Unit 7 Progress Check: MCQ Part B

1.

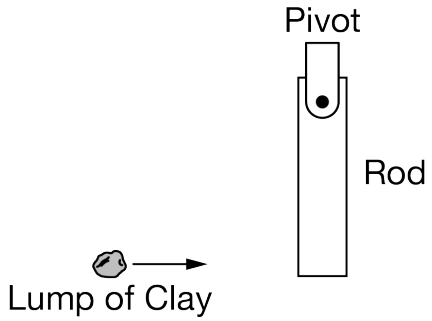

Figure 1
Side View

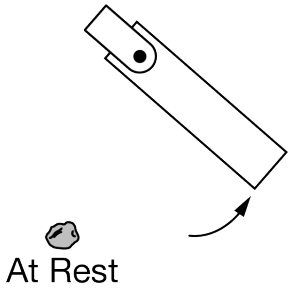

Figure 2
Side View

A rod is at rest on a horizontal surface. One end of the rod is connected to a pivot that allows the rod to rotate around the pivot after a net external force is exerted on the rod. A lump of clay is launched horizontally toward the free end of the rod, as shown in Figure 1. The lump of clay collides with the rod but does not stick to the rod. The lump of clay comes to rest as the rod rotates around the pivot, as shown in Figure 2. Which of the following linear collisions is analogous to the rotational collision that is described?

(A) A block traveling in the positive direction collides with a second block that travels in the negative direction. After the collision, the two blocks move together with a common final speed.

(B) A block traveling in the positive direction collides with a second block that is at rest. After the collision, the two blocks move together with a common final speed.

(C) A block traveling in the positive direction collides with a second block that travels in the negative direction. After the collision, the blocks reverse their directions and travel with their original speeds.

(D) A block traveling in the positive direction collides with a second block that is at rest. After the collision, the first block comes to rest and the second block travels at a nonzero speed in the direction that the first object initially traveled. ✓

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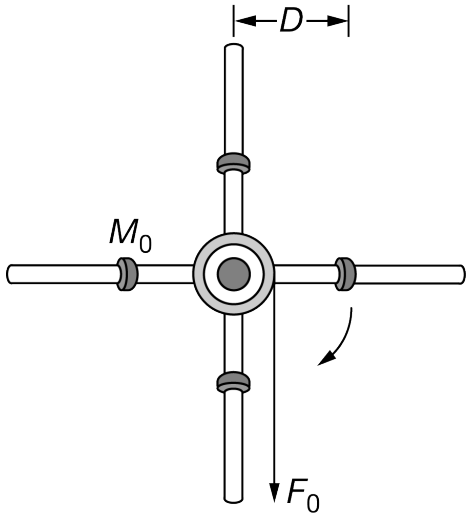
2.



Three disks are concentrically attached to one another, and four rods of negligible mass are attached to the outer disk. Identical objects of mass M_o can be attached to the rods, and their positions on the rods can be adjusted. The disks, rods, and objects form a system that freely rotates around a central axis that is perpendicular to the plane of the page. The objects are initially a distance D away from the axis of rotation. A constant force F_0 is applied tangent to the second disk, as shown in the figure. How can the system be changed so that the change in angular momentum of the system per unit of time is increased?

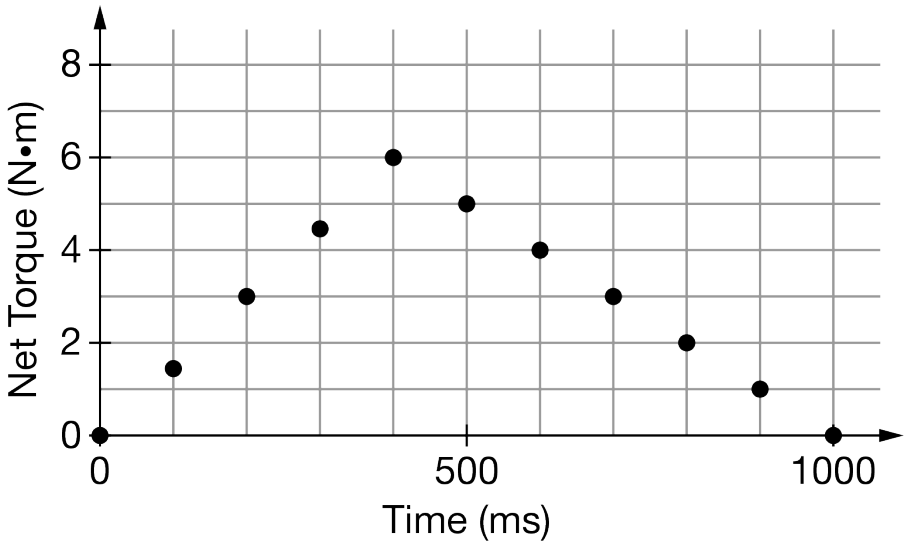
(A) Move the objects of mass M_0 farther away from the axis of rotation.

(B) Move the objects of mass M_0 closer to the axis of rotation.

(C) Increase the magnitude of the net torque exerted on the system. ✓

(D) Decrease the magnitude of the net torque exerted on the system.

3.



The graph shown represents the net torque that a wrench exerts on a bolt as a function of time as the wrench turns the bolt around its central axis of rotation. What is the change in angular momentum of the bolt after $1000\ \text{ms}$?

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(A) Zero

(B) $1.2\,\text{kg} \cdot \text{m}^2/\text{s}$

(C) $3.0\,\text{kg} \cdot \text{m}^2/\text{s}$ ✓

(D) $6.0\,\text{kg} \cdot \text{m}^2/\text{s}$

4. A uniform disk with mass M_0 and radius R is mounted on a vertical axis so that it can rotate freely in a horizontal plane. The rotational inertia of the disk is I_0. The disk is initially at rest. If force F_0 is exerted tangentially to the rim of the disk for time interval Δt, the final angular momentum of the disk is L_0.

Consider a second disk that has the same mass M_0 as the first disk, but its radius is $2R$. The rotational inertia of this disk is $4I_0$. If the same force F_0 is exerted tangentially to the rim of the disk for the same time interval Δt, then the final angular momentum of the second disk would be

(A) L_0

(B) $2L_0$ ✓

(C) $4L_0$

(D) $8L_0$

5. In an experiment, a torque of a known magnitude is exerted along the edge of a rotating disk. The disk rotates about its center. All frictional forces are considered to be negligible. Which of the following quantities should a student collect in order to determine the change in angular momentum of the disk for a specific time interval? Justify your selection.

