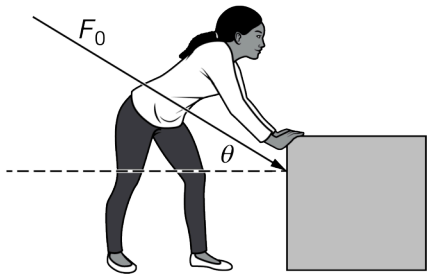
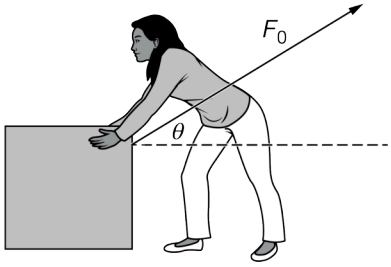
chapter2 PARTB

Scenario 1



Scenario 2



Two students need to move two identical boxes of mass M_0 across a room where friction between the floor and the boxes cannot be neglected. One student moves the first box by pushing with a force of magnitude F_0 at an angle θ from the horizontal, as shown in the figure for scenario 1. The other student moves the second box by pulling with a force of magnitude F_0 at the same angle θ from the horizontal, as shown in the figure for scenario 2.

1. Which of the following is a correct expression for the acceleration of the box in **scenario 2** ?

(A) $\frac{F_0 \cos\theta - \mu(M_0 g - F_0 \sin\theta)}{M_0}$

(B) $\frac{F_0 \cos\theta - \mu(M_0 g + F_0 \sin\theta)}{M_0}$

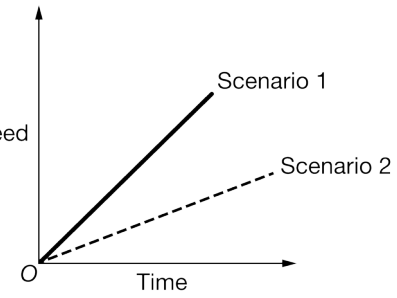
(C) $\frac{F_0 \cos\theta + \mu(M_0 g - F_0 \sin\theta)}{M_0}$

(D) $\frac{F_0 \cos\theta + \mu(M_0 g + F_0 \sin\theta)}{M_0}$

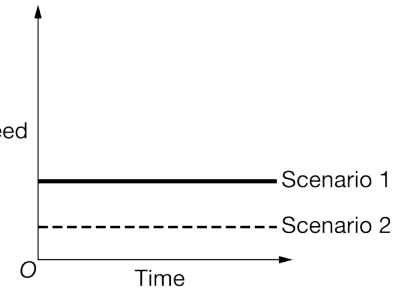
2. Which of the following graphs could describe the motion of the two boxes as they are moved across the room?

chapter2 PARTB

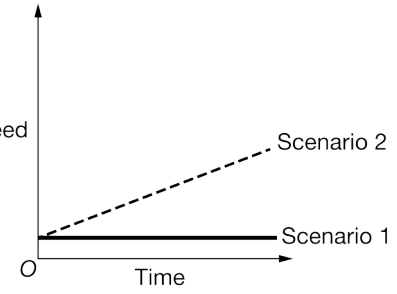
(A)



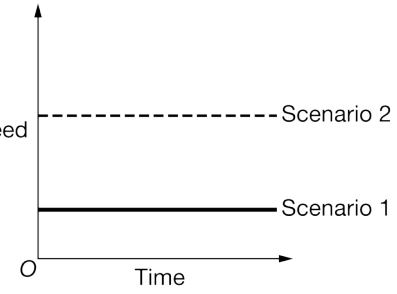
(B)



(C)



(D)



---

3. A 50.0 N box is at rest on a horizontal surface. The coefficient of static friction between the box and the surface is 0.50, and the coefficient of kinetic friction is 0.30. A horizontal 20.0 N force is then exerted on the box. The magnitude of the acceleration of the box is most nearly

(A) 0 m/s^2

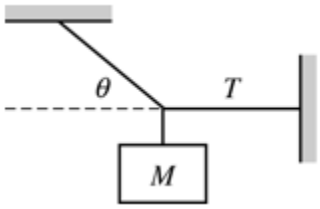
(B) 0.5 m/s^2

(C) 1.0 m/s^2

(D) 4.0 m/s^2

chapter2 PARTB

4.



The horizontal wire shown on the right in the figure above will break when the tension in it exceeds the value T_{max}. What is the maximum mass M that the hanging object can have without the horizontal wire breaking? (Assume the wire on the left does not break prior to the horizontal wire breaking.)

(A) $\frac{T_{\max}}{g}$

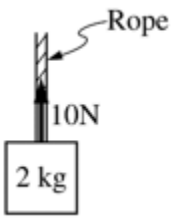
(B) $\frac{T_{\max}}{g\sin\theta}$

(C) $\frac{T_{\max}}{g\cos\theta}$

(D) $\frac{T_{\max}}{g\tan\theta}$

(E) $\frac{T_{\max}\tan\theta}{g}$

5.



A block of mass 2 kg is suspended from a rope, as shown above. If the tension in the rope is 10 N, the acceleration of the block is most nearly

(A) zero

(B) 2 m/s^2 up

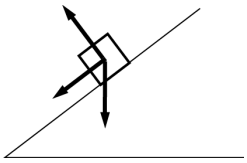
(C) 2 m/s^2 down

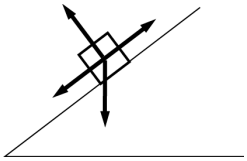
(D) 5 m/s^2 up

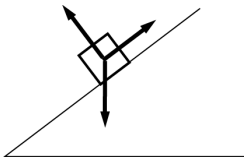
(E) 5 m/s^2 down

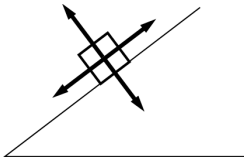
6. A box is given a sudden push up a ramp. Friction between the box and the ramp is not negligible. Which of the following diagrams best represents the directions of the actual forces acting on the box as it moves upward after the push?

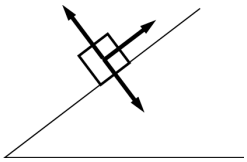
chapter2 PARTB

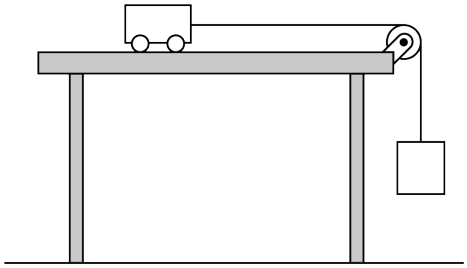
(A) 

(B) 

(C) 

(D) 

(E) 

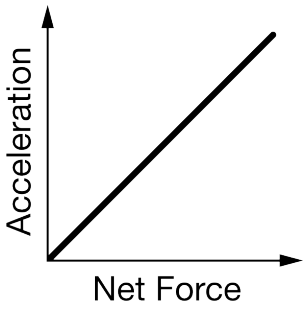


Students work together during an experiment about Newton’s laws. The students use a setup that consists of a cart of known mass connected to one end of a string that is looped over a pulley of negligible friction, with its other end connected to a hanging mass. The cart is initially at rest on a horizontal surface and rolls without slipping when released. The inertia of the cart's wheels is negligible. Students have access to common laboratory equipment to make measurements of components of the system.

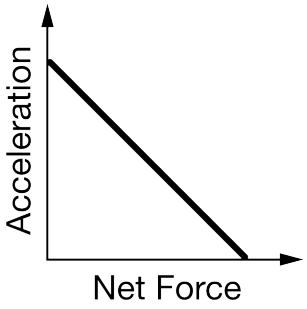
7. By collecting the appropriate data, the students can determine the relationship between the acceleration of the cart and the net force exerted on the cart. Which of the following graphs should the students produce to show the correct relationship?

chapter2 PARTB

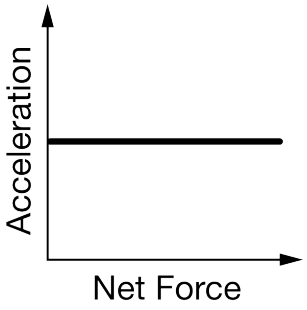
(A)



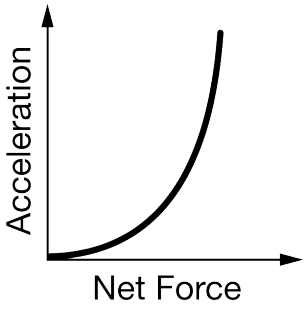
(B)



(C)



(D)



8. Students take measurements of the force F_0 , directed to the left, needed to hold the cart in place as well as the tension F_T in the horizontal section of string. The students take three measurements for each force. Which of the following sets of measurements would provide the most precise determination of the correct relationship between the net force and the vector sum of the individual forces exerted on the cart?

chapter2 PARTB

(A)

$F_0(\mathrm{N})$	$F_T(\mathrm{N})$
4, 5, 5	4, 5, 5

(B)

$F_0(\mathrm{N})$	$F_T(\mathrm{N})$
4, 5, 5	4.02, 4.65, 4.77

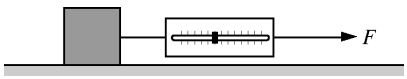
(C)

$F_0(\mathrm{N})$	$F_T(\mathrm{N})$
4.0, 4.7, 4.8	4, 5, 5

(D)

$F_0(\mathrm{N})$	$F_T(\mathrm{N})$
4.0, 4.7, 4.8	4.02, 4.65, 4.77

9.

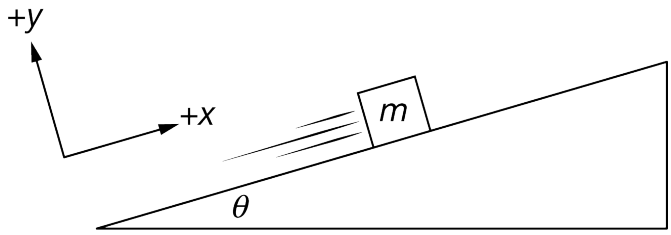


In a lab, a block weighing 80 N is attached to a spring scale, and both are pulled to the right on a horizontal surface, as shown above. Friction between the block and the surface is negligible. What is the acceleration of the block when the scale reads 32 N?

(A) 2.0 m/s^2
(B) 2.5 m/s^2
(C) 4.0 m/s^2
(D) 6.0 m/s^2
(E) 8.0 m/s^2

chapter2 PARTB

10.



A box of mass m slides up a ramp with initial velocity $+v_0$. The kinetic friction force on the box has magnitude f. Which of the following is a correct equation that could be used to determine the acceleration a of the box?

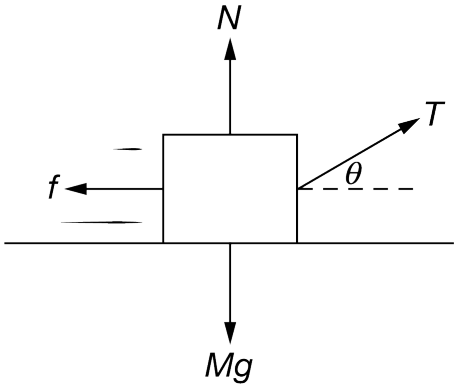
(A) $-f = ma$

(B) $mg \sin \theta - f = ma$

(C) $f - mg \sin \theta = ma$

(D) $-f - mg \sin \theta = ma$

11.



The force diagram above shows a box accelerating to the right on a horizontal surface of non-negligible friction. The tension T is exerted at an angle of 30° above the horizontal. If μ is the coefficient of kinetic friction between the box and the surface, which of the following is a correct mathematical equation derived by applying Newton's second law to the box?

