old (mainly Biology) b) Physics is taught as a separate subject from 15 years old. The course lasts about 4 years.

Greece	a) 2 years b) 4 lessons per week c) 30 weeks per year d) 50 minutes
Ireland	a) 2 years b) In order to get a special grant for science it is necessary to have at least 3 hours per week. c) 30-32 weeks per year d) 40-45 minutes
Italy	For the liceo scientifico (final examination is oral) : a) 3 years b) 2 + 3 + 3 lessons per week c) 34 weeks per year d) 60 minutes
Luxembourg	a) Usually last year only (plus basic knowledge from earlier years) b) 3 (2½) lessons per week in the Latin section of the Scientific Branch 4 lessons per week in the modern languages section of the Scientific Branch c) 40 weeks d) 55 minutes for 4 days of the week and 45 minutes for the other two.
Netherlands	Final examination is oral, in Gymnasium B a) 4 years b) <u>Gymnasium B</u>

	13 - 14	14 - 15	15 - 16	16 - 17	17 - 18
Gymnasium B		2	2	3	3
H. B. S.	2	3	4	5	

Final examination is written and oral.

c) 38-39 weeks per year
d) 50 minutes

Norway	a) 3 years b) 0 + 6 + 6 lessons per week c) 38 weeks per year d) 45 minutes.

Spain

a) After the 4th year pupils take one of two branches, Science, Humanities. The upper Cycle is two years and after this there is a final exam. for those not wanting to enter university there is the Pre-University year. After this there is a Maturity test given at the university which gives access to any university for any faculty

b) A Humanities student has 84 hours of physics
A science student has roughly :

84 hours	5th year
112 hours	6th year
112 hours	Pre-University year
308 hours of physics when be enters the university	

c)

d) 60 minutes

Sweden

There is no terminal examination in the new Gymnasium. Marks are given by the teacher when the pupil leaves school and are founded on continuous assessment and tests during the 3 years at the gymnasium. The answers give the total time that has been devoted to physics in the gymnasium.

a) 3 years
b) 2.5 + 4 + 4 lessons per week
c) Officially 39 weeks but about 6 are lost for tests, sport etc.
d) 40 or 45 minutes

Switzerland

a) A student can prepare for the final examination in 2 years in a private school but in a state school the physics course lasts from 2-4 years
b) e.g. 3 lessons a week over $2\frac{1}{2}$ years
c) 40 weeks
d) 45 minutes

Turkey

a) 3 years (Final examination is only concerned with last year's course)
b) Lycees

	Yr. 1	Yr. 2	Yr. 3
Science section	3	3	4
Lit. section	3	2	2

c) About 36 weeks per year
d) 45 minutes

United Kingdom

All figures are approximate

a) England and Wales 7 years, Scotland 5 or 6 years
b) 27 over 7 years for England, 19 over 5 or 6 years for Scotland
c) 40 weeks per year
d) 35-45 minutes

TABLE XVII

BALANCE OF SCIENCE SUBJECTS IN UPPER ACADEMIC SECONDARY SCHOOL

a) What sciences are taught in the final three years of the academic secondary course ?
b) How many sciences are usually studied at once at this level ?

Belgium	a) Physics, Chemistry, Biology b) Three
Cyprus	a) Physics, Chemistry, Biology (introduced into final year in 1968) b) All three sciences are compulsory, with some variation in depth for science and classics sections
France	a) Physics. Chemistry or Biology b) Two or three
Federal Republic of Germany	a) Prepenultimate year : Physics and Chemistry studied by all pupils, Biology by 70 % Penultimate and final years : Physics 30 %, Chemistry 50 % Biology 70 % b) Science branch : 3 sciences during penultimate year ; thereafter 2 sciences at choice Language branch : 3 sciences during penultimate year, thereafter one, at choice (usually Biology)
Italy	a) All pupils study same syllabus Prepenultimate year : liceo classico, Natural Science Liceo scientifico, Physics and Natural Science b) Penultimate year : liceo classico : Physics and Chemistry liceo scientifico. Physics and Chemistry Final year : liceo classico Physics and Geography ; liceo scientifico, Physics and Geography
Malta	a) Prepenultimate year : General Science is compulsory Penultimate and final years : Physics 80 %, Chemistry 50 %, Biology 30 % b) Two, Usually Physics and Chemistry or Chemistry and Biology
Netherlands	a) Physics, Chemistry, Biology (70 % of pupils) b) Three

Scotland	a) Course leading to academic secondary terminal exam begins in penultimate year Penultimate year : Scottish Certificate of Education, Ordinary Grade - Chemistry (13990 entrants), Physics (13405 entrants), Biology (5221 entrants) Final year : Scottish Certificate of Education, Higher Grade - Chemistry (19455 entrants), Physics (9095), Biology (2210 entrants) b) Two sciences usually studied together (three only rarely). Usual combinations : Physics, Chemistry, - Chemistry, Biology
Switzerland	a) (Details apply to type C of Oberrealschule) Prepenultimate year : Mathematics, Physics, Chemistry, Biology, Geography Penultimate year : Same as for prepenultimate year Final year ; Mathematics Physics Biology b) The subjects listed above are compulsory for all sections

TABLE XVIII

PROFESSIONAL NATIONAL ASSOCIATIONS CONCERNED WITH THE TEACHING OF PHYSICS

Belgium	Association Belge des Professeurs de Physique et Chimie (ABPPC)
Cyprus	None
France	Union des Physiciens, Paris. This organisation publishes a magazine
Federal Republic of Germany	There are institutes conducting research into pedagogy which publish reports in the 'Zeitschrift für den mathematisch - Naturwissenschaftlichen Unterricht' (Dummler Verlag, Bonn) or in the 'Zeitschrift für Naturlehre und Naturkunde' (Aulis Verlag - Köln) An example of this is the Institut für die Pädagogik der Naturwissenschaften an der Universität Kiel
Italy	Societá italiana di fisica (undertakes physical research). Associazione per l'insegnamento della fisica (studies didactic and methodological problems). These two organisations have been set up to deal with all problems concerning the teaching of physics.
Malta	A science Panel Board has recently been formed, which is responsbile for television instruction in science, and for publishing a set of books based on the Nuffield scheme.
Netherlands	Committee for Revision of Physics Curricula (Dr F. Balkema, Mennoter BRAAKLAAN 124, Delft) No publications as yet.
Norway	None
United Kingdom	Association for Science Education (mainly a forum discussion. Publications : Education in Science, School Science Review) Institute of Physics and the Physical Society (Publications : Physics Education, Physics Bulletin)
Switzerland	Verein Schweizerischer Mathematik - und Physiklehrer (Association for Teachers of Maths and Physics in Switzerland). This is part of the Association for teachers in the Gymnasium (verein Schweizerischer Gymnasiallehrer). This organisation writes for the "Gymnasium Helveticum" and produces publications of its own

CHAPTER VI

FUTURE TRENDS

Until comparatively recently a main purpose of physics teaching was seen as the laying of a foundation of classical physics. Modern physics and its applications was regarded as the function of the University or Technical Institute. This is not a stimulating course even for those who will read physics at university and many will not carry on with the subject after leaving school. It is clearly wrong to leave these latter pupils in ignorance of the principles of the modern technology of their everyday experience. Over the years syllabuses have been changing in an endeavour to keep pace with contemporary physics and its applications and this trend will undoubtedly continue.

The traditional essay type of question is in a few cases giving way to the multiple choice type of question. This certainly assists marking problems and, at the same time, can be a searching test of understanding. The use of modern evaluation techniques is graduadlly becoming more widespread.

In the United Kingdom the Nuffield Physics Project has given a new dimension to physics teaching with its aim that, as far as possible, pupils should discover the subject for themselves through their own individual practical work. (See also Chapter III, Physics Teaching Methods, section headed "United Kingdom"). This has necessitated the pruning of some well-established material, Archimedes Principle for Example. A full scale programme has been developed with guide books to the the experiments and to the teaching approach* up to 'O' level or the 16 yr. stage. The next stage up to 'A' level, 18 yrs. is still in the pilot scheme development. At the moment many schools are not following the Nuffield project but it is having a definite effect on teaching methods, syllabus content and style of examination question and it would appear that this influence will continue.

Chemistry and Physics show considerable overlap in a number of vital topics such as kinetic theory, the structure of matter in general and the atom in particular, electrolytic actions and the general concept of energy. It would seem wasteful and perhaps even confusing to present the pupil with these fundamental topics from two different aspects. This point is already recognised in France where physical sciences is taught rather than physics and chemistry as separate subjects and in Sweden the impossibility of distinguishing between atomic chemistry and atomic physics is frankly accepted. In England some schools are pioneering in a physical sciences project and discussions are taking place at various academic levels. But with the present depth of study in the United Kingdom in both subjects, many specialist chemists and physicists would be some what daunted at the prospect of accepting a full commitment in the other subject. This difficulty could be overcome for new teachers by suitable university courses while conversion courses could be used to bridge the gap for existing teachers. It could well be that physical sciences will be a subject of the future.

Table XIX future changes contemplated in the physics programmes in the C.C.C. member countries.

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* Question books for each year are also available and text books following the Nuffield syllabus are now appearing (on the market).

