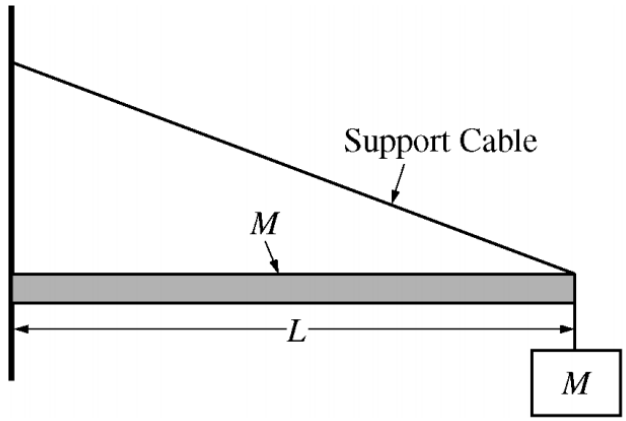
chapter7

1.



The figure above shows a uniform beam of length L and mass M that hangs horizontally and is attached to a vertical wall. A block of mass M is suspended from the far end of the beam by a cable. A support cable runs from the wall to the outer edge of the beam. Both cables are of negligible mass. The wall exerts a force F_W on the left end of the beam. For which of the following actions is the magnitude of the vertical component of F_W smallest?

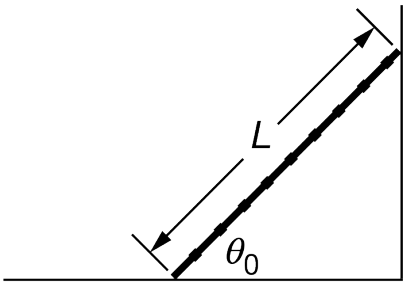
(A) Keeping the support cable and block as shown in the diagram

(B) Moving the lower end of the support cable to the center of the beam and leaving the block at the outer end of the beam

(C) Keeping the lower end of the support cable at the outer end of the beam and moving the block to the center of the beam

(D) Moving both the support cable and the block to the center of the beam

2. A uniform ladder of mass M and length L rests against a smooth wall at an angle θ_0, as shown in the figure. What is the torque due to the weight of the ladder about its base?



(A) $MgL \sin(\theta_0)$

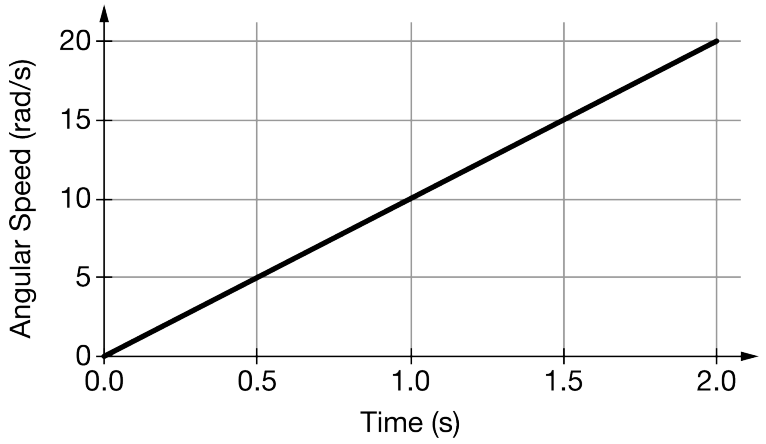
(B) $MgL \cos(\theta_0)$

(C) $\frac{MgL \sin(\theta_0)}{2}$

(D) $\frac{MgL \cos(\theta_0)}{2}$

chapter7

3.



An object rotates with an angular speed that varies with time, as shown in the graph. How can the graph be used to determine the magnitude of the angular acceleration α of the object? Justify your selection.

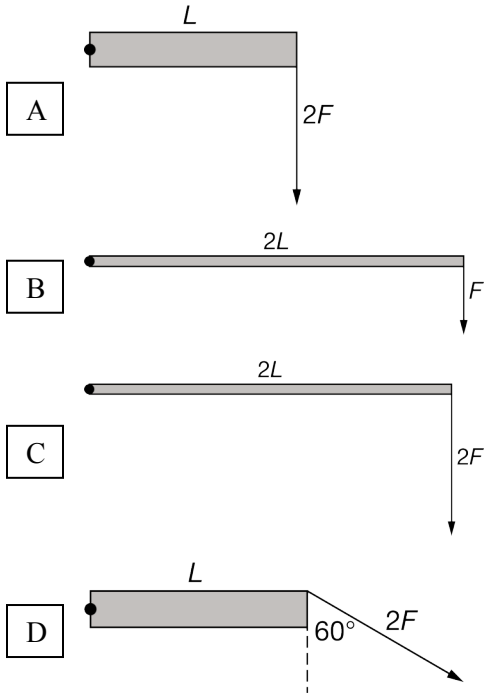
(A) Subtract the greatest value of the angular speed from the smallest value of the angular speed, because $\alpha = \Delta\omega$.

(B) Determine the slope of the line from 0 s to 2 s, because the slope represents $\frac{\Delta\omega}{\Delta t}$.

(C) Determine the area bounded by the line and the horizontal axis from 0 s to 2 s, because $\alpha = \frac{1}{2}\omega\Delta t$.

(D) The angular acceleration cannot be determined without knowing the rotational inertia of the object.

4. Four rods, each of mass M, are pinned at the left end to the horizontal surface of a table and are shown from above in the following figures. Each rod is free to rotate about a pivot at its left end with negligible friction. In each case, forces are exerted on the rod with different magnitudes and in different directions as shown. The rotational inertia of a rod of mass M and length L about the end of the rod is $(1/3)ML^2$. In which cases do the rods experience equal initial angular accelerations? Select two answers.



chapter7

Two small objects of mass m_0 and a rotating platform of radius R and rotational inertia I_p about its center compose a single system. Students use the system to conduct two experiments. The objects are assumed to be point masses.

Experiment 1

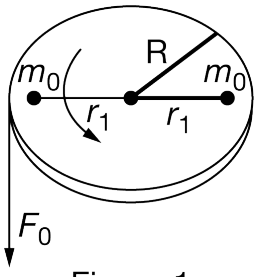


Figure 1

Each object of mass m_0 is placed a distance r_1 away from the center of the platform such that both masses are on opposite sides of the platform. A constant tangential force F_0 is applied to the edge of the platform for a time Δt_0, as shown in Figure 1. The system is initially at rest.

Experiment 2

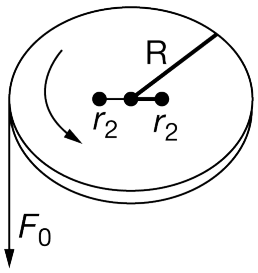


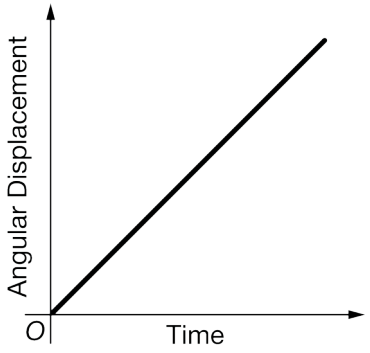
Figure 2

Each object of mass m_0 is placed a distance r_2 away from the center of the platform such that both masses are on opposite sides of the platform. Distance $r_2 < r_1$. A constant tangential force F_0 is applied to the edge of the platform for a time Δt_0 , as shown in Figure 2. The system is initially at rest.

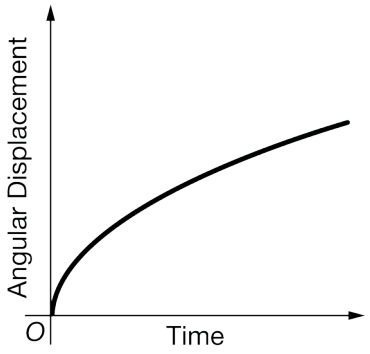
5. Which of the following graphs represents the angular displacement of the system as a function of time for the system in experiment 1?

chapter7

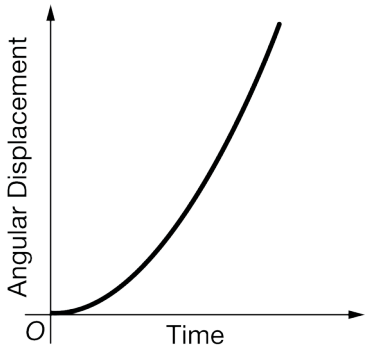
(A)



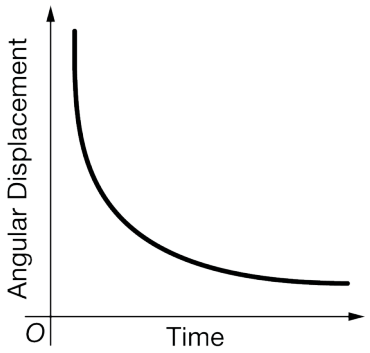
(B)



(C)

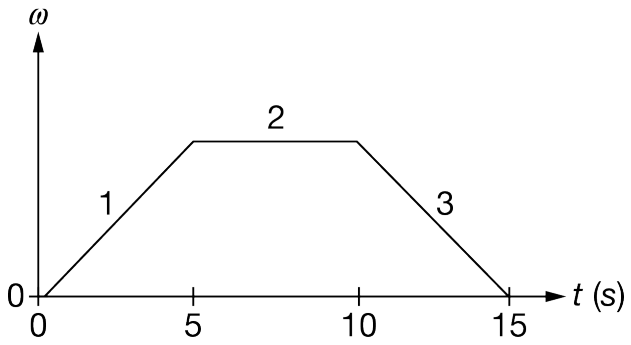


(D)



chapter7

6.



A graph of the angular velocity ω as a function of time t is shown for an object that rotates about an axis. Three time intervals, $1–3$, are shown. Which of the following correctly compares the angular displacement $\Delta\theta$ of the object during each time interval?

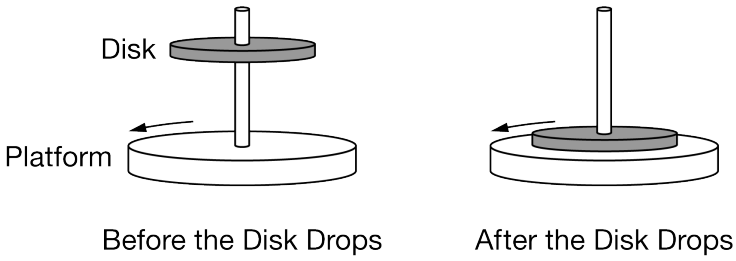
(A) $\Delta\theta_1 = \Delta\theta_3 > \Delta\theta_2$

(B) $\Delta\theta_2 > \Delta\theta_1 = \Delta\theta_3$

(C) $\Delta\theta_3 > \Delta\theta_2 > \Delta\theta_1$

(D) $\Delta\theta_1 > \Delta\theta_2 > \Delta\theta_3$

7.



A platform is initially rotating on smooth ice with negligible friction, as shown at left in the figure. A stationary disk is dropped directly onto the center of the platform. A short time later, the disk and platform rotate together at the same angular velocity, as shown at right in the figure. How does the angular momentum of only the platform change, if at all, after the disk drops? What is a justification for your answer?

(A) It decreases. The top disk exerts a torque on the platform.

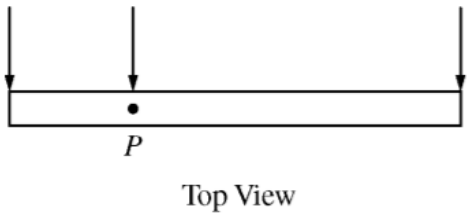
(B) It decreases. The potential energy of the platform-disk-Earth system decreases when the disk drops.

(C) It stays the same. Angular momentum is a conserved quantity.

(D) It stays the same. The torques that the disk and platform exert on each other are equal in magnitude but in opposite directions.

chapter7

8.



Top View

The figure above shows a rod that is fixed to a horizontal surface at pivot *P*. The rod is initially rotating without friction in the counterclockwise direction. At time *t*, three forces of equal magnitude are applied to the rod as shown. Which of the following is true about the angular speed and direction of rotation of the rod immediately after time *t* ?

