HPER K530 Mechanical Analysis of Human Performance Fall, 2003

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MID-TERM

Equations:

$$S = S_0 + v\,t$$

$$S = S_0 + v_0\,t + 1/2\,a\,t^2$$

$$v = v_0 + a\,t$$

$$v^2 = v_0^2 + 2\,a\,(S-S_0)$$

$$e = \sqrt{h_b / h_d}$$

$$F_{CP} = m\,v^2 / r$$

IMPORTANT **READ THIS FIRST:**

* Give each numerical answer correct to **two decimal places**, and make sure that the sign is correct.
* Give the correct **units** for each numerical answer.
* In multiple-choice questions, pick the **BEST** answer.
* Some questions may give you **more information than what you need** to solve them.

1. Which of the following statements is always TRUE?

   When a force is exerted on an object:

   (a) the smaller the force exerted on the object, the larger its linear acceleration.
   (b) the smaller the mass of the object, the larger its linear acceleration.
   (c) the larger the initial linear velocity of the object, the larger its linear acceleration.
   (d) the larger the volume of the object, the smaller its linear acceleration.

2. The slope of the position-time (or displacement-time) curve at a given instant indicates the value of the _____ at that instant.

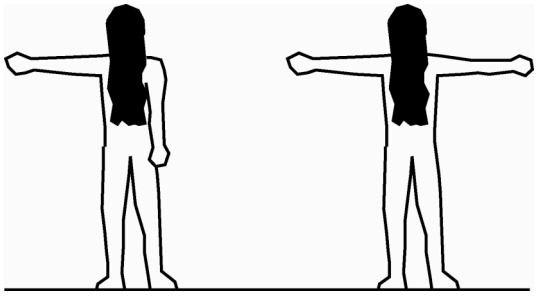
   (a) velocity
   (b) acceleration
   (c) force
   (d) position
   (e) linear momentum

3. A 100 meter swimming race takes place in a 50 meter pool. Assume that the positive direction is the direction of swimming in the first stretch (first 50 meters). How will the **velocity** of the swimmer be as he slows down somewhat, from fatigue, 20 meters before the end of the race? **Read the question carefully!**

   (a) zero
   (b) positive
   (c) negative

4. A gymnast stands on the floor with the left arm stretched out to the left, and the right arm by her side, pointing down. Then, the gymnast moves her right arm up so that both arms now form a cross with the body. If the rest of the body does not move, what happens to the center of mass of the whole body as a result of this action?

   (a) It moves down and to the right.
   (b) It moves up and to the right.
   (c) It does not move.
   (d) It moves up and to the left.
   (e) It moves down and to the left.



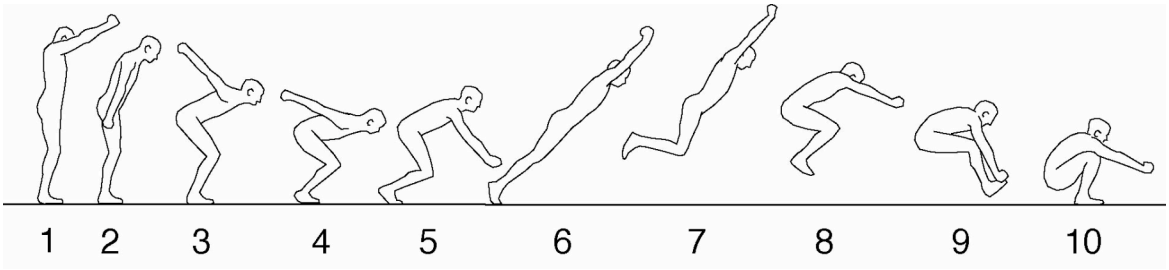
5. Shot putter Kevin Toth's mass is 144 Kg. What is his weight?

6. To calculate the range of a projectile, it is necessary to know:

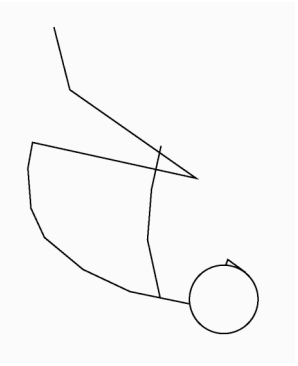
(a) its horizontal velocity at release only.
(b) the magnitude of its resultant velocity vector at release only.
(c) its vertical velocity at release only.
(d) both its horizontal and vertical velocities at release.

