Name	Section	Date	Score
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Phys 20.01 Long exam 4

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2025 W48

Instructions: For comprehension and conceptual questions, choose the best answer. For problem-solving questions, choose the best answer and show your solution and reasoning. Comprehension is 1 pt each, conceptual is 2 pt each, and problem-solving is 3 pt each.

1. Comprehension

1. An object is rotated about a vertical axis by 90° and then about a horizontal axis by 180°. If we start over and perform the rotations in the reverse order, the orientation of the object
   a. will be the same as before
   b. will be different than before
   c. depends on the shape of the object
2. A non-zero net torque will
   a. cause a change in angular velocity
   b. maintain a constant angular velocity
   c. cause linear acceleration
   d. maintain a constant angular momentum
3. The rotational inertia of a rigid body is
   a. dependent on the location of the axis of rotation
   b. large if most of the mass is far from axis of rotation
   c. a measure of its resistance to changes in rotational motion
   d. all of the above
   e. none of the above
4. A disk is rotating at a constant rate about a vertical axis through its center. Point Q is twice as far from the center of the disk as point P is. The angular velocity of Q at a given time is
   a. twice as big as P's
   b. the same as P's
   c. half as big as P's
   d. none of the above
5. When a disk rotates counterclockwise at a constant rate about a vertical axis through its center, the tangential acceleration of a point on the rim is
   a. positive
   b. zero
   c. negative
   d. impossible to determine without more information
6. The equation of motion for a rotating body $\tau = \Delta L/\Delta t$ for torque τ and angular momentum L
   a. is a new law of physics
   b. can be derived from Newton's laws
   c. can be derived, but depends on laws other than Newton's
7. The moment of inertia of a rigid body about a fixed axis through its center of mass is I. The moment of inertia of this same body about a parallel axis through some other point is always
   a. smaller than I
   b. the same as I
   c. larger than I
   d. whether it's larger or smaller depends on the choice of axis
8. Consider a rigid body that is rotating. Which of the following is an accurate statement?
   a. Its center of rotation is its center of gravity
   b. All points on the body are moving with the same angular velocity
   c. All points on the body are moving with the same linear velocity
   d. Its center of rotation is at rest, that is, not moving
9. A disk rolls without slipping along a horizontal surface.The center of the disk has a translational speed v. The uppermost point on the disk has a translational speed
   a. 0
   b. v
   c. $2v$
   d. need more information
10. An ice-skater spins about a vertical axis through her body with her arms held out. As she draws her arms in, her angular velocity
    a. increases
    b. decreases
    c. remains the same
    d. need more information

2. Conceptual

1. Which situation satisfies both the first and second conditions for equilibrium?
   a. A seagull gliding at a constant angle below the horizontal and at a constant speed
   b. An automobile crankshaft turning at an increasing angular speed in the engine of a parked car
   c. A thrown baseball that does not rotate as it sails through the air
   d. Two among the options above
2. Does a rigid object in uniform rotation about a fixed axis satisfy first and second conditions for equilibrium?
   a. Only the first
   b. Only the second

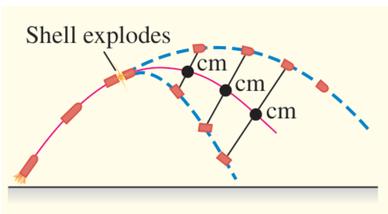
c. Both first and second
d. Neither first and second

3. Does it then follow that every part of this object is in equilibrium?
   a. Yes, because overall system is in rotational equilibrium, implying balanced internal forces throughout
   b. Yes, since the object is rotating uniformly, no part experiences a changing state of motion relative to its immediate surroundings
   c. No, because each part of the object (except those precisely on the axis) is experiencing a centripetal acceleration, requiring a net force
   d. No, this is directly a consequence of the object's center of mass not being in translational equilibrium

