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AUTHOR Francis, Peter R.
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ABSTRACT

This paper discusses the objectives of a program in biomechanics--the analysis of sports skills and movement--and the evolution of the biomechanics program at Iowa State University. The primary objective of such a course is to provide the student with the basic tools necessary for adequate analysis of human movement, with special emphasis upon those sports and games encountered in elementary and high schools. The course also seeks to prepare students in scientific areas that can enrich the undergraduate curriculum and serve as a solid basis for those who will pursue biomechanics at the graduate level. A problem that was identified half a century ago is still prominent in the teaching of biomechanics: most students enrolling for such a course do not have extensive science backgrounds; consequently, they have little or no knowledge of physics. To avoid inefficient use of instructor time, Iowa State University has designed and requires a basic course in physics for all students entering the biomechanics course. The course is designed so that the problems encountered are expressed in biophysical terms. The biomechanics instructor can then begin with a brief review of anatomy and muscle physiology and examination of kinematics and an overview of instrumentation and analysis techniques used in biomechanical investigation, along with practical applications to a variety of games and sports. Students are examined in three ways: review of lab work, written examination, and practical examination. (Slides were used with the presentation.) (DMT)

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THE UNDERGRADUATE BIOMECHANICS EXPERIENCE

AT IOWA STATE UNIVERSITY

Peter R. Francis
Department of Physical Education
Iowa State University
Ames, Iowa 50011

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It is apparent that the course content and mode of instruction of any college level course should be determined largely by the requirements of the student population. This has been the guiding principle in the evolution of the Biomechanics program at Iowa State University.

COURSE OBJECTIVES

If current trends continue, only a small percentage of undergraduates in physical education will proceed to graduate work, and a large majority of those in graduate programs will receive only limited, additional instruction in Biomechanics. Hence, the undergraduate course will be a unique experience for the majority of individuals receiving such instruction. The undergraduate course should therefore provide a body of instruction which is:

1. Clearly defined, and
2. Specific in its applications to the present and future teaching experiences of students.

Furthermore, in departments of physical education we are frequently dealing with students who have had limited preparation in science; consequently, due to the exciting nature of subject matter in Biomechanics, the educator has the opportunity to make important contributions to the broader education of future teachers in this technological society.

In summary, the objectives of the undergraduate course in Biomechanics may be specified as follows:

SLIDE 1 Primary Objective

To provide the student with the basic tools necessary for adequate analyses of human movement, with special emphasis upon those sports and games encountered in elementary and high schools.

Secondary Objectives

To provide students with adequate preparation in appropriate scientific areas, which can:

1. Enrich the undergraduate curriculum, and,

2. Serve as a solid basis for those who will pursue biomechanics at the graduate level.

COURSE CONTENT

The content of the course must be designed to meet the above objectives in a manner most suited to the participants.

In almost all fields of academic study, appropriate levels of proficiency in supporting areas are required for adequate communication between student and instructor. Certain prerequisites should therefore precede the undergraduate course in biomechanics.

Almost half a century ago, Charles H. McCloy recognized that many of his students had such deficient backgrounds in science that he was obliged to precede his instruction of the mechanical analyses of sports skills by an introductory unit in physics. Regrettably, this state of affairs is little improved today! It has therefore become common practice to spend a significant part of the available time in an undergraduate course teaching elementary science. The knowledge inculcated is subsequently utilized in selected applications to sports techniques.

At Iowa State University the Physical Education faculty has recognized that this may not represent the most efficient use of instructor time. Similarly, the Department of Physics recognizes that the teaching of physics is best handled by physicists. An elementary physics course which is elected by numerous physical education majors has, therefore, been adapted to draw upon the subject matter of biomechanics for its illustrative examples. The physics course will soon become a requirement to precede the biomechanics course. An existing required course, Anatomy of Human Movement, covers the information necessary for an adequate understanding of the kinesiological aspects of biomechanics.

At this time the contents of the biomechanics course are as follows:

SLIDE 2

1. "Body of Knowledge"

   a. A brief review of anatomy and muscle physiology and examination of the internal forces encountered in biomechanics.

   b. Lecture and laboratory study of kinematics and kinetics of external forces, encountered in biomechanics.

   c. Overview of instrumentation and analysis techniques used in biomechanical investigations.

2. Practical applications of the "body of knowledge" to a variety of games and sports.

Body of Knowledge

In the study of the "Body of Knowledge," an attempt is made to differentiate between:

1. Information which can be readily learned and retained by verbal dissemination, reading assignments, and classroom demonstration; and

2. Concepts which can be fully appreciated only by "hands-on" interaction by the student working in the practical experimental setting.

