ROTATIONAL PRACTICE MULTIPLE CHOICE

1984

6. An ice skater is spinning about a vertical axis with arms fully extended. If the arms are pulled in closer to the body, in which of the following ways are the angular momentum and kinetic energy of the skater affected?

Angular Momentum	Kinetic Energy
(A) Increases	Increases
(B) Increases	Remains Constant
(C) Remains Constant	Increases
(D) Remains Constant	Remains Constant
(E) Decreases	Remains Constant

Questions 10-12

A cylinder rotates with constant angular acceleration about a fixed axis. The cylinder's moment of inertial about the axis is 4 kg m^2. At time t = 0 the cylinder is at rest. At time t = 2 seconds its angular velocity is 1 radian per second.

10. What is the angular acceleration of the cylinder between t = 0 and t = 2 seconds?
(A) 0.5 radian/s^2 (B) 1 radian/s^2 (C) 2 radian/s^2 (D) 4 radian/s^2 (E) 5 radian/s^2

11. What is the angular momentum of the cylinder at time t = 2 seconds?
(A) 1 kgm m^2/s (B) 2 kgm m^2/s (C) 3 kgm m^2/s (D) 4 kgm m^2/s
(E) It cannot be determined without knowing the radius of the cylinder.

12. What is the kinetic energy of the cylinder at time t = 2 seconds?
(A) 1 J (B) 2 J (C) 3 J (D) 4 J (E) cannot be determined without knowing the radius of the cylinder

19. A particle is moving in a circle of radius 2 meters according to the relation $\theta = 3t^2 + 2t$, where θ is measured in radians and t in seconds. The speed of the particle at t = 4 seconds is
(A) 13 m/s (B) 16m/s (C) 26m/s (D) 52 m/ s (E) 338 m/ s

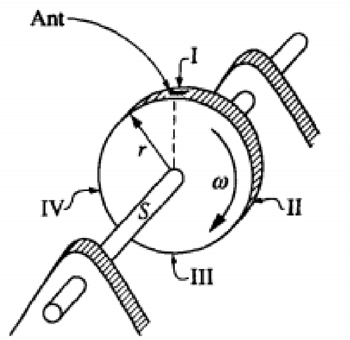
26. A particle of mass m moves with a constant speed v along the dashed line y = a. When the x-coordinate of the particle is x_o, the magnitude of the angular momentum of the particle with respect to the origin of the system is
(A) zero (B) mva (C) mvx_o (D) $mv\sqrt{x^2 + a^2}$ (E) $\frac{mva}{\sqrt{x^2 + a^2}}$

27. A uniform stick has length L. The moment of inertia about the center of the stick is I_o. A particle of mass M is attached to one end of the stick. The moment of inertia of the combined system about the center of the stick is
(A) $I_0 + \frac{1}{4}ML^2$ (B) $I_0 + \frac{1}{2}ML^2$ (C) $I_0 + \frac{1}{2}ML^2$ (D) $I_0 + ML^2$ (E) $I_0 + \frac{5}{4}ML^2$

35. A light rigid rod with masses attached to its ends is pivoted about a horizontal axis as shown above. When released from rest in a horizontal orientation, the rod begins to rotate with an angular acceleration of magnitude
(A) $\frac{g}{7l}$ (B) $\frac{g}{5l}$ (C) $\frac{g}{4l}$ (D) $\frac{5g}{7l}$ (E) $\frac{g}{l}$

1993

Questions 12-13

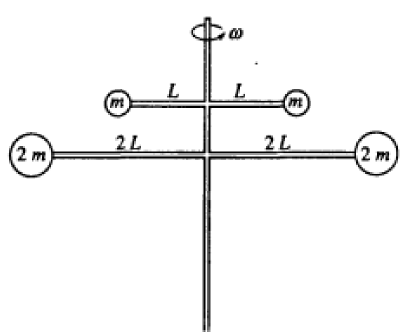


An ant of mass m clings to the rim of a flywheel of radius r, as shown above. The flywheel rotates clockwise on a horizontal shaft S with constant angular velocity ω. As the wheel rotates, the ant revolves past the stationary points I, II, III, and IV. The ant can adhere to the wheel with a force much greater than its own weight.

12. It will be most difficult for the ant to adhere to the wheel as it revolves past which of the four points?
(A) I (B) II (C) III (D) IV
(E) It will be equally difficult for the ant to adhere to the wheel at all points.