TABLE XIX A - FUTURE CHANGES IN PHYSICS PROGRAMMES

Austria	New syllabuses were brought into force in 1967 for pupils aged 15. This means that pupils have to attend secondary school for 9 years instead of 8 years as they did formerly. The new syllabus will be valid for all classes in 5 years time.
Belgium	The present syllabus has only been in force for about 4 years.
Cyprus	A new syllabus for the VI form, following the Education Reform, completed in 1967.
France	There was a reform of the second cycle of secondary education in 1965. The new rules are in force for the 1st and 2nd classes for this academic year (1966-1967) but the old rules still apply for the Mathématiques Elémentaires branch. The new rules were entirely in force by 1967-1968. Reforms 1. additional 30 minutes physics in the 2nd and 1st classes less 30 minutes in Terminal C. 2. Syllabus 2ns class : addition of vector relation p = mg; kinetic theory of gas; new definition on the quantity of heat notion of transformation of heat to work 1st class : notions of electrostatics; introduction of notion of electrostatic potential; condensors and notions on alternating current Terminal : the topics introduced into the syllabus of the 1st class were taken from the terminal class. Additional topic : nuclear reactions
Federal Republic of Germany	There was a new plan in 1962.
Greece	None
Ireland	None. (Syllabus review is due every five years).
Italy	All syllabuses are under general review in order to modernise them and make them more formative.
Luxembourg	In the Latin section in recent years more kinematics and mechanics has been taught while electricity has been incorporated into the syllabus for the preceding year.

Netherlands	This is in discussion in a governmental committee. It is hoped that there will be a change of emphasis from just facts to more understanding and creative thinking.
Norway	There are 5 parallel courses, 3 of which are modern. The modern courses are still being developed but they are already in force.
Spain	No definite answer.
Sweden	The new syllabus has started in 1966 in the first class. The last student examination following the old course took place in 1968. The differences in physics are not very great. The new course has less statics and more dynamics, less geometrical and more optical physics, less calorimetry, thermal expansion of solids but much more kinteic theory of gases, less d.c. and more a.c. A great deal is added in the new course of nuclear physics, semi-conductivity etc. New topics : geophysical applications of meteorology chinatology, seismology
Switzerland	New syllabuses are being tried out in some schools but federal maturity rules will not be changed very quickly. Atomic physics is gaining in importance, but slowly. The tendency is to stress general notions rather than details.
Turkey	The Ministry wants to improve the syllabuses. A science lycée was set up in Ankara some years ago where modern American syllabuses were adopted. From the beginning of this year another lycée in Ankara has started to experiment with the same material. Next year other schools will begin to use the new material. PSSC physics is in use in 2 schools.
United Kingdom	Changes at A Level are gradual. The work of the Nuffield Science Teaching Project will have a profound effect eventually, but probably not in the near future. The trend is towards a stressing of the unifying concepts of physics. Scotland : The present syllabus is a recent development and no particular changes are expected in the near future. N. Ireland : As Scotland.

TABLE XIX B - FUTURE CHANGES IN TEACHING METHODS

Describe briefly any changes in teaching methods contemplated (e. g. use of teaching machines, language laboratories, re-appraisal of role of practical work).

Austria	No change.
Belgium	No change.
Cyprus	Teaching methods have been moving toward more active participation of the pupils. With regard to practical work it is the policy of the Ministry of Education to equip all schools with science laboratory facilities during the next 5 years to facilitate individual work by the pupils. Educational television has been introduced for physics as from this year for lower secondary forms. It is envisaged that these programmes will gradually extend to the upper forms.
France	Many teachers are seeking to improve the quality and interest of practical work after the publication of Brochure No. 110 IPN (Lazerges). There is constant improvement of the apparatus used.
Federal Republic of Germany	Strong emphasis on individual work by the pupils. History of physics in the sense of Problemgeschichte.
Greece	No change.
Luxembourg	No change.
Ireland	No change.
Italy	No change.
Netherlands	This is being discussed - nothing can be said at the moment.
Norway	No remarks.
Spain	Constant drive to give experimental work more importance in physics but there is difficulty with numbers and lack of teachers.
Sweden	Use of overhead projector and internal television for better demonstration of physics experiments have been introduced over the whole country this year. Another new thing in the gymnasium is individual tasks for the pupil. He can do some research into a problem outside the scope of the course and must spend 30-40 hours on it.

Switzerland	a) Practical work in small groups b) Courses on special subjects e. g. Hydrodynamics
Turkey	The Ministry of Education hopes to change the syllabus to give more emphasis to individual work by the pupils, to initiate them into the method of discovery. Special commissions are working on this.
United Kingdom	Experiments in teaching method are not nationally directed. The main influences recently have been the work of the Association for Science Education.

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A IX I

T PHYSICS SYLLABUS IN CCC MEMBER COUNTRIES

(with an indication of the extent to which each topic is studied)

		A	B	CY	F	D	L	EIR	I	NL	N	S	E	CH	TR	SL	GB
530.11	Principle of relativity		c		c	c						c		(b)			
	Equivalence of mass and energy	c	c	b	b	b		c	c	c	c	b		(b)			
	Mass defect	c	c		b	b				b	c	b	c	(b)			
.12	Wave mechanical model of atom		c	c		b						c	b	(b)			
	Quantisation of energy in atom	c	b	c		A				b	c	c	b			c	b
.13	Wave as a propagation of a disturbance and as a form of energy	b	b	b	c	A	c	b		A	c	b	c	b	b	b	
	Propagation of waves in elastic media	b	b	b	c	c	b	b		A	c	b	c	b	b	c	
	Transverse waves in liquids, solids, gas		A	b	A	c		b		A	b	c	b	b	b	b	
	Wavelength, period, frequency	A	A	A	A	A	b	A	b		A	A	b	A	A	A	
	Longitudinal waves	b	A	b	A	A		b		A	b	b	b	b	b	b	
	Group velocity, phase velocity		c			c				A							
	Wave velocity	c	A	A	b	b	b	A		A	A	b	c	b	c	b	
	Phase difference	b	A	A	b	b	b	b		A	A	b	b	b	b	b	
	Graphical representation of waves	A	A		A	b	b		b	A	b	b	b	b	b	b	
.14	Reflection of waves	b	b	A		A	c	A		b	c	b	b	c	b	A	b
	Refraction of waves	b	b	A		A	c	A		b	c	b	b	c	b	A	b
.15	Interference of waves	b	A	b	b	A	b	A		A	c	b	A	b	b	A	b
	Diffraction of waves	b	A	b		b	b	A		b		b	A	b	c	b	b
	Standing waves	b	A	b	A	A	b	A		A	A	b	A	b	b	b	b
.16	Doppler effect	b	A			b				b		c		(b)	b		b
.17	Polarisation	b		b	c	A	b			b					c	b	b
	Forced vibrations	c		b	c	b				c		c			c	b	b
.18	Resonance	b	b	b	b		c	c	c	b	b	c	b	c			b
531.11	Uniform motion in a straight line	b	A	A	A	A	A	A	A	A	A	A	b	A	A	A	b
.12	Irregular motion in a straight line	c	c	A	A	A		A	A	b	c	b	b	b	c	c	b
.13	Uniformly accelerated motion in a straight line	b	A	A	A	A	A	A	A	A	A	A	b	A	b	A	b
	Acceleration	c	A	A		A	A	A	A	A	A	A	b	A	b	A	b

		A	B	CY	F	D	L	EIR	I	NL	N	S	E	CH	TR	SL	GB
.14	Velocity and acceleration as scalars and vectors	c	A	A	A	A	A	A	A	A	A	A	b	A	b	A	b
.15	Uniform motion in a circle	b	A	A	A	A	b	A	A	A	A	A	A	A	b		b
.16	Angular acceleration	c	A	A	b	A		A	b	b	b	c	A	b			b
.17	Linear momentum. Law of conservation	b	b	A	A	A	b	A	A	A	b	A	b	b	b	A	b
.18	Angular momentum. Law of conservation	c		A	b	A		A	A	b		c	b	(b)	c		b
.21	Parallelogram and triangle of forces	b	A	A	A	A	A	A	A	b	b	A	b	A	b	b	b
	Equilibrium of a particle	c	A	A	b	b		A	A	c	A	b	b	A	b	b	b
	Principle of moments ; parallel forces and couples	b	A	A	b	c	A	A	A	b	A	b	b	b	b	b	b
	General conditions of equilibrium of coplanar forces	c	b	A	b	c	A	A	A	b	b		b	b	b	b	b
	Graphical statics			b		c			A				c	c		c	
	Bending moments and shearing forces								b				c				b
	Bows notation. Framework								b								
	Fundamental theorem, plane statics			A					A	b			c	b		b	
.22	Stability of equilibrium : energy tests	c	b		b	c	A	c	A	c			b	(c)	c	b	b
.23	Concept of force	b	A	A	A	b	A	A	A	A	A	A	A	A	b	A	b
	Composition and resolution of forces	b	A	A	A		A	A	A	b	A	A	A	A	b	A	b
	Couples and moments	b	A	A	A	c	A	A	A	b	A	b	A	A	c	c	b
	Theory of balance	b	A	A	(c)		A	A	A	c	A		A			c	b
	Equilibrium of a body under coplanar forces	b	A	A	(b)		A		A	b	A		b	b	c	A	b
.24	Thrust	c		b		b	b	A	b	c	b	b				b	b
.25	Centre of mass	c	A	A	b	c	b	A	A	b	c	c	b	b		c	b
	System of particles : internal and external forces			A	c				A		b	c	b				b
	Particle model		A	A		c					c					A	b
.31	Motion of a particle in a straight line	b	A	A	A	A	b	A	A	A	A	A	b	A	b	A	b
	Motion of a particle under gravity : projectiles	b	b	A	A	A	A	A	b	b	b	b	b	A	b	A	b
	Motion in a circle	b	A	A	A	b	b	A	A	A	A	A	b	A	b		b
	Motion of a particle in a vertical circle			A	c	b	c	A		c	b	b		A			b
	Motion of a particle in a smooth curve		b	A						b	c			b			b
	Motion of connected particles (two)																
.32	Non uniform acceleration - variable force		b	A	b			A	A	c	c	c	b	c	b	b	b
.33	Rigid body free to move in a plane			A				b	A	c							b
.34	Projectiles	b		A	b	b	c	A	b	b	c	b	b	b	b	b	b
.35	Newton's laws of motion. Inertia	b	A	A	b	A	c	A	A	A	A	A	b	A	b	A	b
	Laws of action and reaction	b	A	A	b	A	b	A	A	b	A	b	b	A	c	A	b
	Moments of inertia. Motion of a rigid body about a fixed axis	c		A	b	A		A	b	b	Ab		b	(b)	c		b
.36	Composition and resolution of velocities	b	b	A	A	A	c	A	A	b	A	A	b	b	b	A	b
	Composition and resolution of acceleration	c	b	A	A	A		A	b	c	A	A	b	b	c	A	b
	Composition and resolution of momenta				c	A		A	b			c	b	(c)	c	A	b
.37	Impulse	c	A	b	c	b	b	A	A	A	b	A	b	b	c	A	b
	Relative velocity		b	b	c	c	c	A	A	c	A	A		b	c	b	b