(A) $a = \frac{T\cos(\theta) - \mu Mg}{M}$

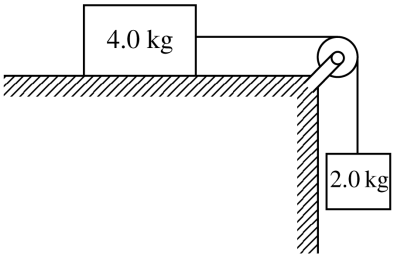
(B) $a = \frac{T\sin(\theta) - \mu Mg}{M}$

(C) $a = \frac{T\cos(\theta) - \mu(Mg + T\sin(\theta))}{M}$

(D) $a = \frac{T\cos(\theta) - \mu(Mg - T\sin(\theta))}{M}$

chapter2 PARTB

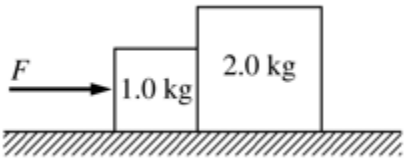
12.



The system shown above is released from rest. If friction is negligible, the acceleration of the 4.0 kg block sliding on the table shown above is most nearly

(A) 0
(B) 1.7 m/s^2
(C) 3.3 m/s^2
(D) 5.0 m/s^2
(E) 10.0 m/s^2

13.



Two blocks of masses 1.0 kg and 2.0 kg, respectively, are pushed by a constant applied force F across a horizontal frictionless table with constant acceleration such that the blocks remain in contact with each other, as shown above. The 1.0 kg block pushes the 2.0 kg block with a force of 2.0 N. The acceleration of the two blocks is

(A) 0
(B) 1.0 m/s^2
(C) 1.5 m/s^2
(D) 2.0 m/s^2
(E) 3.0 m/s^2

14. An elevator carrying a person of mass m is moving upward and slowing down. How does the magnitude F of the force exerted on the person by the elevator floor compare with the magnitude mg of the gravitational force?

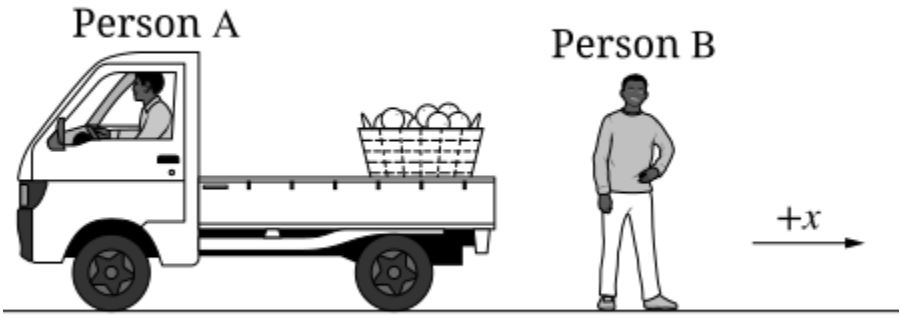
(A) $F < mg$
(B) $F = mg$
(C) $F > mg$
(D) F can be greater than or less than mg, depending on the speed of the elevator.

15. An object is moving to the west at a constant speed. Three forces are exerted on the object. One force is 10 N directed due north, and another is 10 N directed due west. What is the magnitude and direction of the third force if the object is to continue moving to the west at a constant speed?

chapter2 PARTB

(A) 10√3 N , directed northwest
(B) 10√3 N , directed southeast
(C) 10√2 N , directed northwest
(D) 10√2 N , directed southeast

16.



A basket of apples is at rest on the back of a truck that is driven by Person A, as shown. The truck accelerates in the $-x$-direction, and the basket of apples remains at rest relative to the truck. Which of the following describes the relative motion of the basket of apples as the truck accelerates in the $-x$-direction?

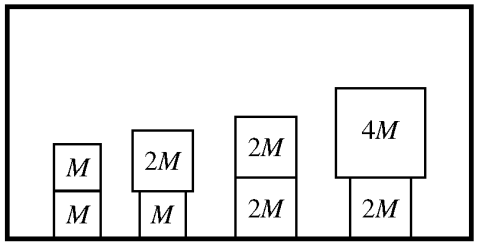
(A) The basket accelerates in the $-x$-direction in the reference frame of Person A.
(B) The basket accelerates in the $-x$-direction in the reference frame of Person B.
(C) The basket remains at rest in the reference frame of Person B.
(D) The basket remains at rest in the reference frame of both Person A and Person B.

17. A small cart is rolling freely on an inclined ramp with a constant acceleration of 0.50 m/s^2 in the -x direction. At time t = 0, the cart has a velocity of 2.0 m/s in the +x-direction. If the cart never leaves the ramp, which of the following statements correctly describes the motion of the cart at a time t > 5 s?

(A) The cart is traveling in the +x-direction and is slowing down.
(B) The cart is traveling in the +x-direction and is speeding up.
(C) The cart is traveling in the –x-direction and is slowing down.
(D) The cart is traveling in the –x-direction and is speeding up.

chapter2 PARTB

Refer to the following material to answer the questions.



The stacks of boxes shown in the figure above are inside an elevator that is moving upward. The masses of the boxes are given in terms of the mass M of the lightest box.

18. Assume the elevator has upward acceleration a, and consider the stack that has two boxes of mass M. What is the magnitude of the force exerted on the top box by the bottom box?

(A) Mg

(B) Ma

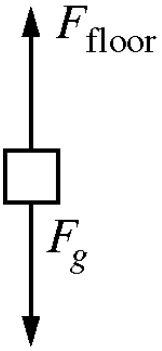
(C) $M(a - g)$

(D) $M(a + g)$

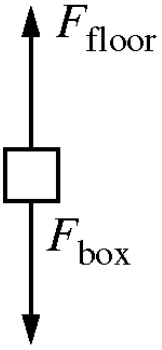
19. Assume the elevator is moving at constant speed, and consider the bottom box in the stack that has two boxes of mass $2M$. Let F_{floor} be the force exerted by the floor on the box, F_g be the force exerted by gravity on the box, and F_{box} be the force exerted by the top box on the bottom box. Which of the following best represents the forces exerted on the bottom box?

chapter2 PARTB

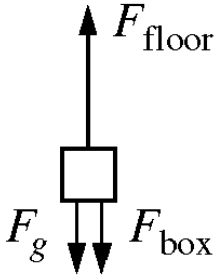
(A)



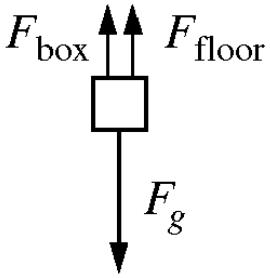
(B)



(C)



(D)



chapter2 PARTB

20.

Speed	10 m/s	20 m/s	30 m/s
Braking Distance	6.1 m	23.9 m	53.5 m

To analyze the characteristics and performance of the brakes on a 1500 kg car, researchers collected the data shown in the table above. It shows the car's speed when the brakes are first applied and the corresponding braking distance required to stop the car. The magnitude of the average braking force on the car is most nearly

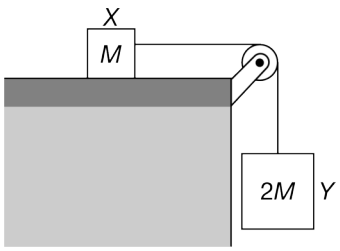
(A) 75,000 N

(B) 30,000 N

(C) 12,000 N

(D) 1600 N

21.



Block X of mass M is attached to block Y of mass $2M$ by a light string that passes over a pulley of negligible friction and mass, as shown above. In which direction will the center of mass (COM) of the two-block system move after it is released from rest, and what is the magnitude of the acceleration a of block X ?

chapter2 PARTB

(A)

(COM)	a
Down and to the right	$\frac{2g}{3}$

(B)

(COM)	a
Remain at rest	$\frac{2g}{3}$

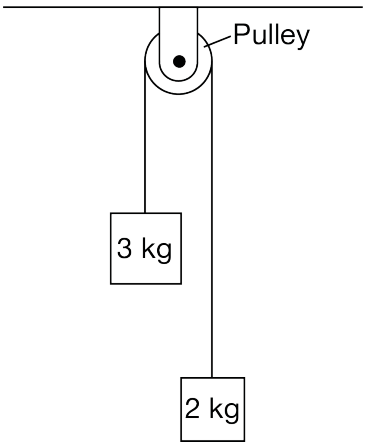
(C)

(COM)	a
Down and to the right	$\frac{3g}{2}$

(D)

(COM)	a
Remain at rest	$\frac{3g}{2}$

22.



An Atwood's machine is set up by suspending two blocks connected by a string of negligible mass over a pulley, as shown above. The blocks are initially held at rest and then released at time $t_0 = 0\,\text{s}$. The speed of the $3\,\text{kg}$ block at time $t_1 = 2.0\,\text{s}$ is most nearly

(A) $2.0\ \text{m/s}$

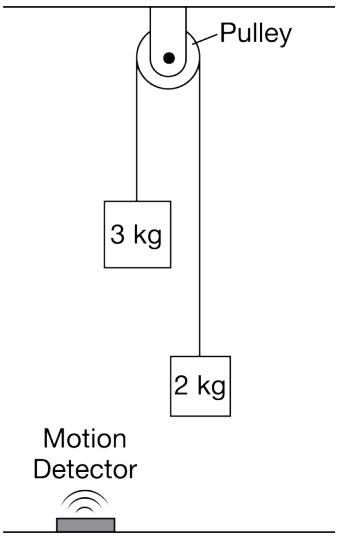
(B) $4.0\,\text{m/s}$

(C) $7.0\,\text{m/s}$

(D) $10.0\,\text{m/s}$

chapter2 PARTB

23.



An Atwood machine is set up by suspending two blocks connected by a string of negligible mass over a pulley, as shown in the figure above. The pulley has negligible mass but there is friction as it rotates. The system is released from rest, and after $1.0\ \text{s}$ the speed of the $3\ \text{kg}$ block is $1.8\ \text{m/s}$. Which of the following is the best estimate of the external frictional force acting on the two-block system?

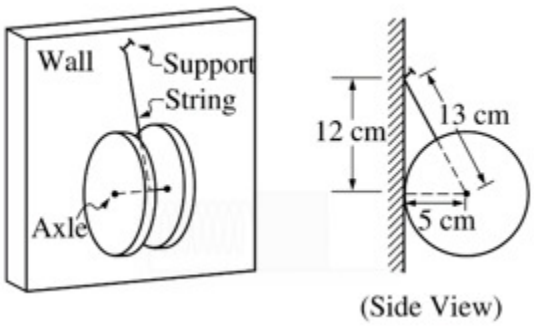
(A) $0.4\ \text{N}$

(B) $0.6\ \text{N}$

(C) $1.0\ \text{N}$

(D) $1.3\ \text{N}$

24.



A uniform spool is suspended from a vertical wall by a string attached to the spool's thin axle. The axle is horizontal, as shown above. The wall is smooth, so it exerts no frictional force on the spool. The tension in the string is 2.6 N. What is the weight of the spool?

(A) 0.5 N

(B) 1.0 N

(C) 1.2 N

(D) 2.4 N

(E) 2.6 N

chapter2 PARTB

25.

	Cart 1	Cart 2
Mass	1 kg	0.5 kg
Average force	30 N	F_2
Average acceleration	30 $\mathrm{m/s^2}$	a_2

The incomplete data in the table above were recorded during an experiment in which two carts on a frictionless one-dimensional track collided head-on. What are the magnitudes of the average force F_2 exerted on cart 2 and the average acceleration a_2 of cart 2 during the collision?

(A)

F_2	a_2
15 N	15 $\mathrm{m/s^2}$

(B)

F_2	a_2
30 N	30 $\mathrm{m/s^2}$

(C)

F_2	a_2
30 N	60 $\mathrm{m/s^2}$

(D)

F_2	a_2
60 N	60 $\mathrm{m/s^2}$

26.

