Chapter 1: Biomechanical Applications to Joint Structure and Function

Multiple Choice
Identify the choice that best completes the statement or answers the question.

____ 1. When you raise a cup to your mouth, a _____ of motion occurs at the elbow joint.
a. rotation only
b. translation only
c. translation and rotation
d. None of the above answers are correct.

____ 2. Hip abduction from an anatomic position would occur in which plane?
a. Sagittal
b. Frontal
c. Transverse
d. Horizontal

____ 3. Which of the following describes the phenomenon that when two forces come in contact, the second force will respond to the contact by the first force with equal magnitude and in the opposite direction?
a. Law of Inertia
b. Law of Reaction
c. Law of Acceleration
d. None of the above answers are correct.

____ 4. A _____ class lever is described by the fulcrum occurring at one end, followed by the resistance (load or weight) and then the force (effort).
a. First
b. Second
c. Third
d. Fourth

____ 5. In what type of lever is the M Ad always less than one?
a. First
b. Second
c. Third
d. Fourth

____ 6. Which of the following *best* describes torque?
a. The force a muscle generates
b. A force times the perpendicular distance from the line of force to the axis of rotation
c. A force times the distance measured along the lever from the line of force to the axis of rotation
d. The distance a muscle can move

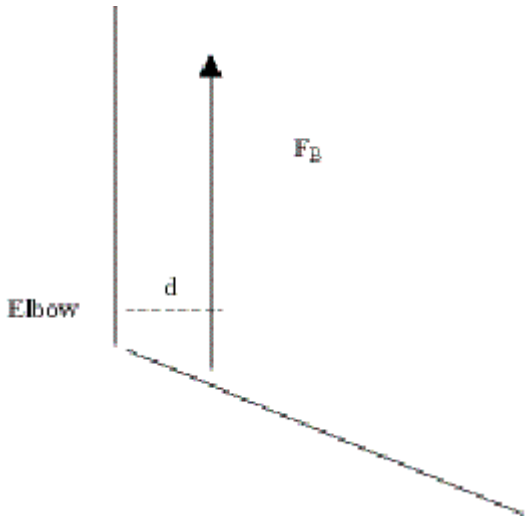


Figure 1-7

____ 7. In Figure 1-7, the biceps is acting on the forearm. What is the ***force*** of the biceps, F_B, given the following: moment arm of the biceps, d = 0.02 m and torque due to the biceps, T_M = –5 Nm?
   a. –0.1 N
   b. 1,250 N
   c. 5 N
   d. –250 N

____ 8. As your patient abducts her shoulder from 90° to 120°, the moment arm decreases. If the torque from the deltoid *remains constant*, the force of the deltoid would _____ as the shoulder abducted.
   a. remain the same
   b. increase
   c. decrease
   d. become 0 N

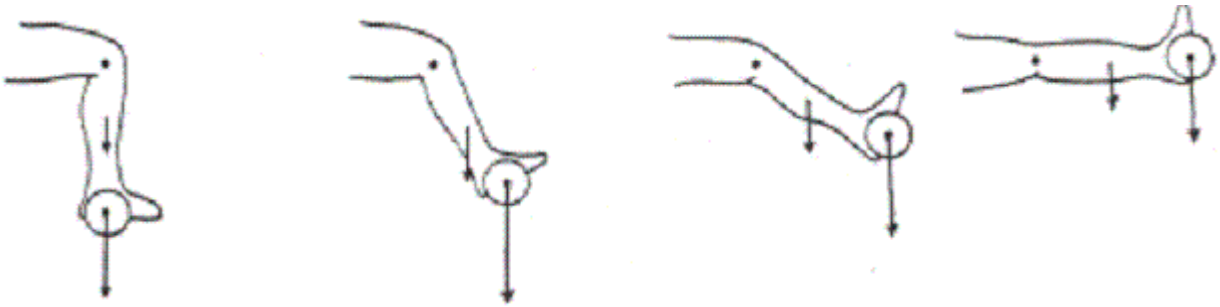


Figure 1-9

____ 9. In Figure 1-9, at which position does the weight have the greatest torque capabilities on the knee joint?
   a. A
   b. B
   c. C
   d. D

____ 10. In Figure 1-9, at which position does the weight produce the greatest distractive on the knee joint?
a. A
b. B
c. C
d. D

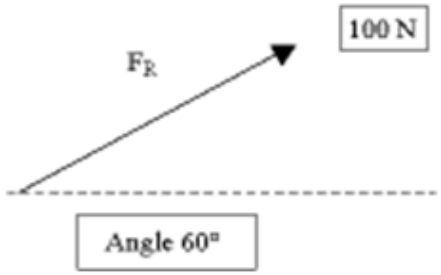
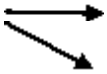


Figure 1-11

____ 11. Which of the following represents the magnitude of each of the two component forces of the resultant, F_R, in Figure 1-11?
a. F_1 = 86.6 N, F_2 = 50 N
b. F_1 = 50 N, F_2 = 60 N
c. F_1 = 10 N, F_2 = 90 N
d. F_1 = 20.6 N, F_2 = 79.4 N

____ 12. Considering the figure below, which of the following answers best represents the direction of the resultant force?

a.
b. 
c. 
d. 