		A	B	CY	F	D	L	EIR	I	NL	N	S	E	CH	TR	SL	GB
531.38	Simple kinetic theory	b	b	b	(c)	b	c	A	A	b	c	b	b	b	c	A	b
.41	Inclined plane	b	A	A	A		A	A	A	b	A	A	b	b	b	c	b
	Friction	c	b	A				A	b	b	A	A	b	(b)	c	c	b
.42	Work and efficiency	b	A	A	A	A	A	A	A	A	A	A	A	A	b	A	b
	Power	b	A	A	A	b	A	A	A	A	A	A	A	b	b	A	b
.51	Hooke's law	b	b	A	b	b	b	A	A	b		c	A	b	b	c	b
	Rigid body about fixed axis	b		b					A	b	b		b	(c)	c		b
	Motion of particles under central force : orbits	b	A	A		b		A	A	A	c		b	(b)	c	c	b
	Simple harmonic motion	b	A	A	A	b	c	A	A	A	c	b	A	A	b	b	b
	Superposition of oscillations	b	A	b	c	b	c	A	b	b		c	b	b	c	b	b
	Simple pendulum	b	A	A	A	A			A	b	b	A	A	b	b	b	b
	Torsional oscillations. Torsional pendulum			b	b			A	b		c		b	c			
	Measurement of time		b	b		c	A	b	b	c	b	A	b		b	A	b
	Vibrating spring	c	b	A	A		b	b	A	c	b	b	b	b	b	b	b
.52	Free fall	b	A	A	A	A	A	A	A	A	A	A	b	b	b	A	b
	Mass and weight	A	A	A	b	A	A	A	A	A	A	A	b	b	b	A	b
.53	Newton's law of gravitation	A	A	A	b	A	c	A	A	b	A	b	A	b	b	c	b
	Relation between G and g		A	A		b	c	A	A	b	b	b	A	b	b	c	b
	Earth's gravitational field	c	b	A	c	c	c	A	A	c	b	A	b	b		c	b
.54	Kepler's laws	b	b			A				b	b	c	b	b	c		b
.55	History of the view of the universe	b	c			b					b	c					
.56	Gyroscope	c															
.57	Rotation of the earth	b	c		(c)					c	b	c	b	(c)	c		b
.61	Conservation of momentum and energy	b	cA	A	A	A	b	A	A	A	A	A	b	A	b	A	b
	Direct impact of smooth bodies : coefficient of restitution	b	c	b	b	c		b	A	b	b	A			c	b	b
	Oblique contact		c		c	c				b					c	b	
	Energy : conservation, potential, kinetic energy	b	A	A	A	A	A	A	A	A	b	A	b	b	b	A	b
.62	Energy of rotation				A	c		A	b	b	b		A	(b)	b		b
.71	Accuracy of measurement. Estimation of errors		A		(c)	b	c		b	b	b	b	b	b	c	b	b
.72	Modulus of elasticity	c		b					b	b	b			b	c		b
	Units CGS and MKS	b	A	A	A	A	A	A	b	A	A	A	A	A	b	A	b
.81	Simple machines			A	c		A	A	A		A		b			b	b
.82	Levers, machines, pulleys	b	A	A	(c)		A	A	A	c	A		b			b	b
.83	Spring balance. Tension			A	(b)		b	A	A	b	A		b	b		b	b
532.11	Elementary hydrostatics	b	A	A	(b)		A	A	A	c			b	b			b
.12	Fluid pressure	b	A	A	b		A	A	A	c	A	c	b	b	c		b
.22	Pascal's principle	b	A	A	b	A	A	A	A	c	A		b	b			b
.31	Archimedes principle	b	A	A	b		A	A	A	c	A		b				b
.41	Specific gravity	b	A	A	A		A	A	A	b	A	A	b	b	b	c	b
.51	Viscosity. Motion of bodies in fluids. Stoke's law			b		c			c	c		b	b		b	c	b

		A	B	CY	F	D	L	IR	I	NL	N	S	E	CH	TR	SL	GB
32.61	Surface tension. Capillarity (experimental)	b	b	b			c			c	b		c		c		b
.71	Dynamics of liquids and gases. Osmosis	b	c	b		c				c	c		b	c	c	b	b
.72	Linked vessels	b	A	A	b	A	A		A	c	b		c				b
533.41	Atmospheric pressure. Variation in time and space	c	A	A	b	A	A	c	A	c		c	b	b	c	b	b
.42	Manometers and pressure gauge. Barometers	b	A	A	b	b	A	b		c	b	b	cb	c		b	b
534.11	Sound as a wave motion	A	A	A	A	A		b	b	b	b	A	c	b	b	A	b
.21	Propagation of sound in a gas	b	c	A	c	b		b	A	b	b	b	c	b	b	b	b
	Propagation of sound in a liquid, solid	c	c	b	c			b	b	c	c	c	c	b	b	b	b
.22	Velocity of sound	b	b	b	b	b		b	b	b	b	b	b	b	b	b	b
	Measurement of velocity of sound (air or Kundt's tube)	b	b	b		A		b	b	b	A	b	c	b	b	b	b
.23	Doppler effect (sound)	b	b			c				b		c		b	b		b
.31	Vibration of strings	b	b	b	c			b		b	c	c	c	A	A	c	b
	Vibration of air columns	b	b		c			b	A	b	c	c	c	A	A	c	b
.32	Musical notes : intensity, pitch, quality	b	c	c				b		c	c	c	c	b	b	b	b
.41	Harmonics	c	c	c	b			c		c					c	c	b
.51	Standing waves	c	b	c	A	A	b	A	A	A	A	b		b	b	b	b
	Interference of sound	c	b	A	c	b	b	A	A	A	b	b	c	b	b	b	b
.52	Resonance	b	b	b	b		c	c	A	b	b	c	c	c	c	b	b
	Beats		b		c				A	b		c		c	c	b	b
.53	Echo	c		b					b	A	b		c		c	b	b
.81	Ultrasonics		c			c						b			c	b	b
535.11	Light as a wave motion	b	A	A	b	A	c	A	A	A	b	b	b	b	b	b	b
.12	Wavelength	b	A	A	A	A	c	A	A	b	A	A	b	b	b	b	b
.13	Doppler effect (optics)	c	b			b				c	c	b					b
.14	Wave particle dualism	c	c	c	c	A		A	c	b		c	b	c		b	b
.21	Velocity of light	b	b	A	c	b	c	b	A	b	b	A	b	b	c	c	b
	Determination of velocity of light	b	b	b		b		c	b	b	c	A	b	b	c	c	b
.22	Photometry	c		b						b	c	A	b		b	c	b
.31	Plane and curved mirrors	A	A	A	A		A	A	A	b	b	b	A	b	b	b	b
.32	Convergent, divergent, thin lenses (formulae)	A	A	A	A		A	A	A	b	b	b	A	A	b	b	b
	Thick lenses			b					b				A				
	Aberrations of lenses (incl. astigmatism)	c	c	A				c	b		b	b	A			c	b
.33	Prism (and disperson)	b	A	A	A		A	A	A	c	b	b	A	A	b	b	b
	Deviation	c	A	A	A			A	A	c	b	b	A	A	b	b	b
.34	Shadows and penumbra	b	A	A	c				A	c		c	b	c	b	b	b