A water-skier with weight F_g = mg moves to the right with acceleration a. A horizontal tension force *T* is exerted on the skier by the rope, and a horizontal drag force F_d is exerted by the water on the ski. The water also exerts a vertical lift force L on the skier. Which of the following are correct relationships between the forces exerted on the skier-ski system? Select two answers.

chapter2 PARTB

A	T - F_d =ma
B	L - F_g = ma
C	L - F_g = 0
D	T - F_d = 0

27. To estimate the height of a building, students release a ball from the top of the building and measure the time it takes to reach the ground. The calculated height turns out to be greater than the actual height. Which of the following could have caused the discrepancy?

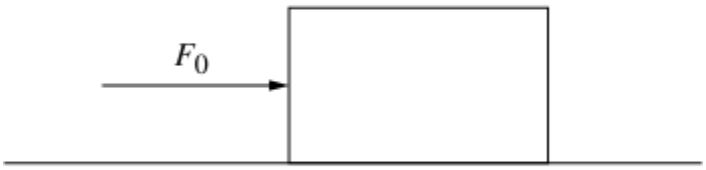
(A) Air resistance is not negligible.

(B) The ball had a nonzero initial horizontal velocity.

(C) The ball had a nonzero initial downward velocity.

(D) The students started measuring the time after the ball was released.

28.



Students are sliding a block along a rough surface by exerting a force F_0 on the block parallel to the surface. Which of the following is correct for F_f, the magnitude of the frictional force between the block and the surface?

(A) F_f is greater when the students slide the block faster.

(B) F_f is greater when the surface on which the block slides is inclined at an angle.

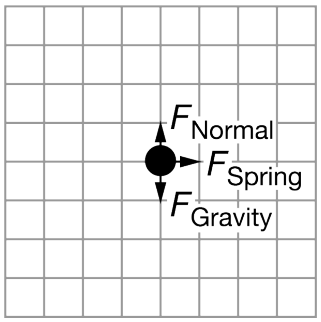
(C) F_f is greater when the block is turned so that it slides on a face with a larger area.

(D) F_f can have a different value when the block is at rest than when the block is moving.

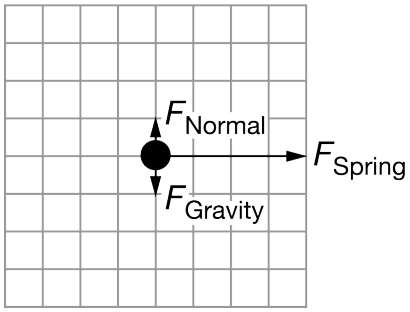
29. A block is pulled along a surface of negligible friction by a spring scale that exerts a force F on the block. The mass of the block is $4\ \text{kg}$, and the spring scale reads $10\ \text{N}$. Which of the following free-body diagrams can be used to show the magnitude and direction of all the forces exerted on the block as it is pulled along the surface?

chapter2 PARTB

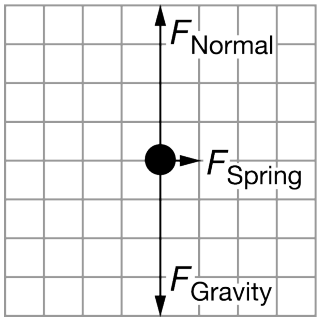
(A)



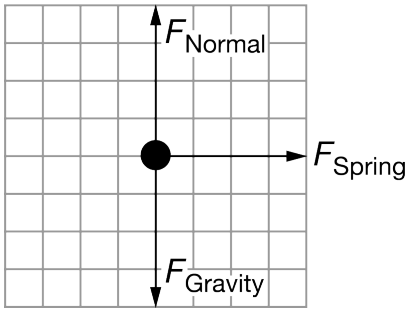
(B)



(C)

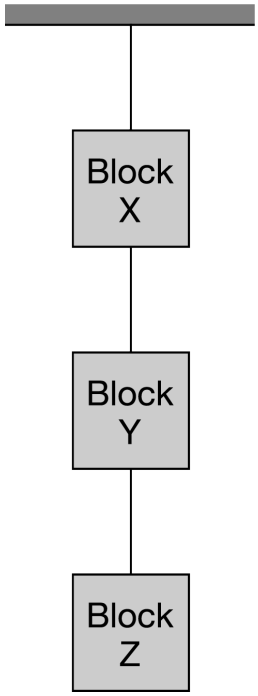


(D)



chapter2 PARTB

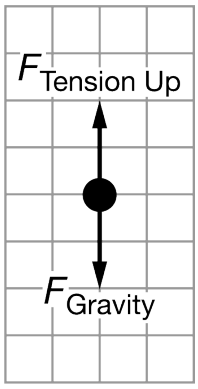
30.



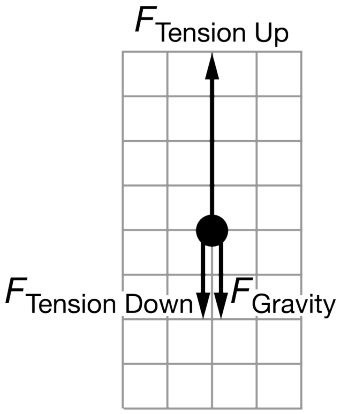
Three identical blocks, X, Y, and Z, hang from identical strings, as shown in the figure. Which of the following free-body diagrams could represent the forces exerted on block Y?

chapter2 PARTB

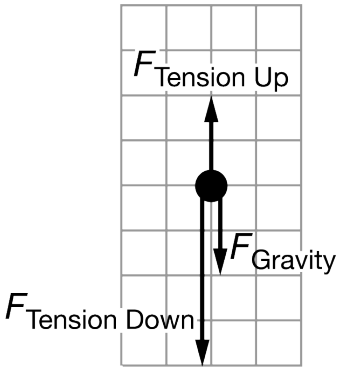
(A)



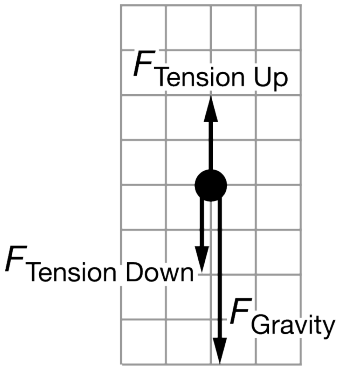
(B)



(C)

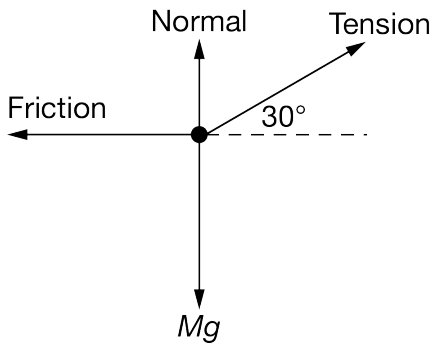


(D)



chapter2 PARTB

31.



The free body diagram shown above is for a $5\ \text{kg}$ box on a rough surface being pulled to the right at a constant speed by a string that is at an angle of 30° above the horizontal. The coefficient of kinetic friction between the box and the surface is 0.30. The tension in this string is most nearly

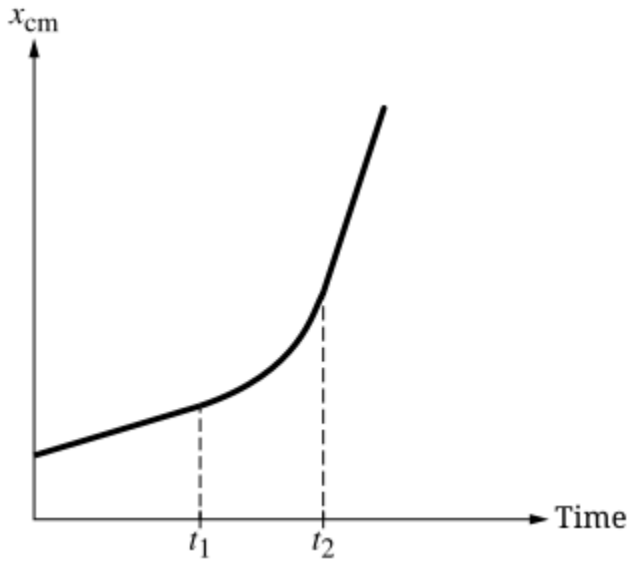
(A) $14.47\ \text{N}$

(B) $16.97\ \text{N}$

(C) $20.53\ \text{N}$

(D) $29.40\ \text{N}$

32.



Two identical objects move along a horizontal track. The graph represents the position of the center of mass of the two-object system x_{cm} as a function of time. Both objects initially move at a constant speed in the same direction. Which of the following could explain the change in motion in the time interval between t_1 and t_2?

(A) An external force in the $+x$-direction was exerted on one of the objects.

(B) An external force in the $-x$-direction was exerted on one of the objects.

(C) An external force in the $+y$-direction was exerted on one of the objects.

(D) Two equal and opposite horizontal forces were exerted on both objects.

chapter2 PARTB

33.



A block of mass M and a block of mass $3M$ are connected by a string, as shown above. The blocks are held with the string horizontally and are released from rest at the same time from a height H above the ground. How does the acceleration of the center of mass of the system compare to the acceleration of the object of mass M ?

(A) The acceleration of the center of mass is 4 times the acceleration of the object of mass M.

(B) The acceleration of the center of mass is one fourth the acceleration of the object of mass M.

(C) The acceleration of the center of mass is the same as the acceleration of the object of mass M.

(D) The acceleration of the center of mass is initially 4 times smaller than the acceleration of the object of mass $3M$, but the accelerations are the same after a long time.

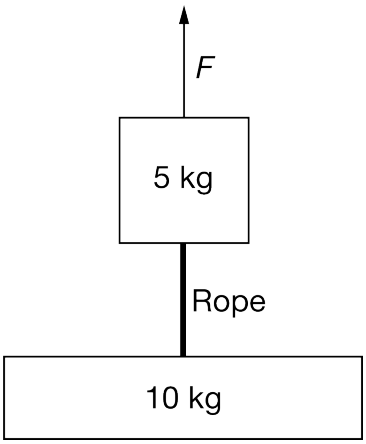
34. A distant planet has an acceleration due to gravity of $4\ \mathrm{m/s^2}$ near its surface. An object is released from rest from the top of a tall cliff on the planet, and the object lands at the bottom of the cliff in 20 seconds. A second object is then thrown upward from the edge of the same cliff with a speed of $4\ \mathrm{m/s}$. The time it takes the second object to reach the bottom of the cliff is most nearly

(A) $19\ \mathrm{s}$

(B) $21\ \mathrm{s}$

(C) $22\ \mathrm{s}$

(D) $80\ \mathrm{s}$



Two blocks are connected by a rope, as shown above. The masses of the blocks are $5\ \mathrm{kg}$ for the upper block and $10\ \mathrm{kg}$ for the lower block. An upward applied force of magnitude F acts on the upper block.

35. If the net acceleration is downward but has a magnitude less than g, then which has the larger magnitude, the force F or the tension in the rope?

chapter2 PARTB

(A) The tension in the rope

(B) Force F

(C) Neither. They have equal but nonzero magnitudes.

(D) Neither. They have equal zero magnitudes.

36. If $F = 300\ \text{N}$, which of the following predictions about the acceleration of the two-block system is correct?

(A) The acceleration is downward with a magnitude of g.

(B) The acceleration is downward with a magnitude of $2g$.

(C) The acceleration is upward with a magnitude of g.

(D) The acceleration is upward with a magnitude of $2g$.

---

37. A block slides down an inclined plane in a classroom. Which of the following pieces of information are needed to determine whether the velocity of the block will be constant? Select two answers.

A The mass of the block

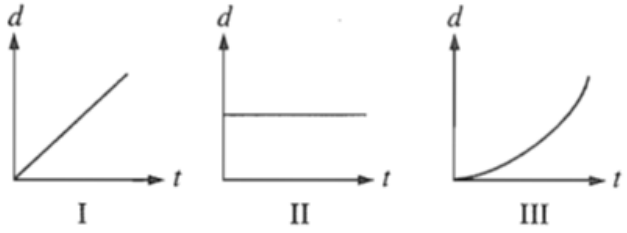
B The angle of the inclined plane

C The acceleration due to gravity in the classroom

D The coefficient of kinetic friction between the block and the inclined plane

---

Three objects can only move along a straight, level path. The graphs below show the position *d* of each of the objects plotted as a function of time *t*.