7. In the sequence shown below, the jumper flexed his knees and hip between images 6 and 7. If he had kept his legs straight and in the same orientation as in image 6, at the time of image 7 his head would have been:

(a) farther down and to the left than in the original jump.
(b) farther up and to the right than in the original jump.
(c) in the same place as in the original jump.



8. The diver shown below is executing a forward somersault. The direction of his angular velocity vector is pointing:



(a) to the reader's left.
(b) away from the paper, toward the reader.
(c) down, toward the bottom of the page.
(d) into the paper, away from the reader.
(e) to the reader's right.

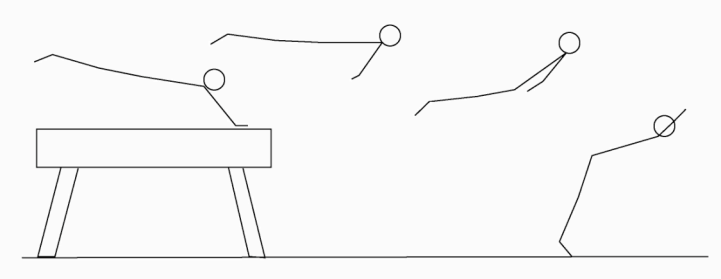
9. Which of the following statements is TRUE?

(a) The vertical velocity of a projectile is constant.
(b) The horizontal velocity of a projectile changes at a constant rate.
(c) The path of a projectile can be changed in mid-air without external forces from solids or fluids.
(d) If two projectiles are released with the same horizontal velocity, the one with the largest vertical velocity at release will land farthest.

10. A 75 Kg sprinter is exerting a 206 N horizontal force **backward** on the ground. Calculate the horizontal acceleration of the athlete. (The forward direction is designated as positive, and the backward direction as negative.)

11. The gymnast shown below had only a small amount of counterclockwise (=backward) angular momentum after leaving the horse, and therefore he was not quite upright by the time that he landed on the ground. Which of the following actions would have made his problem get worse? Remember, to make the problem get worse, **NOT BETTER**.

(a) keep his hands near his thighs throughout the airborne phase
(b) give his body a tucked configuration soon after takeoff
(c) rotate his arms, "windmilling" counterclockwise after takeoff
(d) rotate his arms, "windmilling" clockwise after takeoff



12. Which of the following statements is FALSE? If they are all true, answer "e".

(a) The center of mass of an object is always inside the material that makes up the object.
(b) If a gymnast who is standing on the floor raises her arms toward the ceiling without moving the rest of her body, her center of gravity rises toward the ceiling too.
(c) The suspension method can be used to find the position of the c.m. of an object.
(d) The c.m. of the body is not linked to any particular part of the body.

13. Two satellites are constructed by an electronics company, and then they are weighed. Satellite #1 weighs as much as a car, and satellite #2 weighs as much as a pocket calculator. The two satellites are then taken to outer space on the Space Shuttle. Which satellite will weigh less in outer space?

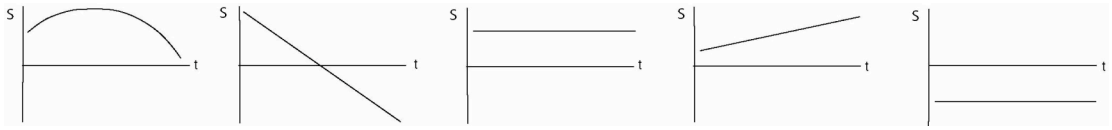
(a) satellite #1
(b) satellite #2
(c) Both will weigh the same.

14. Calculate the value of the impulse that you need to exert on a 117 Kg football player who is running in the positive direction at 6.7 m/s, in order to stop him.

15. Two bobsledding competitors push their sled for 2.3 s with a combined horizontal force of 237 N. The mass of the sled is 64 Kg. Assume that there are no friction forces between the sled and the snow. If the velocity of the sled at the start of the push was zero, calculate the final linear momentum of the sled.

16. Which of the curves shown below describes best the vertical location-time graph of a high jumper during the airborne phase after takeoff from the ground?

