SOLUTIONS

to accompany

basic biomechanics 8th edition by hall

Chapter 1
What Is Biomechanics?

Chapter Overview

The study of human movement, kinesiology, encompasses multiple subdisciplines. Biomechanics is one of the subdisciplines where biological systems are studied from a mechanical perspective. Mechanics is subdivided into kinematics and kinetics. Kinematics is descriptive in nature and explains both static and dynamic motion in terms of displacement, velocity, and acceleration. Kinetics explains the underlying forces that cause and/or result from both static and dynamic motion.

Chapter One gives an overview of the relevant questions being answered by today's biomechanist. A basic understanding of mechanical concepts is essential for a practitioner as well as a researcher. Basic knowledge of the principles of biomechanics is very essential for physical educators, athletic trainers, physical and occupational therapists, coaches, personal trainers, and physicians to be successful.

Analysis of human movement may be either quantitative or qualitative. Both of which are important to the practitioner. The chapter provides an introduction to qualitative analysis and a systematic approach for solving formal quantitative problems.

Teaching Tips

Develop strategies to help students with math phobia. Determine what resources are available, and encourage students early in the term to use those resources. Ask students to solve problems and exercises in groups. This will help students who find it difficult to solve such problems and exercises on their own. In a diverse group, it is important to use examples applicable to specific situations (sport, dance, rehabilitation, etc.) and/or examples applicable to activities common to everyone (walking, climbing stairs, etc.).

Assessment Techniques

1. **Goal Ranking and Matching**

   Ask students to identify two or three learning goals they hope to achieve by participating in the class or lab. Then, ask them to rank the goals according to their relative importance.

After sharing their goals with the instructor, the students will learn what the instructor hopes to achieve so a comparison can be made. In an elective course, this exercise may help a student determine whether to opt out of the course. In a required course, the instructor may use this information to tailor the class to a specific population. For example, physical therapy students in a biomechanics class may have different needs and expectations than students preparing to coach. [Angelo, T.A. & Cross, P.K. (1993). *Classroom Assessment Techniques* (2nd ed.). San Francisco: Jossey-Bass.]

2. **YouTube**

The Internet provides a massive source of content that can be used to supplement the course. Often, students will comprehend a concept much more quickly if they can see a demonstration. YouTube is an excellent source of videos related to many of the biomechanics concepts presented in the text. A couple of samples will be provided for each chapter. As the instructor, you can determine how to best use the videos. For example, you might find applicable videos and assign them to students for outside viewing or as a part of their homework. The videos can also be shown during class, to complement the lecture or discussion. Alternatively, you can assign relevant concepts and challenge the students to find appropriate and accurate videos to share with the class. Like other content that is not peer reviewed, the videos posted on YouTube may or may not be accurate. However, errors can also present "teaching moments."

The following are the links to two concepts presented in Chapter 1.

Biomechanics
http://www.youtube.com/watch?v=x6y70_Hn9SY

Metric System and Standard Measurement Systems
http://www.youtube.com/watch?v=DQPQ_q59xyw&feature=related

The links are provided as examples of videos that can be used to supplement the content of the course. The authors and publishers do not own or endorse the videos or guarantee the links will remain active. If these samples are not active, accurate, or appropriate for your class, please find other samples that will work better for you.

Labs on a Budget

The inclusion of several laboratory experiences is recommended for all undergraduate biomechanics classes. In the absence of expensive research equipment, there are still many items that can be used to help students experiment with the concepts. The authors and publishers do

not own or endorse specific products. However, in selected instances, specific vendor examples are provided. Equipment ideas will be presented in Chapters 5, 10, and 12.

There are many examples of biomechanics and/or physics labs online. Many use very low-cost equipment that are still effective in helping students learn the concepts. The following is an example of a website that has some low-cost experiments relevant to the biomechanics concepts presented in the text: http://www.physicsclassroom.com/lab/. It also provides links to other websites related to labs. The following is an example of a vendor's website that provides low-cost lab equipment: http://www.arborsci.com/.