38. The sum of the forces on the object is zero in which of the cases?

(A) II only

(B) III only

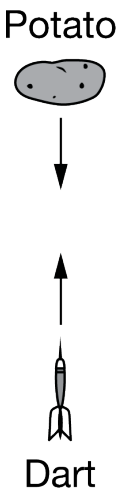
(C) I and II only

(D) I and III only

(E) I, II, and III

---

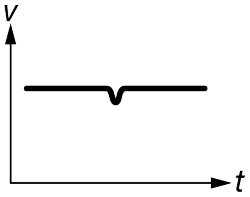
chapter2 PARTB



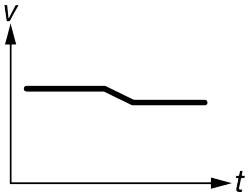
A potato falling vertically downward is struck by a dart that is traveling vertically upward, as shown above. The dart and potato then collide, stick together, and continue moving after the collision.

39. Consider the dart-potato system. Which of the following graphs best represents the speed *v* of the center-of-mass of the dart-potato system, as a function of time *t*, before, during, and after the collision?

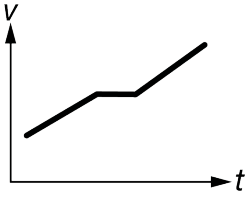
(A)



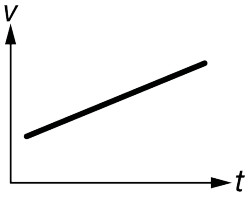
(B)



(C)



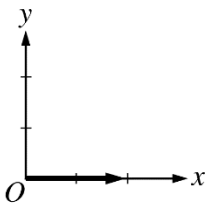
(D)

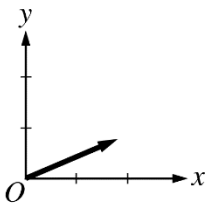


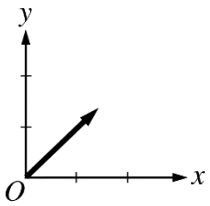
chapter2 PARTB

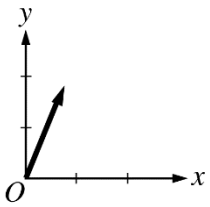
An object of mass m is initially at rest and free to move without friction in any direction in the xy-plane. A constant net force of magnitude F directed in the $+x$ direction acts on the object for 1 s. Immediately thereafter a constant net force of the same magnitude F directed in the $+y$ direction acts on the object for 1 s. After this, no forces act on the object.

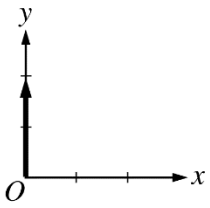
40. Which of the following vectors could represent the velocity of the object at the end of 3 s, assuming the scales on the x and y axes are equal?

(A) 

(B) 

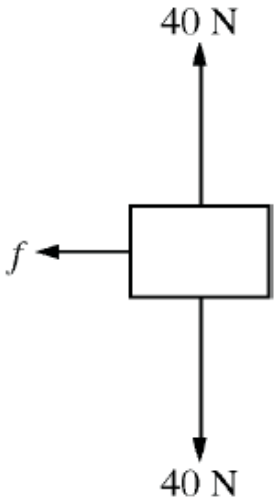
(C) 

(D) 

(E) 

chapter2 PARTB

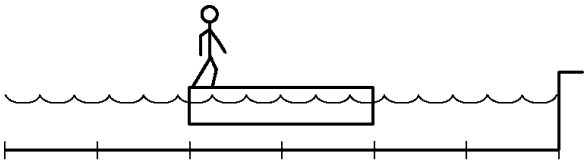
41.



The figure above shows the forces exerted on a block that is sliding on a horizontal surface: the gravitational force of 40 N, the 40 N normal force exerted by the surface, and a frictional force exerted to the left. The coefficient of friction between the block and the surface is 0.20. The acceleration of the block is most nearly

(A) 1.0 m/s^2 to the right
(B) 1.0 m/s^2 to the left
(C) 2.0 m/s^2 to the right
(D) 2.0 m/s^2 to the left

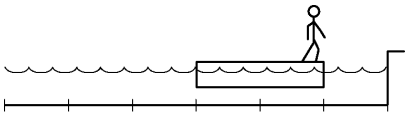
42.



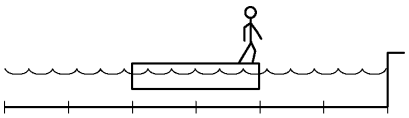
A student stands at one end of a raft floating in a pool with equally spaced marks along the bottom, as shown above. The student and the raft have the same mass. The student walks to the opposite end of the raft. Which of the following best shows the final locations of the raft and student relative to the marks at the bottom of the pool? Assume that there is no drag force between the raft and the water.

chapter2 PARTB

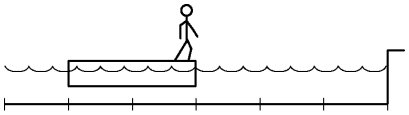
(A)



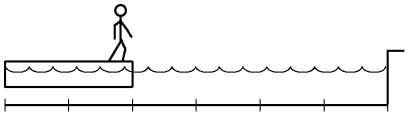
(B)



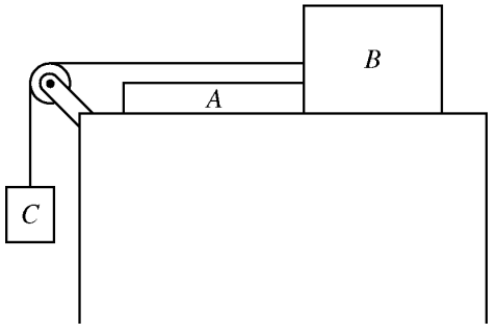
(C)



(D)



43.



Blocks A and B, of masses m_A and m_B, are at rest on a frictionless surface, as shown above, with block A fixed to the table. Block C of mass m_C is suspended by a string that is tied to block B over an ideal pulley. Which of the following gives the magnitude of the force exerted by block A on block B ?

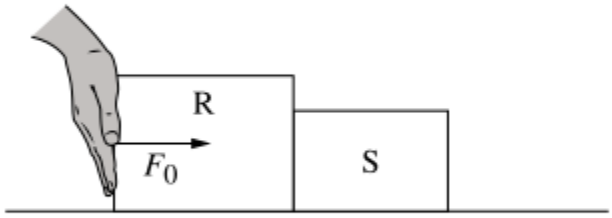
(A) $m_B g$

(B) $m_C g$

(C) $\frac{m_A m_C}{m_A + m_B} g$

(D) $\frac{m_B m_C}{m_A + m_B} g$

chapter2 PARTB



Box R of mass m_{R} and Box S of mass m_{S}, where $m_{\mathrm{R}} > m_{\mathrm{S}}$, are located on a horizontal surface, as shown. A constant horizontal force F_0 is exerted on Box R and causes the system to have an acceleration of magnitude a_0 to the right. The coefficient of kinetic friction between the surface and each box is μ_0.

44. Which of the following is a correct expression for the magnitude of the force F_0 exerted on Box R ?

(A) $(m_{\mathrm{R}} + m_{\mathrm{S}})\mu_0 g$

(B) $(m_{\mathrm{R}} - m_{\mathrm{S}})\mu_0 g$

(C) $(m_{\mathrm{R}} + m_{\mathrm{S}})(a_0 + \mu_0 g)$

(D) $(m_{\mathrm{R}} + m_{\mathrm{S}})(a_0 - \mu_0 g)$

45.

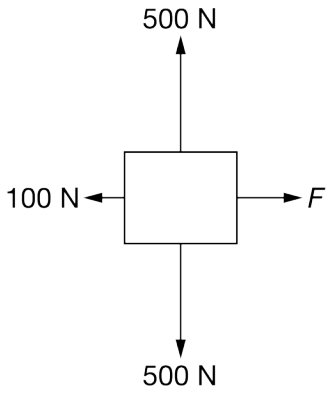
Type of Force	Magnitude (N)
Force due to gravity	10 N
Force of friction	2 N
Horizontal applied force	8 N
Normal force	10 N

The table shows experimental data of the magnitude of four forces exerted on a $2\ \mathrm{kg}$ object as it slides across a horizontal surface. Which of the following could represent the magnitude of the net force that is exerted on the object? Select two answers.

chapter2 PARTB

A	6 N
B	10 N
C	28 N
D	30 N

46.



Note: Figure not drawn to scale.

The figure above shows the forces exerted on a block that is sliding on a rough horizontal surface: The weight of the block is $500\ \mathrm{N}$, the normal force is $500\ \mathrm{N}$, the frictional force is $100\ \mathrm{N}$, and there is an unknown force F exerted to the right. The acceleration of the block is $0.4\ \mathrm{m/s^2}$. The value of F is most nearly

(A) $20\ \mathrm{N}$

(B) $80\ \mathrm{N}$

(C) $110\ \mathrm{N}$

(D) $120\ \mathrm{N}$

47. An object travels down a ramp at a constant acceleration. The object experiences a force of friction and a gravitational force. Which of the following could be true about the motion of the object?

(A) The force of friction between the surface and the object is less than the component of the gravitational force that is parallel to the ramp.

(B) If the object increased in mass, the object's acceleration would change.

(C) If the object increased in mass, the normal force exerted on the object would remain the same.

(D) The force of friction acts in the same direction as the object travels.

chapter2 PARTB

48.

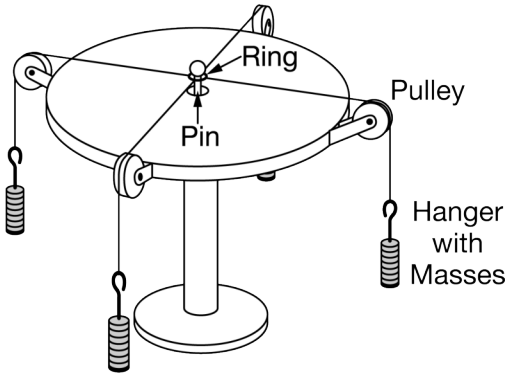


Figure 1

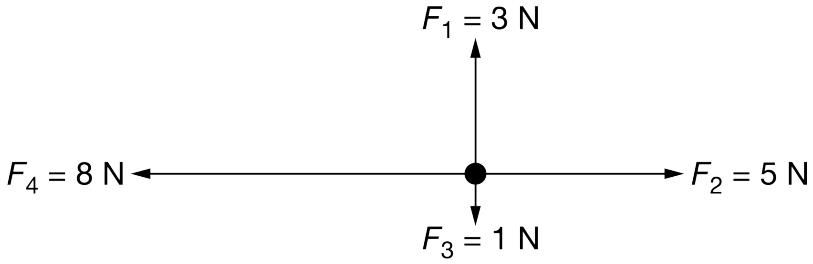


Figure 2

A student is tasked with using a force table to balance a small ring in the center of a pin, as shown in Figure 1. For each of the four strings shown, one end is attached to the small ring, and the other end is attached to a hanger that can hold masses. Each string is wrapped around a pulley so that the hanger and masses are at rest. The location of each pulley may be changed. Figure 2 shows a top-down view of the free-body diagram of the forces exerted on the pin at a particular moment in time. From a top-down perspective, in what direction will the pin accelerate?