4. Where is the cg of a donut?
   a. test
   b. test
   c. test
   d. test

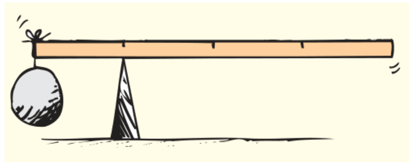
5. Can an object have more than one cg?
   a. No, a rigid object has one cg. If an object is non-rigid, such as a piece of clay or putty, and is distorted into different shapes, then its cg may change as its shape changes. Even then, it has one cg for any given shape

6. Will the center of mass in Fig. 8.32 continue on the same parabolic trajectory even after one of the fragments hits the ground? Why or why not?
   a. No. If gravity is the only force acting on the system of two fragments, the center of mass will follow the parabolic trajectory of a freely falling object. Once a fragment lands, however, the ground exerts a normal force on that fragment. Hence the net external force on the system has changed, and the trajectory of the center of mass changes in response.

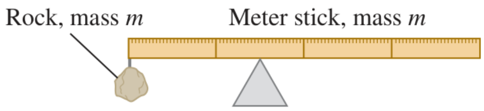


7. Where is the center of mass of Earth's crust?
   a. Like a giant basketball, Earth's crust is a spherical shell with its center of mass at Earth's center

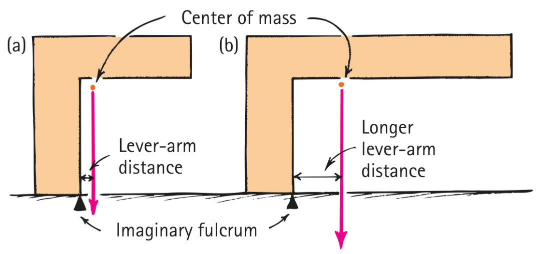
8. A uniform meterstick supported at the 25-cm mark balances when a 1-kg rock is suspended at the 0-cm end. What is the mass of the meterstick?
   a. The mass of the meterstick is 1 kg. why? The system is in equilibrium, so any torques must be balanced: The torque produced by the weight of the rock is balanced by the equal but oppositely directed torque produced by the weight of the stick applied at its CG, the 50-cm mark. The support force at the 25-cm mark is applied midway between the rock and the stick's Cg, so the lever arms about the support point are equal (25 cm). This means that the weights (and hence the masses) of the rock and stick are also equal. (Note that we don't have to go through the laborious task of considering the fractional parts of the stick's weight on either side of the fulcrum because the Cg of the whole stick really is at one point—the 50-cm mark!) Interestingly, the Cg of the rock 1 stick system is at the 25-cm mark —directly above the fulcrum.



9. A rock is attached to the left end of a uniform meter stick that has the same mass as the rock. In order for the combination of rock and meter stick to balance atop the triangular object in Fig. 11.7, how far from the left end of the stick should the triangular object be placed?
   a. Less than 0.25 m
   b. 0.25 m
   c. between 0.25 m and 0.50 m
   d. 0.50 m
   e. more than 0.50 m

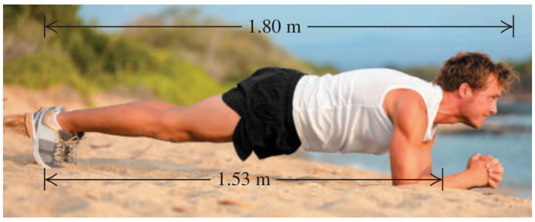


10. The greater torque acts on the object in (b) for two reasons. What are they?



11. The plank (Fig. 11.8a) is a great way to strengthen abdominal, back, and shoulder muscles. You can also use this exercise position to locate your center of gravity. Holding plank position with a scale under his toes and another under his forearms, one athlete measured that 66.0% of his weight was supported by his forearms and 34.0% by his toes. (That is, the total normal forces on his forearms and toes were 0.660w and 0.340w, respectively, where w is the athlete's weight.) He is 1.80 m tall, and in plank position the distance from his toes to the middle of his forearms is 1.53 m. Roughly speaking, where is his center of gravity?
    a. The center of gravity is slightly below our athlete's navel (as it is for most people), closer to his head than to his toes. It's also closer to his forearms than