(A) The initial angular velocity of the disk, because this quantity is related to the angular impulse of the disk.

(B) The amount of time the torque is applied to the disk, because the time interval is related to the angular impulse of the disk. ✓

(C) The mass of the disk, because this quantity is related to the rotational inertia of the disk.

(D) The radius of the disk, because this quantity is related to the rotational inertia of the disk.

6. One end of a horizontal rod is connected to an axle that is connected to a motor that can be adjusted to change the angular speed of the rod as it rotates in a horizontal circle. Students must determine the change in angular momentum of the rod after $10\ \text{s}$. The students use the following procedure.

I. Measure the length of the rod with a meterstick.
II. Ensure that the rod is at rest.
III. Start the stopwatch and simultaneously adjust the motor so that the rod rotates around the axle as the angular speed is slowly increased.
IV. Record the angular speed of the rod when the stopwatch reads $10\ \text{s}$.

The students are provided with the equation for the rotational inertia of the rod about one end, $I = \frac{ML}{3}^2$. Which of the following steps should the students add to the procedure to ensure that the change in angular momentum of the rod can be determined?

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(A) Record the initial angular speed of the rod.

(B) Measure the thickness of the rod with a meterstick.

(C) Determine the net force exerted on the rod from the axle by using a force probe.

(D) Measure the mass of the rod. ✓

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7.