(A)

Angular Speed	Direction of Rotation
Decreasing	Counterclockwise

(B)

Angular Speed	Direction of Rotation
Decreasing	Clockwise

(C)

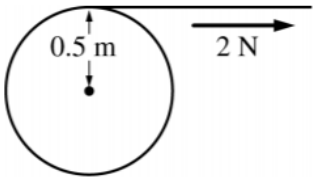
Angular Speed	Direction of Rotation
Increasing	Counterclockwise

(D)

Angular Speed	Direction of Rotation
Increasing	Clockwise

chapter7

9.



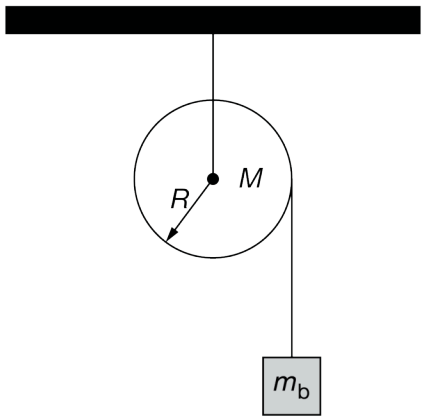
A disk with radius of 0.5 m is free to rotate around its center without friction. A string wrapped around the disk is pulled, as shown above, exerting a 2 N force tangent to the edge of the disk for 1 s. If the disk starts from rest, what is its angular speed after 1 s?

(A) 0 rad/s

(B) 1 rad/s

(C) 4 rad/s

(D) It cannot be determined without knowing the rotational inertia of the disk.



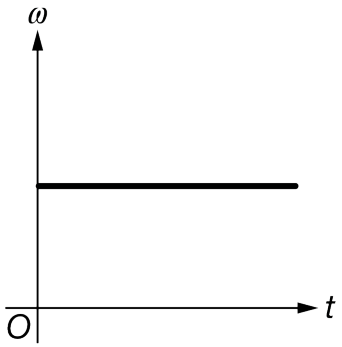
Side View

An axle passes through a pulley. Each end of the axle has a string that is tied to a support. A third string is looped many times around the edge of the pulley and the free end attached to a block of mass m_b , which is held at rest. When the block is released, the block falls downward. Consider clockwise to be the positive direction of rotation, frictional effects from the axle are negligible, and the string wrapped around the disk never fully unwinds. The rotational inertia of the pulley is $\frac{1}{2}MR^2$ about its center of mass.

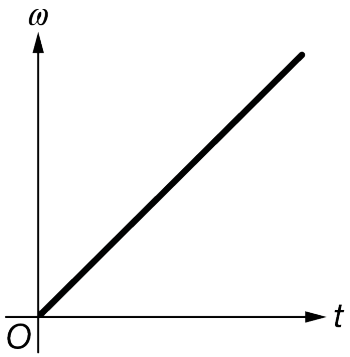
10. Which of the following graphs, if any, shows the angular velocity ω of the pulley as a function of time t after the block is released from rest?

chapter7

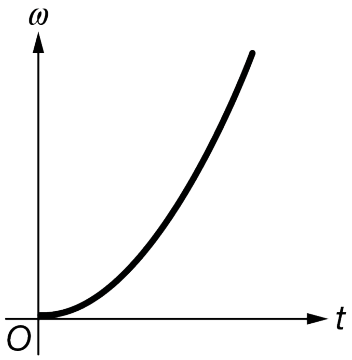
(A)



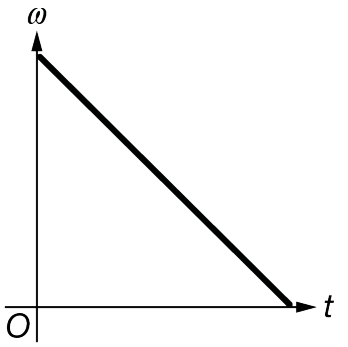
(B)



(C)



(D)



11. How many forces are applied to the pulley-axle system, and how many torques are applied to the pulley about its center when the block is released from rest?

chapter7

(A)

Number of Forces	Number of Torques
4	2

(B)

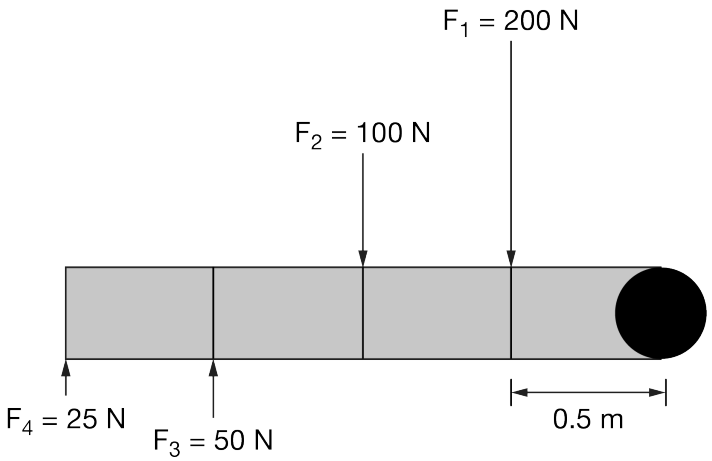
Number of Forces	Number of Torques
4	1

(C)

Number of Forces	Number of Torques
2	2

(D)

Number of Forces	Number of Torques
2	1



The figure above represents a stick of uniform density that is attached to a pivot at the right end and has equally spaced marks along its length. Any one or a combination of the four forces shown can be exerted on the stick as indicated.

12. Two of the four forces are exerted on the stick. Which of the following predictions is correct about the change in angular velocity of the stick per unit of time?

chapter7

(A) When F_1 and F_2 are exerted on the stick, the stick will have the greatest change in angular velocity per unit of time.

(B) When F_1 and F_3 are exerted on the stick, the stick will not change its angular velocity per unit of time.

(C) When F_2 and F_3 are exerted on the stick, the stick's change in angular velocity per unit of time will be in the clockwise direction.

(D) When F_3 and F_4 are exerted on the stick, the stick will have the smallest change in angular velocity per unit of time.

13.

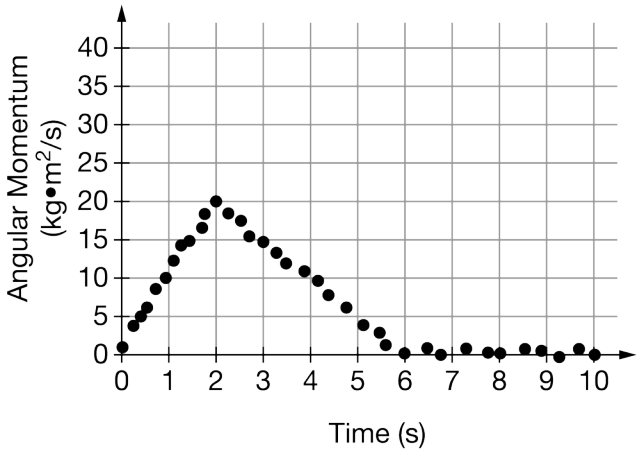


Figure 1. Experiment 1

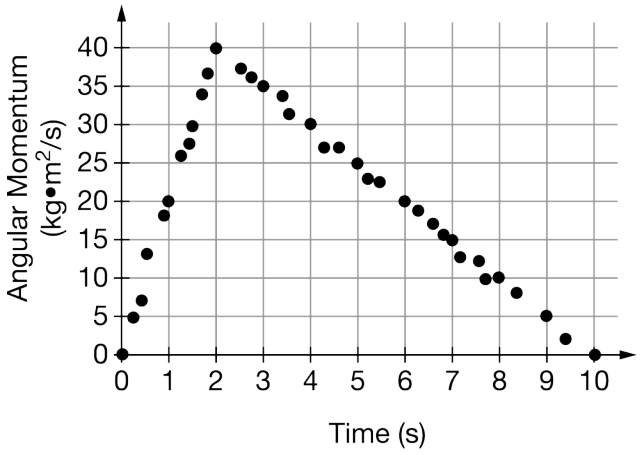


Figure 2. Experiment 2

A horizontal disk is at rest on top of an axle, and the friction between the disk and axle is not negligible. In experiment 1, an applied torque is exerted to the edge of the disk for 2 s. At that moment, the applied torque is removed, and the disk eventually comes to rest as a result of a frictional torque. Graphs of the disk's angular momentum as a function of time are shown in Figures 1 and 2 for the two experiments. Which of the following statements is correct about the applied torque $t_{applied}$ and frictional torque $t_{friction}$exerted on the disk in experiment 1 and experiment 2 ?

---

chapter7

(A)

Applied Torque	Frictional Torque
$\tau_{applied\,1} > \tau_{applied\,2}$	$\tau_{friction\,1} > \tau_{friction\,2}$

(B)

Applied Torque	Frictional Torque
$\tau_{applied\,1} < \tau_{applied\,2}$	$\tau_{friction\,1} > \tau_{friction\,2}$

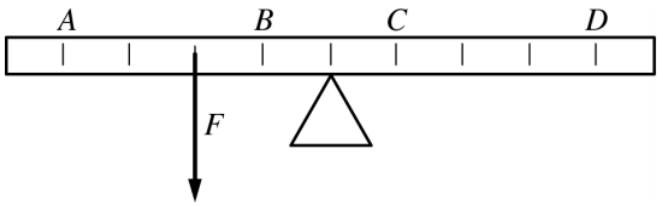
(C)

Applied Torque	Frictional Torque
$\tau_{applied\,1} > \tau_{applied\,2}$	$\tau_{friction\,1} = \tau_{friction\,2}$

(D)

Applied Torque	Frictional Torque
$\tau_{applied\,1} < \tau_{applied\,2}$	$\tau_{friction\,1} = \tau_{friction\,2}$

14.

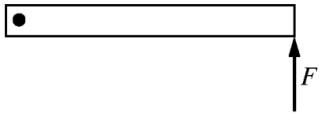


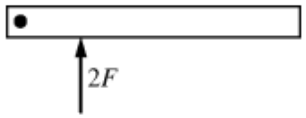
The figure above shows a uniform meterstick that is set on a fulcrum at its center. A force of magnitude F toward the bottom of the page is exerted on the meterstick at the position shown. At which of the labeled positions must an upward force of magnitude $2F$ be exerted on the meterstick to keep the meterstick in equilibrium?

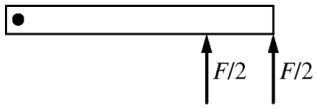
(A) *A*
(B) *B*
(C) *C*
(D) *D*

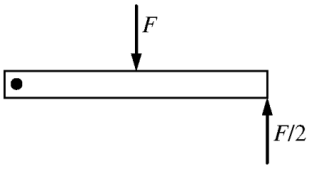
15. A solid metal bar is at rest on a horizontal frictionless surface. It is free to rotate about a vertical axis at the left end. The figures below show forces of different magnitudes that are exerted on the bar at different locations. In which case does the bar's angular speed about the axis increase at the fastest rate?

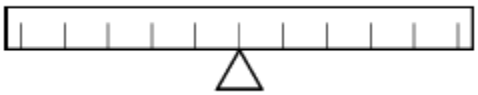
chapter7

(A) 

(B) 

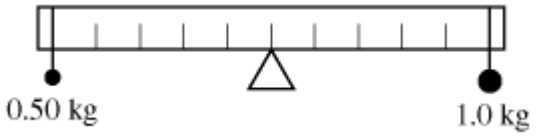
(C) 

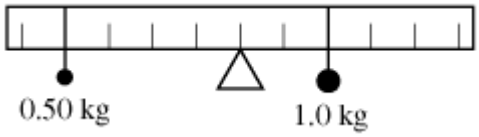
(D) 

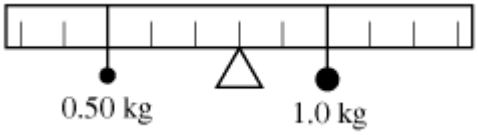
16. 

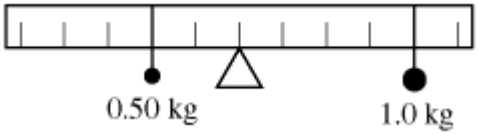
A uniform meterstick is balanced at the center, as shown above. Which of the following shows how a 0.50 kg mass and a 1.0 kg mass could be hung on the meterstick so that the stick stays balanced?