		A	B	CY	F	D	L	EIR	I	NL	N	S	E	CH	TR	SL	GB
535.35	Rectilinear propagation	b	A	A	c		b		A	c	b	A	b	b	b	b	b
.36	Laws of reflection, refraction (index of refraction)	A	A	A	A		A	A	A	b	b	A	b	A	b	b	b
	Total internal reflection, critical angle	b	A	A	A		A	A	A	c	c	b	b	A	b	b	b
	Reflection and refraction waves		b	A	b								A				b
.41	Interference of waves	b	A	b	c	A	b	A	c	A	b	A	b	b	b	b	b
	Interference by division of wave front (Young's slits etc...)	b	A	b	A	A	b	A	c	b	b	A			b	b	b
	Interference by division of amplitudes e.g. thin films		b	b						b	b	A				b	b
.42	Diffraction and diffraction grating	b	A	b			c	A		b	b	A		b	c	b	b
.51	Polarisation (transversality of light waves)	b		b	c	A	c	c		b	b	c	b		c	b	b
.52	Double refraction	b	c	c		b	c	c					b		c		b
.61	Spectrometer. Analysis of spectra	c	b	bA	c	A	c	c	c	c	b	A	b		c	b	b
.62	Infra-red and ultra-violet radiation	c	b	b	b	c	c	c	A	c	b	c	b		c	b	b
.81	Astronomical terrestrial telescopes	A	b						A	b	b	A	A	b	b	b	b
.82	Microscopes	b	b		b				A	b	b	A	A	b	b	b	b
	Magnifying glass	b	A		b				A	b	b	A	A	b	b	b	b
.83	The eye as an optical instrument	b	b		b					c	b	c	A	b	b	b	b
.84	Camera	b	b						b	b	b	b	A	b	b	b	b
.85	Projector	b	c						b	b		c	A	b	b	b	b
.86	Magnification, power, resolving power	c	b		b			b	b	b		A	A			b	b
536.21	Transfer of heat ; conduction, convention, radiation	b	c	A	c		c	A	c	b	b	c	b	b		c	b
.22	Conductivity of a solid : Radiation as form of energy	c	c	A	c			A	c	b	b	c	b	b		b	b
.41	Thermal expansion of solids	b	b	A	b		A	A	A	b	b	c	b	b	b	c	b
	liquids	b	b	A	b		A	A	A	b	b	c	b	b	b	c	b
	Definition of coefficients of expansion	b	b	A	c			A	A	b	A	c	b	b	b		b
.42	Expansion of gases (i) constant pressure	b	b	A	b		A			b	A	b	A	A	b	b	b
	(ii) constant volume	b	b	A	b		A			b	A	b	A	A	b	b	b
.43	Latent heats	b	A	A	b					A		c	b				b
	Changes of state : melting, freezing	b	A	A	c		A	b	A	A	b	A	b	c	b	b	b
	boiling, solidification	b	A	A	c		A	b	A	A	b	A	b	c	b	b	b
	liquefaction	b	A	A	c		c	b	A	b	b	A	b		b	b	b
	sublimation. Triple point fusion	c	bA	A	b		A	b	A			c	b		b	b	b
.44	Saturated, unsaturated vapours ; evaporation, condensation, humidity	b	A		c		b		A	A	A	A	b	c	c	c	b
	Saturated vapour pressure ; Dalton's law	c	A		c		b		A	Ab	A	b	b	c	c		b
.51	Temperature ; its measurement, thermometers, centigrade, absolure	b	A	A	b		A	A	A	b	b	b	b	b	b	b	b
.61	Units of heat	b	A	A	b		b	A	A	b	A	A	b	b	c	b	b
.62	Calorimetry ; elementary	b	A	A	b		b	b	A	A	A	A	b	b	b	b	b
	Specific heats (liquids, solids)	c	A	A	c		b	A	A	b	A	A	b	b	b	b	b

		A	B	CY	F	D	L	EIR	I	NL	N	S	E	CH	TR	SL	GB
63	Specific heats of gases	c	c	A			b	A	b	b	b	b	b	b	c	c	b
.71	The ideal gas ; laws, equation of state	b	A	A	A		A	A	A	A	A	A	b	b	E	b	b
	Real gases deviation from ideal gas laws	c	c	A			c			c	b	c	b			c	b
.72	Kinetic theory of gases : elementary interpretation	b	c	A	b	A	c	A	A	c	A	A	b	b	c	A	b
	advanced interpretation									b		A					b
.73	1st law of thermodynamics	b	A	b	b	b	A	A	A	b	A	A		b		A	b
.74	2nd law of thermodynamics	c			c	c	A	A	b	b	c	c					b
	2nd law of thermodynamics : application (elementary)	c					c	A	b	b			c			c	b
	technological applications						c						c			c	b
.81	Mechanical equivalent of heat	b	A	A		b	b	A	A	b	A		b	b	c	A	b
537.11	Electronic charge	b	A	A	A	A	c	A	A	b	b	b	b	c	c	A	b
	Electronic mass	c	A	A	b	A	c	A	A	b	c	b	b	c	c	b	b
	Deflection of electron beam in electric and magnetic fields	c	b	A	b	A	c	A	b	b	c	A	b	b		b	b
	Acceleration of charged particles	c	c		b	A	c	A	b	b		A	b	b		b	b
	Electron volt	b	b		A	b		A	b	b	b	A	b	b		b	b
	Thomson's experiment, determination of specific charge	c	b					A	b	b		b				b	b
	Millikan's oil drop experiment	b	c			A		b	b	b		b		A		A	b
	Electric field and lines of force	b	A	A	c	A	b	b	A	b	b	A	A	A	c	b	b
	Electric field intensity	b	A	A	c	A	b	b	A	b	b	b	A	A	c	b	b
	Work in an electric field	c	b	A	c	A	b	b	A	b	b	b	A	b	c	b	b
.12	Current as moving charge	b	A	A	b		b	A	A	b	b	b	b	A	c	A	b
.21	Concepts of charge (positive and negative)	b	A	A	A		b	A	A	b	A	A	b	A	c	A	b
	Elementary electrostatics - basic ideas	b	A	A	(b)		b	A	A	b	b	A	b	A	b	A	b
	Electroscope	b		A				A	A	b	A	b	b	b	b	b	b
	Electrostatic machines (Van de Graaf etc.)	c	b	A				A	c	b	c	b	b			b	b
.22	Induction (incl. Faraday's experiment)	b	b	A		A	A	A	b	b	A	b	b	b	c	b	b
	Capacitance and capacitors	b	A	A	(A)	A	A	b	A	A	b	b	b	A	c	b	b
	Parallel plate condensor	b	A	A	(A)	b	A	b	A	A	b	b	b	A	c	b	b
	Linking of capacitors	c	A	A	(b)	c		b	A	c	b	c	b	b	b	b	b
	Energy of charged capacitor		b	A	b	b	b	b	b	b	b	c	b	A	c	c	b
	Dielectric constant	b	A	A		c	c	b	A	b	b	c	b	c	c	b	b
	Effect of dielectric on field, capacitance	b	b	A	(b)	b	c	b	A	b	b	c	b	b		b	b
.23	Inverse square law	b	b	A	(b)	A	b	A	A	b		b	b	b	b	b	b
.24	Potential	b	A	A	(c)	b	c	A	A	A	b	A	A	b	c	b	b
	Gauss' theorem			A		c		A	b	b			A				b
.31	Electrolysis	b	A	A	(A)		b	A	A	b	A	c	b		b	b	b

		A	B	CY	F	D	L	EIR	I	NL	N	S	E	CH	TR	SL	GB
	Faraday's laws	b	A	A	(A)		b	A	A	b	A	c	A		b	b	b
	Simple ionic theory	b	A	A	(A)		b	A	A	b	A	c	b		c	b	b
	Polarisation	b	b	A	(b)		b	A	c	c	A	c	A		c	c	b
	Voltaic cell, lead accumulator	b	b	A	(b)		b	A	A	b	b	c	A		c	c	b
51	Passage of current through gases at normal and reduced pressure	b	A	A	c	A	b	b	A	b	b	b	b		c	c	b
	Discharge tubes	b	b			A		b	A	b	b	c	b		c	c	b
	Cathode rays	b	b	A	A	A	A	b	A	b	b	b	b	b	c	b	b
	Canal rays	c	c			A	A	b	A	b		b	b		c	c	b
	Cathode ray tube	c	b	A	c	A	A	b	A	b	b	b	b	b	c	b	b
	Cathode ray oscilloscope, television	c	c	A	b	A	c	b	A	b		b	b	c	b	c	b
.52	Thermionic emission	b	b	A	b	A	b	A	b	c	c	b	b		c	c	b
	Triode	b	b	A		A		b	c	b	b	A	b		b	c	b
	Use of diode in rectification	b	b	A	c	A		b		b	b	b	b		b	c	b
	Use of diode as amplifier			A		A					b	b			c		
	Use of triode as amplifier	b		A		A				b	b	b	b		c	c	b
	Thermionic diode	c	b	A	b	A	b	b	c	c	b	b	b		c	c	b
.53	X rays	c	b	b	b	A	b	b	A	b	c	b	b		c	c	b
	Laué patterns		c			c				c		c	b				
	X ray spectra		c			c			b	c		b	b				
.54	Transistors		c			c						b				c	b
.71	Units (current, potential difference)	b	A	A	A	b	A	A	A	A	b	A	A	A	b	b	b
	Measurement	b	A	A	A		A	A	A	b	b	A	A	A	b	b	b
.72	Resistance	b	A	A	A		A	A	A	A	b	A	b	A	b	b	b
	Resistivity	b	A	A	A		A	A	A	A	b	b	b		b	b	b
	Ohm's law	A	A	A	A		A	A	A	A	A	A	A	A	b	b	b
	Wheatstone bridge	c	A	A	b		c		b	b	A	A	b	b	b	c	b
	Potentiometer	c	A	A			c		b	b		b	b	A	c		b
	Ballistic galvanometer	c	A	A		A	c	c	b			c	b	b		c	b
.73	Heating effects of a current	b	A	A	A		A	A	A	A	A	b	A	b	b	A	b
	Kirchoff's law	A	A	A			A	A	A	b	b	b	A	b	c	b	b
	Electromotive force	c	A	A	A		b	A	A	b	b	A	A	(c)	b	b	b
	Thermo-electric effect	c	b	A		c		c	b	b	c	b		(c)		c	b
	Thermocouples and applications	c	b	A				c	b	b	c	c		(c)		c	b
.74	Moving coil galvanometer	b	b	A	A		c	A	b	b	A	b	b	(b)	b	b	b

