

PSI AP Physics I

Rotational Motion

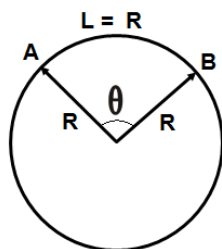
Multiple-Choice questions

1. Which of the following is the unit for angular displacement?

- A. meters
- B. seconds
- C. radians
- D. radians per second

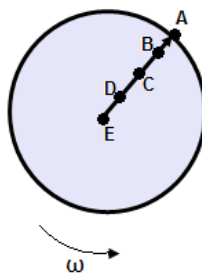
2. An object moves from point A to point B along a circular path with a radius R. What is the size of the angle θ ?

- A. 1 rad
- B. 2 rad
- C. 3 rad
- D. 4 rad



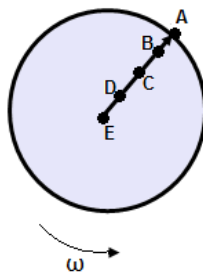
3. A solid disk with a radius R rotates at a constant rate ω . Which of the following points has the greater angular displacement?

- A. A
- B. B
- C. C
- D. All points have the same angular displacement.



4. A solid disk with a radius R rotates at a constant rate ω . Which of the following points has the greater angular velocity?

- A. A
- B. B
- C. E
- D. All points have the same angular velocity.



5. A solid disk with a radius R rotates at a constant rate ω . Which of the following represents the period of rotations?

- A. $2\pi\omega$
- B. $\pi/2\omega$
- C. $2\pi/\omega$
- D. 2ω

6. A toy car moves around a circular track with a radius of 10 m. When the car's velocity is instantaneously directed south, its acceleration is directed west at 10 m/s^2 . When viewed from above, the car moves:
- A. clockwise at 1 rad/s
 - B. clockwise at 10 rad/s
 - C. counterclockwise at 1 rad/s
 - D. counterclockwise at 10 rad/s
7. An object starts from rest and accelerates at a constant rate α in a circular path with a radius R. The radius describes an angle θ after time t. Which of the following represents the angular velocity as a function of θ ?
- A. $2\alpha\theta$
 - B. $2\theta/\alpha$
 - C. $\sqrt{2\alpha\theta}$
 - D. $\sqrt{2\theta/\alpha}$
8. An object starts from rest and accelerates at a constant rate in a circular path. After a certain time t, the object reaches the angular velocity ω . How many revolutions did it make during time t?
- A. $4\pi\omega$
 - B. $4\omega/\pi t$
 - C. $\omega t/4\pi$
 - D. $4\omega t$
9. A rod rotates about a pivot at its center at 2 rad/s. Its angular velocity increases uniformly to 14 rad/s in 3 s. Find the rod's angular acceleration over this time period.
- A. 2 rad/s^2
 - B. 4 rad/s^2
 - C. 6 rad/s^2
 - D. 8 rad/s^2
10. A rod rotates about a pivot at its center at 2 rad/s. Its angular velocity increases uniformly to 14 rad/s in 3 s. Find the rod's angular displacement over this time period.
- A. 6 rad
 - B. 12 rad
 - C. 18 rad
 - D. 24 rad
11. A bicycle wheel of radius 40.0 cm and angular velocity of 10.0 rad/s starts accelerating at 80.0 rad/s^2 . What is the tangential acceleration of the wheel at this time point?
- A. 4 m/s^2
 - B. 32 m/s^2
 - C. 40 m/s^2
 - D. 320 m/s^2