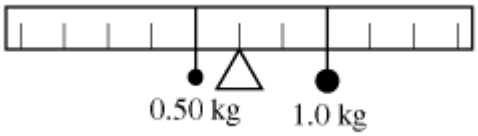
chapter7

(A)


(B)


(C)


(D)


(E)


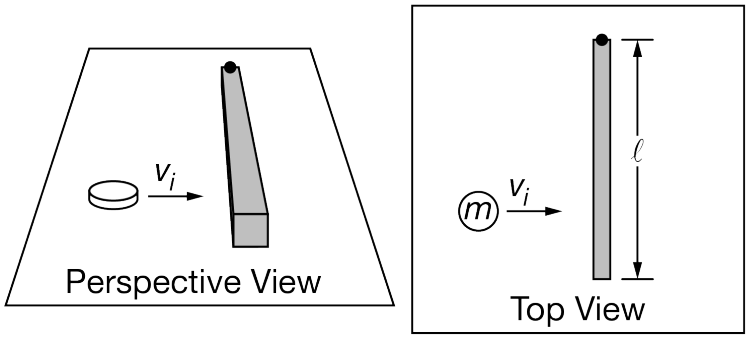


Figure 1

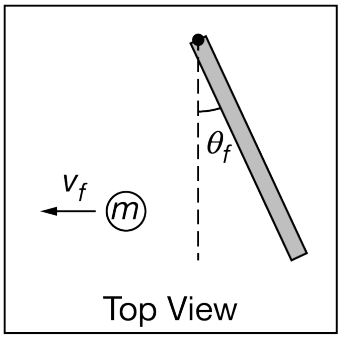


Figure 2

A disk of mass m slides with negligible friction to the right with speed v_i on a horizontal table. The disk collides elastically with a uniform rod of length ℓ that is at rest and free to pivot about one end, as shown in Figure 1 above. The disk rebounds to the left with speed v_f, and the rod rotates with friction and stops at a final angle θ_f from its initial position, as shown in Figure 2.

17. Immediately after the collision, the rod has angular speed ω, and the rod comes to rest a time Δt after the collision. If the rotational inertia of the rod about the pivot is I, the average torque exerted on the rod by friction while the rod is coming to rest is

chapter7

(A) $\frac{I\omega}{\Delta t}$

(B) $\frac{2I\omega}{\Delta t}$

(C) $\frac{I\omega}{\ell\Delta t}$

(D) $\frac{2I\omega}{\ell\Delta t}$

18. Which of the following describes the direction of the forces exerted by the disk and rod on each other during the collision?

(A)

Direction of Force Exerted on Disk by Rod	Direction of Force Exerted on Rod by Disk
Down and to the left	To the right

(B)

Direction of Force Exerted on Disk by Rod	Direction of Force Exerted on Rod by Disk
To the left	To the right

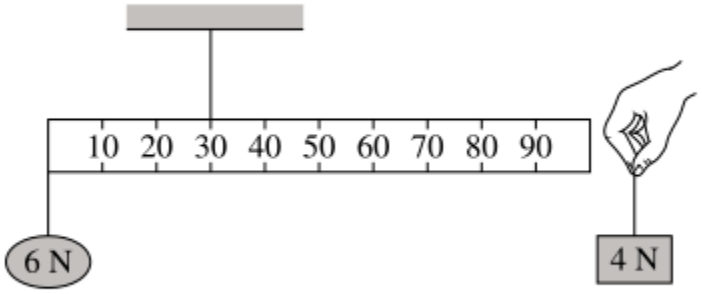
(C)

Direction of Force Exerted on Disk by Rod	Direction of Force Exerted on Rod by Disk
Down and to the left	Up and to the right

(D)

Direction of Force Exerted on Disk by Rod	Direction of Force Exerted on Rod by Disk
To the left	Up and to the right

chapter7



A student suspends a uniform meterstick that weighs $3\ \text{N}$ from the ceiling by a string attached at the $30\ \text{cm}$ mark. While holding the meterstick horizontal, the student hangs an object that weighs $6\ \text{N}$ from the left end of the meterstick. The student attaches a second object that weighs $4\ \text{N}$ at a position x, measured from the left end of the meterstick, so that the meterstick remains horizontal and in static equilibrium.

19. Which of the following is the position x, measured from the left edge of the meterstick, at which the student attaches the $4\ \text{N}$ object?

(A) $30\ \text{cm}$

(B) $45\ \text{cm}$

(C) $60\ \text{cm}$

(D) $75\ \text{cm}$

20. What is the tension in the string that attaches the static two-object-meterstick system to the ceiling?

(A) $0\ \text{N}$

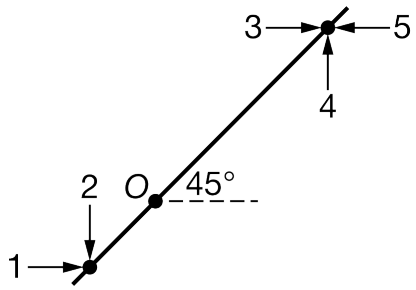
(B) $3\ \text{N}$

(C) $10\ \text{N}$

(D) $13\ \text{N}$

chapter7

21.



The figure above represents the top view of a bar that can pivot about point O. The arrows represent forces of equal magnitude that can be exerted near the ends of the bar in the directions shown. Which of the following forces, when exerted together, would produce a torque about point O with the greatest magnitude?

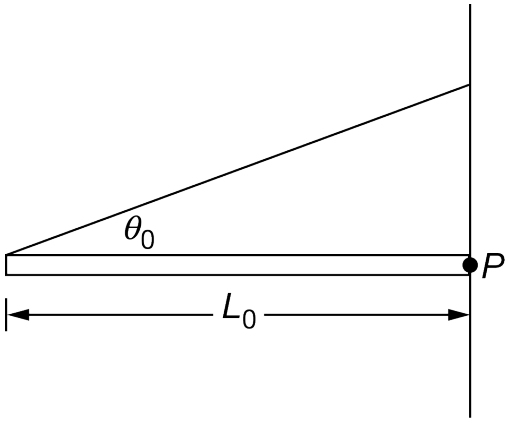
(A) 1 and 2

(B) 1 and 3

(C) 1 and 4

(D) 4 and 5

22.



A uniform horizontal beam of mass M and length L_0 is attached to a hinge at point P, with the opposite end supported by a cable, as shown in the figure. The angle between the beam and the cable is θ_0. What is the magnitude of the torque that the cable exerts on the beam?

(A) $\frac{MgL_0}{2}$

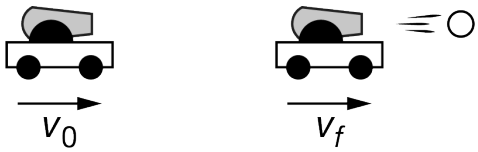
(B) MgL

(C) $\frac{MgL_0 \sin(\theta_0)}{2}$

(D) $MgL_0 \sin(\theta_0)$

chapter7

23.



A cart with a toy projectile launcher attached to its top travels forward at a constant speed v_0. The launcher fires a solid sphere forward at a speed much greater than that of the cart-launcher system. The cart's speed after firing the dart is $v_f < v_0$. Frictional forces are considered to be negligible. Which of the following scenarios best represents the rotational analog to this situation?

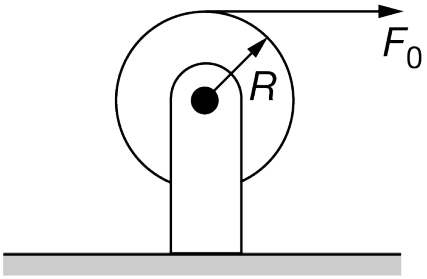
(A) A gaseous planet rotates with a large rotational velocity, causing the middle of the planet's equator to bulge outward.

(B) A spinning platform falls onto a stationary platform. Both platforms rotate together, but at a smaller common rotational speed than that of the spinning platform immediately before the collision.

(C) A child on the edge of a large rotating disk throws a ball in the same direction as the child's tangential velocity.

(D) A figure skater spins with the skater's hands at the skater's waist. When the skater extends the skater's arms outward, the skater's rotational velocity decreases.

24.



A uniform cylinder of radius R, mass M, and rotational inertia I_0 is initially at rest. The cylinder is mounted so that it is free to rotate with negligible friction about an axle that is oriented through the center of the cylinder and perpendicular to the page. A light string is wrapped around the cylinder. At time $t = 0$, the string is pulled with a constant force F_0, which causes the cylinder to rotate, as shown in the figure. After time $t = t_0$, the string is completely unwound from the cylinder and loses contact with it. If necessary, how can a student determine the change in angular momentum ΔL of the cylinder from $t = 0$ to $t = t_0$?

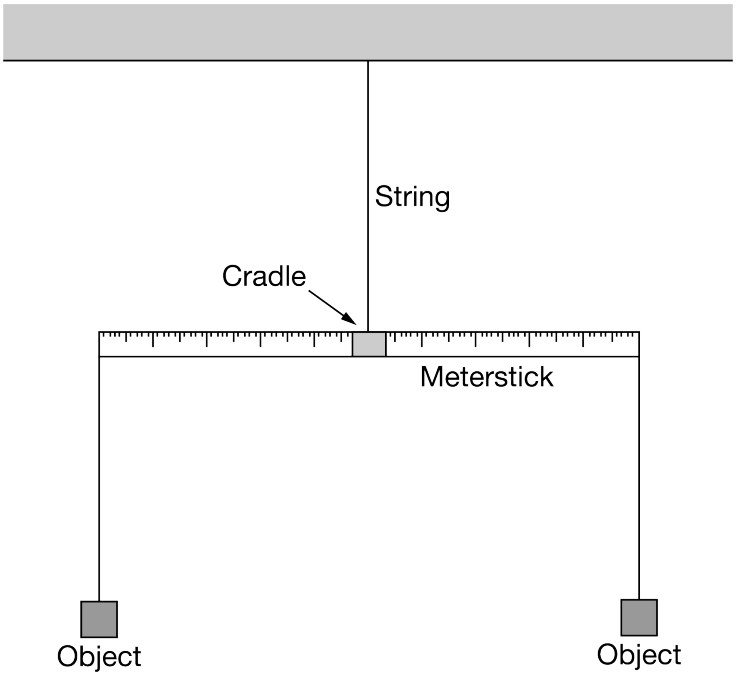
(A) A determination is not necessary. The cylinder does not have a change in angular momentum, because the cylinder does not change its horizontal or vertical position as it rotates.

(B) Multiply F_0, R, and t_0 to calculate the angular impulse. This quantity is equal to ΔL.

(C) Use Newton's second law of motion in the rotational form to determine the angular acceleration of the cylinder. Use the angular acceleration to determine the cylinder's change in angular velocity. Multiply the result by the mass of the cylinder.

(D) Calculate the net torque exerted on the cylinder, then divide the net torque by the cylinder's rotational inertia to find the average angular velocity of cylinder. Multiply the result by the average angular velocity by mass M.

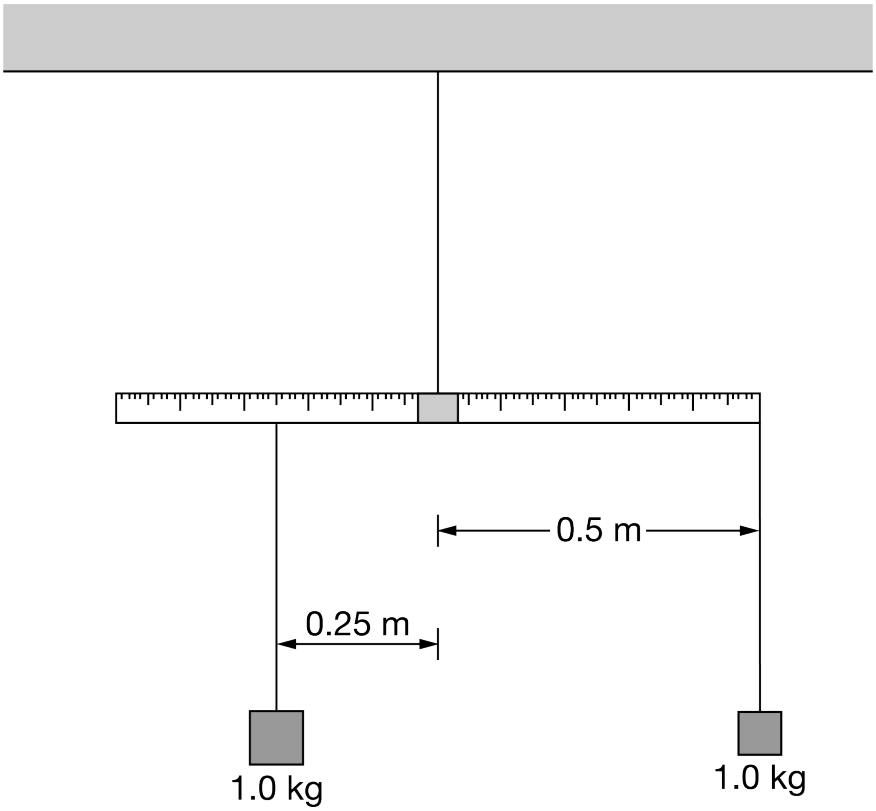
chapter7



One end of a string is attached to the ceiling, and the other end of the string is attached to a cradle that has a meterstick that runs through it. The meterstick can slide through the cradle so that the horizontal position of a point on the meterstick can be changed in the horizontal direction. Students may hang objects of various masses from the meterstick, as shown in the figure. The students notice that when the meterstick-cradle-object-object system is not balanced, the meterstick will rotate.

chapter7

25.