(A) Up and to the right

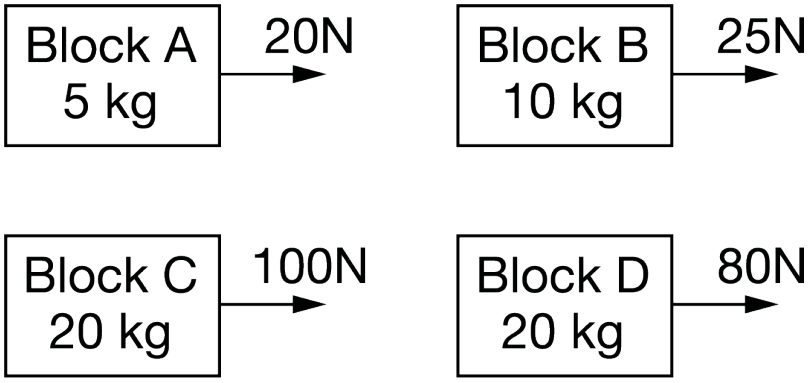
(B) Up and to the left

(C) Down and to the right

(D) Down and to the left

chapter2 PARTB

49.



Given the net forces on and the masses of the blocks shown above, which two blocks have the same acceleration? Select two answers.

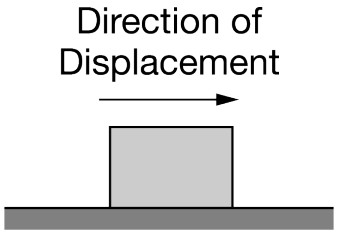
A Block A

B Block B

C Block C

D Block D

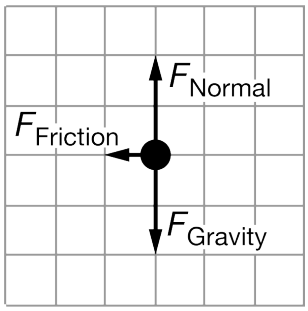
50.



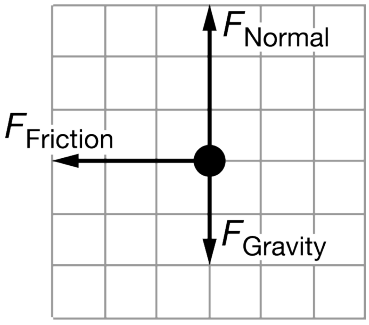
An object slides across a horizontal surface such that it slows down due to the force of friction that is exerted on the object. The object and the direction of its displacement are shown in the figure. Which of the following free-body diagrams could represent the forces that are exerted on the object?

chapter2 PARTB

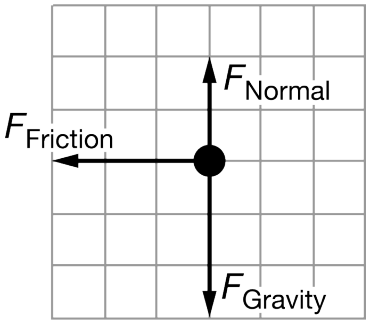
(A)



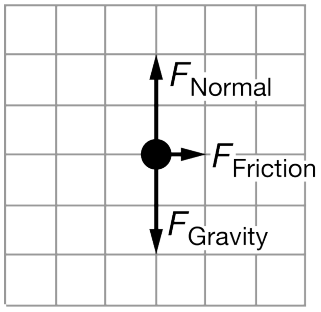
(B)



(C)

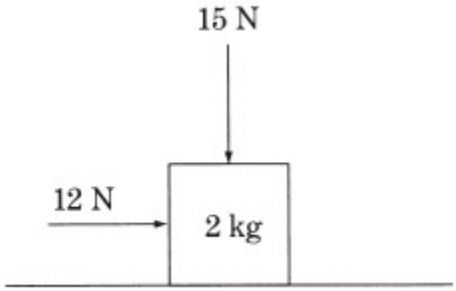


(D)



chapter2 PARTB

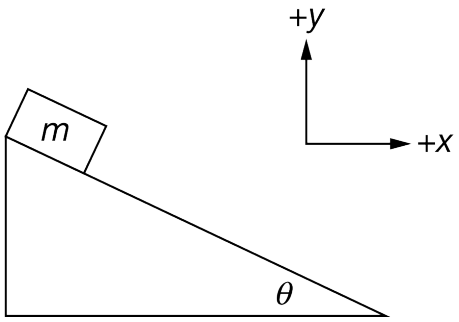
51.



A block of mass 2 kg slides along a horizontal tabletop. A horizontal applied force of 12 N and a vertical applied force of 15 N act on the block, as shown above. If the coefficient of kinetic friction between the block and the table is 0.2, the frictional force exerted on the block is most nearly

(A) 1 N
(B) 3 N
(C) 4 N
(D) 5 N
(E) 7 N

52.



A box of mass m is released from rest and accelerates down a ramp that is at an angle θ to the horizontal, as shown. The coefficient of kinetic friction between the box and the ramp is μ. As the box is sliding down the ramp, how are the magnitudes of the horizontal and vertical components of the box's velocity changing, if at all?

chapter2 PARTB

(A)

Horizontal Component	Vertical Component
Not changing	Not changing

(B)

Horizontal Component	Vertical Component
Not changing	Increasing

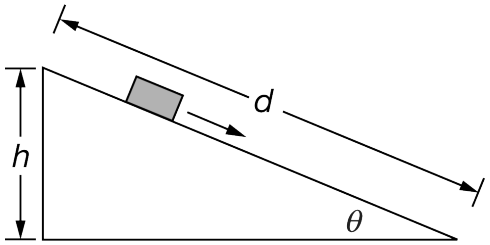
(C)

Horizontal Component	Vertical Component
Increasing	Not changing

(D)

Horizontal Component	Vertical Component
Increasing	Increasing

53.



A box of mass m slides a distance d down a rough incline from an initial height h, as shown in the figure above. The surface of the incline has a coefficient of kinetic friction μ and makes an angle θ with the horizontal. How much mechanical energy is dissipated as the box slides to the bottom of the incline?

(A) $\mu dmg \cos \theta$

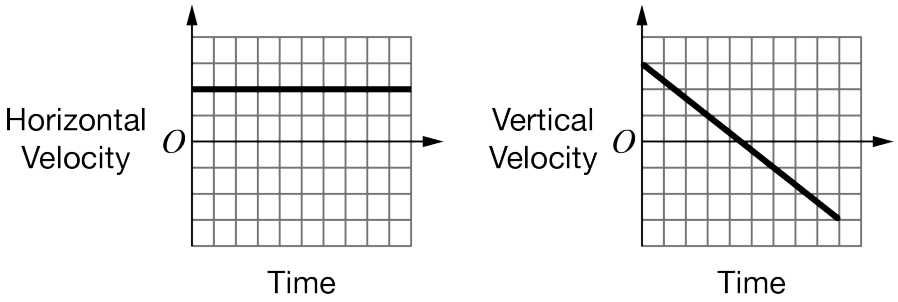
(B) $\mu dmg \sin \theta$

(C) μmgh

(D) μmgd

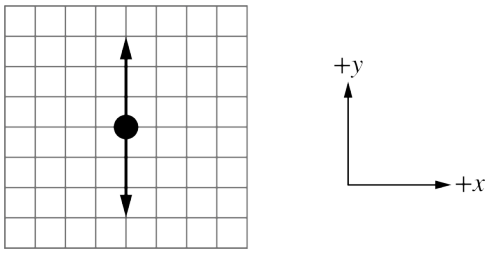
chapter2 PARTB

54.

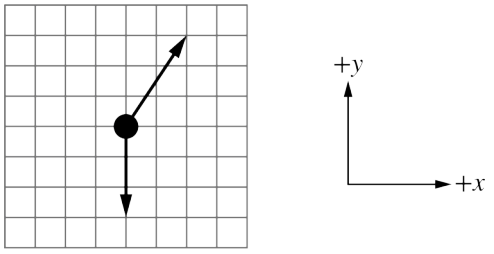


An object is subject to multiple forces that result in the object having horizontal and vertical velocity components v_x and v_y, respectively as a function of time, as shown. Which of the following free-body diagrams could represent the forces exerted on the object?

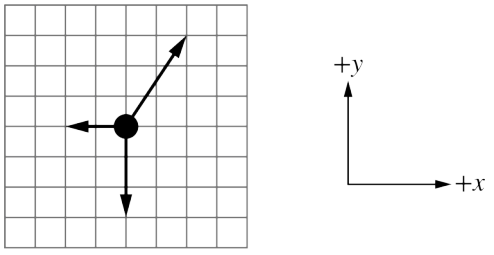
(A)



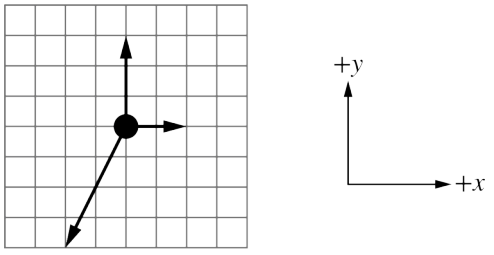
(B)



(C)

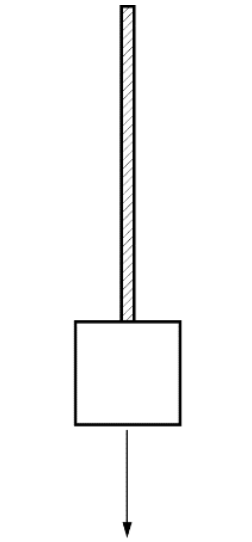


(D)



chapter2 PARTB

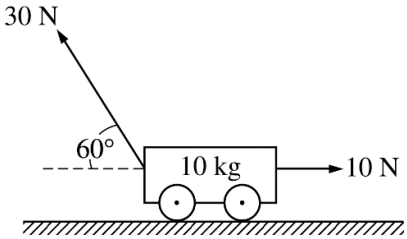
55.



A rope of negligible mass supports a block that weighs 30 N, as shown above. The breaking strength of the rope is 50 N. The largest acceleration that can be given to the block by pulling up on it with the rope without breaking the rope is most nearly

(A) 6 m/s^2
(B) 6.7 m/s^2
(C) 10 m/s^2
(D) 15 m/s^2
(E) 16.7 m/s^2

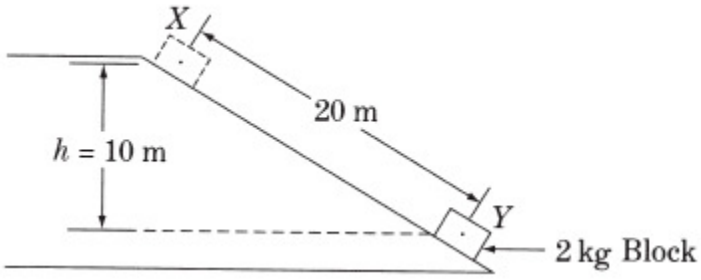
56.



The cart of mass 10 kg shown above moves without frictional loss on a level table. A 10 N force pulls on the cart horizontally to the right. At the same time, a 30 N force at an angle of 60° above the horizontal pulls on the cart to the left. What is the magnitude of the horizontal acceleration of the cart?

(A) 0.5 m/s^2
(B) 1.6 m/s^2
(C) 2.0 m/s^2
(D) 2.5 m/s^2
(E) 2.6 m/s^2

chapter2 PARTB



A 2 kg block, starting from rest, slides 20 m down a frictionless inclined plane from *X* to *Y*, dropping a vertical distance of 10 m as shown above.

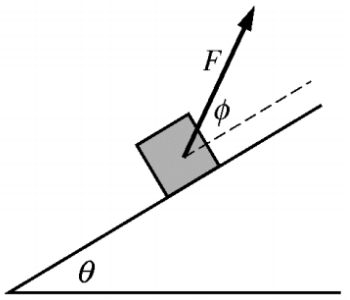
57. The magnitude of the net force on the block while it is sliding is most nearly

(A) 0.1 N
(B) 0.4 N
(C) 2.5 N
(D) 5.0 N
(E) 10.0 N

58. The speed of the block at point *Y* is most nearly

(A) 7 m/s
(B) 10 m/s
(C) 14 m/s
(D) 20 m/s
(E) 100 m/s

59.



