



Drexel-SDP GK-12 LESSON

Lesson: Biomechanics

Subject Area(s) Measurement, Physical Science, Science and Technology

Associated Unit Vital Mechanics

Lesson Title Biomechanics



Angles and mechanics play a large role in sports.

Grade Level 7 (6-12)

Lesson # 3 of 3

Lesson Dependency

Time Required 20 minutes

Summary

Students are introduced to the broad field of biomechanics and its applications, with a focus on how angles are used in 2-D and 3-D motion analysis.

Engineering Connection

Biomechanics is a blend of mechanical engineering and biomedical engineering disciplines that may combine clinical and laboratory environments. Many biochemical interactions in the human body depend on mechanical factors, and the biomechanical community seeks to relate various cause-and-effect scenarios that ultimately contribute to chronic diseases and health conditions. For example, blood vessels may change their structure to normalize mechanical factors like stresses on or within the vessel wall. Even though mechanics (forces and vessel deformation) play an easily identifiable role in this situation, the biology of the vessel depends on chemical signaling.

On a larger scale, musculoskeletal biomechanical engineers examine how we use our bodies, from examining disorders and proposing corrective treatments to improving the efficiency of athletes. Not only are researchers involved in the biomechanics field in university and government laboratories, but consultants are increasingly used to evaluate engineering designs, critique athletic performance, and conduct failure analyses. An illustrative example of ties to athletics is 2007 Heisman winner [Tim Tebow's use of University of Florida's biomechanics laboratories](#) to improve his throwing motion.

Keywords

angle, 2-D, 3-D, motion capture, biomechanics, mechanics, biology, throw, walk, gait

Educational Standards

- PA Science:
 - 3.1.7 – Unifying themes
 - 3.2.7.B – Apply process knowledge to make and interpret observations
- PA Math:
 - 2.1.8.D – Apply ratio and proportion to mathematical problem situations involving distance, rate, time, and similar triangles
 - 2.4.5.B – Use models, number facts, properties, and relationships to check and verify predictions and explain reasoning
 - 2.5.8.B – Verify and interpret results using precise mathematical language, notation and representations, including numerical tables and equations, simple algebraic equations and formulas, charts, graphs, and diagrams
 - 2.7.8.D – Compare and contrast results from observations and mathematical models
 - 2.8.8.B – Discover, describe, and generalize patterns, including linear, exponential, and simple quadratic relationships

Pre-Requisite Knowledge

Students should have an understanding of angles, including the Pythagorean theorem. Knowledge of coordinate systems is also recommended.

Learning Objectives

After this lesson, students should be able to:

- Identify instances of biomechanics
- Describe how motion capture allows for computation of angles
- Describe how angles relate to position in a 2-D scenario
- Predict how forces (from a contracting muscle) cause movement

Introduction / Motivation [refer to video clips]

By a show of hands, who has played a sport and worn protective gear? Used a seatbelt in a car? Used anything that is “ergonomically-correct”? Those are ways in which you were directly affected by the work of biomechanical engineers. *Write biomechanics on the board.* Can someone state (guess) what is studied in the field of biomechanics? (*Fish for answers, then define*). By looking at the tolerable levels of force on the human body (*i.e.* bruising), we can design helmets and pads to cushion impacts, design seat belts in the best position with efficient materials, and re-design objects to reduce overuse injuries. Acura started an ad campaign for its 2009 MDX model car that stated “There is no angle on the human body that was designed for a collision.” (*See film clip*). For the most part, that is true – humans are vulnerable to many external forces and internal (biological) processes. This is why biomechanical engineers seek to understand how the body performs and functions so that products are designed accordingly, therapies can be proposed, and human performance can be optimized.

N.B. I had considered relating this to the movie “Forrest Gump,” but in the movie a brace was put on Forrest’s legs to correct a crooked spine (scoliosis) – this is biomechanically inconsistent with the actual treatment (a back brace).

Biomechanical engineers deal with human motion, which varies considerably unless we practice and repeat it, like in baseball throwing drills (*without throwing, demonstrate foot/arm/follow-through with a baseball*). Because throwing motions and collisions occur on the order of milliseconds, we can’t analyze our direct observations. Motion capture systems, which consist of cameras and sensors, are used to analyze motion. A 2-D analysis may consist of a video that is analyzed frame-by-frame with the use of reference points and software. Accordingly, we must map out the motions, and **angles** are used extensively to describe movement from frame to frame. (*Show pitching video clips*).

Since humans don’t exist in two dimensions, some problems require 3-D motion capture and analysis. To do this effectively, people wear suits with sensors and video is taken from different angles. Video game manufacturers like EA Sports use motion capture to simulate the realistic movements in their software. Biomechanics researchers and consultants use the same principles to examine the forces that occur in the body. (*Show gait analysis video clip*). We see in this example that the angle of the knee is tracked while walking. (*Show 3-D motion capture clip*). In this clip a woman is wearing a 3-D motion capture suit and all of her movements are mapped onto a three-dimensional grid which takes into account all the angles through which her body is moving based on the positions of the sensors.

Vocabulary / Definitions

| Word | Definition |
|----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Biomechanics | Study of mechanics (forces and deformation due to forces) in a biological system. Typical <i>biomechanical</i> systems involve flow of gases and liquids as well as motion of bones due to muscle contraction. |
| Gait | Behavior of lower musculoskeletal system (muscles, bones, ligaments) during walking or running strides. |
| 2-D | Two-dimensional. In geometry, a plane is two-dimensional. Typical axes are x and y. |
| 3-D | Three-dimensional. Most motion doesn't occur in a plane, therefore it is <i>3-D</i> and characterized by 3 axes: x, y, and z. |
| Motion capture | The method used to gather data (still frames from video) for biomechanical analysis. One camera is sufficient for 2-D analysis, but two or more cameras placed at different angles must be used for 3-D analysis of the region of interest. Reference points may be placed in the video region (2-D or 3-D grid) or on the subject to quantify angles and motion. |

Lesson Background & Concepts for Teachers

This lesson aims to highlight the general theme of Biomechanics – the main concept is that our body is a complex engineered system in itself, and research is conducted to understand it. If we reach the point where it is possible to reverse-engineer biological phenomena, it may be possible to solve current health problems and human conditions.

Associated Activities

Play Ball

Lesson Closure

Segue into associated activity.

Additional Multimedia Support

vital_mechanics_3_lesson_biomechanics_multimedia.zip

Owner

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