Consider the situation shown above in which the center of the meterstick is aligned with the center of the cradle, which is at a position of $x = 0$ m. The system is released from rest. Which of the following claims is correct about the motion of the system containing the meterstick, cradle, and two objects if the system is free to rotate?

(A) The system will rotate in the clockwise direction with a constant angular speed.

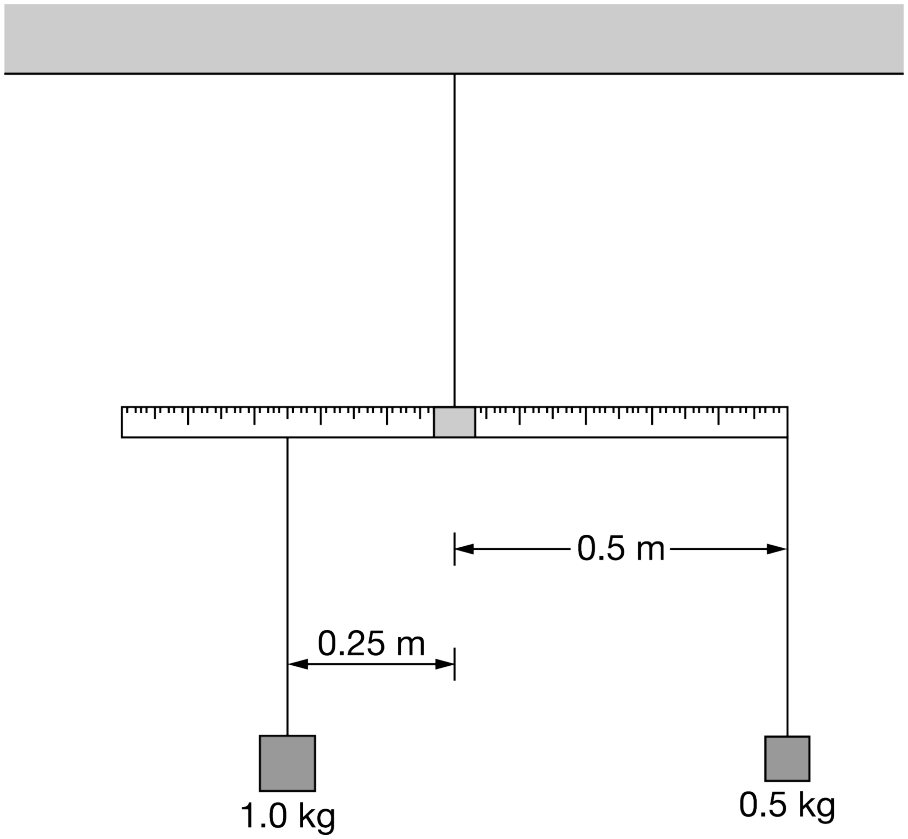
(B) The system will rotate in the clockwise direction with an increasing angular speed.

(C) The system will rotate in the counterclockwise direction with a constant angular speed.

(D) The system will rotate in the counterclockwise direction with an increasing angular speed.

chapter7

26.



Consider the situation shown above in which the center of the meterstick is aligned with the center of the cradle, which is at a position of $x = 0$ m. Which of the following statements is correct about the torques exerted on the meterstick?

(A) The torque exerted by the force due to gravity is the greatest torque exerted on the meterstick.

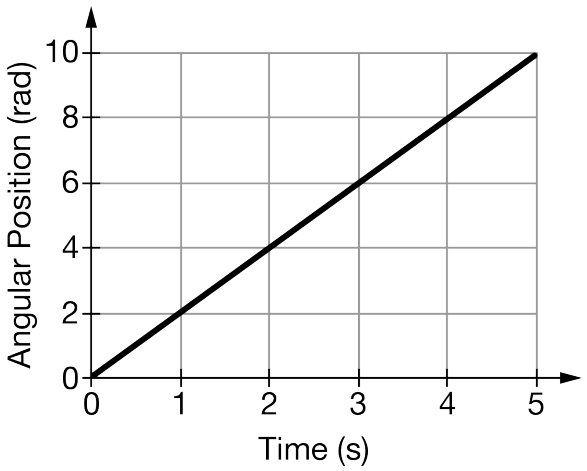
(B) The torque exerted by the 1.0 kg object is the greatest torque exerted on the meterstick.

(C) The torque exerted by the 0.5 kg object is the greatest torque exerted on the meterstick.

(D) The torque exerted by the 1.0 kg object is equal to the torque exerted by the 0.5 kg object.

chapter7

27.



A disk of radius $50\ \text{cm}$ rotates about a center axle. The angular position as a function of time for a point on the edge of the disk is shown. Which two of the following quantities of the point on the edge of the disk can be correctly mathematically determined from the graph using the methods described? Justify your selections. Select two answers.

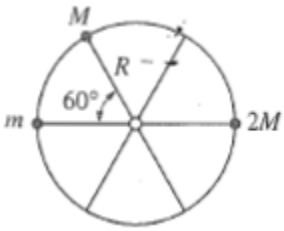
A The angular velocity, because this quantity can be determined by calculating the slope of the graph.

B The translational speed, because $v = r\omega$.

C The angular acceleration, because this quantity can be determined by calculating the area bound by the curve and the horizontal axis from $0\ \text{s}$ to $5\ \text{s}$.

D The translation acceleration, because $a = \frac{v^2}{r}$.

28.



A wheel of radius *R* and negligible mass is mounted on a horizontal frictionless axle so that the wheel is in a vertical plane. Three small objects having masses *m*, *M,* and 2*M*, respectively, are mounted on the rim of the wheel, as shown above. If the system is in static equilibrium, what is the value of *m* in terms of *M* ?

(A) $\frac{M}{2}$

(B) M

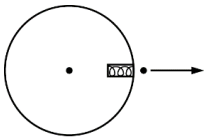
(C) $\frac{3M}{2}$

(D) $2M$

(E) $\frac{5M}{2}$

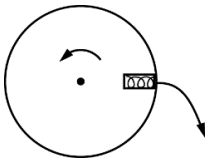
chapter7

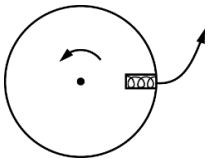
29.

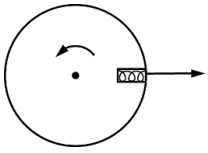


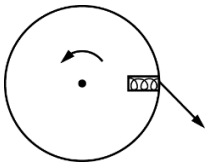
Top View

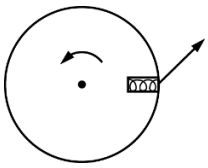
A compressed spring mounted on a disk can project a small ball. When the disk is not rotating, as shown in the top view above, the ball moves radially outward. The disk then rotates in a counterclockwise direction as seen from above, and the ball is projected outward at the instant the disk is in the position shown above. Which of the following best shows the subsequent path of the ball relative to the ground?

(A) 

(B) 

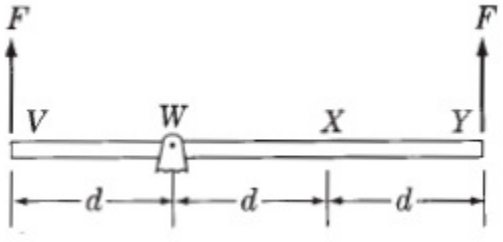
(C) 

(D) 

(E) 

chapter7

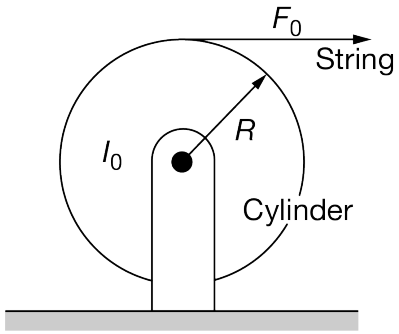
30.



A massless rigid rod of length 3*d* is pivoted at a fixed point *W*, and two forces each of magnitude *F* are applied vertically upward as shown above. A third vertical force of magnitude *F* may be applied, either upward or downward, at one of the labeled points. With the proper choice of direction at each point, the rod can be in equilibrium if the third force of magnitude *F* is applied at point

(A) *W* only
(B) *Y* only
(C) *V* or *X* only
(D) *V* or *Y* only
(E) *V*, *W*, or *X*

31.



In an experiment, a solid, uniform cylinder of unknown radius R and unknown rotational inertia I_0 about a central axle, is initially at rest. A light string is wrapped around the cylinder, as shown in the figure. The string is pulled with a constant unknown force F_0, causing the cylinder to rotate. After an unknown time interval Δt_0, the string is completely unwound from the pulley and loses contact with it. To collect data, a student has access to a meterstick, stopwatch, and force probe. The cylinder may rotate but cannot be moved off of its axle. Indicate whether the force applied to the cylinder F_0 and the rotational inertia of the cylinder I_0 can be measured directly or calculated from measured quantities in the experiment.

chapter7

(A)

F_0	I_0
Measured directly	Measured directly

(B)

F_0	I_0
Measured directly	Calculated from measured quantities

(C)

F_0	I_0
Calculated from measured quantities	Measured directly

(D)

F_0	I_0
Calculated from measured quantities	Calculated from measured quantities

---

A horizontal, uniform board of weight 125 N and length 4 m is supported by vertical chains at each end. A person weighing 500 N is sitting on the board. The tension in the right chain is 250 N.

32. How far from the left end of the board is the person sitting?

(A) 0.4 m
(B) 1.5 m
(C) 2 m
(D) 2.5 m
(E) 3 m

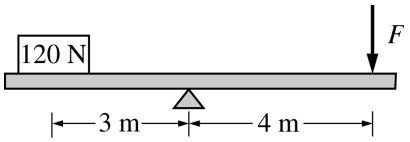
33. What is the tension in the left chain?

(A) 250 N
(B) 375 N
(C) 500 N
(D) 625 N
(E) 875 N

---

chapter7

34.



An object weighing 120 N is set on a rigid beam of negligible mass at a distance of 3 m from a pivot, as shown above. A vertical force is to be applied to the other end of the beam a distance of 4 m from the pivot to keep the beam at rest and horizontal. What is the magnitude F of the force required?

(A) 10 N

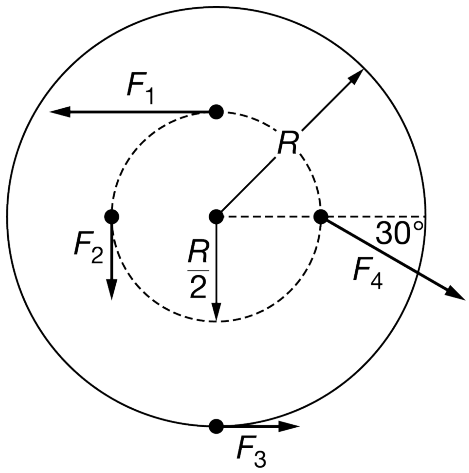
(B) 30 N

(C) 90 N

(D) 120 N

(E) 160 N

35.



Four forces are exerted on a disk of radius R that is free to spin about its center, as shown above. The magnitudes are proportional to the length of the force vectors, where $F_1 = F_4$, $F_2 = F_3$, and $F_1 = 2F_2$. Which two forces combine to exert zero net torque on the disk? Select two answers.