13. What is the magnitude of the minimum adhesion force necessary for the ant to stay on the flywheel at point III?
(A) mg (B) $m\omega^2 r$ (C) $m\omega^2 r^2 + mg$ (D) $m\omega^2 r - mg$ (E) $m\omega^2 r + mg$

20. A turntable that is initially at rest is set in motion with a constant angular acceleration α. What is the angular velocity of the turntable after it has made one complete revolution?
(A) $\sqrt{2\alpha}$ (B) $\sqrt{2\pi\alpha}$ (C) $\sqrt{4\pi\alpha}$ (D) 2α (E) $4\pi\alpha$



26. The rigid body shown in the diagram above consists of a vertical support post and two horizontal crossbars with spheres attached. The masses of the spheres and the lengths of the crossbars are indicated in the diagram. The body rotates about a vertical axis along the support post with constant angular speed ω. If the masses of the support post and the crossbars are negligible, what is the ratio of the angular momentum of the two upper spheres to that of the two lower spheres?
(A) 2/1 (B) 1/1 (C) 1/2 (D) 1/4 (E) 1/8

30. The sphere-rod combination can be pivoted about an axis that is perpendicular to the plane of the page and that passes through one of the five lettered points. Through which point should the axis pass for the moment of inertia of the sphere-rod combination about this axis to be greatest?
(A) A (B) B (C) C (D) D (E) E

1998

6. A wheel of mass M and radius R rolls on a level surface without slipping. If the angular velocity of the wheel is ω, what is its linear momentum ?
(A) $M\omega R$ (B) $M\omega^2 R$ (C) $M\omega R^2$ (D) $M\omega^2 R^2/2$ (E) Zero

Questions 32-33

A wheel with rotational inertia I is mounted on a fixed, frictionless axle. The angular speed ω of the wheel is increased from zero to ω_f in a time interval T.

32. What is the average net torque on the wheel during this time interval?

(A) $\frac{\omega_f}{T}$ (B) $\frac{\omega_f}{T^2}$ (C) $\frac{I\omega_f^2}{T}$ (D) $\frac{I\omega_f}{T^2}$ (E) $\frac{I\omega_f}{T}$

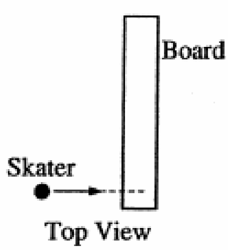
33. What is the average power input to the wheel during this time interval?

(A) $\frac{I\omega_f}{2T}$ (B) $\frac{I\omega_f^2}{2T}$ (C) $\frac{I\omega_f^2}{2T^2}$ (D) $\frac{I^2\omega_f}{2T^2}$ (E) $\frac{I^2\omega_f^2}{2T^2}$

2004

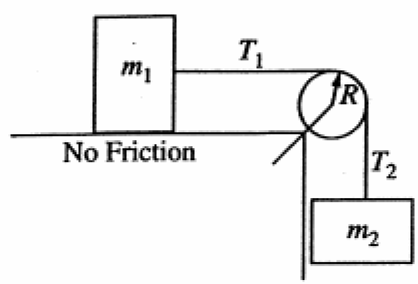
16. A wheel of 0.5 m radius rolls without slipping on a horizontal surface. The axle of the wheel advances at constant velocity, moving a distance of 20 m in 5 s. The angular speed of the wheel about its point of contact on the surface is

(A) 2 radians · s^{-1}
(B) 4 radians · s^{-1}
(C) 8 radians · s^{-1}
(D) 16 radians · s^{-1}
(E) 32 radians · s^{-1}



17. A long board is free to slide on a sheet of frictionless ice. As shown in the top view above, a skater skates to the board and hops onto one end, causing the board to slide and rotate. In this situation, which of the following occurs?

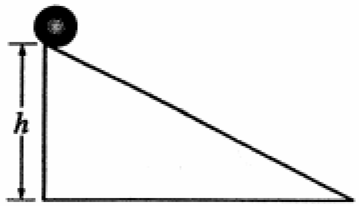
(A) Linear momentum is converted to angular momentum.
(B) Kinetic energy is converted to angular momentum.
(C) Rotational kinetic energy is conserved.
(D) Translational kinetic energy is conserved.
(E) Linear momentum and angular momentum are both conserved.



26. Two blocks are joined by a light string that passes over the pulley shown above, which has radius R and moment of inertia I about its center. T_1 and T_2 are the tensions in the string on either side of the pulley and α is the angular acceleration of the pulley. Which of the following equations best describes the pulley's rotational motion during the time the blocks accelerate?

(A) $m_2 gR = I\alpha$
(B) $(T_1 + T_2)R = I\alpha$
(C) $T_2 R = I\alpha$
(D) $(T_2 - T_1)R = I\alpha$
(E) $(m_2 - m_1)gR = I\alpha$

Questions 7-8



A sphere of mass M, radius r, and rotational inertia I is released from rest at the top of an inclined plane of height h as shown above.

7. If the plane is frictionless, what is the speed v_{cm} of the center of mass of the sphere at the bottom of the incline?

