Unit 7 Progress Check: MCQ Part A

A group of students must conduct an experiment to determine how the location of an applied force on a classroom door affects the rotational motion of the door. The rotational inertia of the door about its hinges is known. The initial angular velocity of the door is zero.

1. Which of the following lists what measuring devices the students need and the measurements they should take to collect the necessary data to test the relationship between a torque exerted on the door and the change in angular velocity of that object about the hinges of the door? Justify your selection.

(A) A protractor to measure the angular displacement of the door and a meterstick to measure the radial distance from the door's hinges to the location where the force is applied.

(B) A stopwatch to measure the time interval during which the force is applied and a meterstick to measure the radial distance from the door's hinges to the location where the force is applied.

(C) A force probe to measure the applied force on the door, and a stopwatch to measure the time interval during which the force is applied, and a meterstick to measure the radial distance from the door's hinges to the location where the force is applied.

(D) A stopwatch to measure the time interval during which the force is applied, a force probe to measure the applied force on the door, a protractor to measure the angular displacement of the door, and a meterstick to measure the radial distance from the door's hinges to the location where the force is applied. ✓

2. The students must determine how to test the relationship between a torque exerted on the door and the change in the angular velocity of the door. All frictional forces are considered to be negligible. How should the experiment be conducted to test the relationship between the torque exerted on the door and the change in the door’s angular velocity in a way that minimizes experimental uncertainty?

(A) The students should perform several trials, applying the same force at the same vertical distance from the floor.

(B) The students should perform several trials, applying the same force at different vertical distances from the floor.

(C) The students should perform several trials, applying the same force at the same horizontal distance from the hinges.

(D) The students should perform several trials, applying the same force at different horizontal distances from the hinges. ✓

3. The students conduct the experiment and gather data about the net torque exerted on the door and angular acceleration of the door for several trials. They create a graph of the door’s angular acceleration as a function of the net torque and sketch a best-fit line through the data. How can the students analyze the data to determine the rotational inertia of the door about its hinges?

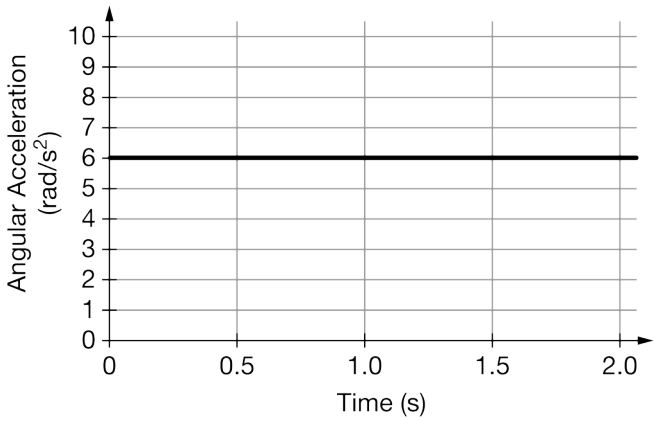
(A) Determine the slope of the best-fit line.

(B) Determine the inverse of the slope of the best-fit line. ✓

(C) Determine the horizontal intercept of the best-fit line.

(D) Determine the vertical intercept of the best-fit line.

Unit 7 Progress Check: MCQ Part A



A point on the edge of a disk rotates around the center of the disk with an initial angular velocity of $3\ \text{rad/s}$ clockwise. The graph shows the point's angular acceleration as a function of time. The positive direction is considered to be counterclockwise. All frictional forces are considered to be negligible.

4. How can the graph be used to determine the angular speed of the disk after $2\ \text{s}$? Justify your selection.

(A) Determine the area bound by the line and the horizontal axis from $0\ \text{s}$ to $2\ \text{s}$, because this area represents the final angular velocity of the point on disk.

(B) Determine the area bound by the line and the horizontal axis from $0\ \text{s}$ to $2\ \text{s}$, because this area represents the change in the angular velocity of the point on disk. ✓

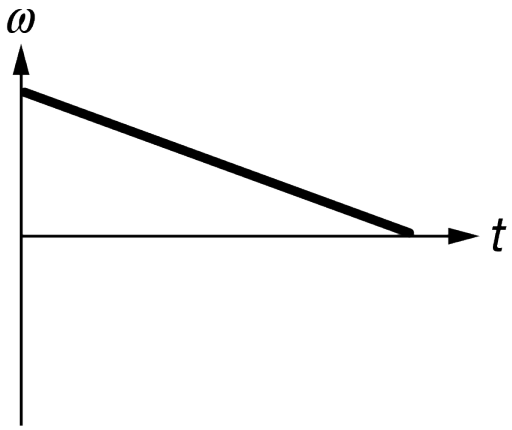
(C) Determine the vertical-axis intercept, because this value represents the final angular velocity of the point on disk.

(D) Determine the slope of the line, because this value represents the change in the angular velocity of the point on disk.

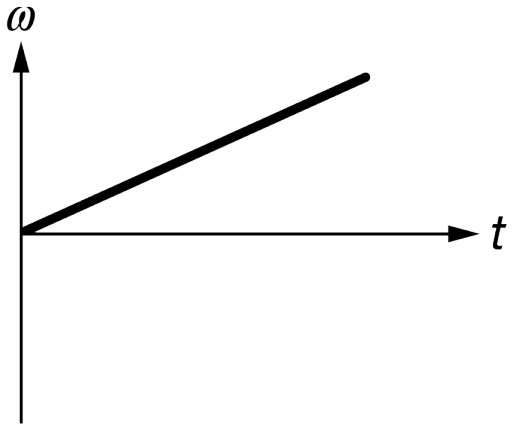
5. Which of the following graphs qualitatively represents the angular velocity ω of the point on the disk as a function of time t between $0\ \text{s}$ to $2\ \text{s}$?