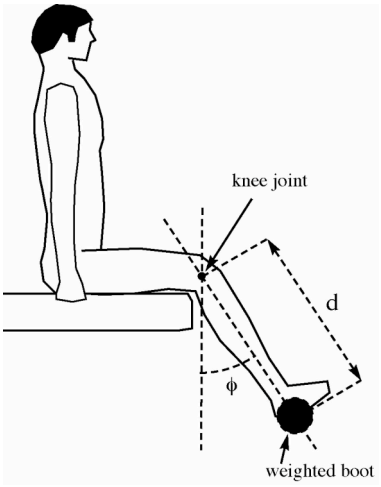
(a) (b) (c) (d) (e)



17. Which of the following is **not** a vector?

(a) force
(b) linear velocity
(c) linear acceleration
(d) angular velocity
(e) mass

18. The mass of the weighted boot shown in the sketch is 23 Kg; the angle between the vertical and the longitudinal axis of the shank is $\phi = 37°$; and the distance d between the knee joint and the weighted boot is 0.34 m. Calculate the value of the torque exerted by the weight of the boot with respect to the knee joint.



19. In a test performed in a lake (i.e., in still water), a particular swimmer was able to maintain a speed of 1.4 m/s for an extended period of time. The swimmer now wants to cross a river that is 350 meters wide and whose current runs at 1.2 m/s. The goal is to reach the opposite bank in the shortest possible time, and it does not matter if the swimmer ends up directly across from the starting point or at a point downstream from the start. Calculate the minimum amount of time that it will take the swimmer to cross the river. (Hint: This problem is not very difficult, but it requires clear thinking on your part.)

20. To facilitate reaching the basketball hoop with the hand while attempting to "dunk" a basketball, the legs of the player should be straight, and pointing vertically downward at the peak of the jump.

(a) TRUE
(b) FALSE

21. Biomechanics research in orthopedics is concerned mainly with:

(a) the achievement of maximum performance in sports.
(b) the design of artificial limbs.
(c) the effects of large accelerations.
(d) safety in the workplace.

22. Which of the following is true?

(a) If velocity is constant, acceleration has to change at a constant rate.
(b) If location is constant, velocity has to be zero.
(c) If acceleration is constant, velocity also has to be constant.

23. In uniformly accelerated motion, it is always true that:

(a) position is constant.
(b) acceleration is constant.
(c) velocity is constant.
(d) acceleration is zero.
(e) velocity is zero.

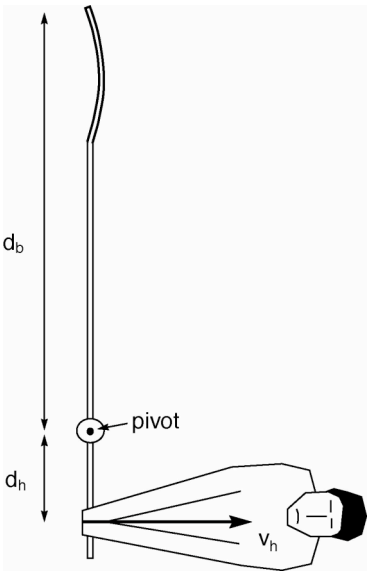
24. If we ignore the effects of air resistance, the sum of the horizontal forces exerted on a gymnast while she is in the air:

(a) depends on the mass of the gymnast.
(b) is equal to the weight of the gymnast.
(c) is zero.
(d) depends on the horizontal velocity of the gymnast.

25. Linear kinematics studies translation and its causes.

(a) TRUE
(b) FALSE

26. The hands of a rower are moving with a linear velocity v_h = 3.9 m/s relative to the pivot of the oar. The distance between the hands and the pivot is d_h = 0.85 m, and the distance between the pivot of the oar and the tip of the blade is d_b = 3.55 m. Calculate the angular velocity of the oar, in degrees/second.



27. Write down the units for **moment arm** (in the **metric system**).

28. A diver has an angular momentum of 41 Kg·m^2/s. Her moment of inertia in a tucked body configuration is 3.87 Kg·m^2. How much time will it take her to complete one turn if she stays in that tucked configuration?

29. The effect of an off-center force is:

(a) a rotation.
(b) a translation plus a rotation.
(c) a translation.

30. The position of a person's center of mass is a weighted average of the positions of the centers of mass of its segments. The body of a diver was considered to be composed of two segments: Segment A comprised the trunk, head and arms, and it had a mass of 37 Kg; segment B comprised the legs, and it had a mass of 17 Kg. Knowing that at a certain instant the centers of mass of segments A and B were at heights of 1.87 m and 1.24 m, respectively, calculate the height of the c.m. of the whole body at that instant.

Name: _____

ANSWERS

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