

AP Physics C

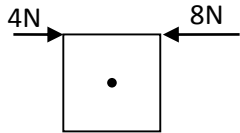
Rotational Dynamics

Multiple Choice Questions

1. Torque is the rotational analogue of

- (A) kinetic energy (B) linear momentum (C) acceleration (D) force (E) mass

Questions 2-4

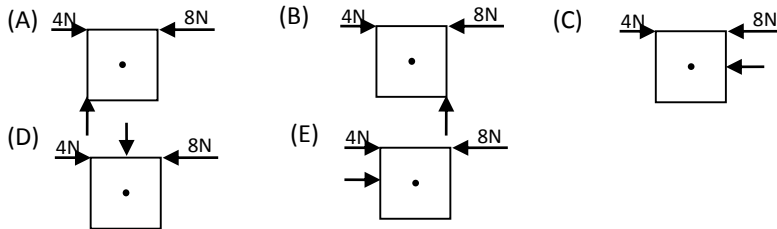


A wooden square of side length 1 m is on a horizontal tabletop and is free to rotate about its center axis. The square is subject to two forces and rotates.

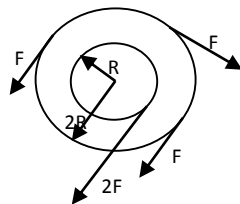
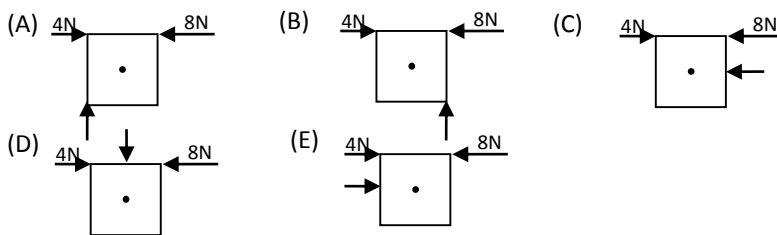
2. Find the net torque of the system

- (A) $4 \text{ N}\cdot\text{m}$ (B) $12 \text{ N}\cdot\text{m}$ (C) $4\sqrt{2} \text{ N}\cdot\text{m}$ (D) $2\sqrt{2} \text{ N}\cdot\text{m}$ (E) $\sqrt{2} \text{ N}\cdot\text{m}$

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



4. Where should another 4N force be applied to set the wooden square to equilibrium?



5. Two wheels are fixed to each other and are free to rotate about a frictionless axis through their concentric center. As shown above four forces are exerted tangentially the wheels. The magnitude of the net torque is

- (A) zero (B) FR (C) $2FR$ (D) $4FR$ (E) $8FR$

6. A baseball player swings his bat with his arms fully extended. If the arms are pulled in closer to the body, in which of the following is true about the angular momentum and kinetic energy of the swing affected?

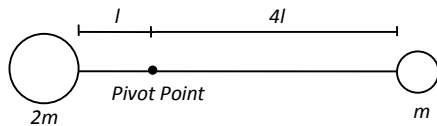
<u>Angular Momentum</u>	<u>Kinetic Energy</u>
(A) Increases	Increases
(B) Increases	Remains Constant
(C) Remains Constant	Increases
(D) Remains Constant	Remains Constant
(E) Decreases	Remains Constant

7. A tire of mass M and radius R rolls on a flat track 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

8. A toy car drives around a circular track with radius 10 meters. 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 (E) with constant velocity

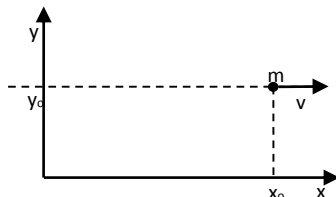


9. Two masses, one with mass m and the other with mass $2m$, are attached to a light rigid rod as shown above. When the system is released from rest the rod begins to rotate with an angular acceleration of

(A) $\frac{g}{7l}$ (B) $\frac{g}{5l}$ (C) $\frac{g}{4l}$ (D) $\frac{5g}{7l}$ (E) $\frac{g}{9l}$

10. A rubber band ball of mass M and radius R (moment of inertia $(2/5)MR^2$) 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) $\frac{7v^2}{10g}$ (E) $\frac{v^2}{g}$



11. 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

(A) zero (B) $mv y_0$ (C) $mv x_0$ (D) $mv\sqrt{x^2 + (y_0)^2}$ (E) $\frac{mv y_0}{\sqrt{x^2 + (y_0)^2}}$

Questions 12-13

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 .