Unit 7 Progress Check: MCQ Part A

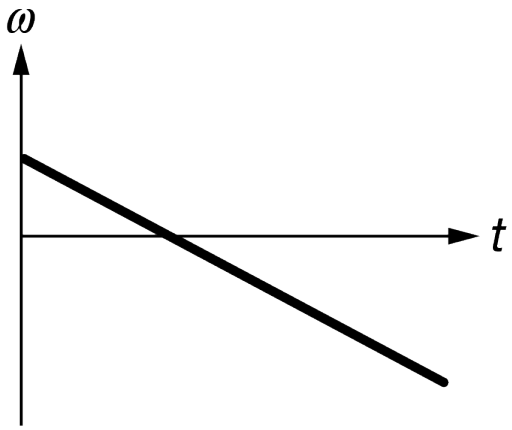
(A)



(B)

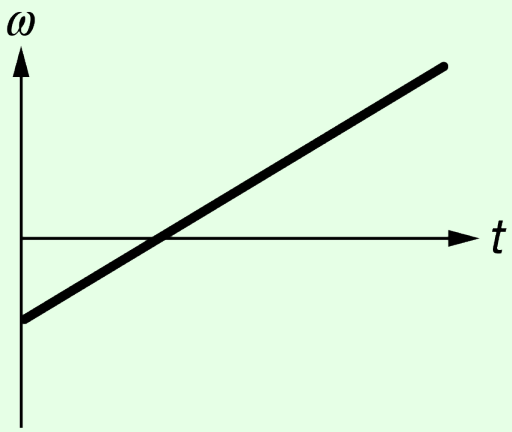


(C)



Unit 7 Progress Check: MCQ Part A

(D)



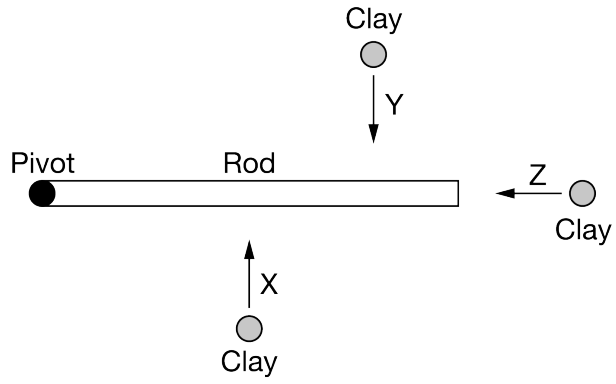
6. What is the angular displacement of the point after 10 s?

(A) 57 radians

(B) 63 radians

(C) 270 radians

(D) 330 radians



Top View

A uniform rod is at rest on a horizontal surface. A student may launch a sphere of clay toward the rod along one of the three paths shown in the figure. Path X and path Z are directed toward the center of mass of the rod. In each case, the sphere of clay is launched with the same linear speed and sticks to the rod. In each case, the time of collision between the sphere of clay and the rod is time t_0. A pivot is fixed to the end of the rod, representing the point at which the rod or clay-rod system may rotate. Frictional forces are considered to be negligible.

7. A sphere of clay travels toward the rod along path Z. A student must predict what will happen to the linear momentum and the angular momentum of the rod-sphere system as a result of the collision. Which of the following correctly predicts the change, if any, of these quantities?

Unit 7 Progress Check: MCQ Part A

(A)

Linear Momentum	Angular Momentum
No change	No change

(B)

Linear Momentum	Angular Momentum
No change	Decreases

(C) ✓

Linear Momentum	Angular Momentum
Decreases	No change

(D)

Linear Momentum	Angular Momentum
Decreases	Decreases

8. Consider the case in which the sphere of clay is launched along path Y. The sphere of clay is launched with a speed v_0 and collides with the rod a distance l away from the pivot. The length of the rod is L. The rotational inertia of the rod about the joint is I_{R}, and the mass of the sphere of clay is m_{c}. The sphere of clay is considered to be a point mass. What is the angular speed ω_f of the clay-rod system immediately after the collision?

(A) $\omega_f = \frac{m_c v_0 l}{m_c L^2 + I_R}$

(B) $\omega_f = \frac{m_c v_0 L}{m_c L^2 + I_R}$

(C) $\omega_f = \frac{m_c v_0 l}{m_c l^2 + I_R}$ ✓

(D) $\omega_f = \frac{m_c v_0 (L-l)}{m_c (L-l)^2 + I_R}$

9. Consider the situation in which three identical spheres of clay are launched simultaneously, one along each possible path. All three spheres of clay are launched with the same initial linear speed and collide with the rod at the same time. The time of collision with the rod for each sphere is time t_0. Which of the following predictions is correct about the motion of the system containing the rod and all three spheres of clay immediately after the collision?

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

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

(C) The system will rotate in the clockwise direction with a changing angular speed.

(D) The system will rotate in the counterclockwise direction with a changing angular speed.

Unit 7 Progress Check: MCQ Part A

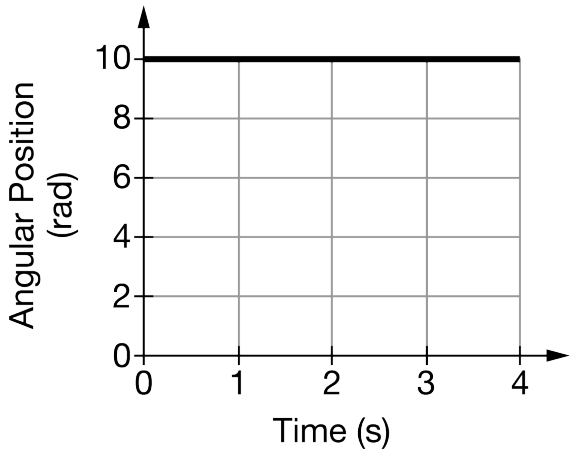
10.

Time (s)	Angular Speed $(\mathrm{rad/s})$
0	50
1	40
2	30
3	20
4	10

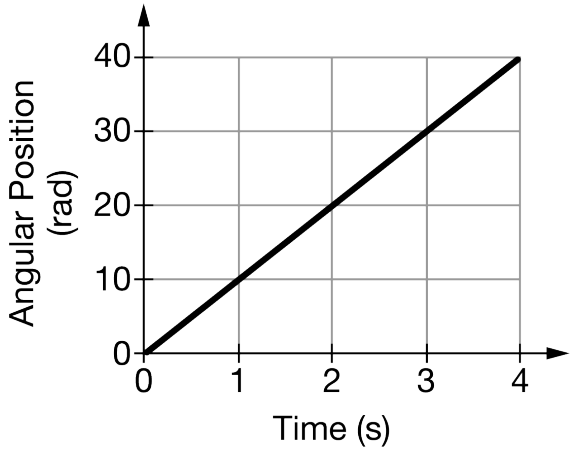
A point on a disk rotates around the center axle of the disk. The table shows the angular speed of the point as a function of time. Which of the following graphs could represent the angular position of the point as a function of time?