A F_1

B F_2

C F_3

D F_4

chapter7

36. For which of the following motions of an object must the acceleration always be zero?

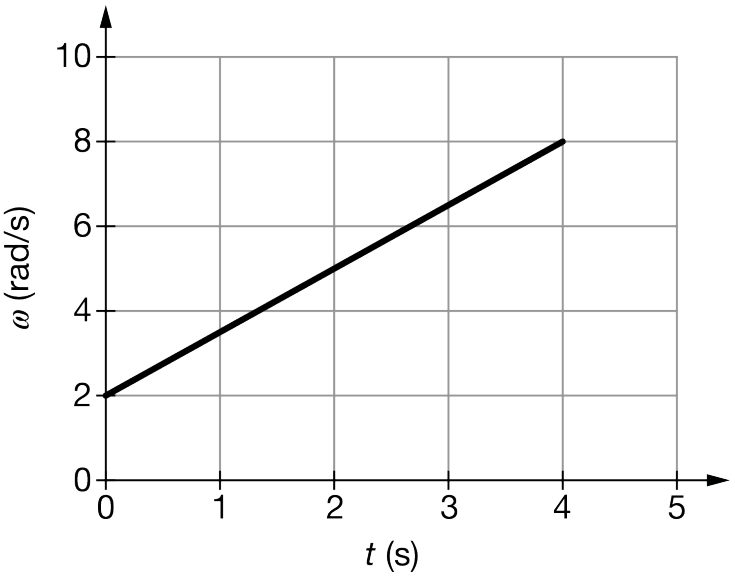
I. Any motion in a straight line

II. Simple harmonic motion

III. Any motion in a circle

(A) I only
(B) II only
(C) III only
(D) Either I or III, but not II
(E) None of these motions guarantees zero acceleration.

37.

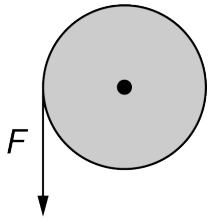


The graph shows the angular velocity ω as a function of time t for a point on a rotating disk. The magnitude of the angular acceleration of the disk at $t = 2\ s$ is most nearly

(A) $0.7\ \text{rad/s}^2$
(B) $1.5\ \text{rad/s}^2$
(C) $10.0\ \text{rad/s}^2$
(D) $20.0\ \text{rad/s}^2$

chapter7

38.



A string of negligible mass is wrapped around the rim of a solid disk that can rotate without friction about its center, as shown above. The string is pulled down with a force of constant magnitude F for an interval of time Δt. If the disk starts from rest, which combination of F and Δt will result in the greatest angular speed of the disk?

(A)

F	Δt
0.10 N	10 s

(B)

F	Δt
0.50 N	2.0 s

(C)

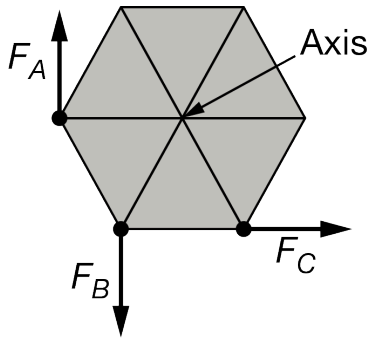
F	Δt
1.0 N	1.5 s

(D)

F	Δt
5.0 N	0.10 s

chapter7

39.



A regular hexagon of uniform density is initially at rest and free to rotate about an axis at its center. Three forces, F_A, F_B, and F_C, have equal magnitude and are able to be applied in the direction and at the point shown in the figure. Which of these forces, if applied individually and for the same time interval, will produce the greatest increase in the hexagon's angular speed?

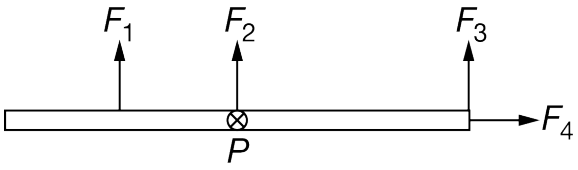
(A) Force F_A

(B) Force F_B

(C) Force F_C

(D) All three forces produce the same change in the hexagon's angular speed.

40.



A horizontal beam is pivoted at point P. Of the four forces shown above, which individually exert no torque on the beam with respect to P ? Select two answers.

A F_1

B F_2

C F_3

D F_4

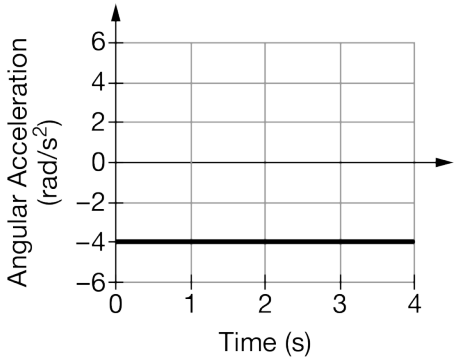
41. An object revolves around a central axis of rotation. The motion of the object is described by the following equation.

$$\omega^2 = (10 \text{ rad/s})^2 - (4 \text{ rad/s}^2)\theta$$

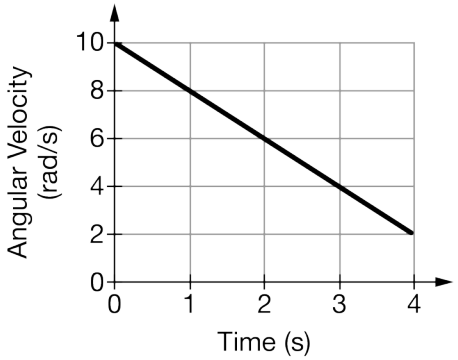
Which two of the following graphs correctly shows the angular motion of the object? Select two answers.

chapter7

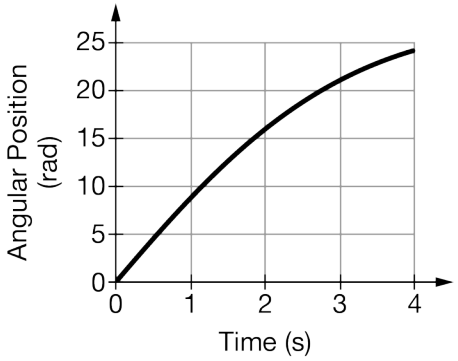
A



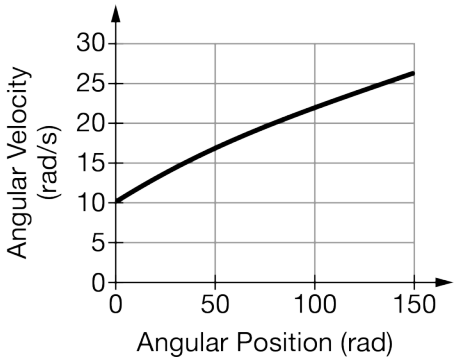
B



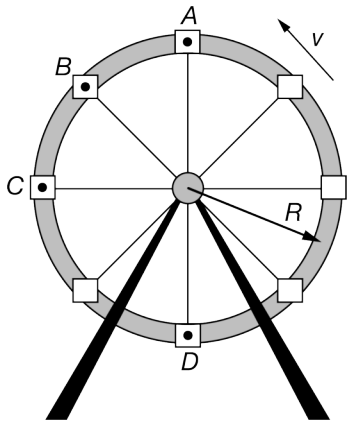
C



D



chapter7



An amusement park ride consists of a large vertical wheel of radius R that rotates counterclockwise on a horizontal axis through its center, as shown above. The cars on the wheel move at a constant speed v. Points A and D represent the position of a car at the highest and lowest point of the ride, respectively. A person of weight F_g sits upright on a seat in one of the cars. As the seat passes point A, the seat exerts a normal force with magnitude $0.8F_g$ on the person. While passing point A, the person releases a small rock of mass m, which falls to the ground without hitting anything.

42. Which of the following best describes the passenger's linear and angular velocity while passing point A ?

(A)

Linear Velocity	**Angular Velocity**
Constant	Changing

(B)

Linear Velocity	**Angular Velocity**
Constant	Constant

(C)

Linear Velocity	**Angular Velocity**
Changing	Changing

(D)

Linear Velocity	**Angular Velocity**
Changing	Constant

chapter7

43. A $3\ \text{kg}$ horizontal disk of radius $0.2\ \text{m}$ rotates about its center with an angular velocity of $50\ \text{rad/s}$. The edge of the horizontal disk is placed in contact with a wall, and the disk comes to rest after $10\ \text{s}$. Which of the following situations associated with linear impulse is analogous to the angular impulse that is described?

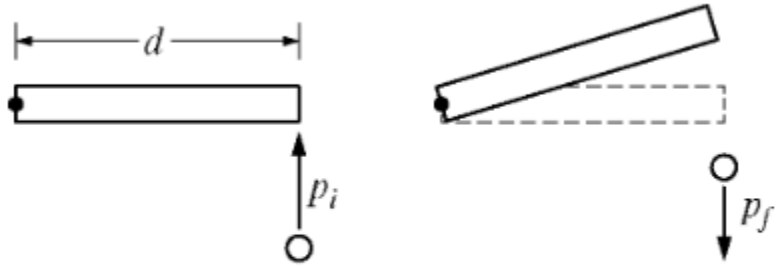
(A) A $3\ \text{kg}$ block is initially at rest. An applied force of $3\ \text{N}$ is applied to the block, but the block does not move.

(B) A $3\ \text{kg}$ block is initially at rest. A net force of $3\ \text{N}$ is applied to the block until it has a speed of $10\ \text{m/s}$.

(C) A $3\ \text{kg}$ block is initially traveling at $10\ \text{m/s}$. An applied force of $3\ \text{N}$ is applied to the block in the direction of its velocity vector for $10\ \text{s}$.

(D) A $3\ \text{kg}$ block is initially traveling at $10\ \text{m/s}$. The block encounters a $3\ \text{N}$ frictional force until the block eventually stops.

44.



Top View

A thin rod of length d on a frictionless surface is pivoted about one end, as shown above, and can rotate freely. The rod is at rest when it is struck by a sphere with linear momentum of magnitude p_i perpendicular to the rod. The sphere rebounds along its original line of motion with momentum of magnitude p_f. What is the magnitude of the angular momentum of the rod immediately after the collision?

(A) $p_f - p_i$

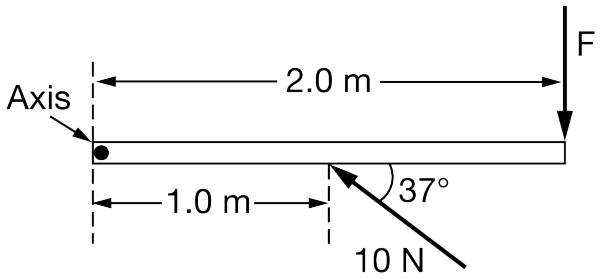
(B) $p_f + p_i$

(C) $(p_f - p_i)d$

(D) $(p_f + p_i)d$

chapter7

45.



Note: Top View

A uniform, rigid rod of length $2\ \text{m}$ lies on a horizontal surface. One end of the rod can pivot about an axis that is perpendicular to the rod and along the plane of the page. A $10\ \text{N}$ force is applied to the rod at its midpoint at an angle of 37°. A second force F is applied to the free end of the rod so that the rod remains at rest, as shown in the figure. The magnitude of the torque produced by force F is most nearly

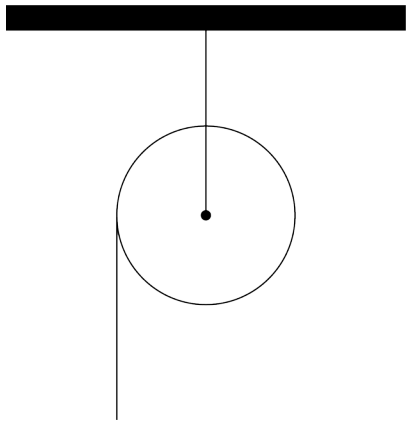
(A) $3.0\ \text{N} \cdot \text{m}$

(B) $6.0\ \text{N} \cdot \text{m}$

(C) $8.0\ \text{N} \cdot \text{m}$

(D) $12.0\ \text{N} \cdot \text{m}$

46.



A light string is attached to a massive pulley of known rotational inertia I_P, as shown in the figure. A student must determine the relationship between the torque exerted on the pulley and the change in the pulley's angular velocity when the torque is applied for $2.0\ \text{s}$. In addition to a stopwatch to measure the time interval, what two measurements could the student make in order to determine the relationship? Select two answers.

