



National Association for  
Sport and Physical Education

*an association of the American Alliance for Health,  
Physical Education, Recreation and Dance*

**NASPE Sets the Standard**

**GUIDANCE DOCUMENT**

## **Guidelines for Undergraduate Biomechanics**

A knowledge of basic and applied biomechanics is essential to the study of human beings engaged in motor performance. A person who understands the anatomical and mechanical phenomena that underlie human movement and who can systematically analyze movement and determine interventions is more likely to improve technique and reduce the risk of injury. Therefore, we recommend that all students of human movement complete at least one course in biomechanics. Specifically, this coursework should provide students with: 1) a basic knowledge of the biomechanical foundations of human movement; 2) the knowledge and skills necessary to complete a systematic analysis and evaluation of human motor performance; and 3) the ability to determine and provide interventions that are likely to improve movement.

Accomplishment of these purposes may take different forms at different academic institutions. Both qualitative and quantitative content approaches are valuable. Analytic methods can range on a continuum from qualitative to quantitative, and students may benefit from developing a repertoire of analytic methods along with a sense of when each is appropriate. Frequent integration and application of concepts are important. Higher order thinking skills (e.g., synthesis and evaluation) are necessary in applied biomechanics. The instructor can facilitate the development of these skills through modeling and guided practice in various scenarios.

### **Prerequisites**

Prerequisites for an introductory undergraduate biomechanics course include: a) the ability to use basic algebraic operations to solve problems that use words, formulas, equations, and graphs; and b) foundational knowledge about the organization and description of the skeletal, articular, muscular, and nervous systems.

### **Guidelines (Minimum Exit Outcomes)**

Ideally, students of human movement would exit their undergraduate studies able to integrate functional anatomy and mechanical concepts to ask complex questions and solve multilevel problems related to human movement in athletic, educational, clinical, and/or work settings. The completion of a full semester course with a lab is the minimum recommendation. However, completion of additional courses in biomechanics and the infusion of biomechanical concepts into other courses are desired.

Guidelines for minimum exit outcomes of an introductory course in biomechanics follow. The order of outcome presentation is not suggestive of the order for planning a course. Course concepts should be presented in an order that meets the unique needs of students in different professional programs.

### **Application of Biomechanics Competencies to Human Movement**

As a minimum, introductory undergraduate biomechanics classes should expose students to the continuum of qualitative to quantitative movement analysis techniques. Instructors may elect to stress different levels of student mastery for different modes of movement analysis. Throughout the course, students should be given the opportunity to observe and ask questions about movement then analyze and evaluate the movement to answer their questions. This process should anatomical and mechanical concepts to a wide variety of activities. These may include improving motor skills, assessing the safety and effectiveness of exercise activities, selecting and adapting sport and exercise equipment, and evaluating movement patterns for the purposes of injury prevention. Activities should be examined across performers of varied gender, age, skill, and fitness levels.

At the conclusion of the course, students should demonstrate basic competence in a systematic approach to the observation, analysis, and evaluation of human movements in athletic, clinical, educational, and work environments. These outcomes are stated to be consistent with the phrase “The student is able to”.

1. Observe and describe a movement technique accurately.
2. Determine the anatomical and mechanical factors basic to the performance of an observed movement.
3. Evaluate the suitability of a performer’s technique with reference to the task at Hand.
4. Identify those factors that limit performance and establish a priority for change in those factors most likely to lead to improvement in performance.

### **Anatomical Bases**

Students should exit having met outcomes related to joint structure and function, muscle mechanics, and neuromuscular function. These competencies should be applied to a variety of human movement settings and integrated with the mechanical bases to solve human motor performance problems. These outcomes are stated to be consistent with the phrase “The student is able to”.

#### **A. Joint Structure and Function**

1. Identify and describe joint actions, axes of rotation, and planes of movement in simple single joint activities and more complex multi- joint motor performances.
2. Observe human movement and explain the reasons for different joint actions and

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ranges of motion using knowledge of joint structure, stability, and mobility.

3. Assess flexibility and create safe and effective stretches for the major muscle groups surrounding each joint.

### B. Muscle Mechanics

1. Identify and describe the roles that muscle groups play (i.e., agonist, antagonist, stabilizer, neutralizer) and their cooperative actions (i.e., isometric, concentric, eccentric) during simple single joint activities and complex multi-joint motor performances.
2. Explain the force-velocity and length-tension relationships of muscle and recognize their application in static positions and dynamic movements.
3. Recognize the use of the stretch-shortening cycle of muscle in human movement and create effective training exercises that utilize this phenomenon.
4. Describe the mechanical response of different muscle fiber types, the influence of training upon them, and the potential for muscle fiber type to influence performance.