Unit 7 Progress Check: MCQ Part A

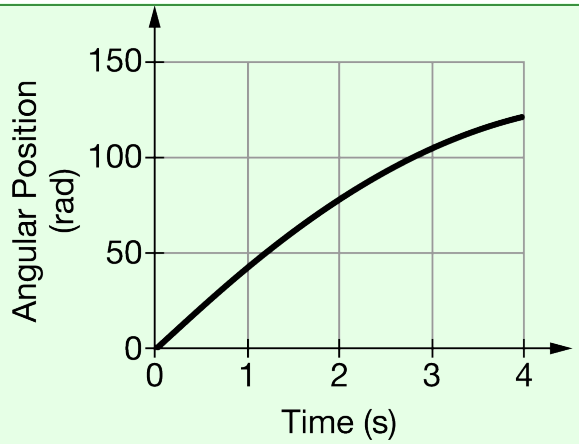
(A)



(B)

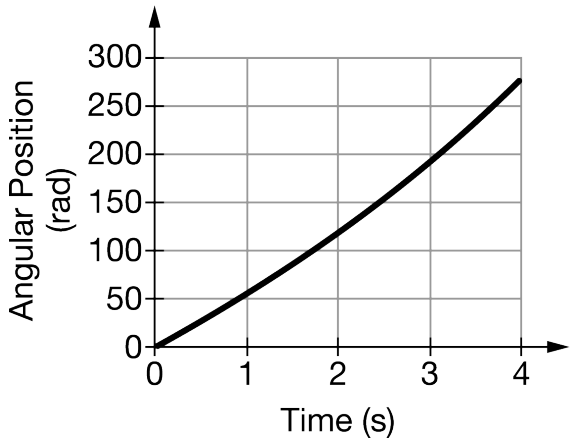


(C)

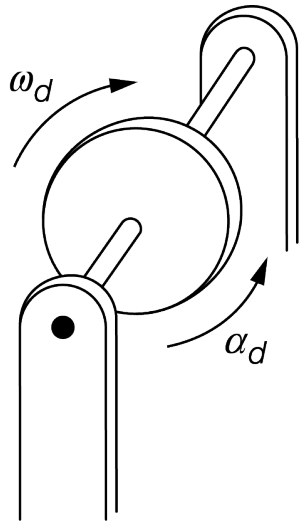


Unit 7 Progress Check: MCQ Part A

(D)



11.



A disk is fixed to a horizontal axle that extends between two supports, as shown in the figure. Frictional forces between the axle and the supports is not negligible. At time t_s, the disk rotates about the center axle with an initial angular speed w_d. A student measures the angular displacement $\Delta\theta_0$ of a point on the edge of the disk from time t_s until the disk no longer rotates. The angular acceleration of the disk is determined to be α_d, and this value remains constant. Based on the data, if possible, how could the student predict the angular displacement of a point on the edge of the disk from time t_s until the disk no longer rotates if the initial angular speed is increased to $2\omega_d$? Justify your selection.

(A) Use the equation $\omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0)$, because the disk comes to rest, $\omega_0 = 2\omega_d$, and $\alpha = \alpha_d$. Solve for $\theta - \theta_0$. ✓

(B) Use the equation $\omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0)$, because the disk comes to rest, $\omega_0 = 2\omega_d$, and $\alpha = 2\alpha_d$. Solve for $\theta - \theta_0$.

(C) An equation is not necessary, because the point on the edge of the disk will have the same angular displacement regardless of its initial angular velocity.

(D) The angular displacement cannot be determined because an equation that includes a term for time must be used.

Unit 7 Progress Check: MCQ Part A

12. A point on a rotating object has an initial angular velocity ω_0 and rotates with an angular acceleration α_0 for a time interval from $t = 0$ to time $t = t_0$. The point then rotates at a constant angular speed until time $t = t_1$. What is the angular displacement of the point from $t = 0$ to $t = t_1$? Express your answer in terms of ω_0, α_0, t_0, t_1, and/or any fundamental constants as appropriate.