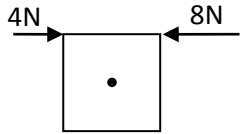
12. A bicycle wheel of radius 40.0 cm and angular velocity of 10.0 rad/s starts accelerating at 80.0 rad/s². What is the centripetal acceleration of the wheel at this time point?
- A. 12m/s²
 - B. 24 m/s²
 - C. 36 m/s²
 - D. 40 m/s²
13. A record on a turntable is spinning and coming to rest. At $t = 0$ s, the angular velocity of the record is 20.0 rad/s with a constant acceleration of -5.0 rad/s². How long does it take for the record to come to rest?
- A. 2 s
 - B. 4 s
 - C. 8 s
 - D. 12 s
14. A record on a turntable is spinning and coming to rest. At $t = 0$ s, the angular velocity of the record is 20.0 rad/s with a constant acceleration of -5.00 rad/s². What is the record's angular velocity at $t = 0.500$ s?
- A. 10.5 rad/s
 - B. 15.5 rad/s
 - C. 16.5 rad/s
 - D. 17.5 rad/s
15. A record on a turntable is spinning and coming to rest. At $t = 0$ s, the angular velocity of the record is 20.0 rad/s with a constant acceleration of -5.0 rad/s². What is the record's angular displacement at $t = 2.0$ s?
- A. 15 rad
 - B. 30 rad
 - C. 40 rad
 - D. 50 rad
16. A tire is rolling with an initial angular velocity of 10.0 rad/s. It slows down with an angular acceleration of -5.0 rad/s² and comes to rest. What is the net angular displacement of the wheel?
- A. 5 rad
 - B. 10 rad
 - C. 25 rad
 - D. 30 rad
17. Find the linear displacement of a car wheel of radius 9.0 m as it moves through an angular displacement of 3.0 rad.
- A. 0.33 rad
 - B. 3.3 rad
 - C. 27 rad
 - D. 81 rad
18. If an object starts from rest and accelerates with a constant angular acceleration of 6.0 rad/s², what is the angular velocity at 3.0 s?
- A. 0.50 rad/s
 - B. 2.0 rad/s
 - C. 18 rad/s
 - D. 54 rad/s

19. A car's tire of radius 0.50 m has an angular velocity of $\omega = 3t^2 - 5t + 20$. Find the angular velocity of the tire at $t = 2.0$ s.
- A. 14 rad/s
 - B. 22 rad/s
 - C. 24 rad/s
 - D. 28 rad/s
20. A car's tire of radius 0.50 m has an angular velocity of $\omega = 3t^2 - 5t + 20$. Find the linear velocity of the tire at $t = 2.0$ s.
- A. 7 m/s
 - B. 11 rad/s
 - C. 12 rad/s
 - D. 14 rad/s
21. An object has an initial angular velocity of 5.0 rad/s and undergoes an angular acceleration of 15 rad/s². What is the final angular velocity after 3.0 s?
- A. 25 rad/s
 - B. 30 rad/s
 - C. 50 rad/s
 - D. 60 rad/s
22. An object has a final angular velocity of 25 rad/s and sweeps through 80.0 rads with an angular acceleration of 2.5 rad/s². What was its initial angular velocity?
- A. 15 rad/s
 - B. 25 rad/s
 - C. 32 rad/s
 - D. 48 rad/s
23. An object has an initial angular velocity of 5.00 rad/s and undergoes a constant angular acceleration of -0.100 rad/s². What is the angular displacement that it moves through in 3.00 s?
- A. 12.3 rad
 - B. 14.6 rad
 - C. 16.3 rad
 - D. 19.3 rad
24. A ball is attached to a string and rotates in a circle. If it takes 1.00 s to complete one revolution, what is the angular velocity of the ball?
- A. 3.14 rad/s
 - B. 6.28 rad/s
 - C. 9.42 rad/s
 - D. 12.6 rad/s

25. Torque is the rotational analog of which of the following quantities?

- A. kinetic energy
- B. linear momentum
- C. acceleration
- D. force

Questions 26-28

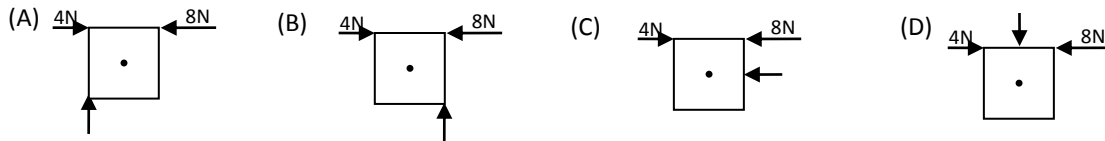


A wooden square of side length 1.0 m is on a horizontal tabletop and is free to rotate about its center axis. The square is subject to two forces and rotates.