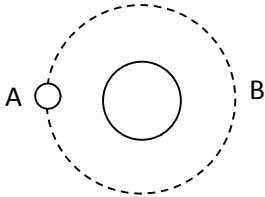
12. What is the average net torque on the wheel during this time interval?

- (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) $\frac{I\omega_f}{t}$

13. 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) $\frac{I^2\omega_f^2}{2t^2}$

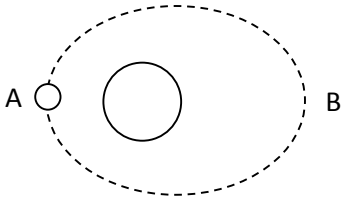
Questions 14-15



14. 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?

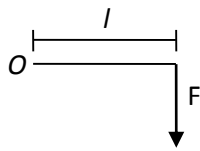
- I. Its angular speed is v/R .
 II. Its tangential acceleration is zero.
 III. The magnitude of its centripetal acceleration is constant.

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

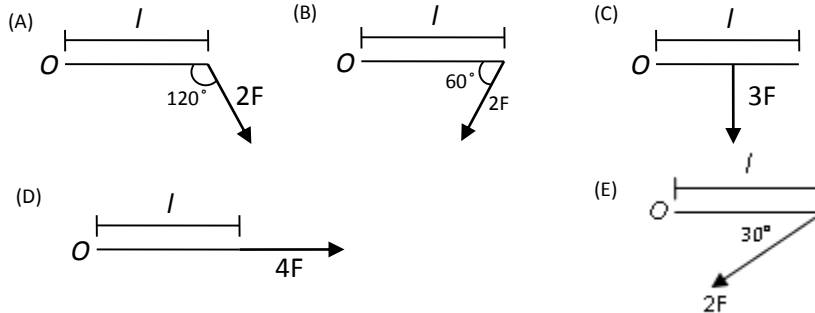


15. The meteor's orbit changes so that it moves in an elliptical orbit. As it moves from point A to point B, which of the following is true about its speed and angular momentum?

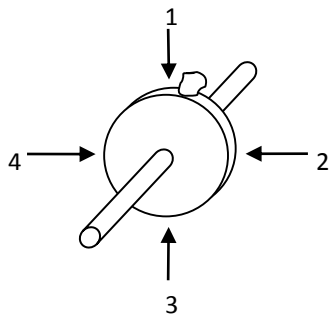
- | <u>Speed</u> | <u>Angular Momentum</u> |
|----------------------|-------------------------|
| (A) Remains constant | Remains constant |
| (B) Increases | Increases |
| (C) Decreases | Decreases |
| (D) Increases | Remains constant |
| (E) Decreases | Remains constant |



16. 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? (All forces lie in the plane of the paper.)



Questions 17-18



A clay blob of mass m is stuck to a wheel of radius R rotates clockwise with constant angular velocity ω . The clay mass passes through points 1, 2, 3, and 4 before making a full revolution.

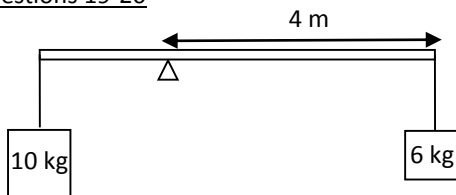
17. At which point will the net force on the mass be greatest?

- (A) Point 1 (B) Point 2 (C) Point 3 (D) Point 4 (E) At all points

18. What is the adhesive force necessary for the clay to stay attached to the wheel at point 3?

- (A) mg (B) $m\omega^2 R$ (C) $m\omega^2 R^2 + mg$ (D) $m\omega^2 R - mg$ (E) $m\omega^2 R + mg$

Questions 19-20



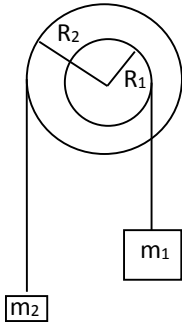
Two masses of mass 10 and 6 kg are hung from massless strings at the end of a light rod. The rod itself is virtually weightless. A pivot is placed off center and the system is free to rotate.