(A) $\omega_0 t_0 + \frac{1}{2}\alpha_0 t_0^2$

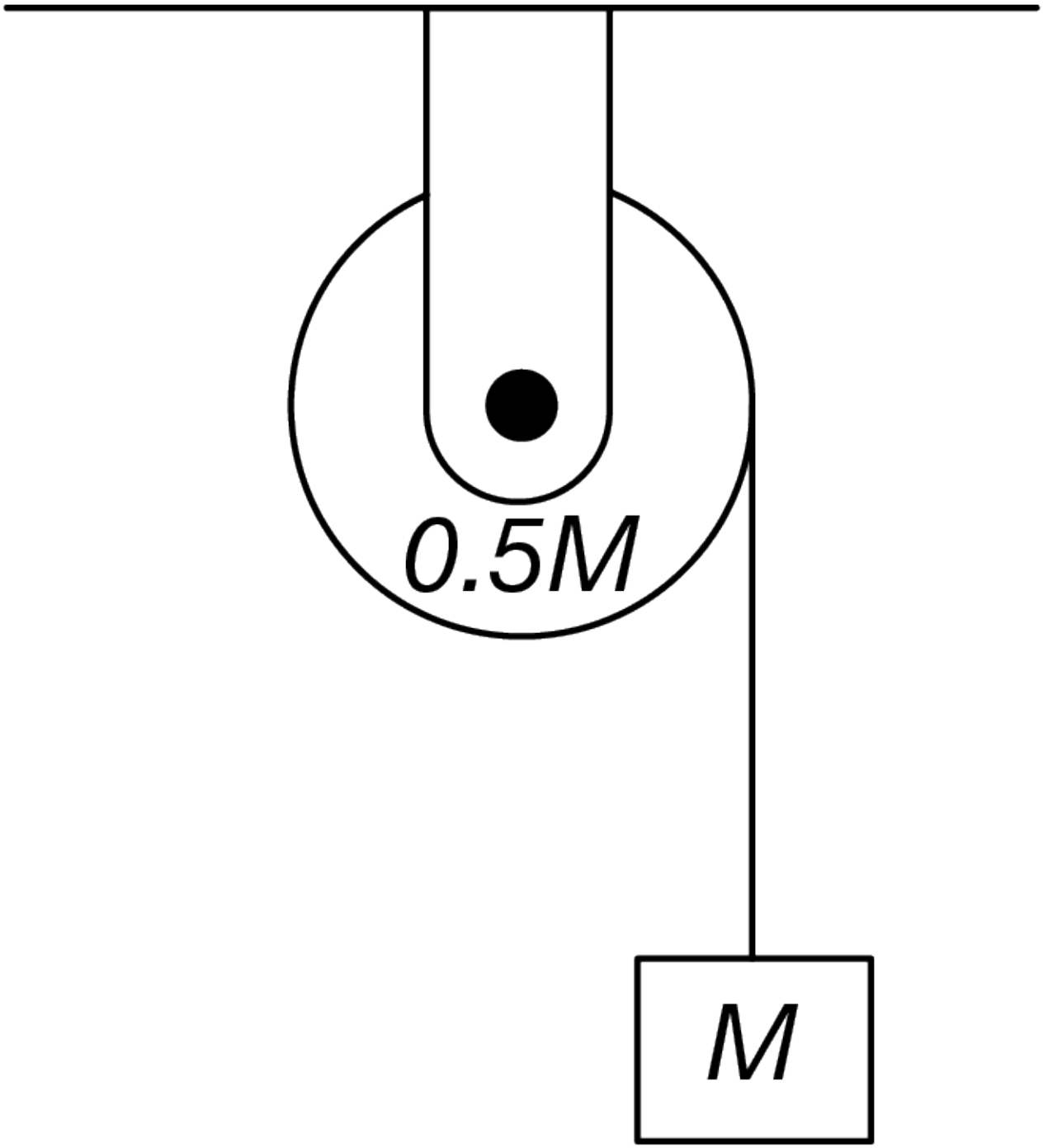
(B) $\omega_0 t_1 + \frac{1}{2}\alpha_0 t_1^2$

(C) $(\omega_0 + \alpha_0 t_0) t_1$

(D) $\omega_0 t_0 + \frac{1}{2}\alpha_0 t_0^2 + (\omega_0 + \alpha_0 t_0) t_1$-$t_0$ ✓

Unit 7 Progress Check: MCQ Part A

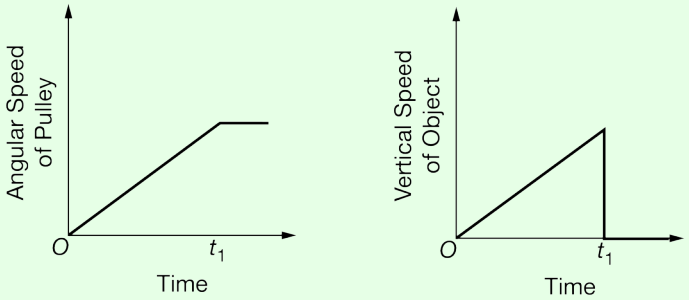
13.



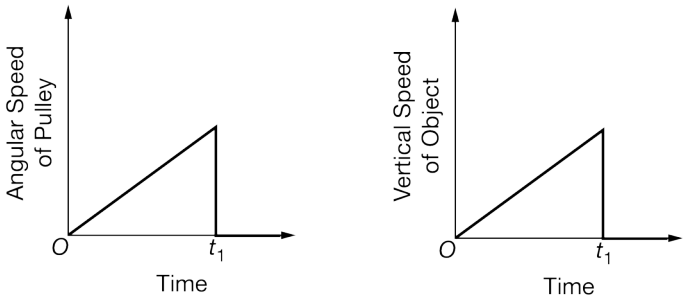
An object of mass M hangs from a string that is looped around a pulley of negligible friction, as shown. The pulley has a mass $0.5\ M$. The object is released from rest and it falls to the floor at time t_1. Which of the following pairs of graphs best represents the angular speed as a function of time for the pulley and the vertical speed as a function of time for the falling object for a short time after it is released from rest?

Unit 7 Progress Check: MCQ Part A

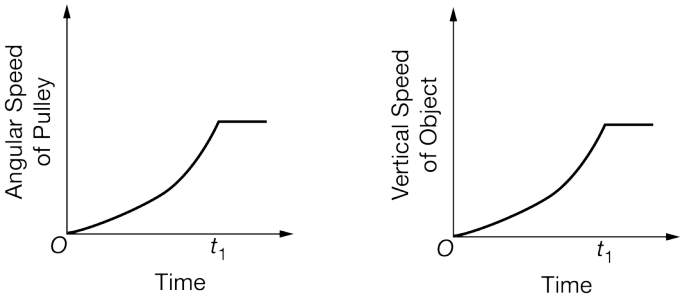
(A) ✓



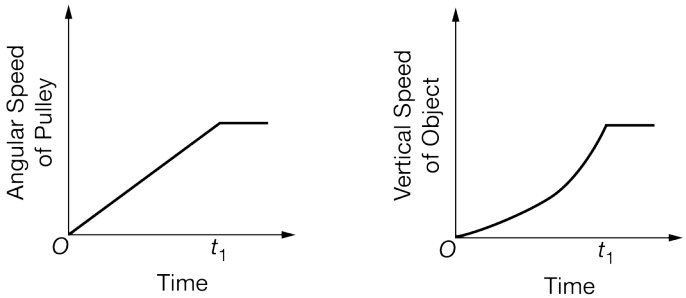
(B)



(C)