____ 13. Which of the following describes the phenomenon that causes a body moving at a constant speed to remain at that speed, unless it is acted upon by another body or force?
a. Impulse
b. Energy level
c. Law of Reaction
d. Law of Inertia

____ 14. Which of the following statements describes the relationship between joint reaction forces and the translational/rotatory component forces?
a. The contact force and translation component force run parallel to each other.

b. The contact force and rotatory component force run parallel to each other.
c. The shear force and translation component force run parallel to each other.

True/False
Indicate whether the statement is true or false.

____ 1. When the centers of mass (CoM) of two adjacent segments are combined, the combined CoM will be located somewhere along a line connecting the two individual CoMs.

____ 2. The *relative* line of gravity changes with changes in body position.

____ 3. An eccentric muscle contraction is an example of a second-class lever system.

Short Answer

1. Is naming the plane of motion considered part of kinetics or kinematics? Why?

2. What happens to the center of gravity (CoG) of the body when the body segments are rearranged? What happens to the CoG if the right upper extremity is amputated?

3. A student is carrying all his books for his Fall semester courses (first year) in his right arm. What does the additional weight do to the combined center of gravity (CoG) of body and books? How will his body most likely respond to this change?

4. Upon what variables is the magnitude of friction dependent?

5. What kind of force system do the fibers within a muscle form? Explain.

6. How do you determine the net effect of two muscle pulls applied to the same spot? What is this process called?

7. Explain how anatomical pulleys affect the magnitude and direction of a muscle force (Fms).

8. If a force is applied at an angle to a lever (not 90°, not 0°), what is the process by which you determine the torque applied to the lever by that force?

9. If a force is applied at an angle to a lever (not 90°, not 0°), what is the process by which you determine the torque applied to the lever by that force?

10. If not all of a muscle's force is contributing to rotation, what happens to the "wasted" force? Describe by resolution of forces.

11. Using the values given in the following problem, determine whether the lever is in rotational or linear (translatory) equilibrium.
    Fms = 50 lb. (rt. of axis) Wt = 10 lb. (rt. of axis)
    Fr = 15 lb. Wr = 6 lb. (clockwise)

(counterclockwise)

Ft = 40 lb. (toward jt)	Wt = 6 lb. (away from joint)
la = 1″ (rt. of jt)	la = 12″ (rt. of jt)

12. If you have a patient with a recent ligamentous injury to his knee, which of the following positions would you want to avoid and why: sitting, prone, supine, sitting with legs over the edge of the bed, or prone with knees flexed to 90°.

Chapter 1: Biomechanical Applications to Joint Structure and Function
Answer Section

MULTIPLE CHOICE

1. ANS: C
   Rotatory and translatory motions in the human body most commonly occur together.

   PTS: 1
2. ANS: B
   The frontal (coronal) plane divides the body into front and back halves. Movements in this plane occur side to side, such as the case in abduction of the hip.

   PTS: 1
3. ANS: B PTS: 1
4. ANS: B PTS: 1
5. ANS: C
   A mechanical advantage occurs when the effort arm is greater than the resistance arm. This is always the case in a third-class level if all forces are equal.

   PTS: 1
6. ANS: B
   Torque equals force times distance. The distance must be represented by the *moment arm* of the force, not just the direct distance as measured up the lever. The moment arm is the perpendicular distance of the line of the force from the axis of rotation.

   PTS: 1
7. ANS: D
   Because $T = (F)$ (MA) therefore, $F = T/\text{MA}$: (–)5 Nm/0.02 m = (–)250 N. The negative sign is used to show direction of the force. Due to the small moment arm, the force necessary to produce (–)5 Nm of torque is quite large.

   PTS: 1
8. ANS: B
   If the torque were to remain the same, the force would have to increase as the moment arm decreases. Force and moment arm have an inverse relationship if torque is to remain constant.

   PTS: 1
9. ANS: D
   The force of the weight did not change from position to position; therefore, position D would have the greatest torque capabilities due to this position offering the largest moment arm of the weight on the lever.

   PTS: 1

10. ANS: A
    When the line of force is parallel with the moving segment, it will create either a distractive or compressive force between the two boney segments. Distraction occurs when there is a pull or movement of one bony segment away from another. Because the weight would be moving the tibia away from the femur, it will create a distractive force.