### C. Neuromuscular Function

1. Define the basic structures (e.g., motor unit, muscle spindle, and proprioceptors) of the neuromuscular system and explain how reflexes (e.g., stretch reflex, reciprocal inhibition) affect human movement.
2. Describe how recruitment and rate coding of motor units regulate muscle force production.

## Mechanical Bases

Students should exit having met outcomes related to basic considerations of human movement and the kinematics and kinetics of motion. These competencies should be applied to a variety of human movement settings and integrated with the anatomical bases to solve human motor performance problems. These outcomes are stated to be consistent with the phrase “The student is able to”.

### A. Basic Considerations

1. Define a movement system and determine the nature of the system’s movement (i.e., linear, angular, general motion).

2. Appropriately represent kinematic and kinetic quantities as vectors and use vectors, vector addition, and vector resolution to enhance the understanding of basic mechanical concepts (e.g., impact of the direction of resultant force application (external forces), the effect of changes in line of muscle pull upon the amount of force used to rotate a segment (internal forces)).

#### B. Movement Kinematics

1. Define the basic terms of distance, displacement, speed, velocity, and acceleration as they relate to linear and angular motion in human movements.
2. Use kinematic variables to compare the quality of various motor performances (e.g., across skill level, fitness level, gender, age, body size and type, etc.).
3. Explain the kinematic relationships between linear and angular motion and apply this relationship to improve motor skill performance (e.g., striking, throwing, kicking) and equipment design (e.g., sport, rehabilitation, work environment).
4. Describe how the variables of release height, angle, and velocity affect projectile motion and apply these variables to a projectile activity to optimize performance.

#### C. Movement Kinetics

1. Define basic terms (e.g., force, inertia, mass, and weight) as they relate to linear motion in human movement.
2. Define basic terms (e.g., torque, moment, moment of inertia, moment arm, radius) as they relate to angular motion.
3. State the linear and angular forms of Newton's laws of motion and explain the relationship between the observed movements of a body experiencing linear or angular motion and the forces/torques responsible for that motion.
4. Explain the effects of weight, normal reaction, friction, buoyancy, drag, and lift upon motor performance.
5. Estimate the location of the center of gravity of persons in any position and describe how changes in location of the center of gravity and other mechanical factors that influence stability.
6. Identify and explain the importance of impulse-momentum, work-energy, and the conservation of momentum to the production of effective human movements.

**Faculty**

Teachers of undergraduate biomechanics should have a doctoral degree and a specialization in biomechanics.

**Facilities and Equipment**

To facilitate achievement of the exit competencies the introductory undergraduate biomechanics course needs to have separate lecture and laboratory sessions. Preferably, laboratory activities take place in a properly equipped biomechanics laboratory space. Other suitable activity areas include gymnasiums, tracks, fields, pools, etc. Laboratory activity ideas can be obtained through biomechanics-related websites.

Minimal and desirable equipment to facilitate laboratory experiences is listed below.

**A. Minimal Equipment for Laboratory Experiences**

1. Anatomical charts and models
2. Goniometers, tape measures, and rulers
3. Digital or shuttered video camera, or camcorder, videocassette recorder with freeze frame, slow motion, and jog-shuttle controls, and monitor for video display
4. Computer equipped with qualitative movement analysis software
5. Stop watches
6. Medical balance scale (height and weight capabilities)
7. Sport, exercise, and rehabilitation implements and equipment (e.g., rackets, bats, balls, protective equipment, golf clubs, dumbbells, therabands, crutches, canes, physioballs, etc.)
8. Video/DVD previously recorded movement library

**B. Desirable Equipment for Laboratory Experiences**

1. Complete computer based quantitative 2D/3D movement analysis system, including shuttered cameras that can be synchronized and analysis software
2. Force platform, A/D converter, and analysis software
3. Electrogoniometer with a computer interface
4. EMG equipment with amplifiers, computer interface, and analysis software
5. Reaction board
6. Electrodynamometer with a computer interface
7. Isokinetic dynamometer

**Approved by:**

**The Biomechanics Academy of the  
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