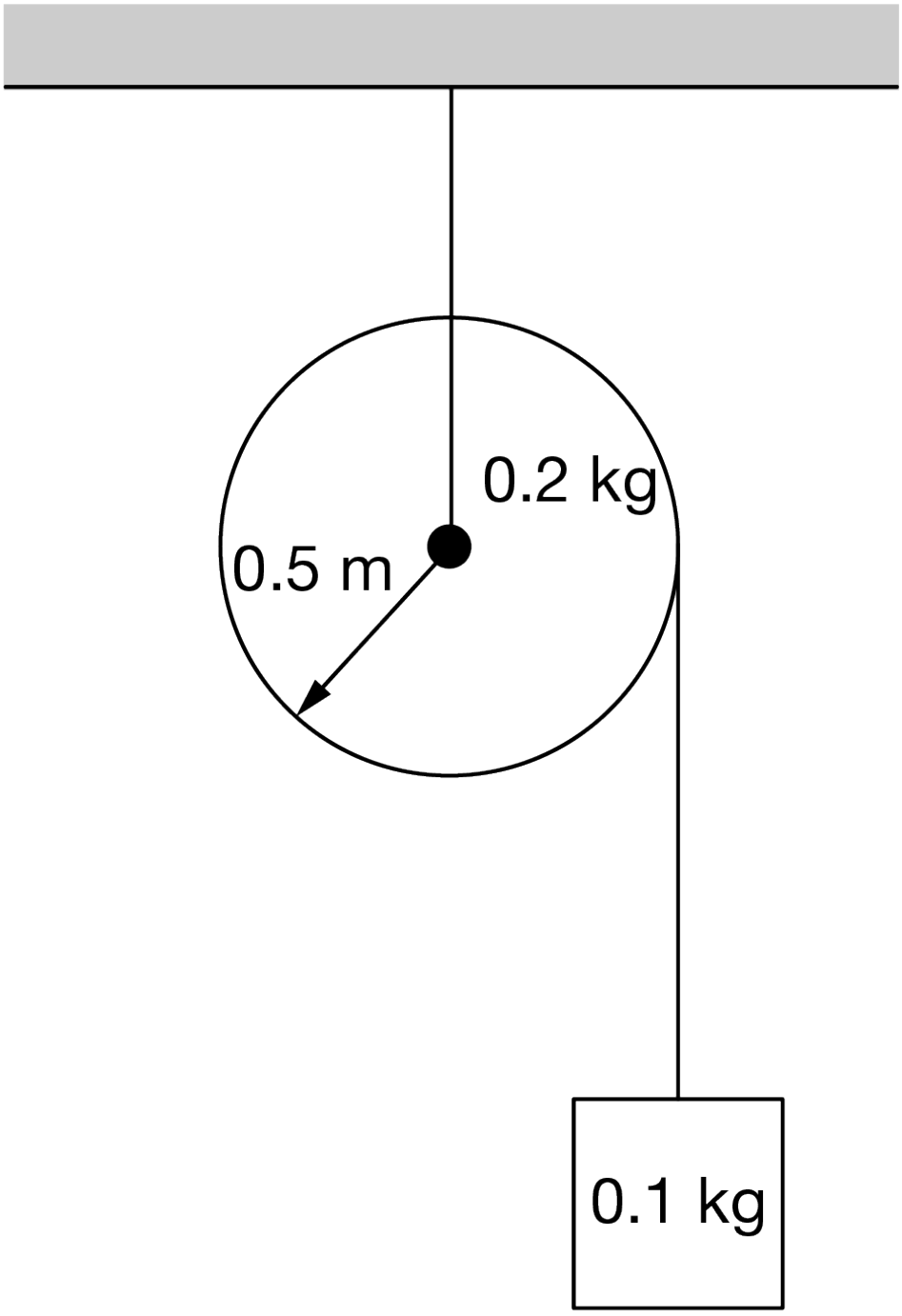

Figure 1

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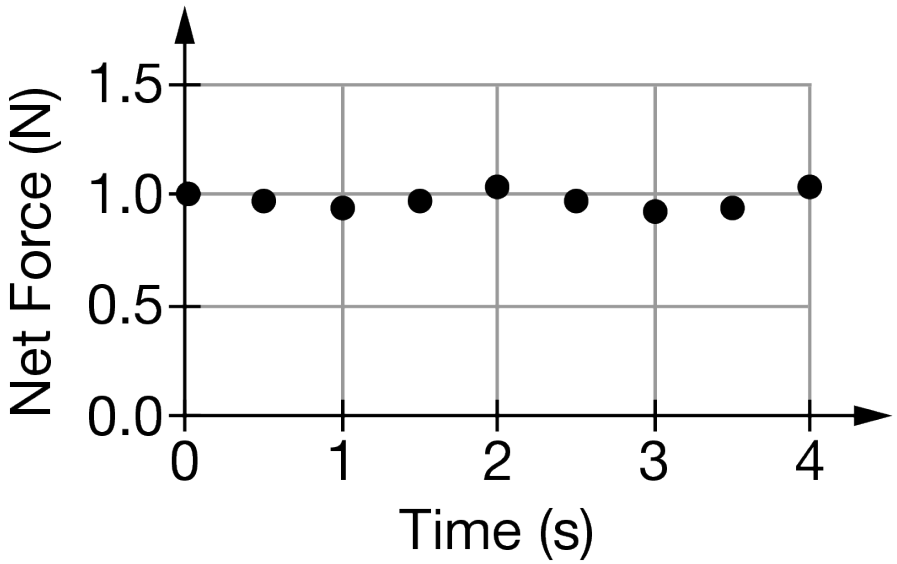

Figure 2

In an experiment, a solid, uniform disk of mass 0.2 kg and radius 0.5 m is suspended vertically and can rotate about its center axle such that frictional forces are considered to be negligible. A string is wrapped around the pulley with one end connected to a block of mass 0.1 kg that hangs from the string at rest, as shown in Figure 1. The block is released from rest and falls to the ground as the pulley rotates. A student collects the necessary data to construct a graph of the net force exerted on the edge of the pulley as a function of time, as shown in Figure 2. How can the student use the graph in Figure 2 to determine the change in angular momentum of the disk from 0 s to 4 s?

(A) Determine the average value of the net force from 0 s to 4 s and multiply the result by the radius of the disk.

(B) Determine the average value of the net force from 0 s to 4 s and divide the result by the radius of the disk.

(C) Determine the area bound by the best fit curve and the horizontal axis from 0 s to 4 s and multiply the result by the radius of the disk. ✓

(D) Determine the area bound by the best fit curve and the horizontal axis from 0 s to 4 s and divide the result by the radius of the disk.

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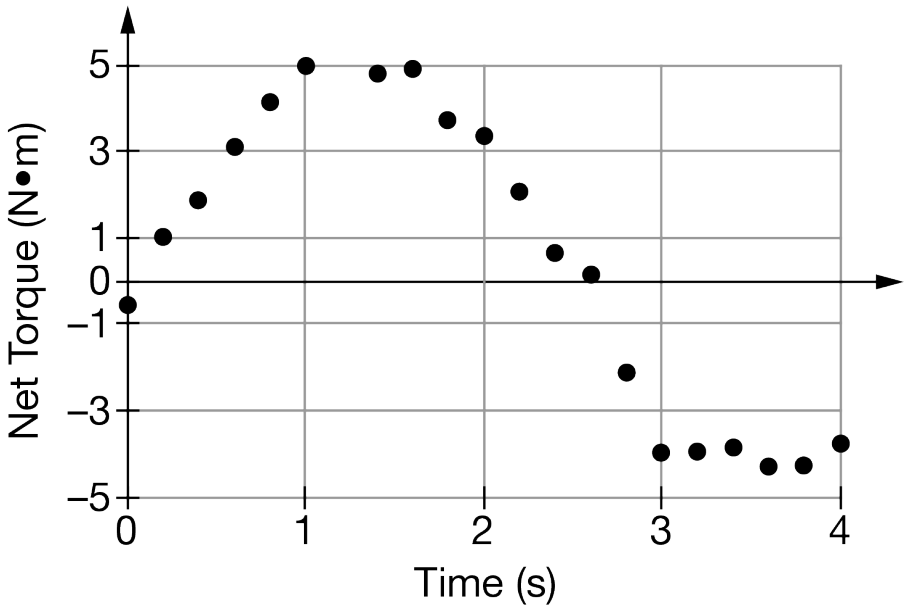
8.



A student conducts an experiment in which data is collected about the net torque exerted on the edge of a disk as it rotates about its center as a function of time. The student creates the graph that is shown. Before the net torque is applied to the disk, it rotates in the positive direction. The student makes the following claim.

"The change in angular momentum of the disk from $0\,\text{s}$ to $4\,\text{s}$ is in the positive direction."

Which of the following statements is correct about the student's evaluation of the data from the graph? Justify your selection.

(A) The student is correct, because there is a greater maximum magnitude of positive net torque exerted on the disk than the maximum magnitude of positive net torque exerted on the disk.

(B) The student is correct, because the area bound by the data and the horizontal axis from $0\,\text{s}$ to $4\,\text{s}$ is positive. ✓

(C) The student is incorrect, because the slope of the line from the data point at $0\,\text{s}$ and the data point at $4\,\text{s}$ is negative.

(D) The student is incorrect, because the net torque at $4\,\text{s}$ is zero.

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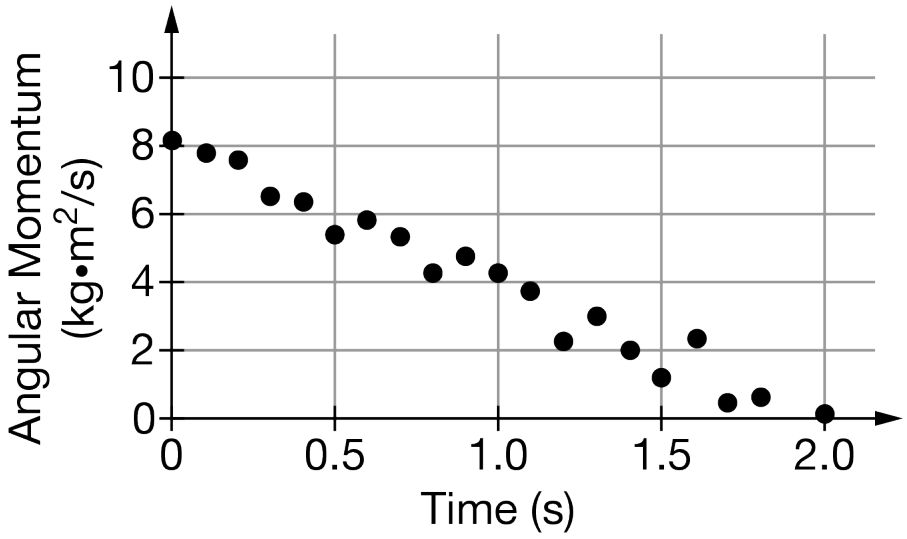
9.