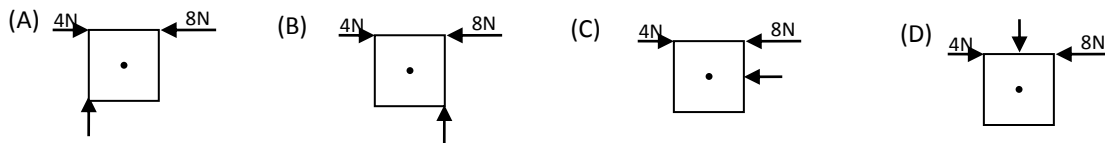
26. Find the net torque of the system.

- A. 2 N-m
- B. 4 N-m
- C. $4\sqrt{2}$ N-m
- D. $2\sqrt{2}$ N-m

27. Where should another 4 N force be applied to maximize its torque?

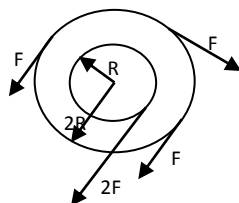


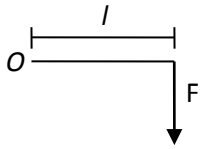
28. Where should another 4 N force be applied to place the block in an equilibrium state?



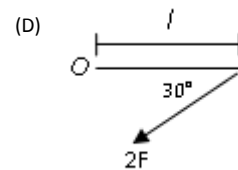
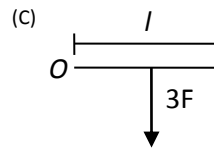
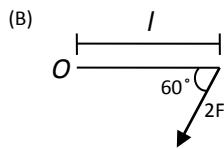
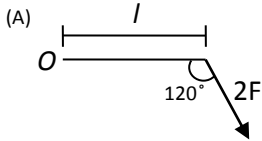
29. Two wheels are fixed to each other and are free to rotate about a frictionless axis through their concentric centers. Four forces are exerted tangentially to the wheels. The magnitude of the net torque is:

- A. zero
- B. FR
- C. $2FR$
- D. $4FR$

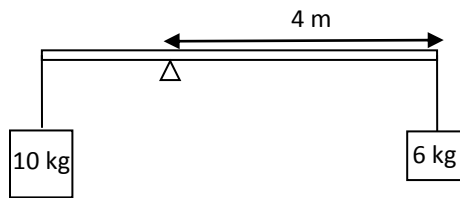




30. In which of the following diagrams is the torque about point O equal in magnitude to the torque about point X in the diagram above?



Questions 31-32



Two masses of mass 10.0 and 6.0 kg are hung from massless strings at the end of a light rod. The rod is virtually weightless. A pivot (fulcrum) is placed off center and the system is free to rotate.

31. If the 6.0 kg mass is 4.0 m away from the pivot, how far away is the 10.0 kg mass if the system is not rotating?

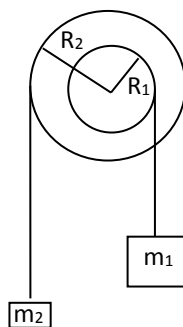
- A. 0.42 m
- B. 2.4 m
- C. 4.8 m
- D. 6.3 m

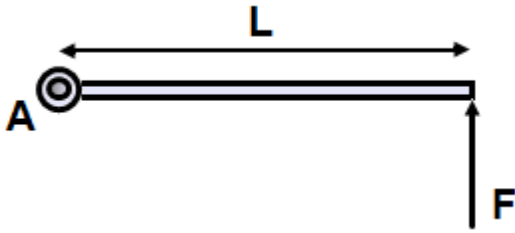
32. If the string supporting the 6.0 kg mass is cut, find the net torque of the system.