		A	B	CY	F	D	L	IIR	I	NL	N	S	E	ÇH	TR	SL	GB
538.11	Magnetic materials (lodestone etc.)	b	A	A	c		c	A	b	c	b	c	c	(b)	c	c	b
	Ferromagnetism (incl. hysteresis)	c	c	A	c	c	c		b		c	c			c	c	b
	Magnetic permeability	c	A	A		c	c		b	c	c	c			c	c	b
.12	Magnetic effects of a current	b	A	A	A		A	A	A	A	A	b	A	A	b	b	b
	Field due to a long straight conductor	b	A	A	A		A	A	A	b	A	c	A	A	b	c	b
	Field at centre of a plane circular coil carrying a current	b	A	A	A		A	A	b	b	c	b	A	A	b	c	b
	Field inside a long solenoid	b	A	A	A		A	c	c	b	A	b	b	A	c	c	b
.13	Energy of magnetic field		c	A			b	A	A			c	b	b		c	b
	Magnetic field	b	A	A	c		b	A	A	b	b	b	b	A	c	b	b
.31	Constants of electric and magnetic field and their relation to the speed of light		b			A		A	c				b	(b)			
	Electromagnetic waves, electromagnetic spectrum radio waves	b	b	b	c	A	c	A	c	c	c	b	b	b	c	b	b
.32	Force between current carrying conductors	b	A	A	b		A	b	b	b	c	b	A	A	b	b	b
	Force on conductor carrying current in magnetic field	b	A	A	A		A	b	b	A	A	b	A	A	b	b	b
.33	Applications ; télephone, telegraph	b	c	b					A		c					c	b
.51	Electromagnetic induction	b	A	A	b	A	A	b	A	b	A	b	b	b	b	b	b
	Self induction	b	A	A	b	A	A	b	A	c	A	c	b	b	c	b	b
	Mutual inductance	b	A	A				b	c				b			c	b
.52	Alternating currents	b	A	b	A	b	b	b	c	b	A	A	b	(b)	c	b	b
	Instantaneous and effective values of current voltage	b	A	A	A	b	b	b	c	b	b	A	b	(b)	b	A	b
	Resistor, capacitor and inductor in alternating current :	b	b	A	A	b	b	b	c	b	A	b	b	b	c	b	b
	elementary and advanced		c			b											
	Alternating current power	c	A	b	b		b	b	c		b	b	b		c	b	b
.53	*Transformer*	b	b	A			c	b	c	b	b	c	b		c	b	b
	Generators	b	b	A			c	b	c	b	b	c	b		c	b	b
	Dynamo, motors	b	b	A				b	c	b	b	c	b		c	b	b
.54	Transmission and distribution of electrical energy	b	b	A			c		c	b	b	c	b		c	b	b
.61	Magnetic field intensity	b	A	A			b	A	A	c		c	b	A	c	b	b
.62	Magnetic flux density (B)	c	A	A	A		c	A	A	b	b	b	b	A	c	b	b
.63	Magnetic moments		b	A	A		c	A	A						c	c	b
.71	Earth's magnetic field	b	c	b	b			A	A	c		c	c	b		c	b
	Compass	b	c	b	b			c	A	c		c	c			c	b
539.11	Particle aspect of radiations photons	c	b	b	b	A	c	b	c	b		c	b	c		b	b
	Photoelectric effect	c	b	b	b	A	b	b		b	c	b	b	c		b	b
	Photocell	c	b	b		A	b	b		b	c	b	b	c		b	b

		A	B	CY	F	D	L	EIR	I	NL	N	S	E	CH	TR	SL	GB
539. 12	Planck's constant	c	A	b	b	A	c	b		b	c	A	b	(A)		c	b
	Energy levels	c	A	b		A		b		b	c	b	b	(A)		b	b
	Line-spectra - emission, absorption	c	b	A		A		b		b	c	b	b	(A)		b	b
	Balmer lines		b	b		A				b		b	b	(c)			b
	Spectroscopy ; inversion of sodium lines	b	A	b		A		c	b	b	b	b		(c)			b
	Franck Hertz experiment		A	b		A		c	b	c		c					
. 13	Isotopes	b	b	b	A	b	c	b	c	A	c	b	b	c	c	b	b
	Mass spectroscope	c	c	b		b		b	c	b		b	b			b	b
. 14	Natural radioactivity and radiation	b	b	b	cb	bA	b	b	c	b	c	b	b	c	c	b	b
	Natural and artificial nuclear transformations	b	c	b	c	b	c	b	c	b	c	b	b	c	c	b	b
	Radioactive half-life and range	c	b	b	A	c	c	b	c	b	c	b	b	b	c	A	b
	Elementary particles and nuclear structures	c	c	b	b	b	c	b	c	b	c	b	b	c		c	b
	Protection from radiation	c	b	b		b		b		c		c				b	b
	Fission	c	c	b	c	b		b	c	b		A	b	c	c	c	b
	Fusion	c	c	b	c	b		b	c	b		A			c	c	b
	Cosmic radiation		c									c					
	i) Law of radioactive decay		c	bA	b	bc		b	c	bc		b	b			b	
	ii) Nuclear reactors																b
. 15	Atomic number	b	A	A	b	A	c	b		b	c	A	b	b	c	A	b
	Atomic models	b	A	b	b	A	c	b	c	b	c	b	b	b	c	b	b
. 16	Matter waves. Diffraction of electrons																
	Electronic microscope																

Key : A = to a very great extent; b = to a moderate extent; c = to a superficial extent

——————— = common core topics

- - - - - - - - - = topics studied by all but two countries

1. G. B. = University of London, University Entrance and School Examinations Council, Summer 1968 and January 1969. Here 'b' simply means that the items is included on the syllabus laid down by the Council for the Physics A-level examination.

One or two extra topics, such as the theory of relativity, advanced atomic physic :x-perimental electronics, hydrostatics, etc., should be made the subject of special study. Thi ar be done in collaboration with chemistry or other subjects.

Occasional visits to industrial and other plants are encouraged by the Danish directives.

The teacher must himself decide on the order in which the syllabus is to be taught.

Federal Republic of Germany

Berlin (7)

The Berlin directives state that neither the inductive nor the deductive method is to be neglected. The first is particularly suited in introducing the pupils to a new world of ideas and to the laws of physics. The second is necessary in putting across an understanding of the inner connection of physical facts.

An active teaching method is encouraged. Class lessons and practical work by the pupils should be complementary. From the numerical results of an experiment the pupil should be helped to find the functional relationship. The ensuing law should be formulated exactly, and an appropriate mathematical formula should also be sought. Mathematics is an indispensable and educationally valuable help in physics. Graphs, diagrams, tables and slide rules should be used.

Hessen (8)

The teaching in the Oberstufe, the Hessen directives say, should "make the pupil increasingly aware of the paradigmatic nature (Modellcharakter) of physical knowledge and of the meaning of theory-building in physics". (9) Experiments should be used as the starting point or confirmation of the discussions - and not only demonstrations , but increasingly experiments by the pupil himself, who must be able to write them up. (10)

The teacher is expected to treat in depth only certain chosen topics from the minimum syllabus, so that sufficient time is left to deal with the topics from the broader syllabus, thus filling out the area covered.

Although the teacher is given a good deal of freedom, the syllabus is ordered around a number of models, e. g. the model of the ideal gas, thus giving the teacher valuable guidance.

The directives stress that the development of the mechanistic view of the world is not to be treated chronologically or anecdotally as a separate chapter, but rather as a developing problem, as a basic principle running through physics. The use of original texts is recommended.

An active method should be used, encouraging the pupil's independence. It is the job of the teacher only to ensure the general lines and the unity of the lesson. However, different methods must be used as necessary. The straight 'lecture type' lesson still has a place in the Oberstufe, so too has the use of questions in the development of an argument. Teaching by means of group work

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(7) Berlin, Senator für Volksbildung - Abt. II (1954).

(8) Hessen, Minister für Erziehung und Volksbildung, (1962a), pp. 10 - 14.

(9) Ib. p. 10.

(10) See Hessen, Minister für Erziehung und Volksbildung, (1961a) p. 13.

One or two extra topics, such as the theory of relativity, advanced atomic physics, experimental electronics, hydrostatics, etc., should be made the subject of special study. This can be done in collaboration with chemistry or other subjects.

Occasional visits to industrial and other plants are encouraged by the Danish directives.

The teacher must himself decide on the order in which the syllabus is to be taught.

Federal Republic of Germany

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(7) Berlin, Senator für Volksbildung - Abt. II (1954).

(8) Hessen, Minister für Erziehung und Volksbildung, (1962a), pp. 10 - 14.

(9) Ib. p. 10.

(10) See Hessen, Minister für Erziehung und Volksbildung, (1961a) p. 13.

(Gruppenunterricht), in which each pupil has a task to perform which, though complete in itself, forms part of a larger whole, is particularly recommended. The separate results should, of course, then be drawn together.