A student conducts an experiment in which a disk may freely rotate around its center in the absence of frictional forces. The student collects the necessary data to construct a graph of the rod's angular momentum as a function of time, as shown. The student makes the following claim.

"The graph shows that the magnitude of the angular acceleration of the disk decreases as time increases."

Which of the following statements is correct about the student's evaluation of the data from the graph? Justify your selection.

(A) The student is correct, because the angular momentum of the disk decreases as time increases.

(B) The student is correct, because the slope of the best-fit curve of the graph remains constant.

(C) The student is incorrect, because the graph shows that the net torque exerted on the disk is constant as time increases. ✓

(D) The student is incorrect, because the graph does not contain enough information to make a direct connection between the angular momentum of the disk and the angular acceleration of the disk.

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10.

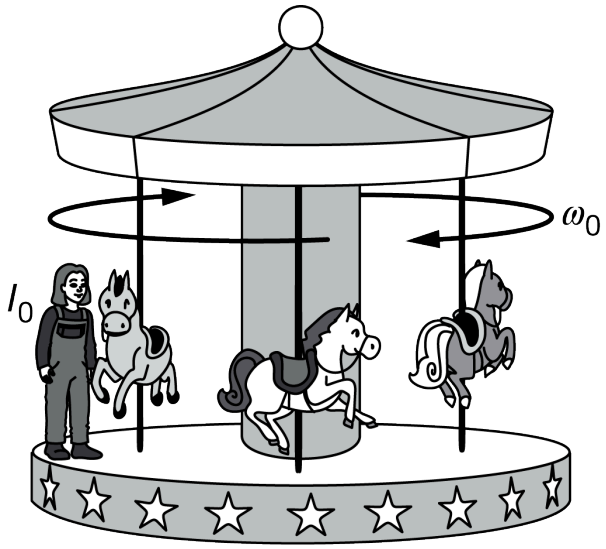

Figure 1

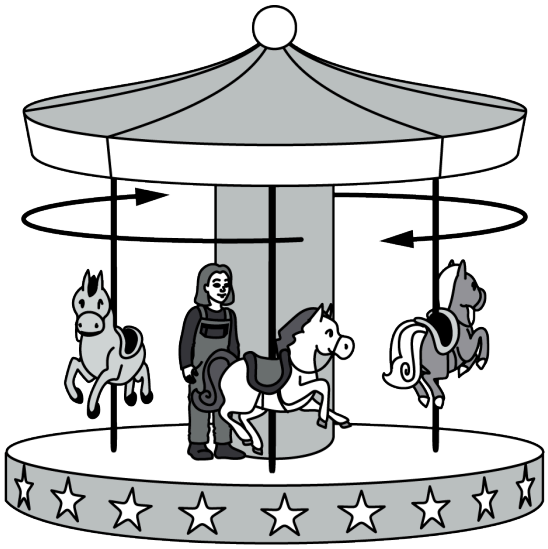

Figure 2

A merry-go-round disk with a rotational inertia of I_d about its center spins around its center axle with an initial angular velocity of ω_0. A child is standing near the edge of the merry-go-round, as shown in Figure 1. The child's rotational inertia about the center of the disk when near the edge is I_0. As the merry-go-round spins, the child moves closer to the center, as shown in Figure 2, until the disk rotates with an angular velocity of ω_1. Which of the following equations could a student use to determine the rotational inertia I_s of the child-merry-go-round system about the center axle immediately after the child has moved to the location shown in Figure 2? Justify your selection.

(A) $I_d\omega_0 = I_s\omega_1$, because the initial angular momentum of the merry-go-round is equal to the final angular momentum of the system.

(B) $I_o\omega_0 = I_s\omega_1$, because the initial angular momentum of the child is equal to the final angular momentum of the system.

(C) $(I_d + I_o)\omega_0 = I_s\omega_1$, because the sum of the initial angular momenta of the merry-go-round and the child is equal to the final angular momentum of the system. ✓

(D) $(I_d - I_o)\omega_0 = I_s\omega_1$, because the difference between the initial angular momenta of the merry-go-round and the child is equal to the final angular momentum of the system.

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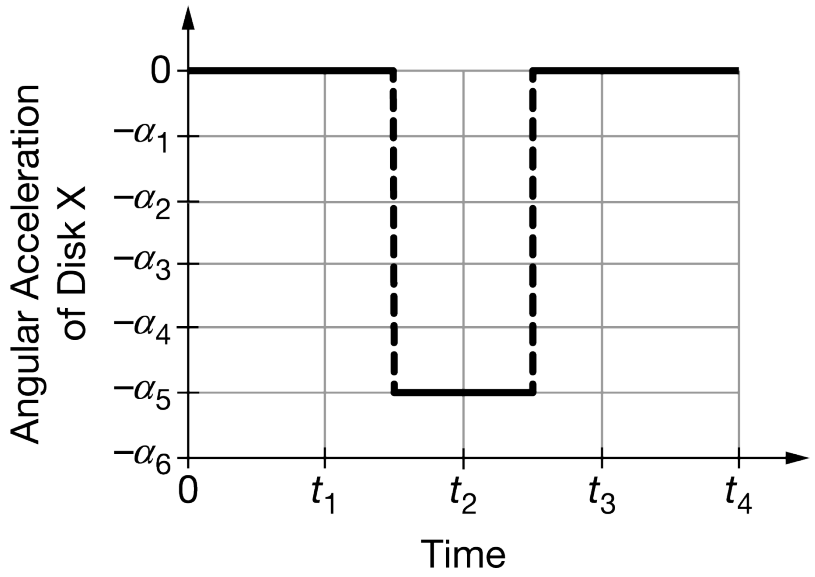
11.



Disk Y of rotational inertia I_Y about its center is held at rest above disk X of rotational inertia I_X about its center. Disk X rotates about its center with an angular velocity $+\omega_1$. Disk Y is slowly lowered onto disk X until both disks are in contact and travel together with a common angular velocity. A graph of disk X's angular acceleration α as a function of time is shown. Which of the following equations can a student use to verify that angular momentum is conserved in the situation? Justify your selection.