to his toes, which is why his forearms sup- port most of his weight

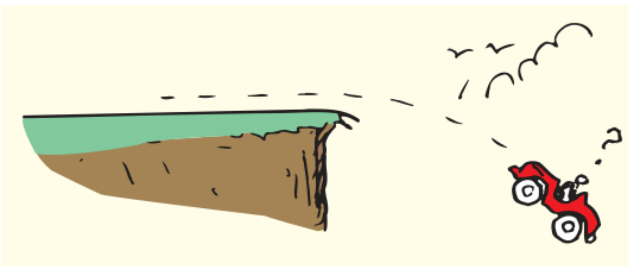


12. Where is Alexei's center of gravity relative to his hands?
    a. test
    b. test
    c. test
    d. test

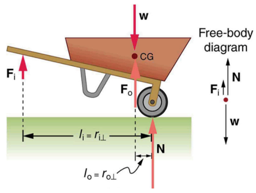
13. why is it dangerous to slide open the top drawers of a fully loaded file cabinet that is not secured to the floor?
    a. The file cabinet is in danger of tipping because the Cg may extend beyond

the support base. If it does, then torque due to gravity tips the cabinet.

14. when a car drives off a cliff, why does it rotate forward as it falls?
    a. when all the wheels are on the ground, the car's Cg is above a support base and no tipping occurs. But when the car drives off a cliff, the front wheels are first to leave the ground and the car is supported only by the rear wheels. The Cg then extends beyond the support base, and rotation occurs. Interestingly, the speed of the car is related to how much time the Cg is not supported and, hence, the amount the car rotates while it falls.



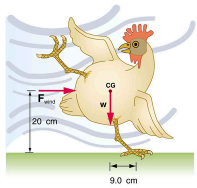
15. In the wheelbarrow of Figure 9.22, the load has a perpendicular lever arm of 7.50 cm, while the hands have a perpendicular lever arm of 1.02 m. (a) What upward force must you exert to support the wheelbarrow and its load if their combined mass is 45.0 kg? (b) What force does the wheelbarrow exert on the ground?
    a. 409 N, 13.6



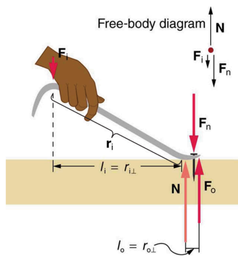
16. Certain types of dinosaurs were bipedal (walked on two legs). What is a good reason that these creatures invariably had long tails if they had long necks?

17. Why are the forces exerted on the outside world by the limbs of our bodies usually much smaller than the forces exerted by muscles inside the body? (in terms of mechanical advantage)

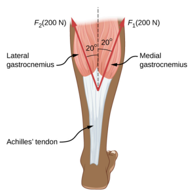
18. (a) What force must be exerted by the wind to support a 2.50-kg chicken in the position shown in Figure 9.31? (b) What is the ratio of this force to the chicken's weight? (c) Does this support the contention that the chicken has a relatively stable construction?



19. What is the mechanical advantage of a nail puller—similar to the one shown in Figure 9.21 —where you exert a force from the pivot and the nail is on the other side? What minimum force must you exert to apply a force of to the nail?

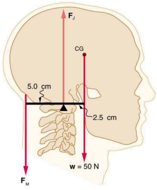


20. Two muscles in the back of the leg pull on the Achilles tendon as shown in Figure 9.35. What total force do they exert? FIGURE 9.35 The Achilles tendon of the posterior leg serves to attach plantaris, gastrocnemius, and soleus muscles to calcaneus bone.