Related Weblinks

- www.acsm.org (American College of Sports Medicine)
- http://www.asbweb.org/ (American Society of Biomechanics)

Solutions to Selected Introductory Problems

8. Solve for x in each of the equations below. Refer to Appendix A for help if necessary.

a. $x = 5^3$
$x = 5 \times 5 \times 5 = 125$

b. $7 + 8 = x/3$
$(7 + 8)3 = (x/3)3$
$45 = x$

c. $4 \times 3^2 = x \times 8$
$(4 \times 9)/8 = (x \times 8)/8$
$4.5 = x$

d. $-15/3 = x + 1$
$-5 - 1 = x$
$-6 = x$

e. $x^2 = 27 + 35$
$x^2 = 62$
$\sqrt{x^2} = \sqrt{62}$
$x = 7.9$

f. $x = \sqrt{79}$

$x = 8.9$

g. $x + 3 = \sqrt{38}$
$x = 6.2 - 3$
$x = 3.2$

h. $7 \times 5 = -40 + x$
$35 + 40 = -40 + x + 40$
$75 = x$

i. $3^3 = x/2$
$(3 \times 3 \times 3)2 = (x/2)2$
$54 = x$

j. $15 - 28 = x \times 2$
$-13/2 = (x \times 2)/2$
$-6.5 = x$

9. Two schoolchildren race across a playground for a ball. Tim starts running at a distance of 15 meters from the ball, and Jan starts running at a distance of 12 meters from the ball. If Tim's average speed is 4.2 m/s and Jan's average speed is 4.0 m/s, which child will reach the ball first? Show how you arrived at your answer. (See Sample Problem 1.) (Answer: Jan reaches the ball first.)

Time = Distance/Speed

$t_{Tim} = 15$ m/4.2 m/s $\qquad t_{Jan} = 12$ m/4.0 m/s

$t_{Tim} = 3.6$ s $\qquad t_{Tim} = 3.0$ s

$3.6 > 3.0$ s

Hence, Jan reaches the ball first.

10. A 0.5-kg ball is kicked with a force of 40 N. What is the resulting acceleration of the ball? (See Sample Problem 2.) (Answer: 80 m/s^2)

1 Newton = 1 kg m/s^2

Force = Mass × Acceleration

$F = ma$

$a = F/m$

$a = (40 \text{ kg m/s}^2)/0.5 \text{ kg}$

$a = 80 \text{ m/s}^2$

Solutions to Selected Additional Problems

3. Sarah goes to the grocery store and spends half of her money. On the way home, she stops for an ice cream cone that costs $0.78. Then, she stops and spends a one-fourth of her remaining money to settle a $5.50 bill at the dry cleaners. How much money did Sarah have originally? *(Answer: $45.56)*

$(x/2 – \$0.78)/4 = \$5.50$

$x = \$45.56$

4. Wendell invests $10,000 in a stock portfolio made up of Petroleum Special at $30 per share, Newshoe at $12 per share, and Beans & Sprouts at $2.50 per share. He places 60% of the money in P.S., 30% in N, and 10% in B & S. With market values changing (P.S. down $3.12, N up 80%, and B & S up $0.20), what is his portfolio worth six months later? *(Answer: $11,856)*

Original investment: $6,000 for 200 shares of P.S
$3,000 for 250 shares of N
$1,000 for 400 shares of B & S

6 months later:

Portfolio value = (200) ($30.00 – $3.12) + (250) [$12.00 + (0.8) ($12.00)]
+ (400) ($2.50 + $0.20) = $11,856

5. The hypotenuse of right triangle *ABC* (shown in the text) is 4 cm long. What are the lengths of the other two sides? *(Answer: A = 2 cm; B = 3.5 cm)*

$A = (4 \text{ cm}) (\sin 30°) = 2 \text{ cm}$

$B = (4 \text{ cm}) (\cos 30°) = 3.5 \text{ cm}$

6. In triangle *DEF*, side *E* is 4 cm long and side *F* is 7 cm long. If the angle between sides *E* and

F is 50°, how long is side *D*? *(Answer: 5.4 cm)*

$D^2 = E^2 + F^2 – 2BC \cos 50°$

$D^2 = (4 \text{ cm})^2 + (7 \text{ cm})^2 – (2)(4 \text{ cm})(7 \text{ cm})\cos 50°$

$D = 5.4 \text{ cm}$

7. An orienteer runs 300 m north and then 400 m to the southeast (at a 45° angle to north). If he has run at a constant speed, how far away is he from the starting position? *(Answer: 283.4 m)*

$d^2 = (300 \text{ m})^2 + (400 \text{ m})^2 – (2)(300 \text{ m})(400 \text{ m})\cos 45°$

$d = 283.4 \text{ m}$

8. John is out for his daily noontime run. He runs 2 km west, then 2 km south, and then runs on a path that takes him directly back to the place he started at. a) How far did John run? b) If he has run at an average speed of 4 m/s, how long did the entire run take?
(Answers: a. 6.83 km; b. 28.5 min)

a. Find the length of the hypotenuse of the triangle formed by the path that took John back to the starting place. The sum of all three sides of the triangle is the distance he ran.