(A) $I_\mathrm{X}\omega_1 = (I_\mathrm{X} + I_\mathrm{Y})(\omega_1 + \alpha_5 t_1)$, because the final velocity of the two-disk system is equal to the initial velocity of disk X plus the magnitude of the area bound by the curve and the horizontal axis from $\frac{3}{2}t_1$ to $\frac{5}{2}t_1$.

(B) $I_\mathrm{X}\omega_1 = (I_\mathrm{X} - I_\mathrm{Y})(\omega_1 + \alpha_5 t_1)$, because the final velocity of the two-disk system is equal to the initial velocity of disk X minus the magnitude of the area bound by the curve and the horizontal axis from $\frac{3}{2}t_1$ to $\frac{5}{2}t_1$.

(C) $I_\mathrm{X}\omega_1 = (I_\mathrm{X} + I_\mathrm{Y})(\omega_1 - \alpha_5 t_1)$, because the final velocity of the two-disk system is equal to the initial velocity of disk X minus the magnitude of the area bound by the curve and the horizontal axis from $\frac{3}{2}t_1$ to $\frac{5}{2}t_1$. ✓

(D) $I_\mathrm{X}\omega_1 = (I_\mathrm{X} - I_\mathrm{Y})(\omega_1 - \alpha_5 t_1)$, because the final velocity of the two-disk system is equal to the initial velocity of disk X minus the magnitude of the area bound by the curve and the horizontal axis from $\frac{3}{2}t_1$ to $\frac{5}{2}t_1$.

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12.

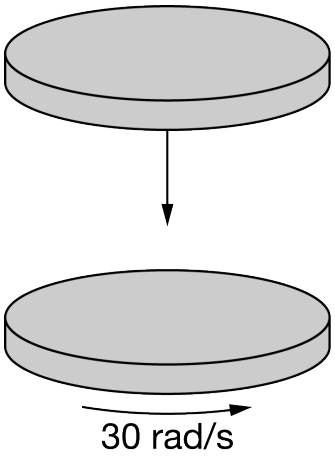

Figure 1

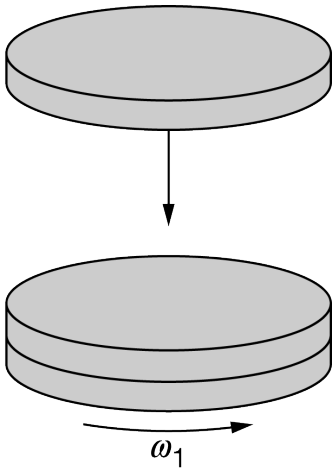

Figure 2

A disk rotates about its center with an angular speed of $30\,\text{rad/s}$. An identical disk is held at rest above the rotating disk and is then gently dropped on the rotating disk, as shown in Figure 1. The two-disk system then rotates with a common angular speed ω_1. A third identical disk is held at rest above the two-disk system. The third disk is gently dropped on the rotating two-disk system, as shown in Figure 2. The three-disk system then rotates with a common angular speed ω_2. What is value of ω_2?

(A) $0\,\text{rad/s}$

(B) $10\,\text{rad/s}$ ✓

(C) $20\,\text{rad/s}$

(D) $30\,\text{rad/s}$

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13.



Figure 1



Figure 2

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Figure 3

An ice skater rotates in a circle about an internal axis of rotation. Figure 1 shows the skater with her arms extended fully outward. Figure 2 shows the skater with her arms partially inward to her body. Figure 3 shows the skater with her arms completely inward and in contact with her body. Which of the following claims is correct about the angular momentum of the skater?

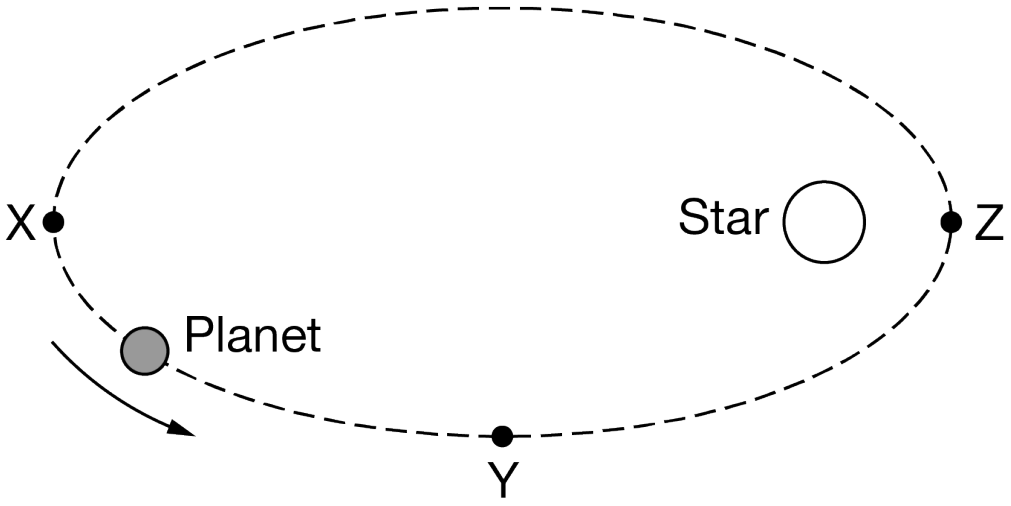
(A) The angular momentum of the skater is greatest in Figure 1.

(B) The angular momentum of the skater is greatest in Figure 2.

(C) The angular momentum of the skater is greatest in Figure 3.

(D) The angular momentum of the skater is the same in all figures. ✓

14.



A planet of mass M_p orbits a star of mass M_s in the path shown above as a result of Newton's law of universal gravitation. Which of the following predictions correctly describes the angular momentum of the planet-star system and the angular velocity of the planet about the axis of revolution as it travels from position X to position Z?