A box of mass *m* is on a rough inclined plane that is at an angle θ with the horizontal. A force of magnitude *F* at an angle Φ with the plane is exerted on the block, as shown above. As the block moves up the plane, there is a frictional force between the box and the plane of magnitude *f*. What is the magnitude of the net force acting on the box?

chapter2 PARTB

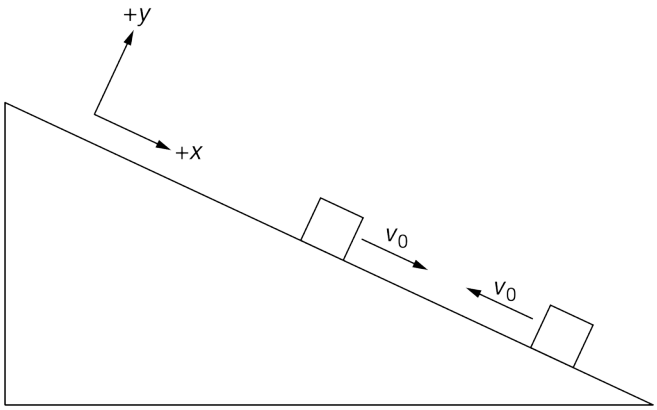
(A) $F \sin \Phi - mg\cos\theta - f$

(B) $F \cos(\Phi + \theta) + mg \sin\theta - f$

(C) $F \cos\Phi - mg \sin\theta - f$

(D) $F \cos(\Phi + \theta) - mg \sin\theta - f$

60.



Two identical blocks slide along a ramp with negligible friction, as shown. The first block has an initial speed v_0 up the ramp while the second has the same initial speed v_0 down the ramp. The coordinate system shown defines down the ramp to be the positive x direction. While both blocks are sliding on the ramp, the center of mass velocity of the two-block system is

(A) constant and zero

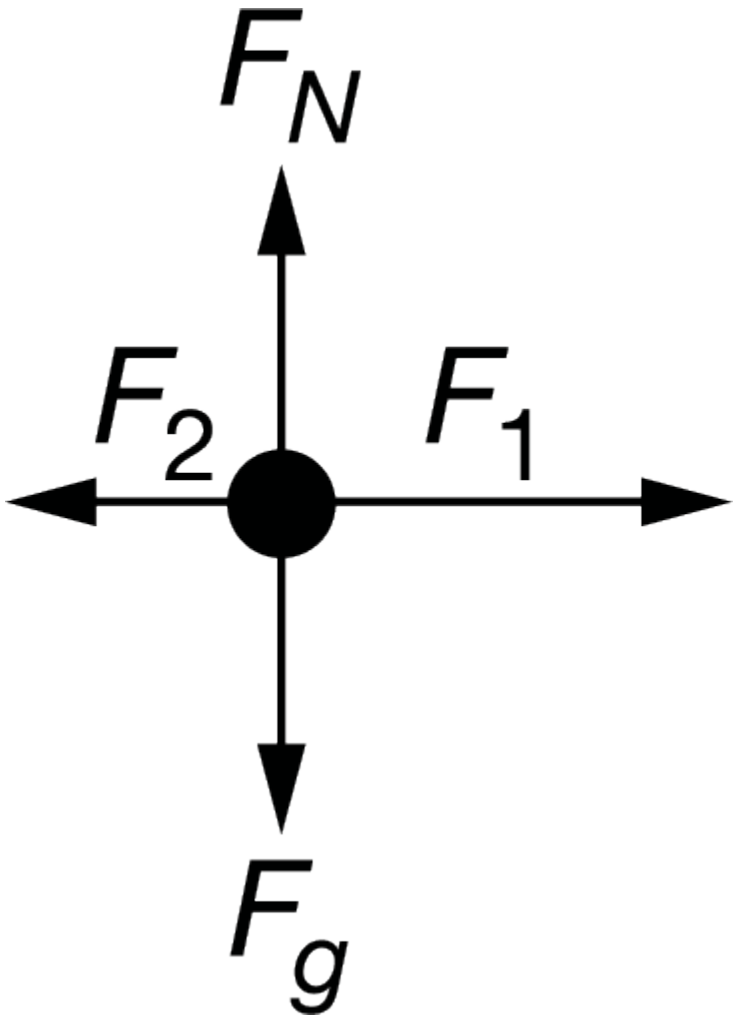
(B) constant but not zero

(C) increasing in the $-x$ direction

(D) increasing in the $+x$ direction

chapter2 PARTB

61.



The diagram above shows the forces exerted on an object. Which of the following dot diagrams best represents the position of the object at equal time intervals?

(A)

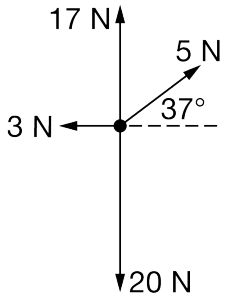
(B)

(C)

(D)

chapter2 PARTB

62.



Note: Figure not drawn to scale.

Four different constant forces are exerted on a $2.0\ \text{kg}$ object. The figure represents the magnitude and direction of each force. If the object is initially at rest, how long will it take the object to reach a speed of $2.0\ \text{m/s}$?

(A) $0.20\ \text{s}$
(B) $1.0\ \text{s}$
(C) $2.0\ \text{s}$
(D) $4.0\ \text{s}$

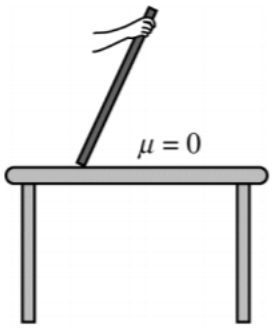
63.

Gravitational Force of Object A on Object B	Gravitational Force of Object B on Object A
$2.7 \times 10^{-10}\text{N}$	$2.7 \times 10^{-10}\text{N}$

Object A of mass $2\ \text{kg}$ is gravitationally attracted to object B of mass $2\ \text{kg}$ as the two objects float in space. Frictional forces are negligible. The gravitational forces of attraction between the two objects are shown in the table above. Which of these claims about the motion of the center of mass of the two-object system is true?

(A) The center of mass will not accelerate.
(B) The center of mass will accelerate at $0.675 \times 10^{-10}\ \text{m/s}^2$.
(C) The center of mass will accelerate at $5.4 \times 10^{-10}\ \text{m/s}^2$.
(D) The center of mass will accelerate at $2.7 \times 10^{-10}\ \text{m/s}^2$.

64.



A meterstick is held as shown above and then released from rest. The tabletop has negligible friction. Which figure below best indicates the path of the center of mass of the meterstick as it falls?

chapter2 PARTB

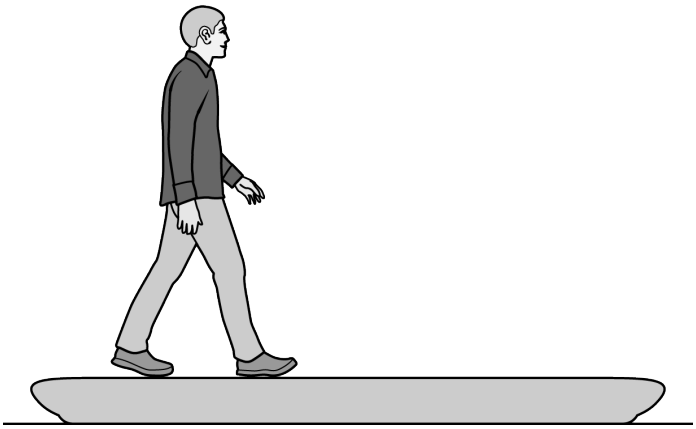
(A) 

(B) 

(C) 

(D) 

65.



A person of mass $60\ \text{kg}$ is initially standing at one end of a small raft that has a mass of $40\ \text{kg}$. The raft is in the middle of a lake, and the drag force between the raft and the water is negligible. The person begins to walk to the right, as shown above, at a speed v relative to the water. As a result, the raft will

(A) remain at rest

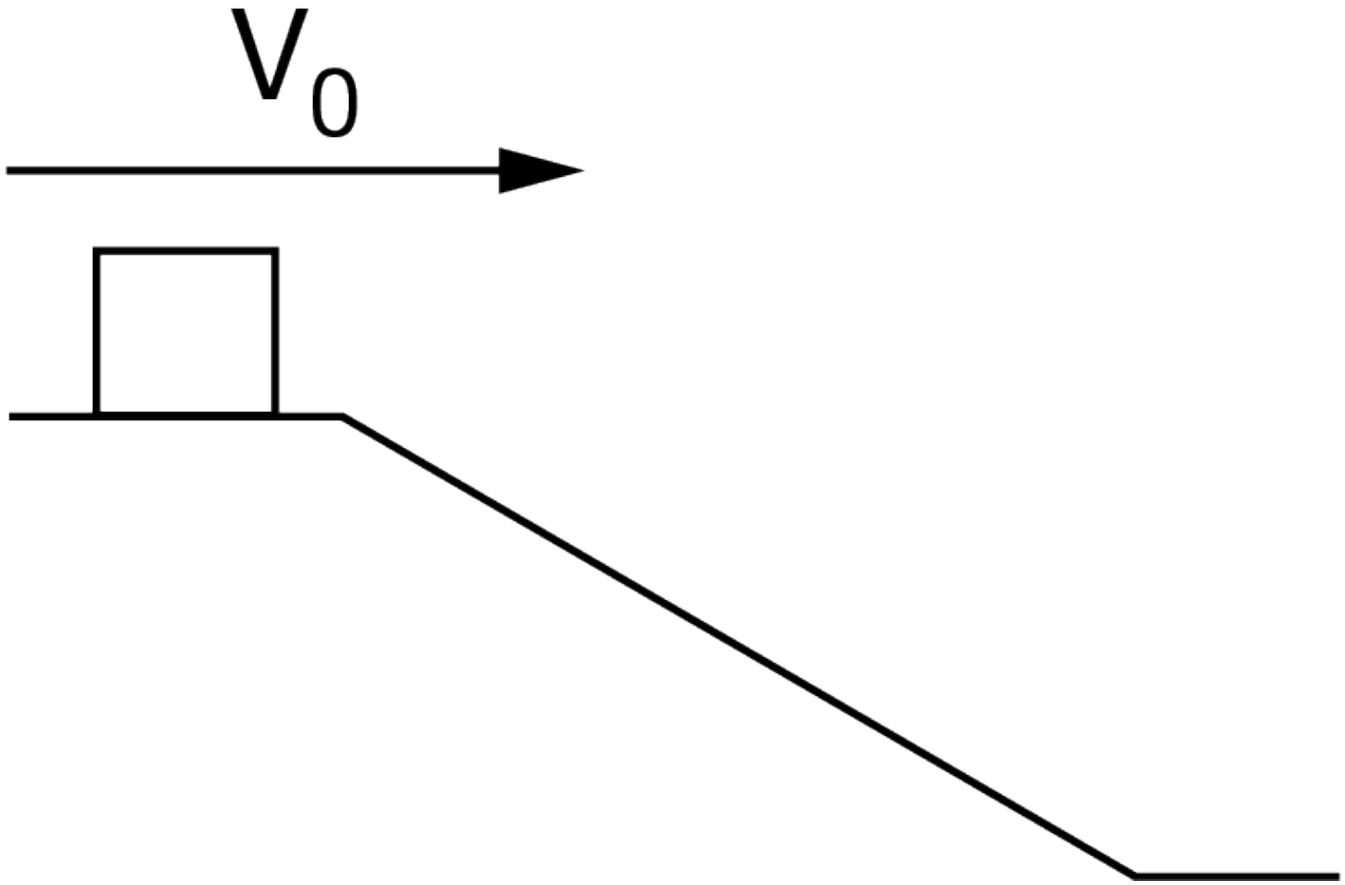
(B) move to the left at a speed less than v

(C) move to the left at a speed equal to v

(D) move to the left at a speed greater than v

chapter2 PARTB

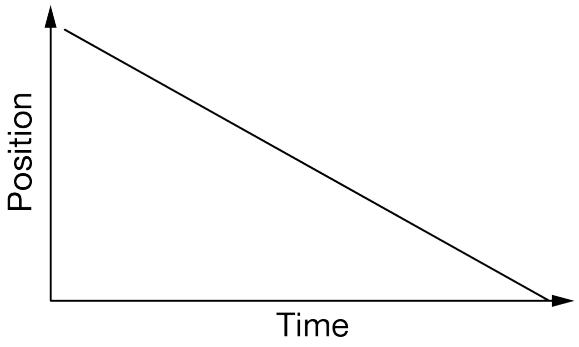
66.