   (A) $\sqrt{2gh}$

   (B) $\frac{2Mgh}{I}$

   (C) $\frac{2Mghr^2}{I}$

   (D) $\sqrt{\frac{2Mghr^2}{I}}$

   (E) $\sqrt{\frac{2Mghr^2}{I + Mr^2}}$

8. If the plane has friction so that the sphere rolls without slipping, what is the speed v_{cm} of the center of mass at the bottom of the incline?

   (A) $\sqrt{2gh}$

   (B) $\frac{2Mgh}{I}$

   (C) $\frac{2Mghr^2}{I}$

   (D) $\sqrt{\frac{2Mghr^2}{I}}$

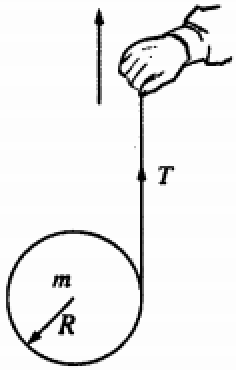
   (E) $\sqrt{\frac{2Mghr^2}{I + Mr^2}}$

2009

8. A disk is free to rotate about an axis perpendicular to the disk through its center. If the disk starts from rest and accelerates uniformly at the rate of 3 radians/s^2 for 4 s, its angular displacement during this time is

   (A) 6 radians
   (B) 12 radians
   (C) 18 radians
   (D) 24 radians
   (E) 48 radians

Questions 23-24



A solid cylinder of mass m and radius R has a string wound around it. A person holding the string pulls it vertically upward, as shown above, such that the cylinder is suspended in midair for a brief time interval Δt and its center of mass does not move. The tension in the string is T, and the rotational inertia of the cylinder about its axis is $\frac{1}{2}mR^2$.

23. The net force on the cylinder during the time interval Δt is

(A) T
(B) mg
(C) $T - mgR$
(D) $mgR - T$
(E) zero

24. The linear acceleration of the person's hand during the time interval Δt is

(A) $\frac{T - mg}{m}$

(B) $2g$

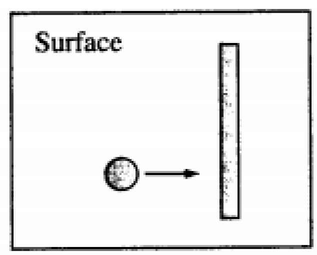
(C) $\frac{g}{2}$

(D) $\frac{T}{m}$

(E) zero

25. A figure skater goes into a spin with arms fully extended. Which of the following describes the changes in the rotational kinetic energy and angular momentum of the skater as the skater's arms are brought toward the body?

	Rotational Kinetic Energy	Angular Momentum
(A)	Remains the same	Increases
(B)	Remains the same	Remains the same
(C)	Increases	Remains the same
(D)	Decreases	Increases
(E)	Decreases	Remains the same

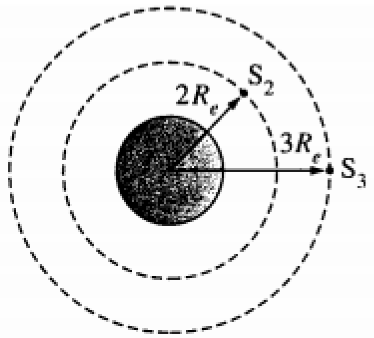


Top View

12. A disk sliding on a horizontal surface that has negligible friction collides with a rod that is free to move and rotate on the surface, as shown in the top view above. Which of the following quantities must be the same for the disk-rod system before and after the collision?

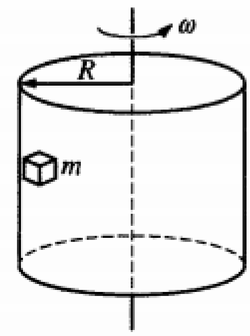
I. Linear momentum
II. Angular momentum
III. Kinetic energy

(A) I only
(B) II only
(C) I and II only
(D) II and III only
(E) I, II, and III



33. The figure above represents satellites S_2 and S_3 of equal mass orbiting Earth in circles of radii $2R_e$ and $3R_e$, respectively, where R_e is the radius of Earth. How do the kinetic energy and the angular momentum of S_3 compare with those of S_2 ?

	Kinetic Energy	Angular Momentum
(A)	Less for S_3	Greater for S_3
(B)	Greater for S_3	Greater for S_3
(C)	The same for both	The same for both
(D)	Less for S_3	Less for S_3
(E)	Greater for S_3	Less for S_3



35. A block of mass m is placed against the inner wall of a hollow cylinder of radius R that rotates about a vertical axis with a constant angular velocity ω, as shown above. In order for friction to prevent the mass from sliding down the wall, the coefficient of static friction μ between the mass and the wall must satisfy which of the following inequalities?

(A) $\mu \geq mg$

(B) $\mu \geq \frac{g}{\omega^2 R}$

(C) $\mu \geq \frac{\omega^2 R}{g}$

(D) $\mu \leq \frac{g}{\omega^2 R}$

(E) $\mu \leq \frac{\omega^2 R}{g}$