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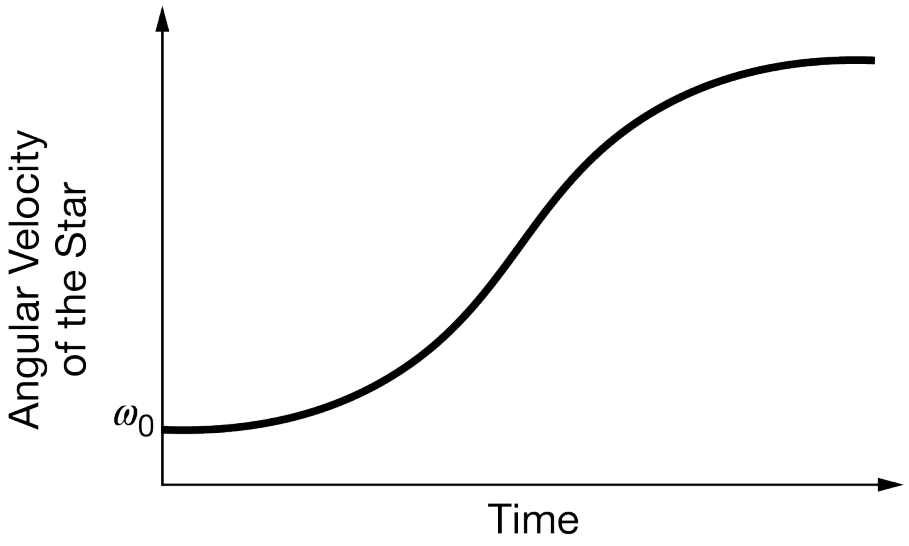
(A) The angular momentum of the system increases, and the angular velocity of the planet increases.

(B) The angular momentum of the system increases, and the angular velocity of the planet remains constant.

(C) The angular momentum of the system remains the same, and the angular velocity of the planet increases. ✓

(D) The angular momentum of the system remains the same, and the angular velocity of the planet remains the same.

15.



An isolated spherical star of radius R_0 rotates about an axis that passes through its center with an angular velocity of ω_0. Gravitational forces within the star cause the star's radius to collapse and decrease to a value $r_0 < R_0$, but the mass of the star remains constant. A graph of the star's angular velocity as a function of time as it collapses is shown. Which of the following predictions is correct about the angular momentum $\vec{L}$ of the star immediately after the collapse?

(A) $\vec{L}$ will be greater after the collapse.

(B) $\vec{L}$ will be less after the collapse.

(C) $\vec{L}$ will be the same as before the collapse. ✓

(D) The magnitude of $\vec{L}$ will be the same as before the collapse, but the direction of the angular momentum will be in the opposite direction after the collapse.

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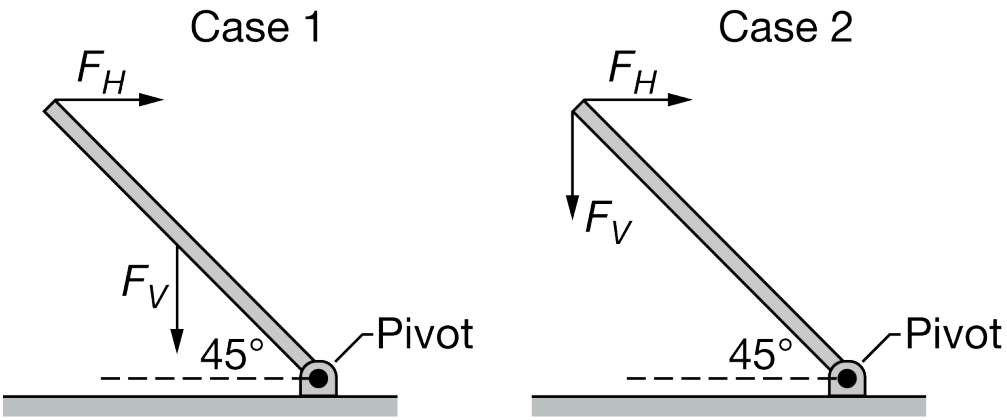
16.



A rod of negligible mass may rotate about a pivot such that frictional forces are considered to be negligible. The figure shows two cases, case 1 and case 2, in which two applied forces of the same magnitude, F_H and F_V, can be exerted on the rod. Which of the following two statements are correct about the net torque exerted on the rod? Select two answers.

A The net torque exerted on the rod in case 1 is smaller than the net torque exerted on the rod in case 2.

B The angular acceleration of the rod in case 1 is greater than the angular acceleration of the rod in case 2 . ✓

C The net torque exerted on the rod in case 1 will cause the rod to rotate in the counterclockwise direction.

D The net torque exerted on the rod in case 2 is zero. ✓

17.

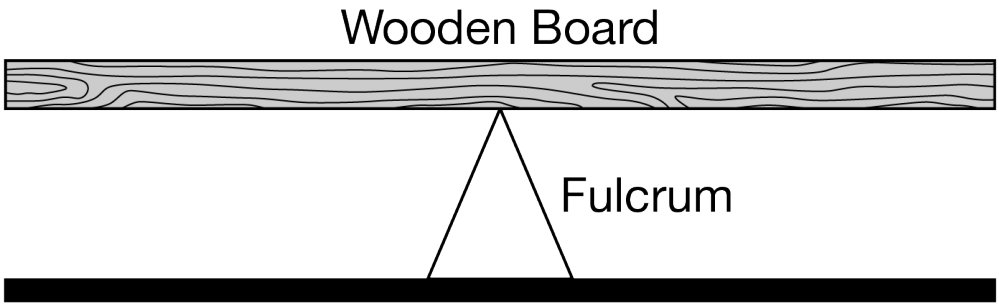


Figure 1

A wooden board of unknown mass is placed on a fulcrum and remains in static equilibrium, as shown in Figure 1. One end of a string is attached to an object of unknown mass, as shown in Figure 2, and can be hung from the board. A student must hang three objects from the wooden board so that the board does not rotate. The student must then mathematically verify whether or not the system remains in static equilibrium. Which two of the following measurements should the student collect in order to make the verification? Justify your selections. Select two answers.

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A	The mass of the wooden board, because the force due to gravity is exerted on the board.	
B	The mass of each object, because each object exerts an external force on the board.	✓
C	The length of the wooden board, because the board is an extended object.	
D	The horizontal distance each hanging object is from the tip of the fulcrum, because this distance is perpendicular to the direction of the force that a hanging object applies to the board.	✓

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18.