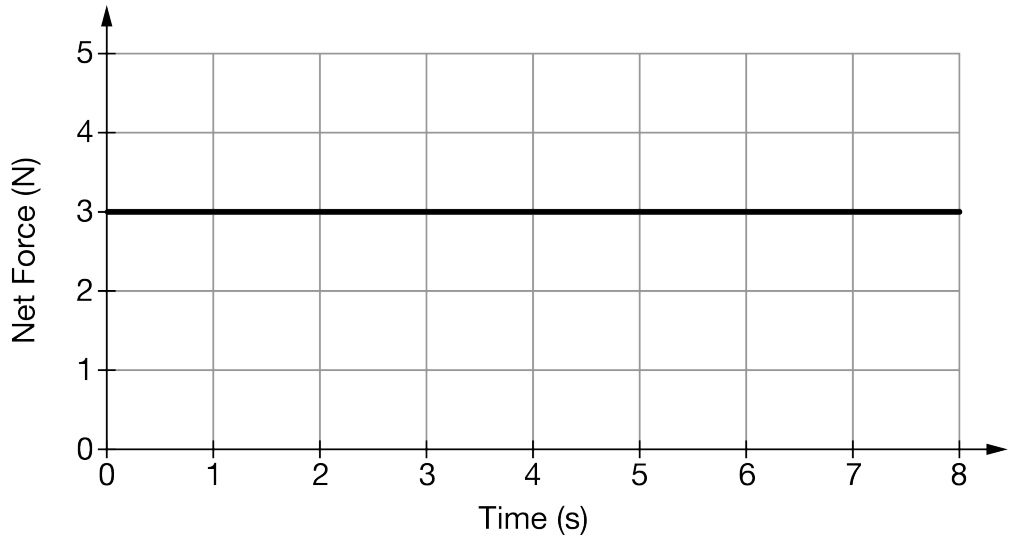


(D)



Unit 7 Progress Check: MCQ Part A

14.



A net force is applied to the edge of a disk that has a diameter of $0.5\ \text{m}$. The disk is initially at rest. A graph of the net force as a function of time for the edge of the disk is shown. The net force is applied tangent to the edge of the disk. How can a student use the graph to determine the change in angular momentum of the disk after $8\ \text{s}$? Justify your selection.

(A) Determine the vertical intercept, multiply the result by $0.25\ \text{m}$, and then multiply that result by $8\ \text{s}$. This procedure can be used because $\Delta L = \tau \Delta t$ with $\tau = rF$. ✓

(B) Determine the slope of the curve of the graph from $0\ \text{s}$ to $8\ \text{s}$, multiply the result by $0.25\ \text{m}$, and then multiply that result by $8\ \text{s}$. This procedure can be used because $\Delta L = \tau \Delta t$ with $\tau = rF$.

(C) Determine the slope of the curve of the graph from $0\ \text{s}$ to $8\ \text{s}$, multiply the result by $0.50\ \text{m}$, and then multiply that result by $8\ \text{s}$. This procedure can be used because $\Delta L = \tau \Delta t$ with $\tau = rF$.

(D) Determine the area bound by the curve and the horizontal axis $0\ \text{s}$ to $8\ \text{s}$, multiply the result by $0.50\ \text{m}$, and then multiply that result by $8\ \text{s}$. This procedure can be used because $\Delta L = \tau \Delta t$ with $\tau = rF$.

15.

Time (s)	Net Torque ($\text{N} \cdot \text{m}$)
0	0
2	1.5
4	3.0
6	4.5

A net torque is applied to the edge of a spinning object as it rotates about its internal axis. The table shows the net torque exerted on the object at different instants in time. How can a student use the data table to determine the change in angular momentum of the object from $0\ \text{s}$ to $6\ \text{s}$? Justify your selection.

Unit 7 Progress Check: MCQ Part A

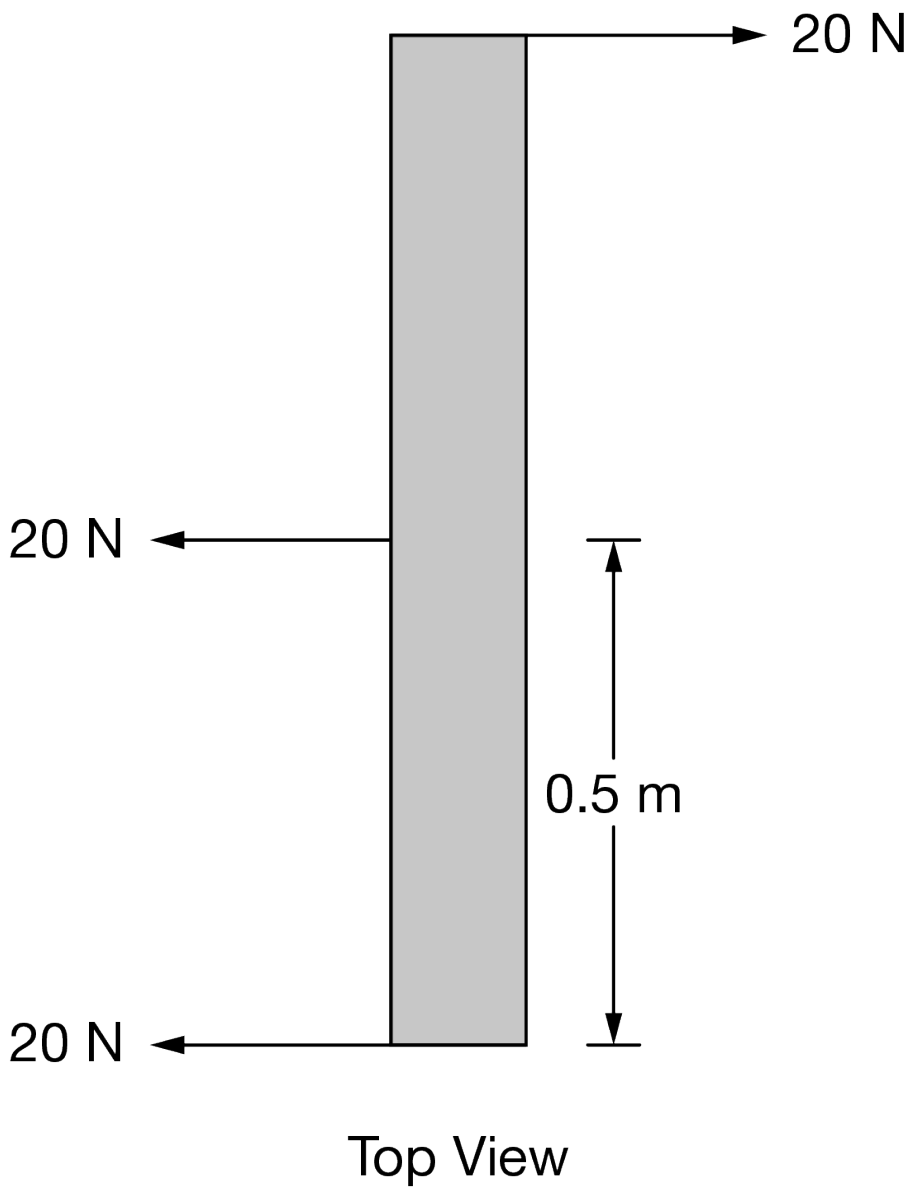
(A) Multiply the maximum net torque by 6 s, because $\Delta L = \tau \Delta t$.