- A. 60 N-m
- B. 120 N-m
- C. 240 N-m
- D. 480 N-m

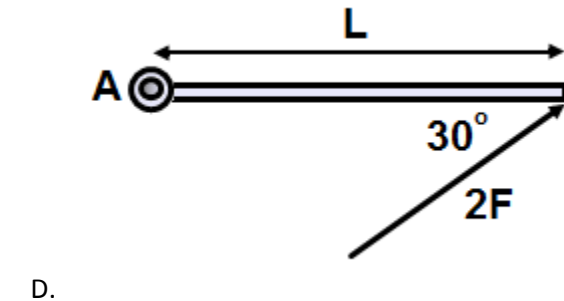
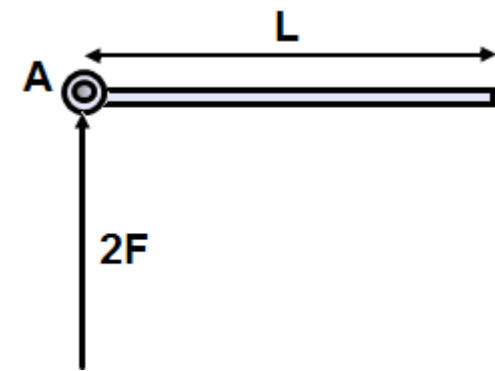
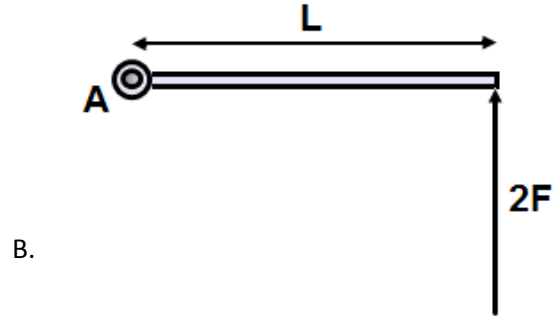
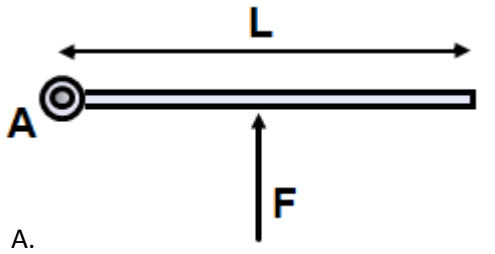
33. Which of the following must be true for the below system of two concentric massless pulleys and two masses to be at equilibrium?

- A. $m_1 = m_2$
- B. $m_1 R_1 = m_2 R_2$
- C. $m_1 R_2 = m_2 R_1$
- D. $m_1 R_1^2 = m_2 R_2^2$





34. As shown above, a rod with a length L is free to rotate about point A . An external force F is applied perpendicular to the rod. In which of the following cases is the torque on the rod the same as the above?



35. A force, F is applied to a doorknob and a second force, $2F$ is applied to the same door at its midpoint. Both forces are perpendicular to the door plane. Which of the following is the correct ratio between the torque of the first force and the torque of the second force?

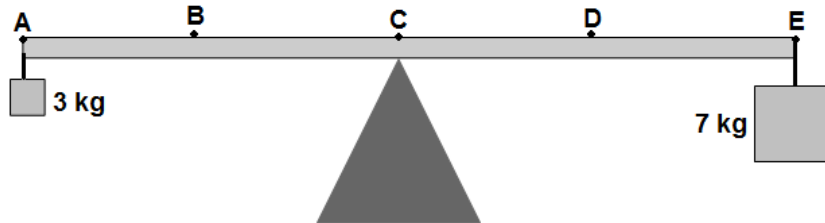
- A. 2:1
- B. 1:2
- C. 4:1
- D. 1:1

36. In translational motion, mass is a measure of an object's acceleration in response to a force. What is the rotational analog of mass?

- A. torque
- B. moment of inertia
- C. angular acceleration
- D. angular momentum

37. When a solid object rotates with a constant angular acceleration, which of the following is true?
- A. All points on the object rotate with the same centripetal acceleration.
 - B. The net torque applied to the object must be zero.
 - C. The net torque applied to the object must be a constant.
 - D. All points on the object rotate with the same tangential acceleration.

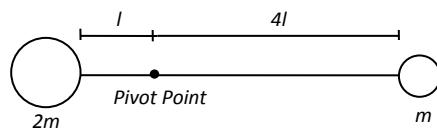
38. In the diagram below, two boxes with masses, 3 kg and 7 kg are attached to the ends of a 1 m long lever. At which of the following points should the lever be placed on a fulcrum in order to keep the lever at equilibrium?
- A. A or E
 - B. B
 - C. C
 - D. D