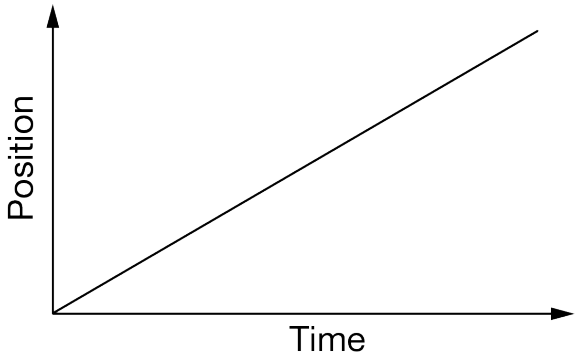
A block is moving horizontally with a speed of v_0 when it encounters a ramp, as shown above. Which of the following graphs best represents the position of the block measured from the top of the ramp as a function of time if friction is negligible?

chapter2 PARTB

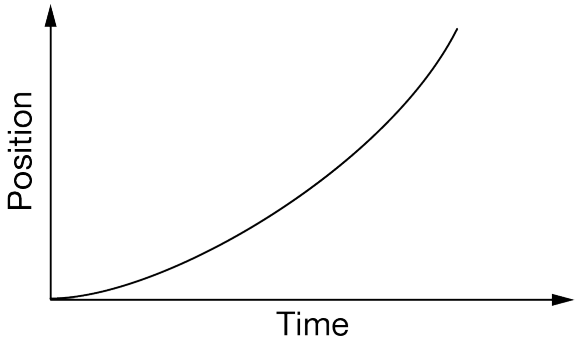
(A)



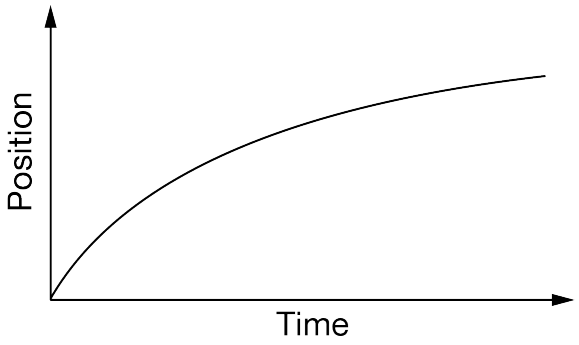
(B)



(C)

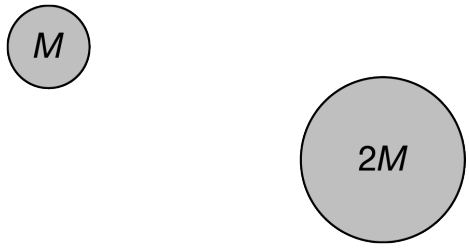


(D)



chapter2 PARTB

67.



Two spheres of mass M and $2M$ float in space in the absence of external gravitational forces, as shown in the figure. Which of the following predictions is correct about the motion of the center of mass of the two-sphere system?

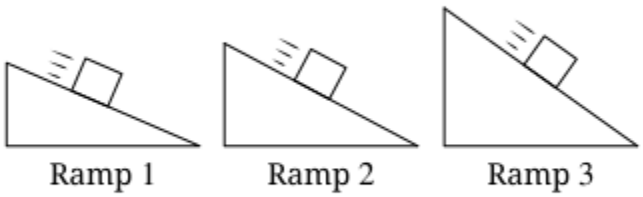
(A) The center of mass remains at rest.

(B) The center of mass accelerates toward the sphere of mass M.

(C) The center of mass accelerates toward the sphere of mass $2M$.

(D) The answer cannot be determined without knowing the distance of separation between the center of mass for each sphere.

68.



Three identical blocks, A, B, and C, slide on three different rough ramps, 1, 2, and 3, respectively. Ramp 3 is steeper than Ramp 2, which is steeper than Ramp 1, as shown. The blocks slide with constant velocities. Which block, if any, experiences the greatest net force?

(A) Block A

(B) Block B

(C) Block C

(D) All blocks experience the same net force.

chapter2 PARTB

69. Three forces act on an object. If the object is in translational equilibrium, which of the following must be true?

I. The vector sum of the three forces must equal zero

II. The magnitudes of the three forces must be equal

III. All three forces must be parallel.

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

70.

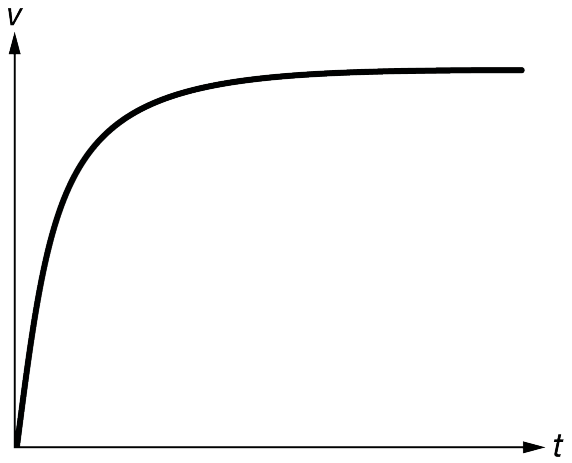
Force Label	Magnitude of Force (N)
F_{Applied}	28
F_{Friction}	4
F_{Gravity}	20
F_{Normal}	20

A $2\ \mathrm{kg}$ object is initially at rest at time $t = 0\ \mathrm{s}$. It then slides across a rough, horizontal surface under the influence of only the four forces shown in the table above. What is the speed of the object at time $t = 3\ \mathrm{s}$?

(A) $12\ \mathrm{m/s}$
(B) $14\ \mathrm{m/s}$
(C) $24\ \mathrm{m/s}$
(D) $36\ \mathrm{m/s}$

chapter2 PARTB

71.



An object is released from a large height above the ground and takes a very long time to reach the ground. The only forces exerted on the object are the force of Earth's gravity and the force of friction exerted by Earth's atmosphere as the object falls. A graph of the object's speed v as a function of time t is shown above. Which of the following claims best describes the force of friction exerted on the object?

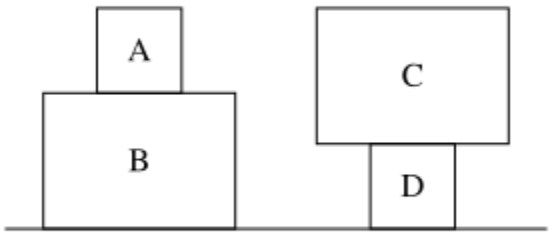
(A) It is initially zero and increases until it is equal to the force of gravity.

(B) It is initially equal to the force of gravity and decreases until it is zero.

(C) It is always equal to the force of gravity.

(D) It is always greater than the force of gravity.

72.



The diagram shows four blocks, A, B, C, and D, at rest. Blocks A and D have mass m_0, while blocks B and C have mass M_0, where $M_0 > m_0$. Which of the following correctly ranks the blocks according to the magnitudes of the net forces exerted on the blocks?

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

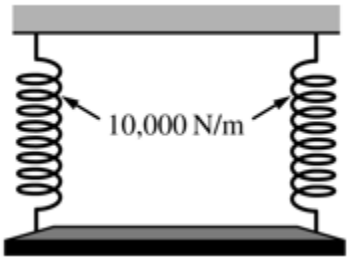
(B) $(\mathrm{A} = \mathrm{D}) < (\mathrm{B} = \mathrm{C})$

(C) $\mathrm{A} < \mathrm{D} < \mathrm{C} < \mathrm{B}$

(D) $\mathrm{A} < \mathrm{C} < \mathrm{B} < \mathrm{D}$

chapter2 PARTB

73.



A board is hung from two springs, as shown in the figure above, with the board in equilibrium. Each spring has a spring constant of 10,000 N/m. How far will each spring stretch when a person of mass 50 kg sits on the board and the board again comes to equilibrium?

(A) $\frac{1}{400}$ m

(B) $\frac{1}{200}$ m

(C) $\frac{1}{40}$ m

(D) $\frac{1}{20}$ m

(E) $\frac{1}{10}$ m

74. Two students wish to determine the value of g, the acceleration due to gravity at Earth's surface. The students have a collection of blocks of different masses, a string of negligible mass, a pulley of negligible mass, and a device for measuring acceleration. The students attach two of the blocks to the ends of the string and pass the string over the pulley so the blocks hang vertically on either side. The blocks are then released from rest, and their acceleration is measured. The students' data for one trial are shown below, with m_1 and m_2 equal to the masses of the blocks. Considering the gravitational forces acting on the blocks, do the data provide a reasonable determination of the value of g, and what is a possible justification for why or why not?

m_1 (grams)	400
m_2 (grams)	600
$a\ \left(\mathrm{m/s^2}\right)$	1.0

(A) Yes, because the value of g may be calculated by applying Newton's second law and using the gravitational forces to determine the net force on the blocks-string system.

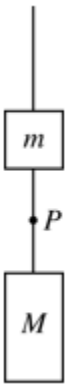
(B) Yes, because the value of g may be calculated by applying Newton's third law and using the gravitational forces as an action-reaction force pair.

(C) No, because the blocks' acceleration has a magnitude significantly less than g.

(D) No, because the calculated value of g is too small, possibly due to an additional force exerted on the blocks-string system.

chapter2 PARTB

75.



Two blocks of masses *m* and *M* are suspended as shown above by strings of negligible mass. If a person holding the upper string lowers the blocks so that they have a constant downward acceleration *a*, the tension in the string at point *P* is

(A) $(M+m)g - ma$

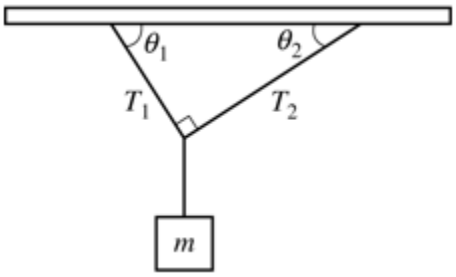
(B) $(M+m)g - Ma$

(C) $Mg - (M+m)a$

(D) Mg

(E) $M(g-a)$

76.



A box of mass *m* hangs from massless strings, as shown in the figure above. The angle between strings 1 and 2 is 90^{o}, and the angles that the strings make with the ceiling are Θ_1 and Θ_2, respectively. If T_1 is the tension in string 1, which of the following are the magnitudes of the horizontal and vertical components of the tension in string 2 ?

chapter2 PARTB

(A)

Horizontal Component	Vertical Component
$T_1 \cos\theta_1$	$mg - T_1 \sin\theta_1$

(B)

Horizontal Component	Vertical Component
$T_1 \cos\theta_1$	$mg - T_1 \cos\theta_1$

(C)

Horizontal Component	Vertical Component
$T_1 \sin\theta_1$	$mg - T_1 \sin\theta_1$

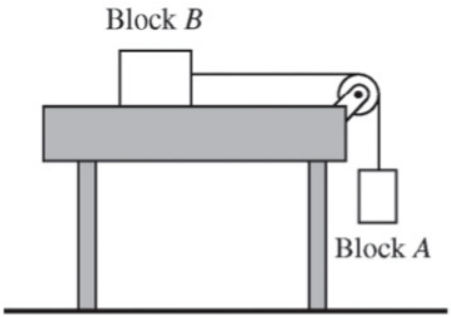
(D)

Horizontal Component	Vertical Component
$T_1 \sin\theta_1$	$mg - T_1 \cos\theta_1$

(E)

Horizontal Component	Vertical Component
$T_1 \sin\theta_1$	$mg + T_1 \sin\theta_1$

77.