19. If the 6 kg mass is 4 meters away from the pivot how far away is the 10 kg mass?

- (A) 0.42 m (B) 2.4 m (C) 4.8 m (D) 6.3 m (E) 9.8 m

20. If the string supporting the 6 kg block is cut find the net torque of the system

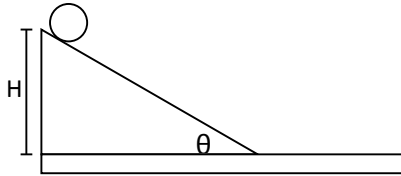
- (A) 60 kgxm (B) 120 kgxm (C) 240 kgxm (D) 480 kgxm (E) 0



21. Which of the following must be true for the system to be at equilibrium?

- (A) $m_1 = m_2$ (B) $R_1 m_1 = R_2 m_2$ (C) $R_1 m_2 = R_2 m_1$
 (D) $R_1^2 m_1 = R_2^2 m_2$ (E) $R_2^2 m_1 = R_1^2 m_2$

Questions 22-27



A ball of rotational inertia $(2/5)MR^2$ 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.

22. 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) $g \sin^2 \theta$ (E) 0

23. How fast is the ball traveling at the bottom of the incline?

- (A) $2gh$ (B) gh (C) $4 \sin \theta gh$ (D) $\sqrt{2gh}$ (E) $\sqrt{h/g}$

In another scenario there is friction between the ball and incline so that the ball rolls down without slipping.

24. 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) $mg \sin^2 \theta$ (E) $5(g \sin \theta)/7$

25. How fast is the ball traveling at the bottom of the incline?

- (A) $2gh$ (B) gh (C) $\sqrt{10gh/7}$ (D) $\sqrt{2gh}$ (E) $\sqrt{h/g}$

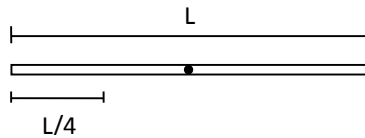
26. How does the translational kinetic energy compare to the rotational kinetic energy?

- (A) K_e without friction is greater than K_e with friction
- (B) K_e with friction is greater than K_e without friction
- (C) They are both the same
- (D) Cannot be determined without knowing the ball's mass
- (E) None of the above

27. If the ball is replaced with a disk of rotational inertia $(1/2)MR^2$, how will the velocity at the bottom change?

- (A) The disk will travel faster
- (B) The disk will travel slower
- (C) The disk will move at the same speed
- (D) Cannot be determined without knowing the ball's mass
- (E) None of the above

Questions 28-29



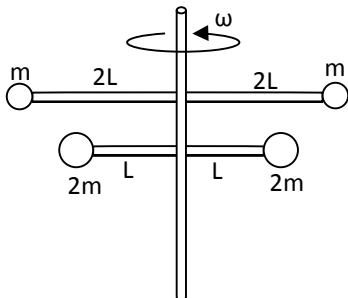
A rod of length L is rotated about its center which has a moment of inertia $(1/12)ML^2$.

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

- (A) $(1/12)ML^2$
- (B) $(3/4)ML^2$
- (C) $(7/48)ML^2$
- (D) $(15/29)ML^2$
- (E) ML^2

29. What is the moment of inertial at one end of the rod?

- (A) $(1/12)ML^2$
- (B) $(1/3)ML^2$
- (C) $(7/12)ML^2$
- (D) $(1/6)ML^2$
- (E) $(19/26)ML^2$



30. The system above rotates with a speed 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?

- (A) 2/1
- (B) 4/1
- (C) 1/2
- (D) 1/4
- (E) 1/1

Answers 1d 2d 3b 4a 5d 6c 7a 8a 9e 10d 11b 12e 13b 14e 15e 16e 17e 18e 19b 20c 21b 22b 23d 24e 25c 26a
27b 28c 29b 30a