39. Two uniform disks have the same radius but different masses: disk 1 has a mass M , disk 2 has a mass $2M$. What is the ratio of the moment of inertia of the first disk to the second disk?
- A. 1:4
 - B. 1:2
 - C. 2:1
 - D. 4:1
40. Two uniform disks have the same mass but different radii: disk 1 has a radius R and disk 2 has a radius $2R$. What is the ratio of the moment of inertia of the first disk to the second disk?
- A. 1:4
 - B. 1:2
 - C. 2:1
 - D. 4:1
41. A bicycle wheel of radius, r rolls with a constant angular velocity on a horizontal surface without slipping. Which of the following is the right formula for the velocity of the center of mass?
- A. $v = r\omega$
 - B. $v = r/\omega$
 - C. $v = \omega/r$
 - D. $v = \omega^2 r$

42. Two masses, one with mass m , and the other with mass $2m$, are attached to a light rigid rod as shown below. When the system is released from rest, the rod begins to rotate with an angular acceleration of:

- A. $-g/4l$
- B. $-g/5l$
- C. $-g/7l$
- D. $-g/9l$



Questions 43-44

A wheel with rotational inertia, I is placed on an axle and is free to rotate without friction. The angular speed, ω of the wheel is increased from zero to ω_f in a time interval, t .

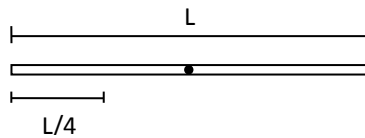
43. What is the average net torque on the wheel during this time interval?

- A. $\frac{I\omega_f}{t}$
- B. $\frac{\omega_f}{t^2}$
- C. $\frac{I\omega_f^2}{t}$
- D. $\frac{I\omega_f}{t^2}$

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

- A. $\frac{I\omega_f}{2t}$
- B. $\frac{\omega_f}{2t^2}$
- C. $\frac{I\omega_f^2}{2t}$
- D. $\frac{I\omega_f}{2t^2}$

Questions 45-46



A rod of length, L is rotated about its center with $I = \frac{ML^2}{12}$.

45. What is the moment of inertia at a point $L/4$ away from the center?

- A. $\frac{ML^2}{12}$
- B. $\frac{3ML^2}{4}$
- C. $\frac{7ML^2}{48}$
- D. $\frac{15ML^2}{29}$

46. What is the moment of inertia at either end of the rod?

- A. $\frac{ML^2}{12}$
- B. $\frac{ML^2}{3}$
- C. $\frac{7ML^2}{12}$
- D. $\frac{ML^2}{6}$

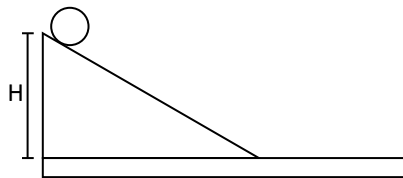
47. A rubber band ball of mass, M and radius, R , with $I = \frac{2MR^2}{5}$, rolls without slipping up an incline with an initial speed, v . The ball reaches a maximum vertical height of:

- A. $\frac{v^2}{5g}$
- B. $\frac{2v^2}{5g}$
- C. $\frac{v^2}{2g}$
- D. $\frac{7v^2}{10g}$

48. An experiment is performed in a physics class where three objects, an empty can, a D battery and a marble, roll down an incline of height, H without slipping. A box slides down an adjacent frictionless incline of the same height. Which of the four objects reaches the bottom of their inclined planes first?

- A. empty can
- B. battery
- C. marble
- D. box

Questions 49-54



A ball with $I = \frac{2MR^2}{5}$, is released from rest at the top of an incline of height, H at an angle, θ . There is no friction between the ball and the surface of the incline.

49. What is the acceleration of the ball as it slides down the incline?

- A. $g/2$
- B. $g\sin\theta$
- C. $2g\cos\theta$
- D. $g\sin^2\theta$

50. What is the velocity of the ball at the bottom of the incline?

- A. $2gH$
- B. gH
- C. $4gH\sin\theta$
- D. $\sqrt{2gH}$

The ball is still released from rest at the top of the incline, but this time, there is friction between the ball and the incline so that the ball rolls down without slipping.