Block *A* hangs from a light string that passes over a light pulley and is attached to block *B*, which is on a level horizontal frictionless table, as shown above. Students are to determine the mass of block *B* from the motion of the two-block system after it is released from rest. They plan to measure the time block *A* takes to reach the floor. The students must also take which of the following measurements to determine the mass of block *B*?

chapter2 PARTB

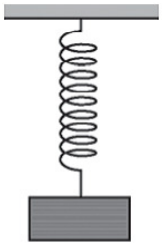
(A) Only the mass of block *A*

(B) Only the distance block *A* falls to reach the floor

(C) Only the mass of block *A* and the distance block *A* falls to reach the floor

(D) The mass of block *A*, the distance block *A* falls to reach the floor, and the radius of the pulley

78.



A block of known mass hanging from an ideal spring of known spring constant is oscillating vertically. A motion detector records the position, velocity, and acceleration of the block as a function of time. Which of the following indicates the measured quantities that are sufficient to determine whether the net force exerted on the block equals the vector sum of the individual forces?

(A) Acceleration only

(B) Acceleration and position only

(C) Acceleration and velocity only

(D) Acceleration, position, and velocity

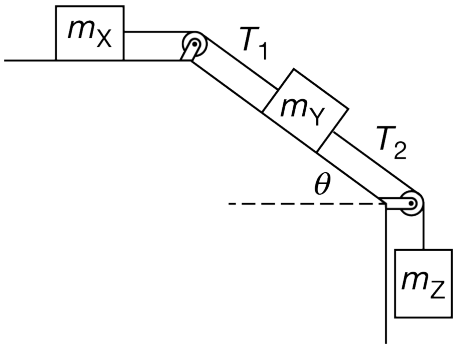
79.

Block X	$T_1 - m_{\mathrm{X}} g \sin\theta - \mu m_{\mathrm{X}} g \cos\theta = m_{\mathrm{X}} a$
Block Y	$T_2 - T_1 - \mu m_{\mathrm{Y}} g = m_{\mathrm{Y}} a$
Block Z	$m_{\mathrm{Z}} g - T_2 = m_{\mathrm{Z}} a$

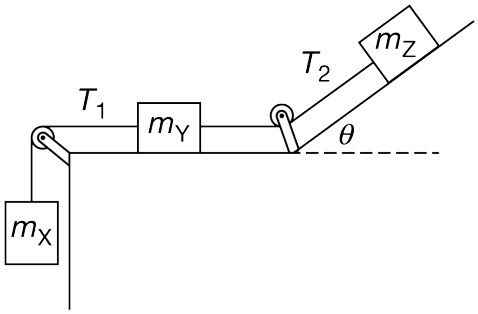
The table above shows equations describing the forces and acceleration a of three blocks that are connected by light strings, some of which run over pulleys. The pulleys are all massless and frictionless, and the coefficient of kinetic friction between each block and surface is μ. In the diagrams below, the mass of each block and the tension in each of the two strings are labeled. Which of the following arrangements could be described by the equations in the table above?

chapter2 PARTB

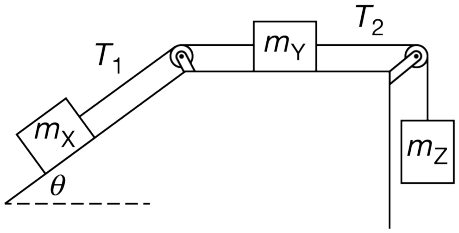
(A)



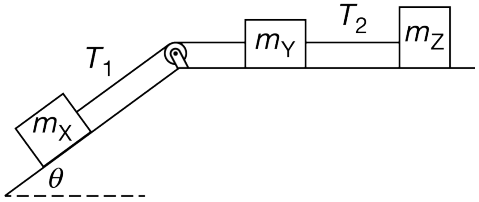
(B)



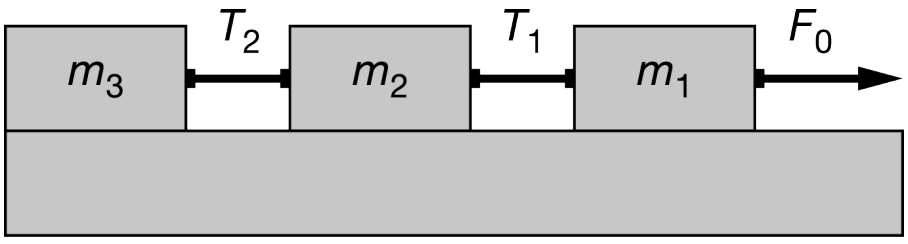
(C)



(D)



80.

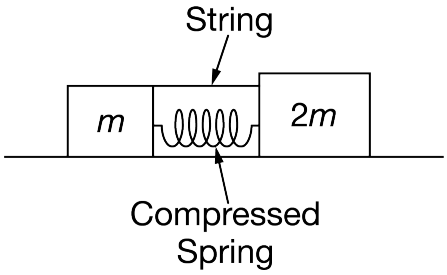


Three blocks are connected by strings and pulled to the right by a force with magnitude F_0, as shown in the figure above. All frictional forces are negligible. The tension in the right and left strings have magnitudes T_1 and T_2, respectively. Taking the positive direction to be toward the right, which of the following is a correct equation of motion for the block of mass m_2 ?

chapter2 PARTB

(A) $T_1 + T_2 = m_2 a$
(B) $T_1 - T_2 = m_2 a$
(C) $T_1 + F_0 - T_2 = m_2 a$
(D) $T_1 = m_2 a$

81.



Two blocks, with masses indicated in the figure above, are at rest on a horizontal surface and connected by a string of negligible mass and a compressed spring. There is negligible friction between the blocks and the surface. The string is cut, and the spring pushes the blocks away from each other. Which of the following statements are true about the motion of the blocks immediately after the string is cut? Select two answers.

A The velocity of the center of mass of the two-block system is zero.

B The velocity of the center of mass of the two-block system is directed toward the right.

C The magnitude of the acceleration of the left block is equal to that of the right block.

D The magnitude of the acceleration of the left block is greater than that of the right block.

82.



The figure above shows two blocks of unequal masses M and m that are sliding on a track with equal speeds v in opposite directions. Which of the following conditions could cause the velocity of the center of mass of the two-block system to change between the instant pictured above and the instant immediately after the collision? Select two answers.

A The track is not horizontal.

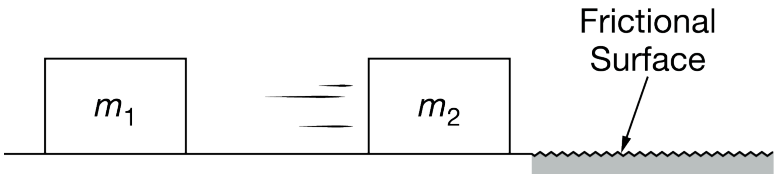
B The blocks stick together after they collide.

C There is friction between the blocks and the track.

D The blocks bounce off each other when they collide.

chapter2 PARTB

83.



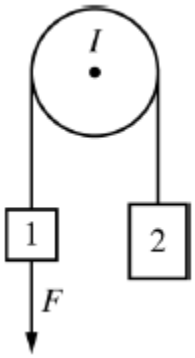
A block of mass m_1 collides with a block of mass m_2 such that block of mass m_1 becomes at rest while block of mass m_2 slides across a surface of negligible as it travels with a constant speed toward the frictional surface, as shown above. The coefficient of kinetic friction between block of mass m_2 and the frictional surface is μ_k. What is the rate of change of the speed of the center of mass of the two-block system after the block of mass m_2 enters the frictional surface?

(A) $\frac{\mu_k m_2 g}{2}$

(B) $\mu_k m_2 g$

(C) $\frac{\mu_k m_2 g}{2(m_1+m_2)}$

(D) $\frac{\mu_k m_2 g}{(m_1+m_2)}$



Two blocks are connected by a string with negligible mass that passes over a pulley with nonzero rotational inertia I, as shown above. The axle of the pulley has negligible friction. The string does not slip on the pulley. Block 1 has mass 4 kg and block 2 has mass 6 kg. An additional force with magnitude F is initially exerted on block 1 so that the blocks do not move and is then removed.

84. Which of the following is most nearly the value of F?

(A) 20 N

(B) 40 N

(C) 60 N

(D) F cannot be determined without knowing the value of I.

---

chapter2 PARTB

85.



Objects 1 and 2 have masses M_1 and M_2, respectively, where $M_1 < M_2$. The objects are in outer space far away from any other objects, as shown above. Point P is located halfway between their centers. At what location, if any, is the gravitational field due to the two objects equal to zero?

(A) Somewhere between object 1 and point P

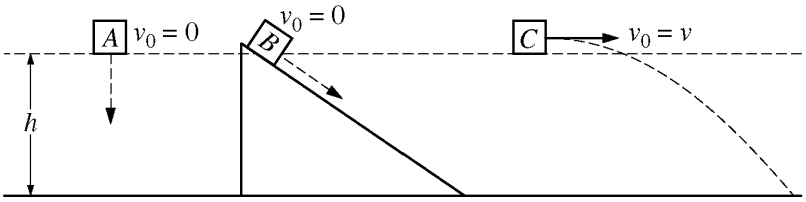
(B) At point P

(C) Somewhere between point P and object 2

(D) The gravitational field due to the two objects is nonzero everywhere.

Refer to the following material to give answers to the group of questions.

Three identical blocks each take a different path from a height *h* to the ground. Block *A* is released from rest and falls vertically. Block *B* is released from rest and slides down a frictionless incline. Block *C* is projected horizontally with an initial speed *v*.



86. Which block takes the longest time to reach the ground?

(A) A

(B) B

(C) C

(D) The blocks take the same time to reach the ground.

---

87. A student predicts that a block sliding down a ramp inclined at 45 degrees should have an acceleration of approximately $7\ \mathrm{m/s^2}$. The block is released from rest, and the student measures the distance the block travels and the time it takes to travel that distance. The student determines that the block's acceleration is only $5.5\ \mathrm{m/s^2}$. Which of the following is the most likely reason for the difference between the predicted and calculated accelerations?

chapter2 PARTB

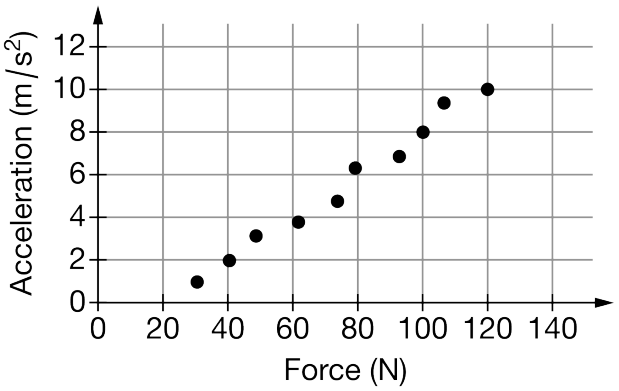
(A) The student's model used to make the prediction did not account for the mass of the block.

(B) The student's model used to make the prediction did not account for all of the forces that are exerted on the block.

(C) The student's experimental procedure did not measure the correct quantities needed to calculate the acceleration.

(D) The student's experimental procedure did not use enough trials to accurately determine the block's acceleration.

88.



A person exerts a continually increasing force on an object in a constant direction. A graph of the acceleration of the object as a function of the applied force is shown above. Which of the following best explains why a best-fit line would not pass through the origin?

(A) An additional force is exerted on the object in the same direction as the applied force.

(B) An additional force is exerted on the object in the direction opposite the applied force.

(C) The object was moving at constant speed before the force was applied.

(D) Data was not collected for applied forces less than $20\ \text{N}$.