Through efficient time-tabling, lecture-demonstrations and related laboratory experiments can be juxtapositioned so as to reinforce essential concepts at appropriate times.

SLIDE 3 For example, slide 3 shows a laboratory experiment which is performed in conjunction with the study of linear kinematics. Students examine the velocity and acceleration characteristics of swimmers. Measurements of stroke length and stroke frequency are also made--and in an effort to reinforce this latter concept, students will later work on PLATO terminals and will manipulate comparable variables for speed skaters, cyclists, sprinters, and rowers.

During the study of angular kinematics, a laboratory experiment using graph check sequence pictures of golf swings is used to compute the angular velocity and acceleration characteristics of golfers.

The study of kinetics has frequently been confusing to students, undoubtedly one of the reason for this may be found by examining available textbooks. No respected engineering text deviates from a logical approach to kinetics -- the nature of forces is examined and all of the forces present in even the most simple analysis are accounted for before analysis is undertaken. In contrast, texts dealing with the biomechanics of sports frequently omit reference to certain significant forces, and the discussion of the remaining forces is not systematic.

Careful scrutiny of our field of interest will reveal that there are six, and only six, forces of any significance in biomechanical analyses. These forces may be systematically classified into three categories, as follows:

1. Weight
2. Contact forces
   a. Normal reaction
   b. Friction
3. Fluid forces
   a. Buoyancy
   b. Drag
   c. Lift

Students readily appreciate that as an aid to memory the three categories of force contain one, two, and three forces, respectively.

SLIDE 4 Each of these forces is defined, demonstrated and studied in some detail and, where appropriate, laboratory experiments are performed.

SLIDE 5 For example, ~~slide 5~~ illustrates experiments with friction. Experiments such as these are performed under controlled conditions in the laboratory and also in realistic "field conditions" on actual playing surfaces.

SLIDE 6
SLIDE 7

The concept of weight and center of gravity is fully appreciated after an examination of angular kinetics.

SLIDE 8
SLIDE 9
SLIDE 10

Although most indoor work is carried out in a relatively unsophisticated laboratory-lecture room, the work in fluid mechanics is continued in the Department of Aerospace Engineering. Characteristically, departments of physical education lack such facilities, but it is frequently possible to obtain the use of engineering facilities through diplomacy and common research interests with engineering colleagues.

SLIDE 11
SLIDE 12
SLIDE 4

Following examinations of the six significant forces, the technique of drawing two-dimensional free body diagrams is introduced. The student is expected to be able to sketch the outline of an instantaneous position in the execution of any familiar skill, then, significant forces are represented in approximate magnitude, direction, and point of application, by vector arrows. As an aid to memory in future analyses, forces are considered, by convention, in the sequence in which they were studied in the earlier part of the course.

The model is then subjected to analysis, the results of which are used as a guide in the study of the real system. It can be seen that not only does the technique allow for a logical and detailed study of gross motor skills, but also serves as a recognizable introduction to the concept of mathematics modeling.

Practical Applications

During the second major part of the course, information gained in the "Body of Knowledge" section is applied to selected sports and skills. These applications are carried out whenever possible in the locations in which the activities are performed and employ subjects of a wide variety of ability levels. A blackboard is always available for analysis, so that selected phases of skills can be illustrated using free body diagrams.

Student evaluation is based upon laboratory reports, two midterm quizzes and upon a final written examination. The final examination follows the pattern set in the "Practical Applications" section of the course. At each of a variety of locations, students observe performers demonstrating sport skills. Attention is drawn to a specific part of each skill and questions are posed about the mechanics of the execution of the skill. In each instance the specified part of the skill is being performed inadequately as the result of inefficient mechanics. Credit is awarded for identification of faults and for correct explanation of the mechanics involved.

Separate sheets of paper are used for each written discussion. Upon completing the analysis of a skill, the students give the appropriate sheet of paper to the instructor before proceeding to subsequent locations. While moving from one demonstration area to the next, students are encouraged to discuss previous analyses with one another and with the instructor. It is felt that this type of evaluation procedure is in itself a learning experience, is consistent with the primary course objective, and is thus more appropriate than more conventional written examinations.

In summary, the undergraduate biomechanics experience at Iowa State University has been designed to meet the needs of the future teachers of physical education. Following the study of a well-defined, utilitarian body of knowledge, each student is given the opportunity to apply pertinent concepts in systematic analyses of gross motor skills.

The techniques used to aid the student in acquiring an adequate level of proficiency are in many instances comparable to those employed in numerous successful programs of biomechanics, but a number of unique aspects have evolved from the availability of local facilities and the interests of involved personnel. It is hoped that some of the innovations discussed may prove to be useful to other teachers of biomechanics.