$h^2 = (2 \text{ km})^2 + (2 \text{ km})^2$
$h = 2.83 \text{ km}$
$d = 2.83 \text{ km} + 2 \text{ km} + 2 \text{ km} = 6.83 \text{ km}$

b. $t = 6{,}830 \text{ m}/4 \text{ m/s}$

$t = 1707.5 \text{ s} = 28.5 \text{ min}$

9. John and Al are in a 15 km race. John averages 4.4 m/s during the first half of the race and then runs at a speed of 4.2 m/s until the last 200 m, which he covers at 4.5 m/s. At what average speed must Al run to beat John? *(Answer: just over 4.3 m/s)*

Total time for John to complete the race:

$t = (7{,}500 \text{ m}/4.4 \text{ m/s}) + (7{,}300 \text{ m}/4.2 \text{ m/s}) + (200 \text{ m}/4.5 \text{ m/s}) = 3487 \text{ s}$

John’s average speed:

s = l/t = 15,000 m/3487 s

s = 4.3 m/s

Hence, Al must run at an average speed greater than 4.3 m/s to beat John.

10. A sailboat heads north at 3 m/s for 1 hour and then tacks back to the southeast (at 45° to north) at 2 m/s for 45 minutes. a) How far has the boat sailed? b) How far is it from its starting location? *(Answers: a. 16.2 km; b. 8.0 km)*

a. l = (3 m/s) (3600 s) + (2 m/s) (2700 s)

l = 10.8 km + 5.4 km
l = 16.2 km

b. $d^2 = (10.8 \text{ km})^2 + (5.4 \text{ km})^2 - (2)(10.8 \text{ km})(5.4 \text{ km})\cos 45°$

d = 8.0 km

Chapter 2
Kinematic Concepts for Analyzing Human Motion

Chapter Overview

Communicating specific information about human movement requires specialized terminology that identifies body positions and directions. The anatomical reference position is used as the starting place. The sagittal, frontal, and transverse planes, with their respectively associated mediolateral, anteroposterior, and longitudinal axes, provide frames of reference for the description of body movements. The three general categories of movement are linear motion along a straight or curved line, angular motion around an axis, and general motion, which is a combination of linear and rotary motion. A body of terminology is presented in the chapter that describes direction with respect to the human body and the actions that occur at different joints. The Cartesian coordinate system is presented as a spatial reference system.

Physical educators, clinicians, and coaches all routinely perform qualitative analyses to assess, correct, or improve human movement. Visual observation is the most commonly used approach for qualitatively analyzing mechanics. To be effective, an analyst must have knowledge of the biomechanics of the movement and must carefully plan and conduct the analysis. This chapter introduces a systematic approach for planning and conducting qualitative analysis and introduces various tools used for such investigations.

Teaching Tips

Physical practice of various movements will help students learn and remember terminology discussed in the chapter. Use movement examples from a variety of activities including those specific to the represented students and those common to all movers. A dancer can demonstrate a pirouette (transverse plane movement around the longitudinal axis), a gymnast can demonstrate a cartwheel (frontal plane movement around the anteroposterior axis), and a student in a wheel chair can demonstrate the action at the elbow during forward propulsion (sagittal plane movement around the mediolateral axis). To start the practice of qualitative analysis have students observe the more obvious mechanical problems in a movement (either live demonstration or video demonstration). Practice analysis throughout the semester to increase familiarity with the techniques.

Assessment Techniques

1. **Background Knowledge Probe**

   Students are asked to answer a few questions about a topic before the topic is presented in class as a pretest. The information from this pretest can be used to determine whether students have the required background to proceed with certain information. For example, it is helpful to know what background students have in anatomy before proceeding with biomechanics. The information may be used to determine a starting point for the class or to determine who needs to be referred for remedial work. [Angelo, T.A. & Cross, P.K. (1993). *Classroom Assessment Techniques* (2nd ed.). San Francisco: Jossey-Bass.]

2. **YouTube**

   The following are the links to two concepts presented in Chapter 2.