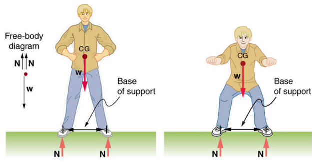


21. Even when the head is held erect, as in Figure 9.39, its center of mass is not directly over the principal point of support (the atlanto-occipital joint). The muscles at the back of the neck should therefore exert a force to keep the head erect. That is why your head falls forward when you fall asleep in the class. (a) Calculate the force exerted by these muscles using the informa-

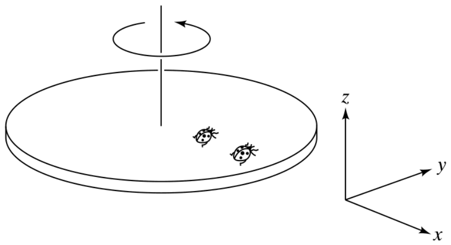
tion in the figure. (b) What is the force exerted by the pivot on the head? FIGURE 9.39 The center of mass of the head lies in front of its major point of support, requiring muscle action to hold the head erect. A simplified lever system is shown.



22. The person on ... is more stable.
    a. the left
    b. the right
    c. neither side (as they have the same stability)



23. A ladybug sits at the outer edge of a merry-go-round,and a gentleman bug sits halfway between her and the axis of rotation. The merry-go-round makes a complete revolution once each second. The gentleman bug's angular speed is
    a. half the ladybug's
    b. the same as the ladybug's
    c. twice the ladybug's
    d. impossible to determine

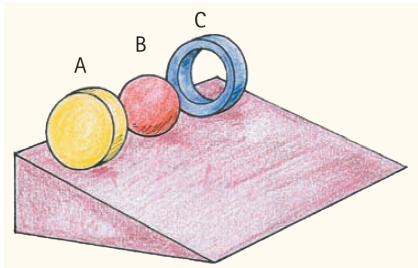


24. If the merry-go-round is turning and slowing down, then at the instant shown in the figure, the tangential component of the ladybug's (cartesian) acceleration is
    a. in the $+x$ direction
    b. in the $-x$ direction
    c. in the $+y$ direction
    d. in the $-y$ direction
    e. in the $+z$ direction
    f. in the $-z$ direction
    g. zero

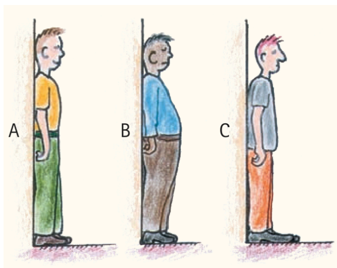
25. If the merry-go-round is turning and slowing down, then the vector expressing her angular velocity is
    a. in the $+x$ direction
    b. in the $-x$ direction
    c. in the $+y$ direction
    d. in the $-y$ direction
    e. in the $+z$ direction
    f. in the $-z$ direction
    g. zero

26. A phonograph record rotates at 45 rpm. Through what angle does it turn in 0.2 s?
    a. 9°
    b. 15°
    c. 54°
    d. 96°

27. Beginning from a rest position, a solid disk A, a solid ball B, and a hoop C race down an inclined plane. Rank them in reaching the bottom: winner, second place, and third place.
    a. test
    b. test
    c. test
    d. test



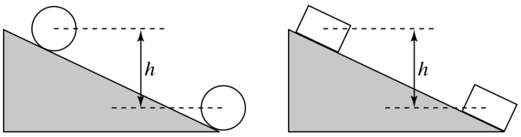
28. Three health sci grad students in good physical shape stand with their backs against a wall. Their task is to lean over and touch their toes without toppling over. Rank their chances for success from highest to lowest.
    a. test
    b. test
    c. test
    d. test



3. Problem solving

Rollin' vs. slidin'. A ball initially at rest rolls without slipping down an inclined plane, as shown below.

1. Make a diagram of the ball on the incline showing all forces acting on the ball. Describe each force in words. Which force causes the ball to roll by creating a torque about its center?
2. Now consider a block sliding down an identical inclined plane. The block travels the same vertical distance as the ball before arriving at the bottom. Which arrives at the bottom with more linear momentum? Why? Write down your reasoning.
    a. rolling ball
    b. sliding block
    c. it is the same for both at the bottom
    d. cannot be determined



The impossible tiptoe. You can probably stand flat-footed on the floor and then rise up and balance on your tiptoes. Why are you unable do it if your toes are touching the wall of your room? (Try it!) Write your reasoning.

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