    PTS: 1
11. ANS: A
    Sin 60 = 0.866 multiplied by the force of 100 N = 86.6 N, and Cos 60 = 0.05 multiplied by the force of 100 N = 50 N.

    PTS: 1
12. ANS: C
    You find the resultant pull of the two forces by drawing the two forces, creating a parallelogram by adding sides parallel to each of the forces, and drawing a diagonal within the parallelogram. The resultant is the diagonal with its point of application at the original source and whose arrow head (limit of magnitude) is at the opposite corner of the parallelogram. This is called composition of forces.

    PTS: 1
13. ANS: D
    Newton's Law of Inertia addresses the conditions under which an object will be in equilibrium.

    PTS: 1
14. ANS: A
    The contact force runs perpendicular to the joint surface which is in the same plane as the lever. The translational force runs parallel with the lever; therefore, these two forces run parallel to each other.

    PTS: 1

TRUE/FALSE

1. ANS: T PTS: 1
2. ANS: T

   The human body can be considered as a single rigid object. Even though the center of gravity does not change base on position, the relative line of gravity will shift so that it remains vertically downward.

   PTS: 1
3. ANS: T

In this case, the force of gravity would be considered the effort force, and the muscle resisting this force would be considered the resistance force. Because gravity typically acts at a distance farther from the axis than does the pull of the muscle, this would mean that the force involved is acting on the system as a second-class lever.

PTS: 1

SHORT ANSWER

1. ANS:
   Kinematics. It is purely a description of motion without regard to the forces causing it.

   PTS: 1
2. ANS:
   (1) The CoG shifts in the direction(s) of the location of the segments with the greatest mass. (2) The CoG shifts down and to the left once the mass of the right arm is removed, because the lower and left halves of the body are now relatively heavier.)

   PTS: 1
3. ANS:
   The center of gravity (for body and books) will be higher and to the right of S2. Because this new location of the CoG would bring the line of gravity (LoG) to the right side of his base of support, he will lean to the left to bring the LoG back to the middle of the base of support (most stable place). The shift in the CoG is unavoidable. The shift of the LoG is an automatic adaptation but under some volitional control.

   PTS: 1
4. ANS:
   The magnitude of friction is dependent upon (1) the magnitude of contact between the two surfaces on which the friction is occurring—increased contact increases the maximum value of static friction or the absolute value of kinetic friction; (2) the nature of the contacting surfaces—the rougher one or both of the surfaces (increased coefficient of static or kinetic friction), the greater is the maximum value of static friction or the absolute value of kinetic friction; and (3) the shear force(s) on the objects—friction has magnitude only when there is attempted motion (static friction) or actual motion (kinetic friction) between the two surfaces—the magnitude of friction on a *static* object will always equal the *net* shear force on that object; the magnitude of friction on a moving object is always the product of the contact force and the coefficient of kinetic friction.

   PTS: 1
5. ANS:
   Concurrent. Each fiber represents a separate force vector with the same general point of application but which pulls at an angle to each other.

   PTS: 1
6. ANS:

You find the resultant pull of the two forces by drawing the two forces, creating a parallelogram by adding sides parallel to each of the forces, and drawing a diagonal within the parallelogram. The resultant is the diagonal with its point of application at the original source and whose arrow head (limit of magnitude) is at the opposite corner of the parallelogram. This is called composition of forces.

PTS: 1

7. ANS:
Anatomical pulleys (always single pulleys) do not affect the magnitude of Fms but do change the direction of pull. The change in action line generally brings the action line away from the joint axis, thus increasing the moment arm or rotatory component of the applied force.

PTS: 1

8. ANS:
Resolve the force into its components, which are perpendicular (rotatory) and parallel (translatory) to the lever. Torque for the force is then determined by multiplying the magnitude of the rotatory component by its distance (lever arm) from the joint axis.

PTS: 1

9. ANS:
Resolve the force into its components that are perpendicular (rotatory) and parallel (translatory) to the lever. Torque for the force is then determined by multiplying the magnitude of the rotatory component by its distance (lever arm) from the joint axis.

PTS: 1

10. ANS:
The “wasted” force goes toward translation. The translatory component (ft) is a force applied parallel to the shaft of the bone, either toward the joint (compression or joint reaction force) or away from the joint (distraction).

PTS: 1

11. ANS:
In this instance, the lever is rotating clockwise with a magnitude of 57 in-lb. The lever is not in linear equilibrium according to the information given. There is a net joint compression of 34 lb.

PTS: 1

12. ANS:
Sitting with legs over the edge of the bed. In this position, gravity is parallel to the limb, creating a full distractive force. Because this is usually a position of relaxation for the muscles, the only force to counteract the distraction of the limb weight is tension in the injured ligaments.

PTS: 1