(B) Divide the maximum torque by 6 s, because $\Delta L = \tau \Delta t$.

(C) Create a graph of net torque as a function of time and graph four points of data by using the table. Determine the slope of the curve from 0 s to 6 s, because the shape of the curve on the graph will be a right triangle and the slope can be directly determined.

(D) Create a graph of net torque as a function of time and graph four points of data by using the table. Determine the area bound by the curve and the horizontal axis from 0 s to 6 s, because the shape of the curve on the graph will be a right triangle and the area can be directly determined. ✓

16.



A rod is initially at rest on a rough horizontal surface. Three forces are exerted on the rod with the magnitudes and directions shown in the figure. The force exerted in the center of the rod is an equidistant 0.5 m from both ends of the rod. If friction between the rod and the table prevents the rod from rotating, what is the magnitude of the torque exerted on the rod about its center from frictional forces?

Unit 7 Progress Check: MCQ Part A

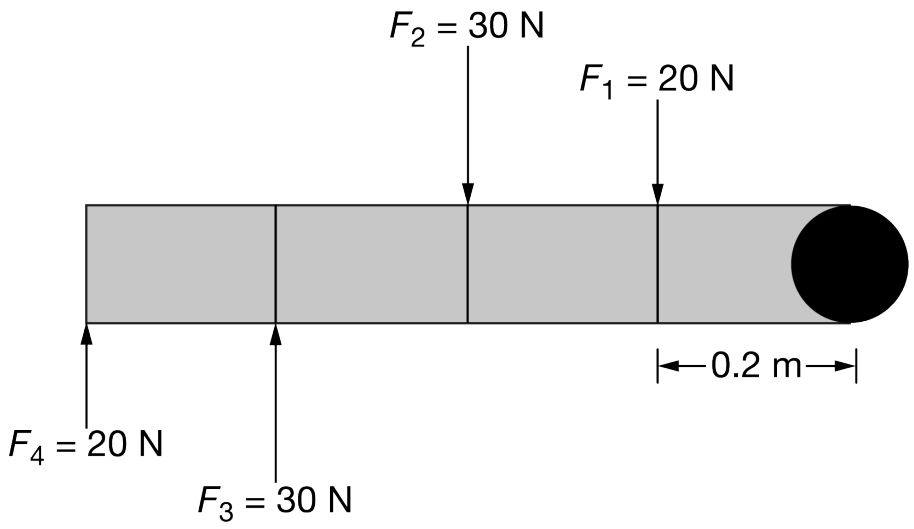
(A) $0\ \text{N} \cdot \text{m}$

(B) $10\ \text{N} \cdot \text{m}$

(C) $20\ \text{N} \cdot \text{m}$ ✓

(D) $30\ \text{N} \cdot \text{m}$

17.



A rod may freely rotate about an axis that is perpendicular to the rod and is along the plane of the page. The rod is divided into four sections of equal length of $0.2\ \text{m}$ each, and four forces are exerted on the rod, as shown in the figure. Frictional forces are considered to be negligible. Which of the following correctly describes an additional torque that must be applied in order to keep the rod from rotating?

(A) $18\ \text{N} \cdot \text{m}$ clockwise

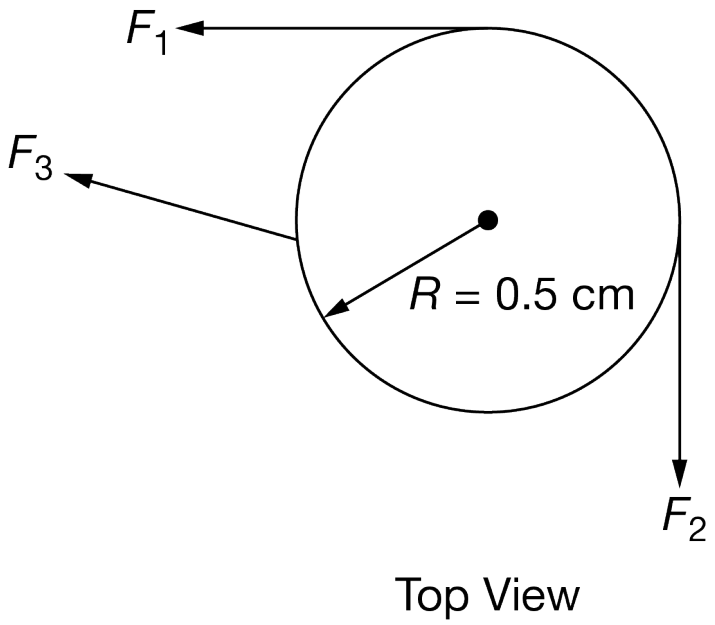
(B) $18\ \text{N} \cdot \text{m}$ counterclockwise ✓

(C) $50\ \text{N} \cdot \text{m}$ clockwise

(D) $50\ \text{N} \cdot \text{m}$ counterclockwise

Unit 7 Progress Check: MCQ Part A

18.



A disk of radius $R = 0.5$ cm rests on a flat, horizontal surface such that frictional forces are considered to be negligible. Three forces of unknown magnitude are exerted on the edge of the disk, as shown in the figure. Which of the following lists the essential measuring devices that, when used together, are needed to determine the change in angular momentum of the disk after a known time of 5.0 s?