A Mass of the pulley

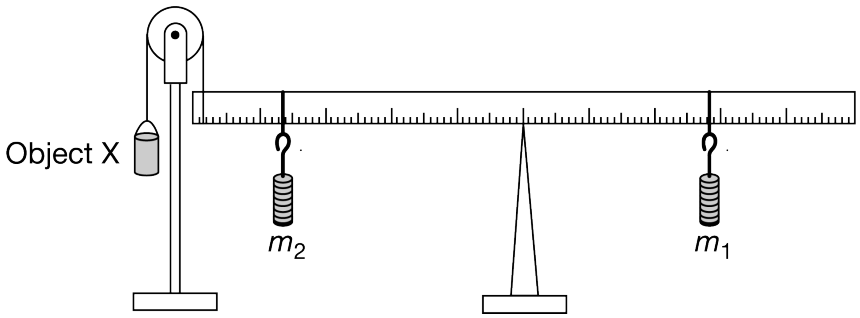
B Radius of the pulley

C Entire length of the string

D Force exerted on the string to turn the pulley

chapter7

47.



The center of mass of a uniform meterstick is placed on a fulcrum. Two objects of known mass, m_1 and m_2, are hung at known positions on the meterstick. One end of a string is attached to one end of the meterstick, and the other end of the string is looped around a pulley and connected to hanging object X of unknown mass, as shown in the figure. The meterstick does not rotate and is level with the horizontal. Which of the following measuring devices, if any, should be used to make measurements to determine the unknown mass of object X? Justify your selection.

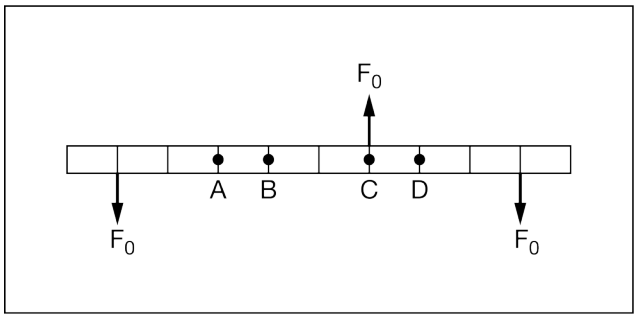
(A) A ruler, because the length of the string that is looped around the pulley should be measured.

(B) A protractor, because the angle between the force due to gravity exerted on objects m_1 and m_2 and the distance between where the force is applied and the tip of the fulcrum should be measured.

(C) A motion sensor, because the distance per unit of time of object X should be measured.

(D) No additional equipment or measurements are needed, because the force due to gravity exerted on objects m_1 and m_2 and the distance between where the force is applied and the tip of the fulcrum are already known.

48. Three identical forces of magnitude F_0 are applied to a meterstick that rests on a horizontal table, as shown in the diagram. At what location on the meterstick would a fourth force, also of magnitude F_0, need to be applied in order to establish static equilibrium?



Top View

(A) A

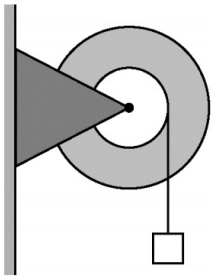
(B) B

(C) C

(D) D

chapter7

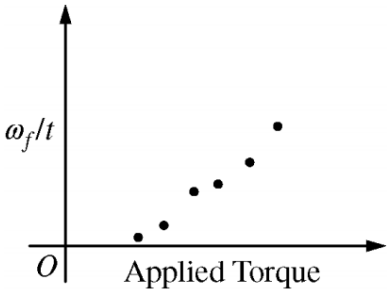
49.



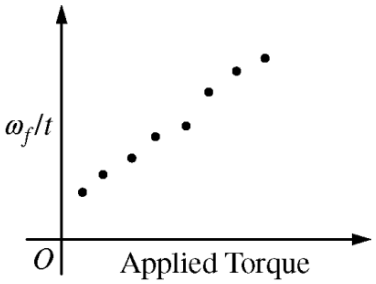
A student conducts an experiment to determine the relationship between applied torque and change in angular velocity. The student uses the apparatus shown in the figure above, consisting of two disks that are glued together and mounted on a horizontal axle. Blocks of varying mass are hung from a string wound around the smaller disk. The blocks are released from rest, exerting different torques on the disks, and are allowed to fall a fixed distance. For each block, the time of fall t and the final angular velocity ω_f of the disks are measured. There is considerable friction between the disks and the axle. Which of the following best represents a plot that can be obtained from the student's data?

chapter7

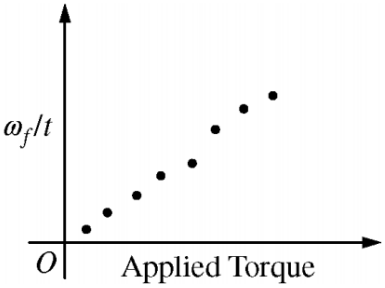
(A)



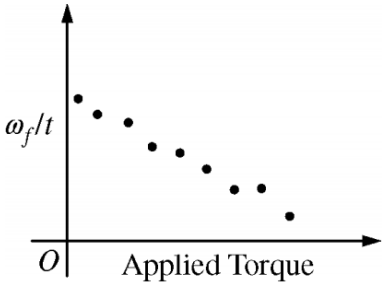
(B)



(C)

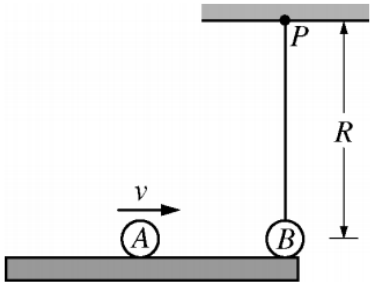


(D)



chapter7

50.



Steel sphere A of mass *M* is moving along a horizontal surface with constant speed *v*. Identical steel sphere *B* is at rest and hangs on a string of length *R* attached to a support at point *P*, as shown in the figure above. The spheres collide, and as a result sphere A stops and sphere *B* swings a vertical height *h* before coming momentarily to rest. Knowing values for which of the following will allow determination of the angular impulse on sphere *B* with respect to *P* due to the collision?

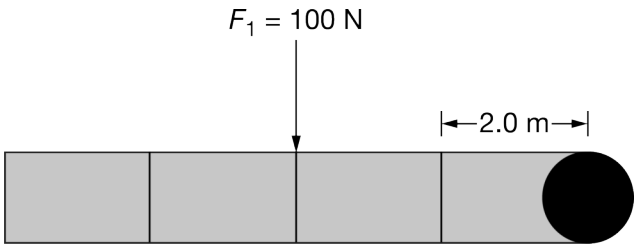
(A) *M* and *v* only

(B) *M*, *v*, and *h*

(C) *R* and *h*

(D) *R*, *M*, and *v*

51.



A rod initially at rest as shown in the figure rotates freely around a pivot such that frictional forces are considered to be negligible. The rod is divided equally into four sections, with the length of each segment equal to $2.0\ \mathrm{m}$. A downward force $F_1 = 100\ \mathrm{N}$ is applied in the position and direction shown. A student must apply a force F_2 to the rod so that the rod remains in equilibrium. To satisfy the condition, what magnitude of force can be exerted on the rod and at what distance away can F_2 be applied? Select two answers.

chapter7

A

Magnitude of F_2	Distance from pivot (m)
50	8.0

B

Magnitude of F_2	Distance from pivot (m)
150	6.0

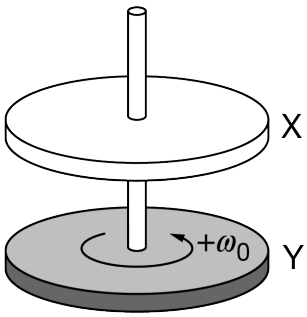
C

Magnitude of F_2	Distance from pivot (m)
200	2.0

D

Magnitude of F_2	Distance from pivot (m)
250	1.0

52.



Disk X is held at rest above disk Y, which rotates with angular velocity $+\omega_0$ about its center, as shown in the figure. Disk Y is slowly lowered onto disk X until the disks remain in contact and travel together at angular velocity $+\omega_1$. Which of the following linear collisions is analogous to the rotational collision that is described?

(A) Block X travels toward block Y with velocity $+v_1$. Block Y is initially at rest. After the collision, block Y travels with velocity $+v_1$, and block X remains at rest.

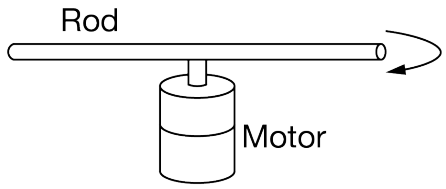
(B) Block X travels toward block Y with velocity $+v_1$. Block Y is initially at rest. After the collision, block X and block Y travel together with velocity $+v_2$.

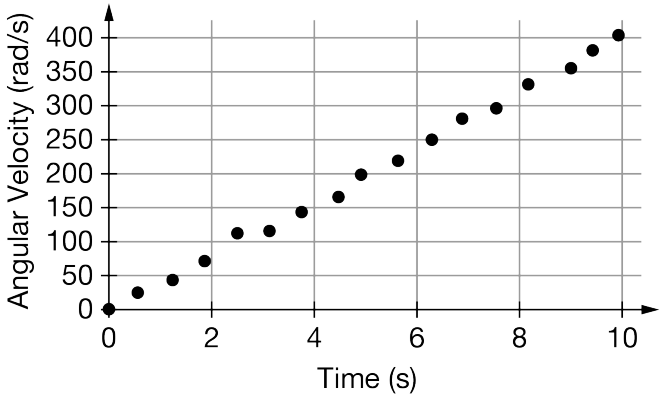
(C) Block X travels toward block Y with velocity $+v_1$. Block Y is initially traveling toward block X with velocity $-v_1$. After the collision, block X and block Y travel together with velocity $+v_2$.

(D) Block X travels toward block Y with velocity $+v_1$. Block Y is initially traveling toward block X with velocity $-v_1$. After the collision, block X travels with velocity $-v_2$ and block Y travels with velocity $+v_3$.

chapter7

53.





A group of students conduct an experiment on the rotational motion of a horizontal, rigid rod that is connected to a motor, as shown in the figure. The students collect the data necessary to create a graph of the angular velocity of the disk as a function of time. One student in the group states that the graph shows that a net external torque is exerted on the rod, because the rod's angular momentum increased. Do the data support the student's statement? Justify your selection.

(A) Yes, because the angular velocity increases with time. Therefore, the angular momentum of the rod increases with time. This can only occur as the result of a net torque.

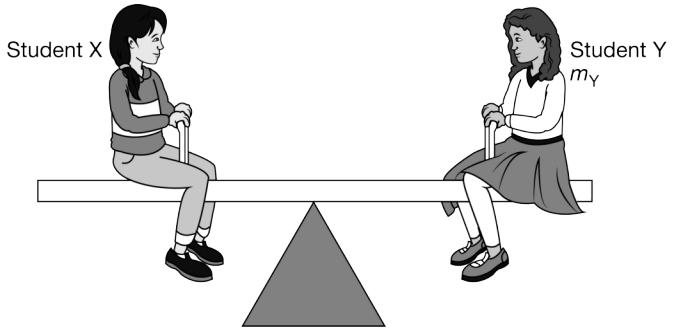
(B) Yes, because the area bound between the best-fit line of the data and the horizontal axis from 0 s to 10 s is a positive value. Therefore, the angular displacement of the rod is nonzero. This can only occur as the result of a net torque.

(C) No, because the slope of a best-fit line to the data is constant. Therefore, a net torque cannot have been exerted on the rod.

(D) No, because the graph does not contain enough information to make statements regarding the angular momentum and/or net torque exerted on the rod.

chapter7

54.



Two students, X and Y, sit on a seesaw that is in static equilibrium, as shown in the figure. A fulcrum is located at the center of the seesaw. The mass m_Y of Student Y is known. A third student, Z, must determine the mass of Student X. Which of the following measurements should Student Z make in order to determine the mass of Student X? Justify your selection.

(A) The length of the seesaw, because the entire length of the seesaw is in static equilibrium.

(B) The distance that Student X is from the edge of the seesaw and the distance that Student Y is from the edge of the seesaw, because the seesaw would no longer be in static equilibrium if one or both students moved closer to the edge of the seesaw.

(C) The distance that Student X is from the center of the seesaw and the distance that Student Y is from the center of the seesaw, because these are the distances from the fulcrum to the location of the forces exerted on the two-student-seesaw system.

(D) The mass of the seesaw, because a force due to gravity is exerted on the seesaw from Earth.

chapter7

55.