Double periods (Blockstunden) should sometimes be used, so that the matter can be dealt with more intensively and in greater depth. Discussions (das Kolloquium) are also recommended. So are study groups which go beyond the narrow bounds of the individual subjects. Thus there may be a science study group. "The success of the work in the upper forms depends decidedly on whether one is able to overcome the unconnectedness (Beziehungslosigkeit) of the separate subjects" (11).

The Hessen directives (12) stress two points regarding method : the paradigmatic approach (das exemplarische Verfahren), and the need to integrate what is learned in the different subjects (Integrationsverfahren). The paradigmatic approach is necessary to avoid : a superficial, encyclopaedic knowledge ; a lack of clarity in the pupil's education ; and confused ideas. The potential range of topics to be covered is well beyond what the pupil could be expected to acquire. The programme should be limited, by careful choice, to those topics which are essential and which have value as typical instances of some wider application. On the other hand, the integration approach in to assure that the connections between the chosen topics treated in any one subject are brought out, as also the interrelations between the various subjects.

Nordrhein-Westfalen (13)

Of the general principles ennunciated by the Nordrhein-Westfalen directives, two are most relevant here : the teaching programme must be chosen with the pupils for whom it is destined clear in mind - the environment of their lives must be taken into account ; and the topics chosen must be *such that they permit one to go from the particular to the general.*

Although, more specifically, teaching method cannot be simply a matter of the whim of the teacher, neither is method to be equated with technique. The method must be such as to make the pupil problem-oriented (Problembewusstsein) and concerned with tackling (Auseinandersetzung) reality.

An active method is therefore to be encouraged, more and more on his own. The pupil must also be able to see and experience the empirical contents before a conceptual deepening is attempted.

In general, the method chosen must be suitable to the task at hand and so will have to be varied depending on the matter to be treated. Some different approaches which may be used as appropriate are : the straight 'lecture' type teaching ; the use of questions to develop a theme ; the dialogue (Unterrichtsgespräch) ; and group work (Gruppenunterricht) - see page 96 . In the dialogue

(11) Ib. p. 14. The course of the last two paragraphs is indeed : Hessen, Minister für Erziehung und Volksbildung (1961a), pp. 13 and 14, which on the whole refer to methods in the Oberstufe in general and not specifically to physics teaching methods and which is a reproduction of the Stuttgarter Empflhlungen, 1961. See also Hessen, Minister für Erziehung und Volksbildung, (1956) pp. 104 ff.

(12) See especially Hessen, Minister für Erziehung und Volksbildung, (1956) pp. 106 and 107, dealing with teaching methods in general, but which may be applied to physics.

(13) Nordrhein-Westfalen, das Kultusministerium, (1963).

approach the teacher only gives the lesson its overall structure. His own part in the discussion should as far as possible not be in the form of questions, but rather of prods or of indicating the wider issue.

Above all, the pupil must acquire the right attitude to learning and the teacher must help him to learn by his own efforts.

In the Oberstufe the pupil must master the methods of intellectual work. For instance, he should sometimes be given a limited topic to develop over a fair period of time. Double periods should sometimes be used in the teaching so that a more intense, thorough and connected treatment of the subject-matter may be possible. Group discussion (das Kolloquium) is useful for handling a theme which cuts across disciplines. In it different forms of communication can be used : for instance, talks or reports on group work. In addition, cross-disciplinary study groups can be formed. The success of the Oberstufe depends on the ability to over-come the unconnectedness of the separate subjects (14).

In dealing specifically with physics teaching methods, the Nordrhein-Westfalen directives point out that the field is so large and the number of items so great that it is impossible for there to be a complete treatment. Besides in the upper classes, there must be a limitation of the subject-matter so as to permit a scientific and theoretical deepening. So as to obtain a coherent choice of topics, the teacher should decide on a guiding theme which overlaps different sections of the physics corpus (übergreifendes Leitthema) and should treat only those topics necessary to the development of that superordinated theme. Some such themes are : the atomic model and its development ; the particle/wave dualism ; and electromagnetic waves, the ether problem, space, time and relativity.

The teacher is free to choose his own themes. However, they should be such as to : fulfil the teaching aims laid down ; permit the pupil to build on past knowledge and experience ; and ensure that there is, in the Obersekunda, a thorough treatment of mechanics and, later of at least optics and electricity, and that the teaching leads on to an area of recent physics.

The directives develop the three themes given above. Here we set forth the general headings for the first one :

The atomic model and its development

1. Motion and the basic formula of mechanics.
2. The law of the conservation of energy and momentum ; law of thrust.
3. Uniform circular motion and harmonic vibration.
4. Geocentric and heliocentric theories ; the movement of the planets ; the law of gravity.
5. From the atomic hypothesis of Democritus to atoms in the kinetic theory of gases (the small ball model of matter).
6. The atomic structure of electricity :
   a) The concept of charge
   b) The quantisation of charge
   c) Calculation of electronic mass
   d) The atomic model of Thomson (in connection with the atomic structure of electricity).
7. An orientation introduction to the wave and photon theories of light.
8. The Rutherford and the Bohr atomic models.
9. Natural radioactivity.

The entire approach is a paradigmatic one and one which strives to integrate the topics covered. Also experimentation is stressed -as for instance in the use of the ripple tank.

(14) This paragraph is based on pages X-XII of Nordrhein-Westfalen, das Kultusministerium, (1963), which reproduce the Stuttgarter Empfehlungen.

France (15)

France is at present in a period of educational reform. Hence the directives to hand on physics teaching method are rather out of date. The following has been based entirely on a conference originally given in 1955 by the Inspecteur Général de l'Instruction Publique, Monsieur Guy Lazerges.

The dogmatic teaching method, in which the teacher simply gives a straight lecture, is strongly criticised. It does not respect the basic principle that the pupil must be rendered capable of learning for himself. However, Lazerges grants that it has got a role to play as a means of putting across information that simply needs to be put across.

The fundamental mistake is to forget that children are not adults. They have a different way of thinking, for instance, and they are in a process of becoming adults.

Lazerges gives three basic methodological directives which sum up what he terms the natural method. The first is : from child to adult. That is to say that the teacher must always try to use the processes of thought proper to the children.

The second is : from the known to the unknown. This is the method of re-discovery. In a first sense this is to rectify and to render organised and scientific the knowledge which the pupils already possess confusedly and implicity from their own experiences. In a second sense this is, first of all, to present new knowledge experimentally, and then to draw out the scientific laws and explanations which apply - but even this must be done within the framework of what the pupil already knows.

The third is : from the concrete to the abstract. This is the active method. That is to say the method which utilised the spontaneous interests of the pupils. This method is less imperative at the higher stages when the pupils have already developed abstract intellectual interests.

Luxembourg (16)

The Luxembourg directives state that the physics teaching should revolve around the practical. Each physical phenomenon should be introduced and defined by means of a carefully chosen experiment. It is through the experiment that the pupil will grasp the law of the phenomena. The 'discovery method' should be used in obtaining the solution of the problem. Calculations will merely be an auxiliary to the practicals.

At first the teacher should confine himself to qualitative experiments so that the pupil gets into the habit of observing a physical phenomena. This observation should be directed, to avoid the pupils' concerning themselves with irrelevant facts. The teacher should later go on to quantitative experiments and accustom the pupils to make calculations. After drawing a conclusion from the facts he will lead the pupils on to the physical law.

From the outset the teacher should try to accustom the pupils to scientific language and symbolism and should teach them to retain certain fundamental facts and certain general properties of matter. The scientific nomenclature should not be learned, however, by repetition but by constant use.

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(15) France, Lazerges, (1958).

(16) Luxembourg, Ministry of Education, (1962).

The teacher should try to make the pupils understand the significance for physics of the phenomena studied and should avoid digressions. He should try to give the pupils the fundamental concepts and essential laws by the most direct method. His treatment of the subject need not follow a rigorous pattern.

The physical laws and properties of matter should be illustrated by examples and exercises. These latter should not be simple numerical calculations, but should call upon the pupils' reasoning and observation. A historical treatment, showing the evolution of a theory, for instance, should also be used. Physics should be presented as a science undergoing constant change, with open and unanswered questions.

Malta (17)

The Malta directives state that : as far as possible, and where facilities exist, or can be made available by the teacher, the syllabus in the Sciences will be done on a practical basis, and experiments... will form an essential part of any science teaching.

While the teacher is free to assess the amount of 'laboratory' time to be spent by his individual class or classes in the course of one term, it will be assumed that pupils doing science will spend the maximum amount of time in the laboratories, and to receive theoretical as well as practical instruction in the science rooms and laboratories.

It will be noted that the syllabus lays down the general body of science knowledge to be assimilated by the pupil in a particular field. It is essential, however, that this knowledge will not remain abstract ; and opportunity will be taken, in every respect, to bring down science knowledge to the concrete. The pupils will be given every facility
a) to do and to experiment on their own, under guidance ... ; and
b) through practical work and independent effort to develop their abilities within the area of knowledge outlined by the syllabus ...

Library reading and reading for information on the subject will be encouraged throughout. Guidance will also be given to the pupils at every stage to compile their own work-book or 'science papers', and, in the later stages and particularly in the Sixth Form, to have written evidence of their own 'research' work, both from source books not prescribed by the syllabus and as a result of experiments carried out in the laboratory.

Note-books of personal laboratory work, experiments and independent study, under guidance in every science, will form an integral part of the working out of the curriculum, for presentation at the end of each year's work.