51. What is the velocity of the ball at the bottom of the incline?
- A. $2gH$
 - B. gH
 - C. $\sqrt{10gH/7}$
 - D. $\sqrt{2gH}$
52. What is the acceleration of the ball as it rolls down the incline?
- A. $g/2$
 - B. $g\sin\theta$
 - C. $\mu mg\cos\theta$
 - D. $5g\sin\theta/7$
53. How does the translational kinetic energy (KE_T) compare to the rotational kinetic energy (KE_R) for the above two scenarios (incline without friction, and incline with friction)?
- A. $KE_T > KE_R$ for the incline without friction.
 - B. $KE_T < KE_R$ for the incline without friction.
 - C. They are both the same.
 - D. Cannot be determined without knowing the mass of the ball.
54. If the ball is replaced with a disk ($I = \frac{MR^2}{2}$), how will the velocity at the bottom of the incline change?
- A. The disk will travel faster.
 - B. The disk will travel slower.
 - C. The velocity will be the same.
 - D. Cannot be determined without knowing the mass of the ball.
55. The Earth moves around the Sun in an elliptical orbit. As the Earth approaches its closest point to the Sun in its orbit, the Earth's linear velocity increases. Which of the following doesn't change in the Earth-Sun system?
- A. orbital radius
 - B. kinetic energy
 - C. potential energy
 - D. angular momentum
56. A baseball player swings his bat with his arms fully extended. If his arms are pulled in closer to his body, which of the following choices correctly describes the impact of his motion on his swing's angular momentum and kinetic energy?

Angular Momentum

Kinetic Energy

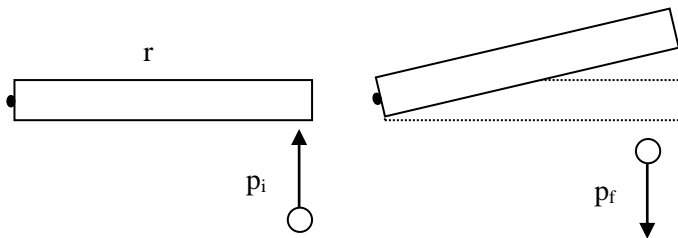
- | | |
|---------------------|------------------|
| A. increases | increases |
| B. increases | remains constant |
| C. remains constant | increases |
| D. remains constant | remains constant |

57. An ice skater performs a fast spin by pulling her outstretched arms down and close to her body. What happens to her angular momentum with respect to the axis of rotation?
- increases
 - decreases
 - stays the same
 - depends on her initial rotational velocity

58. An ice skater performs a fast spin by pulling her outstretched arms down and close to her body. What happens to her kinetic energy?
- increases
 - decreases
 - stays the same
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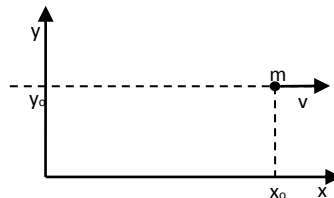
59. A thin rod of length, r on a frictionless surface, pivots about its left end as shown below. The rod is at rest and is hit by a sphere, which causes the rod to rotate counterclockwise about its pivot. The initial momentum of the sphere is p_i and its final momentum is p_f , in the opposite direction of its initial movement. What is the magnitude of the angular momentum of the rod immediately after the collision?

- $(p_f - p_i)r$
- $(p_f + p_i)r$
- $(p_f - p_i)$
- $(p_f + p_i)$



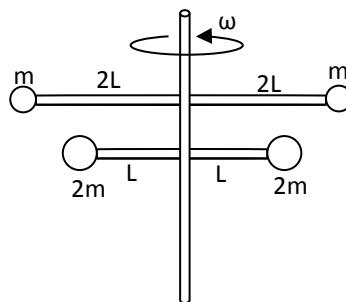
60. A particle of mass, m moves with a constant speed, v along the dashed line $y = y_0$. When the x -coordinate of the particle is x_0 , the magnitude of the angular momentum of the particle with respect to the origin of the system is:

- zero
- $mv y_0$
- $mv x_0$
- $mv\sqrt{x^2 + y_0^2}$



61. The system below rotates with an angular velocity, ω . If the mass of the rod supports is negligible, what is the ratio of the angular momentum of the two upper spheres to the two lower spheres?

- 1/4
- 1/2
- 2/1
- 4/1



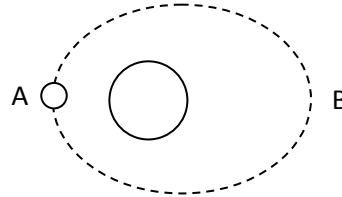
62. The below is an exaggerated view of the earth's elliptical orbit about the sun (it is actually very close to a circle). As it moves from point A to point B, which of the following is true about its speed and angular momentum?