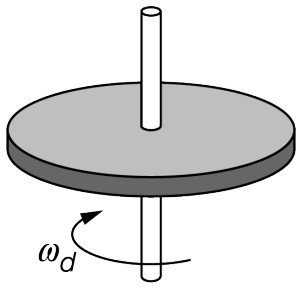


Figure 1

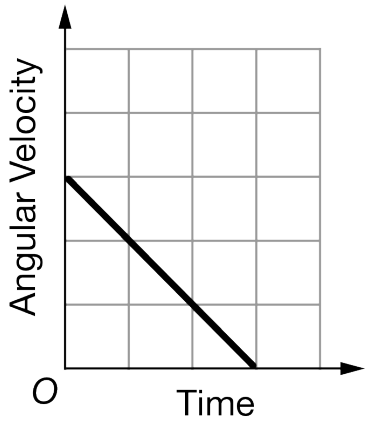


Figure 2

A uniform disk spins about an axis that passes through the center of the disk and is perpendicular to the plane of the disk, as shown in Figure 1. The disk has an initial angular velocity of ω_d and uniformly accelerates to rest over time. The angular velocity of the disk as a function of time is shown in Figure 2. A student must determine the angular displacement of a point on the edge of the disk from $t = 0$ to the instant in time the disk comes to rest if the point's initial velocity is changed to $2\omega_d$ but its angular acceleration is the same as shown in Figure 2. How can the graph in Figure 2 be changed before the student can determine the angular displacement? Justify your selection.

(A) Recreate the graph with a vertical intercept that is twice the value of the intercept shown in Figure 2, because the angular velocity is increased from ω_d to $2\omega_d$. The horizontal intercept should be the same in both graphs, because the angular acceleration is the same in both graphs.

(B) Recreate the graph with a vertical intercept that is twice the value of the intercept shown in Figure 2, because the angular velocity is increased from ω_d to $2\omega_d$. The slope of the line should be the same in both graphs, because the angular acceleration is the same in both graphs.

(C) Recreate the graph with the same vertical intercept in both graphs, because the angular acceleration is the same in both graphs. The slope of the curve in the new graph should be twice as steep as the slope in Figure 2, because the angular velocity is increased from ω_d to $2\omega_d$.

(D) Recreate the graph with the same vertical intercept in both graphs, because the angular acceleration is the same in both graphs. The horizontal intercept in the new graph should be twice the value of the horizontal intercept in Figure 2, because the angular velocity is increased from ω_d to $2\omega_d$.

chapter7

56.

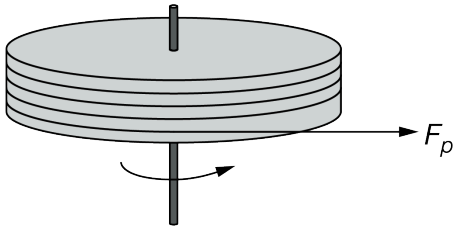


Figure 1

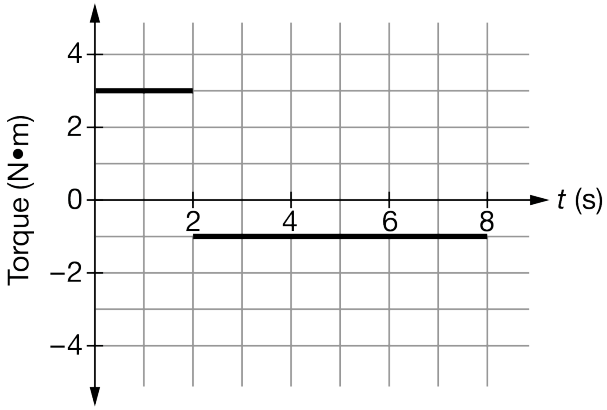


Figure 2

A solid disk rests on a central axle. A string is wound around the disk, which causes the disk to rotate about its axle when pulled with a constant force F_P, as shown in Figure 1. The force is exerted on the string until the string completely unwinds and detaches from the disk at time $t = 2$ s. A graph of the net torque as a function of time is shown in Figure 2. How can a student determine what the change in angular momentum of the disk would be between 0 s and 2 s if friction were negligible? Justify your selection.

(A) The net torque exerted on the disk during the time interval $0\text{ s} < t < 2\text{ s}$ is $6\text{ N} \bullet \text{m}$. After $t = 2$ s the net torque, which is the frictional torque $\tau_{Friction}$, is $-6\text{ N} \bullet \text{m}$. Using this information, it can be inferred that the torque τ_P due to F_P is $0\text{ N} \bullet \text{m}$. Therefore, the change in angular momentum from τ_P, if friction were negligible, would be zero.

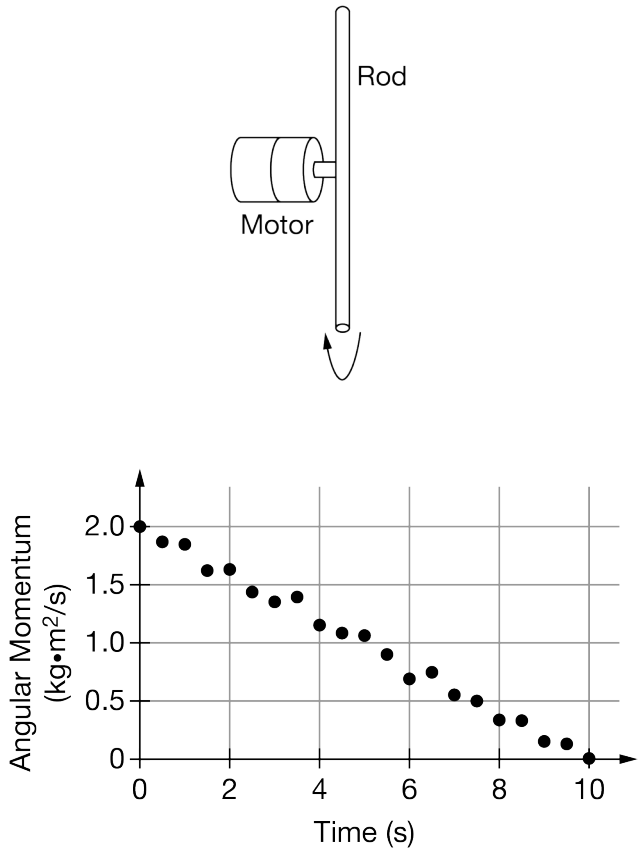
(B) The net torque exerted on the disk during the time interval $0\text{ s} < t < 2\text{ s}$ is $3\text{ N} \bullet \text{m}$. After $t = 2$ s the net torque, which is the frictional torque $\tau_{Friction}$, is $-1\text{ N} \bullet \text{m}$. Using this information, it can be inferred that the torque τ_P due to F_P is $2\text{ N} \bullet \text{m}$. Therefore, the change in angular momentum from τ_P, if friction were negligible, would be $2\text{ N} \bullet \text{m}$ multiplied by 2 s.

(C) The net torque exerted on the disk during the time interval $0\,\text{s} < t < 2\,\text{s}$ is $3\,\text{N} \cdot \text{m}$. After $t = 2\,\text{s}$ the net torque, which is the frictional torque $\tau_{Friction}$, is $-1\,\text{N} \cdot \text{m}$. Using this information, it can be inferred that the torque τ_P due to F_P is $4\,\text{N} \cdot \text{m}$. Therefore, the change in angular momentum from τ_P, if friction were negligible, would be $4\,\text{N} \cdot \text{m}$ multiplied by $2\,\text{s}$.

(D) The net torque exerted on the disk during the time interval $0\,\text{s} < t < 2\,\text{s}$ is $6\,\text{N} \cdot \text{m}$. After $t = 2\,\text{s}$ the net torque, which is the frictional torque $\tau_{Friction}$, is $-6\,\text{N} \cdot \text{m}$. Using this information, it can be inferred that the torque τ_P due to F_P is $12\,\text{N} \cdot \text{m}$. Therefore, the change in angular momentum from τ_P, if friction were negligible, would be $12\,\text{N} \cdot \text{m}$ multiplied by $2\,\text{s}$.

chapter7

57.



A vertically oriented rod may freely rotate around a horizontal axle through its center. A student applies a force on one end of the rod so that the rod rotates around the axis. The student collects the necessary data to generate the graph that is shown. After observing the data, the student makes the following statement.

"For the time interval shown, the magnitude of the net torque exerted on the rod decreases over time."

Do the data support the student's statement? Justify your selection.

(A) Yes, because the angular momentum decreases to zero.

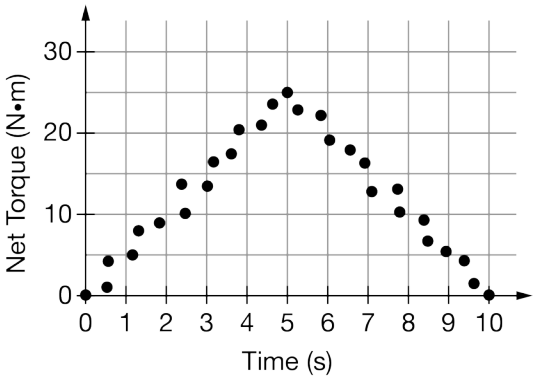
(B) Yes, because the slope of the best-fit line remains constant.

(C) No, because the angular momentum decreases to zero.

(D) No, because the slope of the best-fit line remains constant.

chapter7

58.



In an experiment, a student applies a net force to the edge of a disk for 10 s. The student may change the magnitude and the direction of the force at any time in the experiment. A graph of the net torque exerted on the edge of the disk as a function of time is shown. After observing the graph, the student concludes that the angular momentum of the disk has not changed. Does the graph support the student's conclusion? Justify your answer.

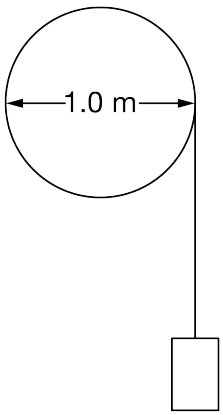
(A) Yes, because the change in the net torque from 0 s to 10 s is zero.

(B) Yes, because the slope of the curve of the graph from 0 s to 5 s has the same magnitude but opposite sign as the slope of the curve from 5 s to 10 s.

(C) No, because the area bound by the curve and the horizontal axis from 0 s to 10 s is not zero.

(D) No, because the graph cannot be used to determine how the angular momentum has changed.

59.



In an experiment, students must determine the angular momentum of a vertically rotating nonuniform disk of diameter 1.0 m. A central axle of negligible friction is located at the center of the disk and is oriented perpendicular to the plane of the page. A string is wound around the disk, and an object of unknown mass is attached to the string, as shown in Figure 1. The object is released from rest, which causes the disk to rotate as the object falls. The disk's angular position as a function of time is shown in Figure 2. The tension in the string is 5 N and remains constant. Which of the following mathematical routines could a student use to determine the change in angular momentum of the disk during a time interval Δt ? Justify your selection.

(A) Use $\Delta L = \tau \Delta t$, where $\tau = rF \sin\theta$ with $r = 0.5$ m, $F = 5$ N, and $\theta = 0^{\circ}$.

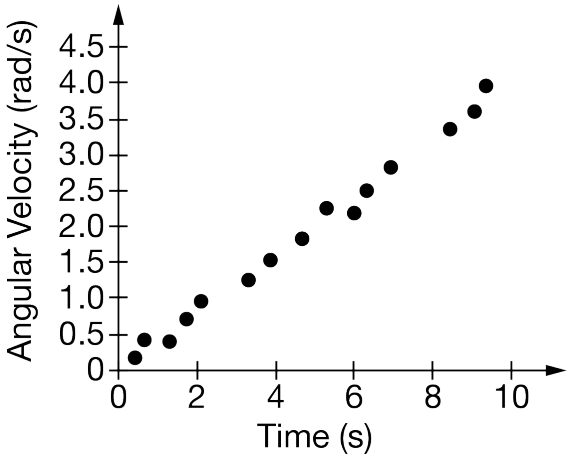
(B) Use $\Delta L = \tau \Delta t$, where $\tau = rF \sin\theta$ with $r = 0.5$ m, $F = 5$ N, and $\theta = 90^{\circ}$.

(C) Use $\Delta L = \tau \Delta t$, where $\tau = rF \sin\theta$ with $r = 1.0$ m, $F = 5$ N, and $\theta = 0^{\circ}$.