In the sciences in particular no hard and fast lines are to be drawn between home-work, school work, rough work, and fair copy work. As far as the pupil is concerned, working at a science is a unitary activity, and while aspects of work can and should be diversified, no unnatural break or useless repetition should be allowed. The idea of the 'file' or one unitary work-book for each pupil in science has much to recommend it.

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(17) Malta (1965). The first six paragraphs are taken from the general note on science teaching, p. 107. The rest is a note to the sixth form physics syllabus, pp. 119 - 120.

... Special attention is to be given to the pupil in the Sixth Form to develop what is generally called "free and easy movement in the laboratory", full acquaintance with items of apparatus and equipment, their scope and purpose, care, maintenance and arrangement ; a body of knowledge that is grounded in and tested by experiential work through laboratory techniques and constant experimental application ; general information and a fairly wide measure of reading ; personal and individual work-books and written evidence of "research" within their reach. Practical applications of knowledge assimilated will be required throughout ; and, as in the previous forms, the subject matter of the prescribed syllabus will be justified only if it is done on laboratory basis in both years of the course.

There will be no break in the continuity of the subject from the earlier years to the end of the second year of the Sixth Form. The process is one of broadening, elaborating and raising the standard of knowledge of the pupil in the subject, both in the field of theory and particularly of individual development in practical laboratory experience, of current knowledge in the science.

Sweden (18)

The directives lay down that to a large extent the subject-matter should be presented inductively. However, the pupil is also to become acquainted with the deductive method. On the other hand, as the inductive method is time-consuming and the deductive is often mathematically demanding, "the teacher need not hesitate to present considerable portions of the subject-matter without discussing step by step how it has been derived". (19)

As soon as possible the presentation of new matter should be done through demonstrations, practicals and films.

Matter which the pupils have studied in advance should be discussed in class and alternative solutions presented.

Mathematical training in the treatment of physical phenomena is essential. However, besides mathematical problems, the pupils should also be given non-mathematical problems requiring theoretical reasoning.

With reference to study techniques, the Swedish directives stress in general an active approach and independent work on the part of the pupils and consider in particular : note-taking, the use of problem-solving, special reading techniques required for physics and the ability to carry out practicals. Pupils should learn to organise their own notes and to use diagrams. There should be more practical work than demonstrations. The pupils should gradually take responsibility for preparing the experiments themselves. Sources of experimental errors should be discussed. Long-term home-work (långläxer) which develop into minor project work (beting) are important in connecting experimental evidence to theory.

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(18) Sweden, Läroplan (1966), pp. 247-306.
(19) Ib., p. 297.

As the language in physics is so specialised, the pupils should be given special physics reading instructions based on their earlier training in reading. This could be done in small groups. The pupils should also be introduced to the use of a specialist physics library and the necessary texts should be made available.

The pupils must be gradually introduced to the study techniques needed. This should be done by giving individual attention to the pupils during group lessons in the first year.

Instead of having the physics lessons spread thinly over the whole year, a partial concentration is recommended. Thus, in the first year, there could be 4 hours per week of physics in the first half of the autum term, then a break, resuming with 3 hours per week in the spring.

United Kingdom (20)

The Nuffield Physics project aims at a course and a presentation which will ensure that :

a) the physics programme is complete in itself ;

b) builds on the natural curiosity of the children ;

c) is relevant to the world outside the classroom ;

d) gives a broad picture of what modern science is about and the way modern scientists think ;

e) does not contain too much material, but presents a few important ideas which the pupil can make his own ;

f) strives to lead the pupils to understanding and not just to knowledge ; and

g) is permeated by a spirit of inquiry.

The syllabus cannot be seen just as a list of topics in isolation from the teaching method and the course is to be presented as a unified whole of interlocking topics. There is a strong emphasis on the pupils doing experiments themselves.

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(20) Based on Lewis, Dr. John, The Nuffield Physics Project, in Unesco, New trends in physics teaching, volume 1, 1968, which is an adaptation of an article by Dr. Lewis, published in the Bulletin of the Institute of Physics and the Physical Society, March 1965.

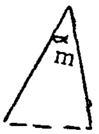
APPENDIX III

SAMPLE EXAMINATION QUESTIONS

France

Physical Sciences

A - 1. A simple pendulum of length 1, is swung from its position of equilibrium by an angle α_m (angular amplitude). Calculate the speed v of this pendulum when it passes through its position of equilibrium.

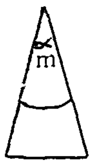


2. Calculate the relationship between the tension of the wire when the pendulum passes through its position of equilibrium (apparent weight of the pendulum) and its real weight.

Numerical application for these two questions

$1 = 2.45$ metres, $\alpha_m = 60°$; $g = 9.8$ metres/seconde^2

B - When the angle α is small enough for the formula of approximation to be applied : $\cos \alpha_m \simeq 1 - \frac{\alpha_m^2}{2}$



and when the arc S_m can be presumed to be a segment of a horizontal straight line. express v as a function of S_m.

Numerical application

$1 = 2.45$ metres ; $S_m = 20$ cms ; $g = 9.8$ metres/seconde^2

C - To measure the speed V of a projectile of mass m, the following experiment is carried out :

The projectile is drawn horizontally onto a big pendulum of mass M (the wire is long enough for the pendulum to be considered as a simple pendulum of length 1). The projectile embeds itself into the mass of the pendulum, whose centre of gravity is disturbed from its position of equilibrium, after the shock, by a distance d (considered as horizontal). tal).

By applying the theorem of conservation of momentum calculate V as a function of M, m, d, 1.

Numerical application

M = 18 kg. ; m = 12 g. ; 1 = 2.45 m ; d = 20 cms

D - In the above experiments, calculate the loss of kinetic energy of the whole, projectile and pendulum, after the shock. What has become of the energy that has disappeared in this way ?

Federal Republic of Germany

Hessen - Reifeprufung, 1963 (Gutenbergschule, Wiesbaden)
Pupils must do Question 1 and Either Question 2 or Question 3.

1. What is meant by a 'standing wave' ? How in the course of instruction were standing electric waves produced and how demonstrated ? How can the wave-length be calculated and how can one find the speed of propagation dependent on the medium ?

2. How is the electric conductivity of gases under normal pressure to be explained ? During the course of instruction which occurrences shed light on the process of conduction ?

3. When the light of a mercury high-pressure lamp is made to act upon a vacuum photo-cell, electrons are released from the layer of metal. The phenomena can be expressed by means of the energy formula $h.V = 0.5.m.v^2 + A$, where $0.5m.v^2$ is the kinetic energy of an electron, A is the energy of the electron freeing itself from the metal surface, h is the Planck constant, and V is the frequency of light. The kinetic energy can be calculated by the opposite field method. If U_0 is the voltage difference between cathode and anode which acts as a complete brake on the speed of the electron it can be stated that 0.5mv $0.5mv^2 = eU_0$. The work involved in flying off A can be eliminated if one works with several light frequencies ($H = e.\Delta U_0 : \Delta V$). The experiment will be performed for three different frequencies (yellow filter $V = 5.19.\ 10^{14}\ sec^{-1}$, blue filter $V = 6.88\ 10^{14}\ sec^{-1}$). the braking tensions U_0 read off and the switching plan is to be given. A U_0 - V graph is to be inserted from which the Planck constant h is to be read off. The experiment is to be described, the occurrences to be explained and the results are to be interpreted in relation to their importance.

Netherlands

Einde examen der Hogereburgerschole B, 1967

A - In a Wilson cloud chamber a radioactive substance is emitting alpha particles. The path of the alpha particles in the cloud chamber can be made visible by a path of very small droplets.
Explain the reason for the production of the track.

B - An alpha particle collides with a proton which may be considered to be stationary : the collision is fully elastic. Before the collision the alpha particle has the kinetic energy of $8 : 0 \times 10^{-14}$ J. The paths of the alpha particle and the proton lie in a horizontal plane.

a) Calculate the speed of the alpha particle before collision
b) Calculate the speed of the alpha particle and the proton after the collision.

Suppose now that the collision takes place in a vertical magnetic field.

Calculate the ratio of the radii of the circular paths of the alpha particle and the proton after the collision, assuming that the speeds of the alpha particle and the proton are in the ratio 3 : 8. Mass of alpha particle = 6.4×10^{-27}
Mass of proton particle = 1.6×10^{-27}

The mass of each may be assumed to be constant.

C - A and B are two point sources emitting waves of the same frequency. The sources are coherent, in phase and have the same amplitude.

a) Under what conditions would an (a) interference maximum, (b) interference minimum, be produced at a point (which does not lie on the line AB).

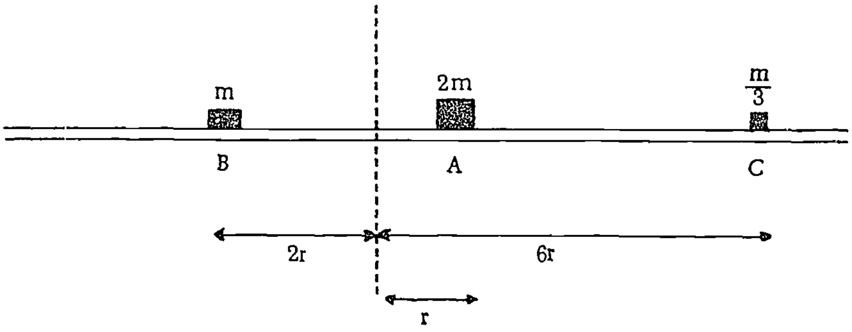
The distance AB is 40 cm. The wavelength is 8 cm.
A line is drawn through B perpendicular to AB.

b) Calculate the distance from B of 2 successive maxima lying on S.