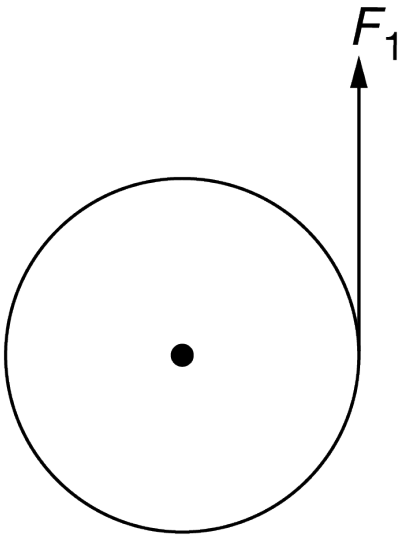

Figure 1
Top View

Note: Vectors not drawn to scale.

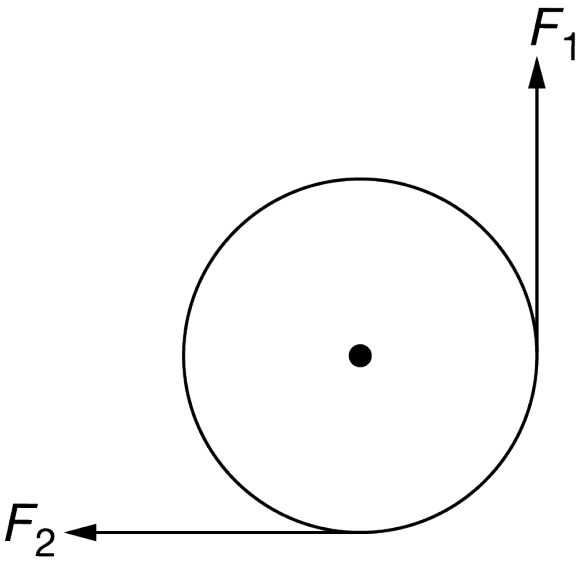

Figure 2
Top View

Note: Vectors not drawn to scale.

A rigid disk with rotational inertia I_0 about its center of mass is initially at rest. The disk is free to rotate without friction about a vertical axis through its center. A constant force F_1 that results in a torque τ_1 is applied to the edge

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of the disk. This torque causes the disk to rotate, as shown in Figure 1. After a time Δt_0, a second force F_2 is also applied to the edge of the disk, resulting in a torque τ_2, as shown in Figure 2. Which two of the following predictions are correct about the motion of the disk after F_2 is applied to the disk? Select two answers.

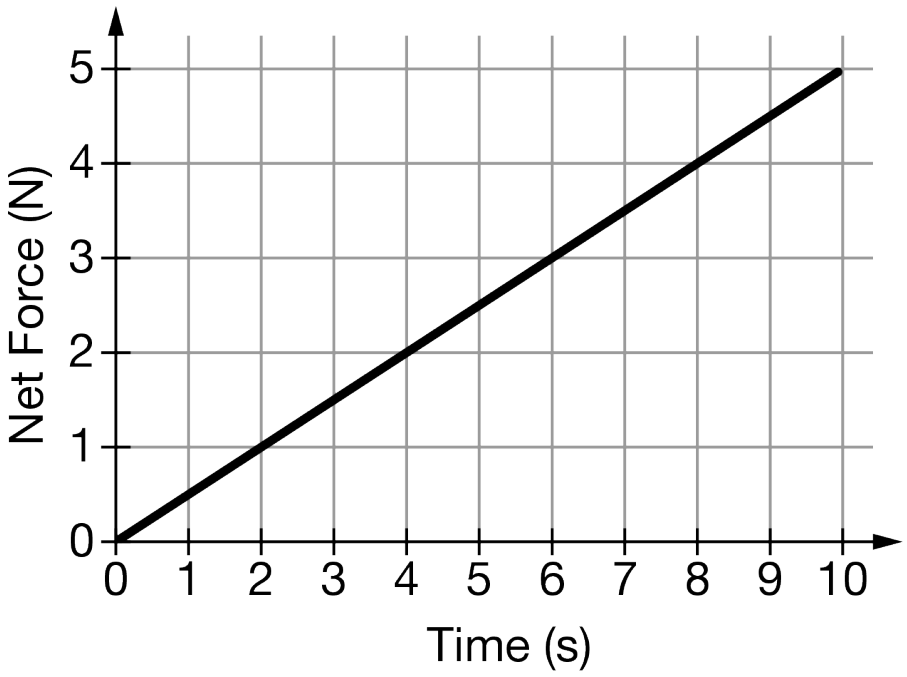
A If the magnitude $\tau_2 < \tau_1$, the disk will continue to spin in the same direction but with zero change in angular velocity per unit time.

B ✓ If the magnitude $\tau_2 = \tau_1$, the disk will continue to spin in the same direction but with zero change in angular velocity per unit time.

C If the magnitude $\tau_2 = 2\tau_1$, the disk will eventually come to rest and then spin in the opposite direction with a smaller change in angular velocity per unit of time than before τ_2 was applied.

D ✓ If the magnitude $\tau_2 > 2\tau_1$, the disk will eventually come to rest and then spin in the opposite direction with a greater change in angular velocity per unit of time than before τ_2 was applied.

19.



A disk that can freely spin about a central axis is initially at rest until a net force is applied to the disk. The net force is exerted tangentially on the edge of the disk, which has radius $0.5\ \text{m}$, mass $0.25\ \text{kg}$, and rotational inertia $0.0625\ \text{kg} \cdot \text{m}^2$. The magnitude of the force as a function of time is shown in the graph. Which two of the following statements are correct about the disk? Select two answers.

A The disk's translational acceleration at $10\ \text{s}$ is $2.5\ \text{m/s}^2$.

B ✓ The disk's angular acceleration at $10\ \text{s}$ is $40\ \text{rad/s}^2$.

C The angular impulse exerted on the disk from $0\ \text{s}$ to $10\ \text{s}$ is $25\ \text{N} \cdot \text{m} \cdot \text{s}$.

D ✓ The final angular momentum of the disk at $10\ \text{s}$ is $12.5\ \text{kg} \cdot \text{m}^2/\text{s}$.