(D) Use $\Delta L = \tau \Delta t$, where $\tau = rF \sin\theta$ with $r = 1.0$ m, $F = 5$ N, and $\theta = 90^{\circ}$.

chapter7

60.



In an experiment, a disk of known rotational inertia I rotates as a result of a known force that is applied to the disk's edge. The angular velocity of the disk is measured as a function of time, as shown in the graph. Students must determine the relationship between the magnitude of the change in angular momentum of the disk from $t = 0$ s to $t = 10$ s and the torque applied to the disk. What quantity could the students measure in order to make the determination? Justify your selection.

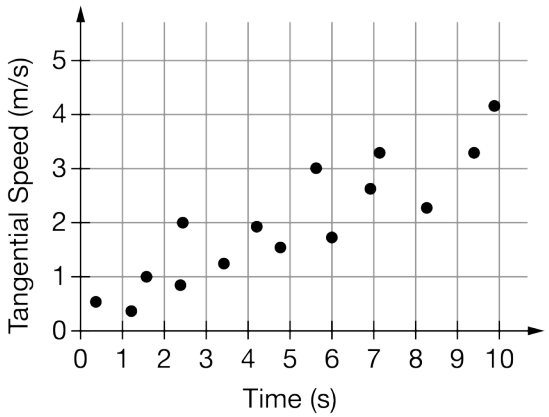
(A) the radius r of the disk, because $\tau = Fr \sin \theta$

(B) The acceleration of a point on the disk, because $F = ma$

(C) The mass m of the disk, because $I = \frac{1}{2}mr^2$

(D) The direction of the rotation, because a change in angular momentum is a vector quantity

61.



In an experiment, an external torque is applied to the edge of a disk of radius 0.5 m such that the edge of the disk speeds up as it continues to rotate. The tangential speed as a function of time is shown for the edge of the disk. The rotational inertia of the disk is $0.125\ \text{kg} \cdot \text{m}^2$. Can a student use the graph and the known information to calculate the net torque exerted on the edge of the disk?

chapter7

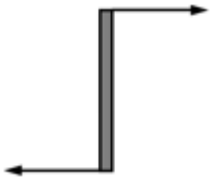
(A) Yes, because the slope of the graph multiplied by the rotational inertia is equal to the net torque exerted on the edge of the disk.

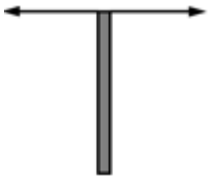
(B) Yes, because the change in tangential speed per unit of time can be multiplied by the rotational inertia divided by the radius of the disk.

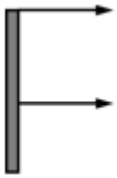
(C) No, because the net force exerted on the edge of the disk must first be determined before the net torque can be calculated.

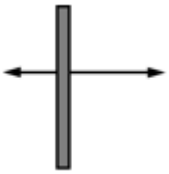
(D) No, because the change in tangential speed of the edge of the disk per unit of time cannot be used to determine the angular acceleration of the disk.

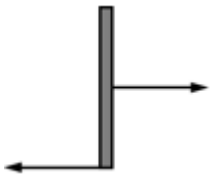
62. The figures below indicate forces acting on a rod in different situations. The lengths of the force vectors are proportional to the magnitudes of the forces. In which situation is the rod in both translational and rotational equilibrium?

(A) 

(B) 

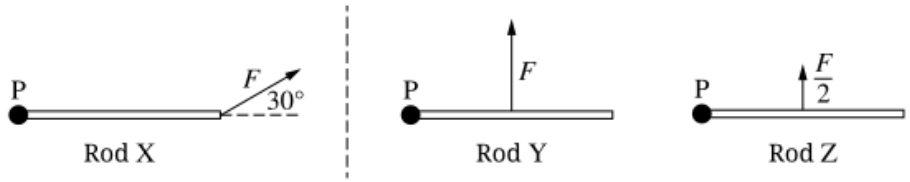
(C) 

(D) 

(E) 

chapter7

63.



Forces are exerted on identical rods X, Y, and Z. The rods are each free to rotate about the pivot P on the left end of the rod. The forces exerted on rods Y and Z are applied to the midpoints of the rods. Which of the following identifies the rod that has the same torque about P as Rod X and provides correct reasoning?

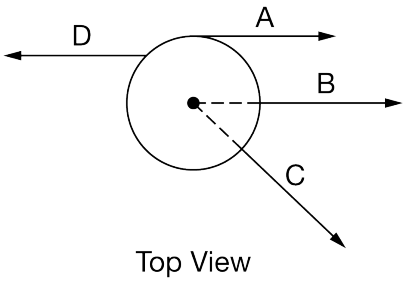
(A) Rod Y, because the magnitude of the force exerted on Rod X is equal to the magnitude of the force exerted on Rod Y.

(B) Rod Y, because the magnitude of the perpendicular component of the force exerted on Rod X is half the magnitude of the force exerted on Rod Y, but the force on Rod X is exerted at twice the distance from P.

(C) Rod Z, because the magnitude of the perpendicular component of the force exerted on Rod X is equal to the magnitude of the force exerted on Rod Z.

(D) Rod Z, because the magnitude of the force exerted on Rod X is twice the magnitude of the force exerted on Rod Z, but the force on Rod X is exerted at twice the distance from P.

64.



A horizontal disk is free to rotate about an axle at its center. The labeled arrows in the figure represent forces of equal magnitude that are exerted on the edge of the disk in the directions shown. Which of the following correctly ranks the magnitude τ of the torque about the axle exerted by each force?

(A) $\tau_{\mathrm{A}} = \tau_{\mathrm{B}} = \tau_{\mathrm{C}} = \tau_{\mathrm{D}}$

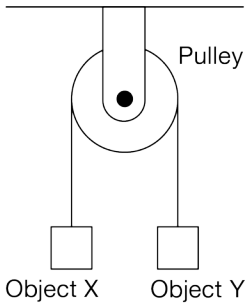
(B) $\tau_{\mathrm{A}} > \tau_{\mathrm{D}} > (\tau_{\mathrm{B}} = \tau_{\mathrm{C}})$

(C) $(\tau_{\mathrm{A}} = \tau_{\mathrm{B}} = \tau_{\mathrm{D}}) > \tau_{\mathrm{C}}$

(D) $(\tau_{\mathrm{B}} = \tau_{\mathrm{C}}) > \tau_{\mathrm{D}} > \tau_{\mathrm{A}}$

chapter7

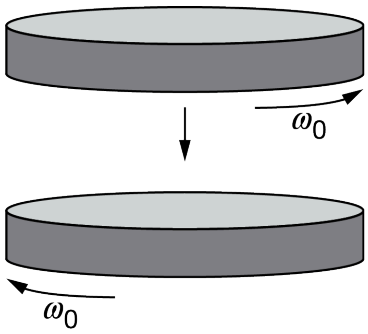
65.



In an experiment, one end of a string is attached to object X, and the other end of the string is attached to object Y. The string is then placed around a pulley, as shown in the figure, and the system containing object X, object Y, the string, and the pulley remains at rest. A support string connects the pulley to the ceiling. Which two of the following measuring devices could students use to mathematically verify that the net torque exerted on the system is zero? Select two answers.

- A Stopwatch
- B Meterstick
- C Protractor
- D Electronic balance

66.



Two identical disks rotate about their centers in opposite directions with the same magnitude of angular speed ω_0. The top disk is dropped onto the bottom disk, as shown in the figure, so they collide and stick together. Which of the following predictions is correct about the motion of each individual disk after the collision?

(A) Each disk will spin with the same final angular velocity ω_f where $\omega_f = 0$.

(B) Each disk will spin with the same final angular velocity ω_f where $\omega_f > \omega_0$.

(C) Each disk will spin with the same final angular velocity ω_f where $0 < \omega_f < \omega_0$.

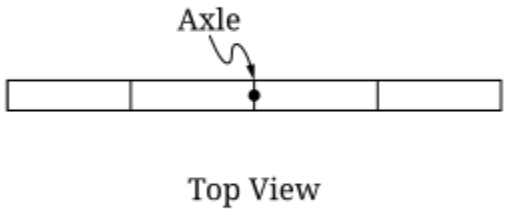
(D) Each disk will spin with the same final angular velocity ω_f where $\omega_f = \omega_0$.

67. Two identical wheels, wheel 1 and wheel 2, initially at rest begin to rotate with constant angular accelerations α. After rotating through the same angular displacement, $\Delta\theta_0$, the angular velocity of wheel 1 is ω_1 and the angular velocity of wheel 2 is $\omega_2 = 3\omega_1$. How does the angular acceleration of wheel 2, α_2, compare to the angular acceleration of wheel 1, α_1 ?

chapter7

(A) $\alpha_2 = \alpha_1$
(B) $\alpha_2 = \frac{\alpha_1}{3}$
(C) $\alpha_2 = 3\alpha_1$
(D) $\alpha_2 = 9\alpha_1$

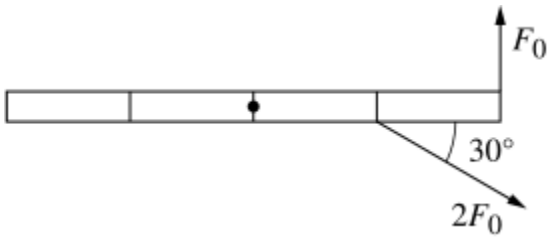
68.



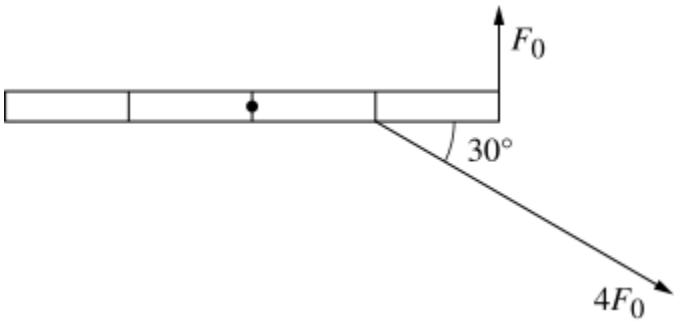
A uniform rod is free to rotate about a fixed vertical axle at its midpoint, as shown. Two forces are exerted on the rod. Which of the following scenarios represents a rod that is in static equilibrium? Select two answers.

chapter7

A



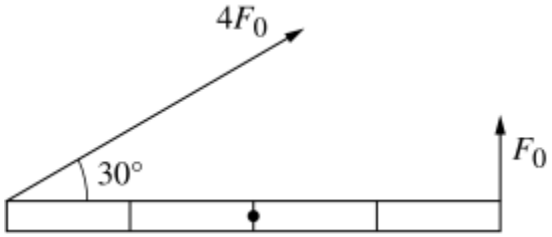
B



C



D



69.

Object	Mass (kg)	Position on Meterstick (m)
1	0.5	20
2	0.3	60
3	0.2	70
4	?	?

Students place the center of mass of a meterstick at the tip of a fulcrum so the meterstick does not rotate. Three objects of various mass are placed at different positions on the meterstick, as shown in the table. A fourth object is placed on the meterstick so that the meterstick and all four objects remain in static equilibrium. Which of the following could represent the mass of the object and its position on the meterstick?

chapter7

(A)

Mass (kg)	Position on Meterstick (m)
0.12	66

(B)

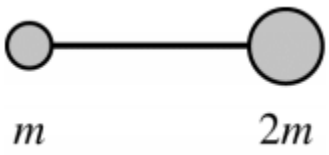
Mass (kg)	Position on Meterstick (m)
0.50	66

(C)

Mass (kg)	Position on Meterstick (m)
0.12	34

(D)

Mass (kg)	Position on Meterstick (m)
0.50	34



A system consists of two spheres, of mass m and $2m$, connected by a rod of negligible mass, as shown above. The system is held at its center of mass with the rod horizontal and released from rest near Earth's surface at time $t = 0$.

70. Which of the following best explains why the system does not rotate around its center of mass as it falls?

(A) The Earth exerts the same gravitational force on both spheres, causing them to accelerate at the same rate.

(B) The Earth exerts the same gravitational force on both spheres, generating torques that cancel out.

(C) The Earth exerts a larger gravitational force on the sphere of mass $2m$, but that sphere is closer to the center of mass and the torques cancel out.

(D) The Earth exerts a larger gravitational force on the sphere of mass $2m$, but that sphere has more inertia and the torques cancel out.