(A) Force probe and protractor ✓

(B) Force probe, protractor, and motion sensor

(C) Electronic balance and force probe

(D) Electronic balance, force probe, and motion sensor

Unit 7 Progress Check: MCQ Part A

19. A student conducts an experiment to test the relationship between the net torque exerted on an object and the change in angular momentum of the object. A variable net torque is exerted on the object to make it rotate about its internal axis. Data from the experiment are used to construct a graph of the net torque exerted on the object as a function of time, as shown in Figure 1. A graph is also created of the angular momentum of the object as a function of time, as shown in Figure 2. Which of the following statements about the change in the object's angular momentum for a given time interval is correct? Justify your selection.

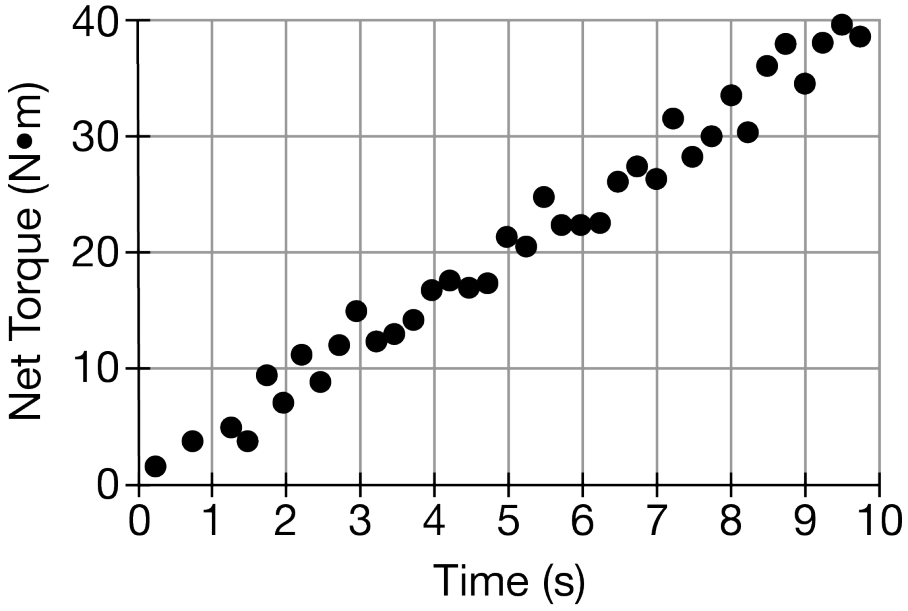


Figure 1

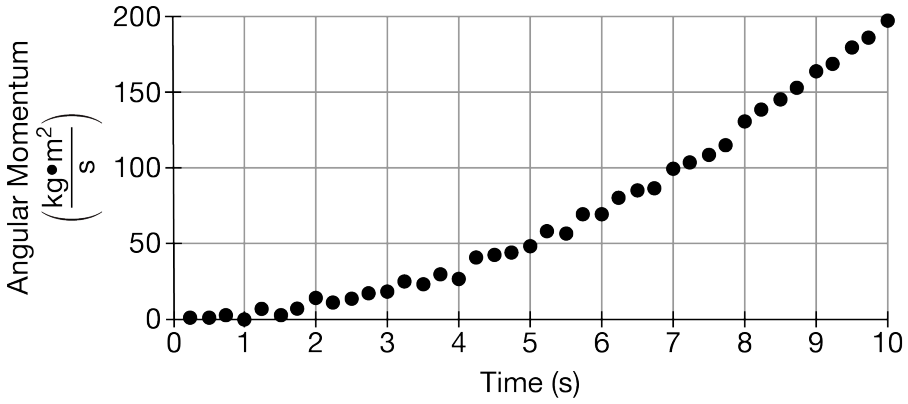


Figure 2

Unit 7 Progress Check: MCQ Part A

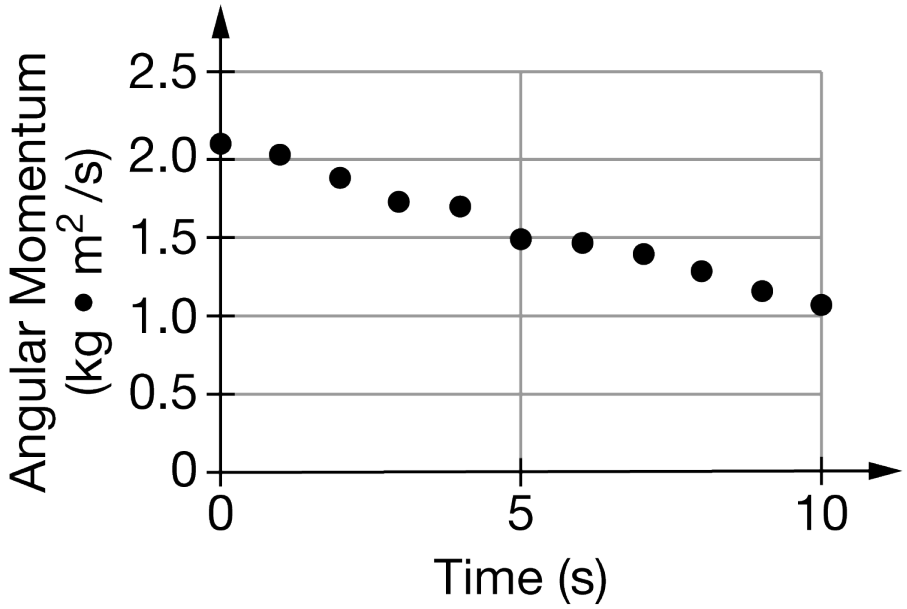
(A) The change in the object's angular momentum for a given time interval remains the same throughout the experiment. This is because the slope of the best-fit line in Figure 1 is constant.

(B) The change in the object's angular momentum for a given time interval remains the same throughout the experiment. This is because the net torque and angular momentum increase in Figure 1 and Figure 2, respectively.

(C) The change in the object's angular momentum for a given time interval does not remain the same throughout the experiment. This is because the slope of the best-fit line in Figure 1 is a nonzero constant. ✓

(D) The change in the object's angular momentum for a given time interval does not remain the same throughout the experiment. This is because the net torque is nonzero in Figure 1.

20.