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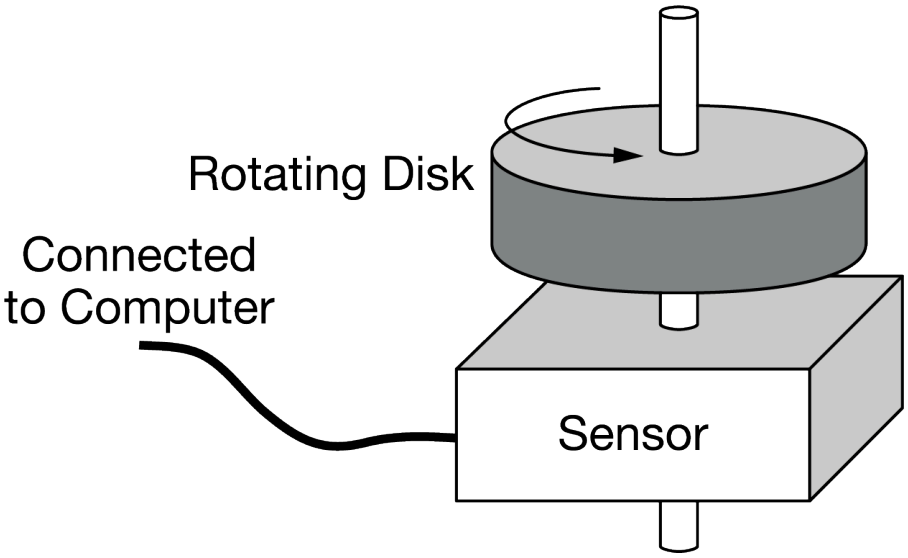
20.



In an experiment, a horizontal cylindrical disk may spin about a central vertical axle. A digital sensor is connected to the axle so that students may measure the angular speed of the disk as it rotates. Students may vary the angular speed of the disk-axle apparatus as data is collected. Students want to plot the magnitude of the angular momentum of the disk as a function of time for a known time interval Δt_0. The students are provided with the equation for the rotational inertia of the disk about its center, $I = \frac{1}{2}MR^2$. What two additional quantities should the students measure or determine in order to produce the desired graph? Select two answers. Justify your selections.

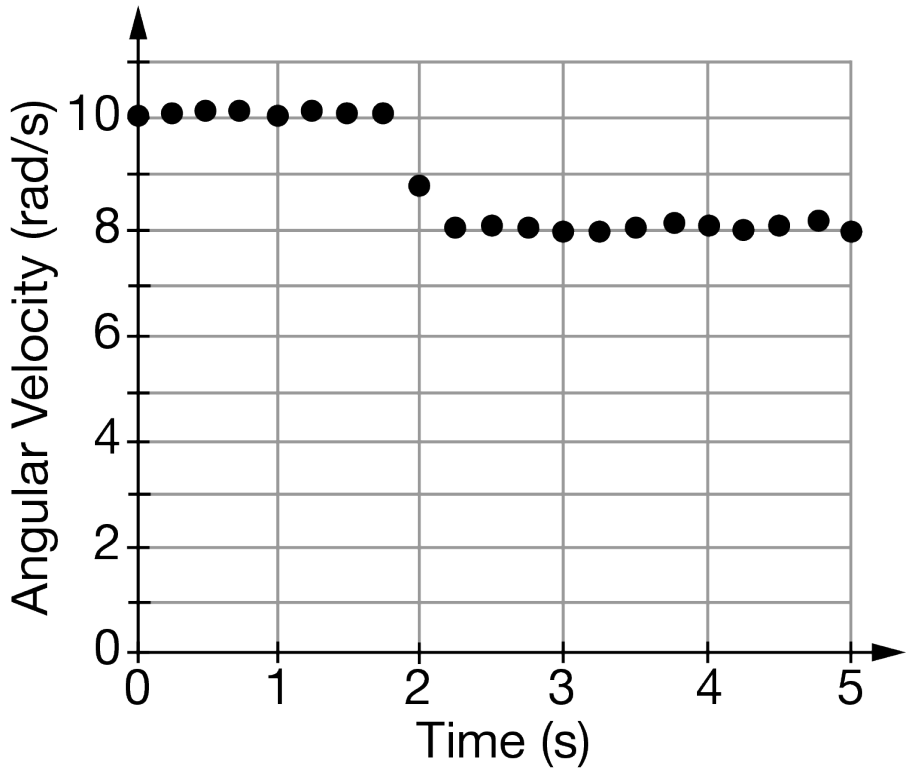
A	The mass of the disk, because this quantity is necessary to determine the rotational inertia of the disk	✓
B	The thickness of the disk, because this quantity is necessary to determine the rotational inertia of the disk	
C	The radius of the disk, because this quantity is necessary to determine the rotational inertia of the disk	✓
D	The volume of the disk, because this quantity is necessary to determine the rotational inertia of the disk	

21. A student is asked to design an experiment to determine the change in angular momentum of a disk that rotates about its center and the product of the average torque applied to the disk and the time interval in which the torque is exerted. A net force is applied tangentially to the surface of the disk. The rotational inertia of the disk about its center is $I = \frac{1}{2}MR^2$. Which two of the following quantities should the student measure to determine the change in angular momentum of the disk after 10 s? Select two answers.

A	The magnitude of the net force exerted on the disk	✓
B	The distance between the center of the disk and where the net force is applied to the disk	✓
C	The radius of the disk	
D	The mass of the disk	

Unit 7 Progress Check: MCQ Part B

22.



In an experiment, disk X is held at rest above disk Y that rotates about its center with a constant angular velocity. A student slowly lowers disk X onto disk Y until both disks come into contact and rotate with a common angular velocity. The student collects the necessary data to graph the angular velocity of disk Y as a function of time, as shown in the graph. Both disks are identical. How can the student use the graph to determine the magnitude of the angular impulse on disk Y? Select two answers.

A	Determine the angular velocity at 1.0 s. Determine the angular velocity at 3.0 s. Determine the magnitude of the difference of the two angular velocity values. Multiply the result by the rotational inertia of disk Y.	✓
B	Determine the slope of the best-fit curve from 1.75 s and 2.25 s. Multiply the result by the rotational inertia of disk Y. Multiply the result by 0.5 s.	✓
C	Determine the area bound by the curve from 0 s and 5 s. Multiply the result by the rotational inertia of disk Y. Multiply the result by 5 s.	
D	Determine the area bound by the curve from 1.75 s and 2.25 s. Multiply the result by the rotational inertia of disk Y. Multiply the result by 0.5 s.	