Sweden

Central Test, penultimate year, 1969

4.



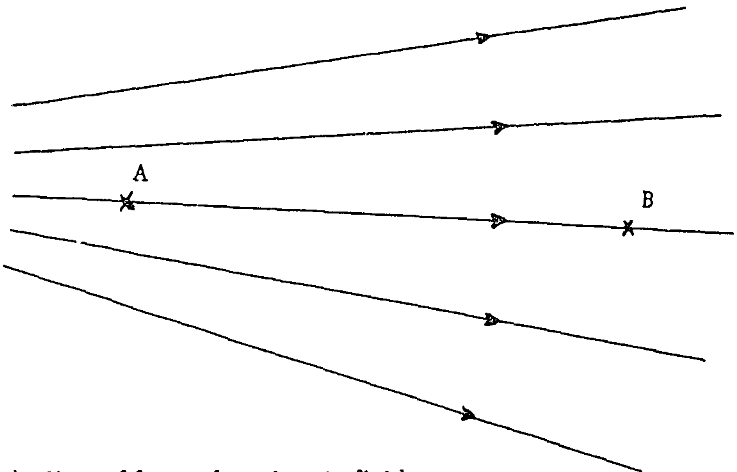
A horizontal circular disc is rotating about a vertical axis through its centre. On the disc there are three particles, A; B and C, with masses 2m, m, and $\frac{m}{3}$ at distances r, 2r and 6r from the centre, as shown in the sketch. What can you say about the centripetal forces acting on the particles ?

a) The force acting on A is the largest
b) The force acting on B is the largest
c) The force acting on C is the largest
d) The forces are all three of the same magnitude

6. A wire of conducting material is to be 4.0 metres long and have a cross-section area of 2.0 square millimetres. Its resistance must not exceed 35 milli-ohms. State a material from which the wire can be made.

11. A dynanometer with range 0 to 10 newtons is hung from the ceiling of a lift. A body of mass 500 grams is hung on the dynamometer. When the lift starts the dynamometer reads 3.9 newtons for the first 3 seconds. What is the acceleration of the lift during this time ?

15.



The figure shows the lines of force of an electric field.

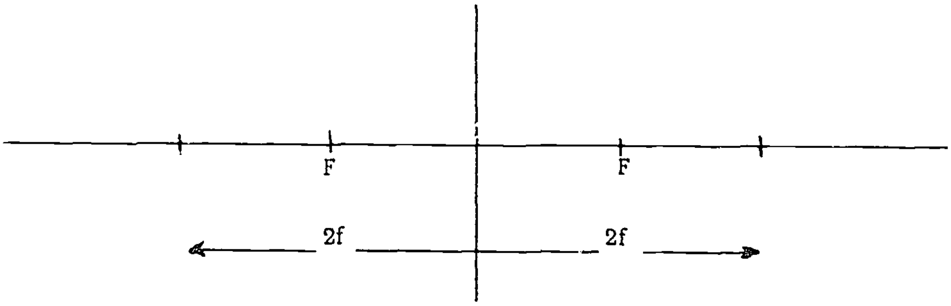
a) Is the field stronger at A or at B ? Justify your answer

b) The field-strength at A is 3.0 volts/metre (or newtons/ampere second). A negative charge of 42 micro-ampere seconds (42 x 10 ampere seconds) is placed at A. Mark on the figure the direction of the force acting on that charge, and find its magnitude.

c) When the charge mentioned above is moved from A to B, how much does the potential energy of the charge change, if the potential difference between these two points is 15 volts ?

Central test, final year, 1969

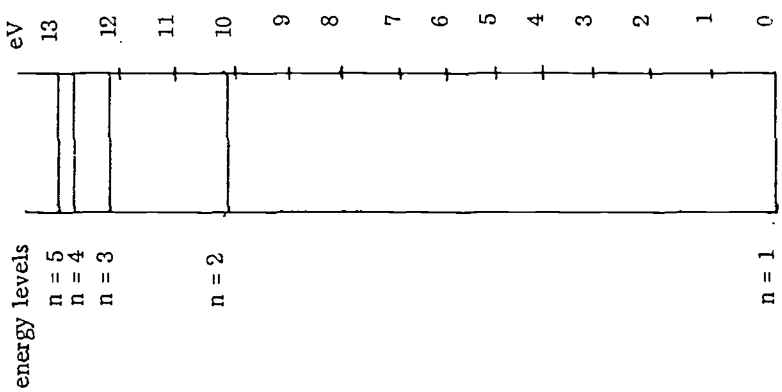
2.



An object on the axis of a thin convex lens moves from a point just less than 2f from the lens in, to the first focus (f from lens). Describe the image, and describe the way it moves, by choosing among a, b, c, d, e.

a) real, diminished and inverted : and moves from distance 2f on other side, away
b) real, magnified, and inverted : and moves from distance 2f on other side, away
c) real, magnified, and erect : moves from f on other side to infinity
d) virtual magnified erect : moves from f on other side to infinity
e) virtual magnified inverted : moves from f on other side to infinity

15.



An electron with energy 20.0 electron-volts moves past a hydrogen atom. During that, the hydrogen atom is excited from its ground-level to the next level above. The actual energy levels are given in the figure. With what velocity does the original impinging electron leave the encounter ? The answer should not be given with more than 2-figure accuracy.

(Answer books are provided)

United Kingdom

There are two papers in physics and one practical examination : instructions are issued to supervisors of the practical examination some weeks in advance. A special paper of a higher standard may also be taken in addition.

Oxford and Cambridge Schools Examination Board. Advanced Level, June 1968

Explain the terms surface tension and angle of contact. How is each defined ?

Describe a method for measuring the surface tension of a liquid which wets glass. Give the theory of the method. State clearly the quantities which have to be measured and estimate the likely percentage error involved in each.

A heavy glass sphere is supported over a dish of water. The level of the water is gradually raised until the sphere is totally immersed. Explain how the force on the sphere due to surface tension varies with the position of the sphere relative to the surface of the liquid. Assume the liquid wets glass.

State the laws of electromagnetic induction and describe briefly experiments to show their validity.

A coil A passes a current of 1.25A when a steady potential difference of 5V is maintained across it, and an r.m.s. current of 1A when it has across it a sinusoidal potential difference of 5V r.m.s. at a frequency of 50Hz (cycles per second). Explain why the current is less in the second case, and calculate the resistance and the inductance of the coil.

The same coil A, which has 100 turns, has a second coil B with 500 turns wound on it so that all the magnetic flux produced by A is linked by B. Find the r.m.s. value of the e.m.f. that appears across the open-circuit ends of B when a sinusoidal alternating current of 1A r.m.s. at a frequency of 50 Hz is passed through A. Why is the ratio of this e.m.f. to the r.m.s. potential difference across A not the same as the ratio of the number of turns in B and A, i.e. 5 :1 ?

Explain why the insertion of an iron core into the coils would decrease the current in A and increase the e.m.f. across B, if the alternating potential difference across A were kept unchanged ; the effects of hysteresis and eddy currents in the iron may be neglected.

Special paper

State Newton's law of gravitation. In what respects is the constant G believed to be universal ?

Explain how apparent value of the acceleration due to gravity is affected by the earth's rotation. Assuming the earth to be a homogeneous sphere of radius 6371 km and density 5.517 g cm^{-3}, rotating about the polar axis at a uniform rate, show that the apparent value of the acceleration of gravity at a point on the earth's surface at latitude Θ is given approximately by the relation :

$$g_{\Theta} = g_{90} (1 - \lambda \cos^2 \Theta)$$

and find the values of the constants g_{90} and

Outline briefly a method which could be used to determine the value of the constant

The results of measurements have yielded a value for almost twice that calculated. How may this difference be explained ?

$$(G = 6.673 \times 10^{-8}\ cm^3\ g^{-1}\ s^{-2})$$

Practical

Calibrate a thermocouple for use as a thermometer and determine the melting point of the substance N.

Set up the potentiometer to measure potential differences between 0 and 5mV. (The resistance of the potentiometer wire and the e.m.f. of the cell will be specified).

Calibrate the thermocouple at the temperatures of melting ice and boiling water. Assuming these to be 0° and 100° C respectively and that the e.m.f. of the thermocouple varies linearly with temperature over this range, draw a cooling curve for substance N of which only a small quantity is provided over the range 90° - 70° C and deduce the melting point of N.

Joint Matriculation Board, Advanced Level, May 1968

What do you understand by a black body ? In what respects does the radiation from a black body at 1,000° K ? How would you devise a black body to radiate at 1,000° K ?

A blackened sphere, of radius 2.0 cm., is contained within a hollow evacuated enclosure the walls of which are maintained at 27° C. Assuming that the sphere radiates like a black body and that Stefan's constant is 5.7×10^{-12} joule cm.$^{-2}$ sec.$^{-1}$ deg.$^{-4}$ K., calculate the rate at which the sphere loses heat when its temperature is 227° C.

June 1969

Sketch a graph illustrating how the current in a gas discharge tube (e.g. a neon lamp) varies as the p.d. applied to it is increased from zero. How do you account for the form of the graph. ?

Describe and explain the nature of the spectrum of the light from such a tube.

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