Speed

- A. remains constant
- B. increases
- C. decreases
- D. decreases

Angular Momentum

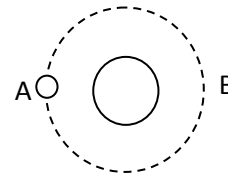
- remains constant
- increases
- decreases
- remains constant



Multi Correct Questions: For each of the questions or incomplete statements below, two of the suggested answers will be correct. For each of these questions, you must select both correct choices to earn credit. No partial credit will be earned if only one correct choice is selected. Select the two that are best in each case.

63. A meteor of mass, M moves with a constant speed, v in a circular orbit of radius R . Which of the following statements are true?

- A. The tangential acceleration is zero.
- B. The tangential acceleration is a constant, non zero value.
- C. Its angular momentum is not constant.
- D. The magnitude of the centripetal acceleration is constant.



64. Two students of different masses are about to get on a see-saw. If they want to place the see-saw in equilibrium, what factors must they consider?

- A. The mass of the see-saw plank that they sit on.
- B. The mass of each student.
- C. The distance each student sits away from the fulcrum of the see-saw.
- D. The length of the see-saw plank.

65. Two children are in a playground. One of them is on a merry-go-round that is rotating in a clockwise direction, and the other one is next to the merry-go-round. Which of the following actions will result in a change in the angular momentum of the single child – merry-go-round system?

- A. The child on the merry-go-round moves towards the center of it.
- B. The child on the merry-go-round moves in a concentric circle around it.
- C. The other child pushes tangentially on the merry-go-round, increasing its angular velocity.
- D. The other child jumps on to the merry-go-round.

66. A disc is rotating about its center of mass. Point A is 0.06 m from the axis of rotation. Point B is 0.12 m from the axis of rotation. What quantities are the same for both points?

- A. The angular displacement.
- B. The linear displacement.
- C. The angular velocity.
- D. The tangential velocity.

67. You are choosing a screwdriver to loosen a stuck screw. Which of the following qualities of the screwdriver will allow you to deliver the most torque to the screw?

- A. Increased length of the screwdriver shank.
- B. A handle with a small diameter.
- C. A handle with a large diameter.
- D. Increased width of the blade.

68. Which of the following situations will increase the moment of inertia of a solid cylinder ($I = \frac{1}{2} MR^2$) by the same amount?
- A. Constant mass, double radius.
 - B. Quadruple mass, constant radius.
 - C. Double mass, constant radius.
 - D. Constant mass, quadruple radius.
69. A solid cylinder of radius, R rolls down an incline. Which of the following objects, if set in motion at the same time on an identical incline, will get to the bottom of the incline before this hoop?
- A. Cylindrical shell of radius R .
 - B. Solid sphere of radius R .
 - C. Solid sphere of radius $2R$.
 - D. Solid cylinder of radius $R/2$.
70. Leonardo da Vinci conceived of a flywheel with a variable moment of inertia. It consisted of a vertical axle, with four rods attached to the axle in a horizontal manner, equally spaced around the axle. At the end of each rod, a small chain hung vertically with a sphere attached to the bottom of each chain. If an external torque was applied to the axle, it would rotate and the spheres would move outward and upward from the axle. Which of the following statements are true?
- A. The angular momentum of the flywheel is conserved.
 - B. The angular momentum of the flywheel is not conserved.
 - C. The moment of inertia of the flywheel increases.
 - D. The moment of inertia of the flywheel decreases.

Multiple Choice Answer Key

1. C
2. A
3. D
4. D
5. C
6. A
7. C
8. C
9. B
10. D
11. B
12. D
13. B
14. D
15. B
16. B
17. C
18. C
19. B
20. B
21. C
22. A
23. B
24. B
25. D
26. A
27. B
28. A
29. D
30. D
31. B
32. C
33. B
34. D
35. D
36. B
37. C
38. D
39. B
40. A
41. A
42. D
43. A
44. C
45. C
46. B
47. A
48. D
49. B
50. D
51. C
52. D
53. A
54. B
55. D
56. C
57. C
58. A
59. B
60. B
61. C
62. D
63. A, D
64. B, C
65. C, D
66. A, C
67. C, D
68. A, B
69. B, D
70. B, C