During an experiment, students collect data about the angular momentum of a rigid, uniform spinning wheel about an axle as a function of time, which was used to create the graph that is shown. A frictional torque is exerted on the wheel. A student makes the following statement about the data.

"The frictional torque exerted on the wheel is independent of the wheel's angular speed."

Does the data from the graph support the student's statement? Justify your selection.

(A) Yes, because the slope of the line is constant. ✓

(B) Yes, because the angular momentum of the wheel decreases as time increases.

(C) No, because the area bound by the curve and the horizontal axis from $0\,\text{s}$ to $10\,\text{s}$ is a positive value.

(D) No, because the data does not provide information about the relationship between net torque and angular speed.

Unit 7 Progress Check: MCQ Part A

21.

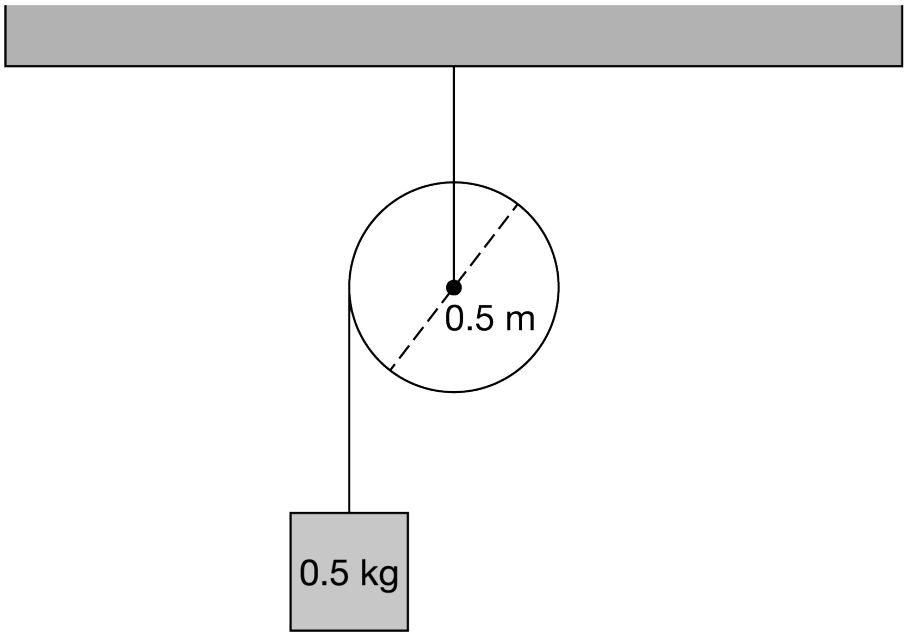


Figure 1

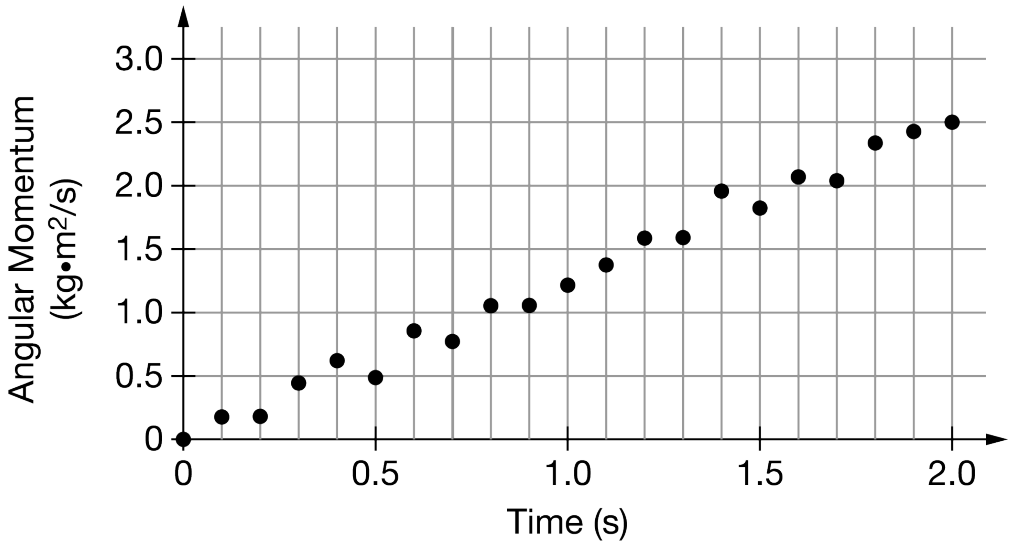


Figure 2

In an experiment, one end of a light string is attached and wrapped around a pulley of diameter $0.5\ \text{m}$. The other end of the string is connected to a block of mass $0.5\ \text{kg}$. The block is released from rest, and the pulley begins to spin in the counterclockwise direction, as shown in Figure 1. Students collect the necessary data to create the graph of the magnitude of the angular momentum of the pulley as a function of time shown in Figure 2. The students state that the graph shows that the net torque exerted on the pulley is constant. Do the data from the graph support the students' statement? Justify your selection.

Unit 7 Progress Check: MCQ Part A

(A) Yes, because the slope of the best-fit line is constant. ✓

(B) Yes, because the angular momentum is increasing with time.

(C) No, because the slope of the best-fit line is positive.

(D) No, because the area under the best-fit line is increasing with time for a specific time interval.

22.

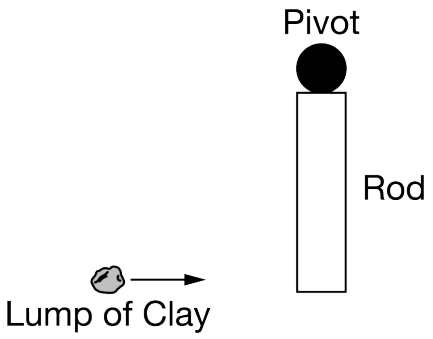


Figure 1
Side View

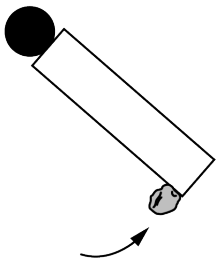


Figure 2
Side View

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 and sticks to the rod, and the clay-rod system rotates, 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 two blocks move at different speeds in the same direction.