   Axes and Planes
   https://www.youtube.com/watch?v=UsZwsjGuDxU

   Anatomical Directions
   http://www.youtube.com/watch?v=CHKFFgxxw1M&feature=related

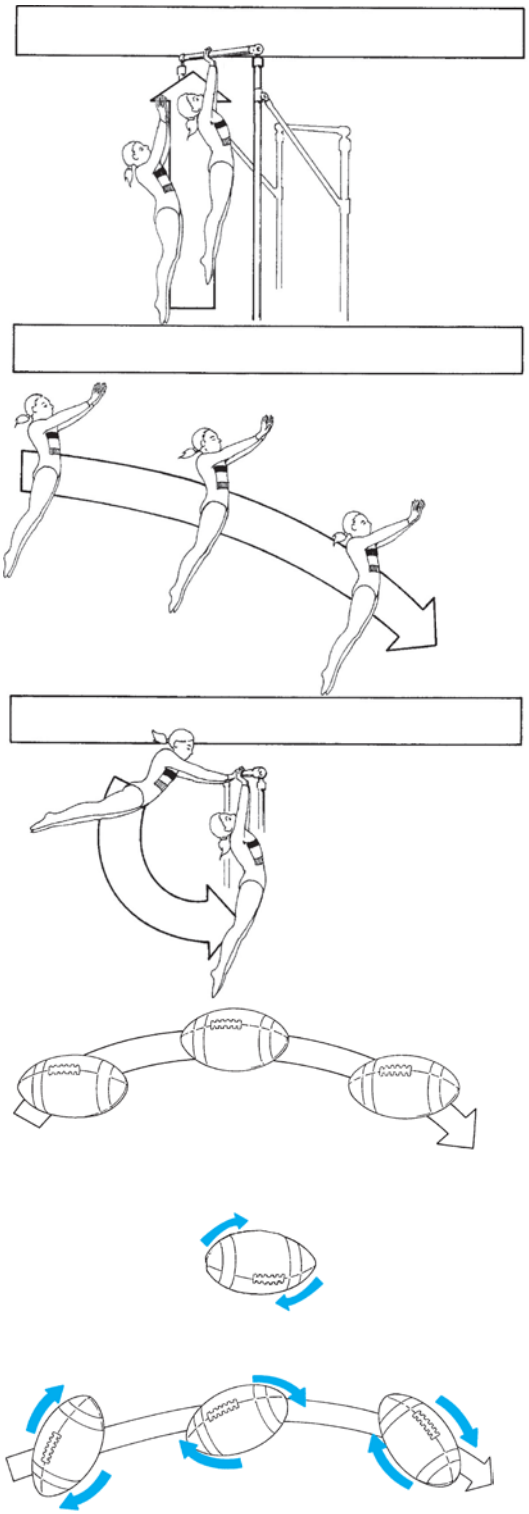
   The links are provided as examples of videos that can be used to supplement the content of the course. The authors and publishers do not own or endorse the videos or guarantee the links will remain active. If these samples are not active, accurate, or appropriate for your class, please find other samples that will work better for you.

Related Weblinks

- www.arielnet.com (Ariel Dynamics Worldwide)
- www.motionanalysis.com (Motion Analysis Corporation)
- www.simi.com (SIMI Reality Motion Systems)

Introductory Quiz

Label the following six movements as angular, curvilinear, general, or rectilinear.



Chapter 2: Laboratory Experiences Kinematic Concepts for Analyzing Human Motion

NAME: _____

DATE: _____

1. Observe and analyze a single performer executing two similar but different versions of a particular movement—for example, two pitching styles or two gait styles. Explain what viewing perspectives and distances you selected for collecting observational data on each movement. Write a paragraph comparing the kinematics of the two movements.

   Movement selected

   Viewing perspectives

   Reasons for selection of viewing perspectives

   Viewing distances

   Reasons for selection of viewing distances

   Kinematic comparison

2. Observe a single sport skill as performed by a highly skilled individual, a moderately skilled individual, and an unskilled individual. Qualitatively describe the differences observed.

   Sport skill selected

Highly Skilled Performer	Moderately Skilled Performer	Unskilled Performer

3. Select a movement at which you are reasonably skilled. Plan and carry out observations of a less-skilled individual performing the movement, and provide verbal learning cues for that individual, if appropriate. Write a short description of the cues provided, with a rationale for each cue.

Movement selected

Cues Provided	Rationale

4. Select a partner, and plan and carry out an observational analysis of a movement of interest. Write a composite summary analysis of the movement performance. Write a paragraph identifying in what ways the analysis process was changed by the inclusion of a partner.

Movement selected

Analysis of Performance

How the analysis process was different when working with a partner

5. Plan and carry out a video session of a slow movement of interest as performed by two different subjects. Write a comparative analysis of the subjects' performances.

Subject 1 Performance	Subject 2 Performance