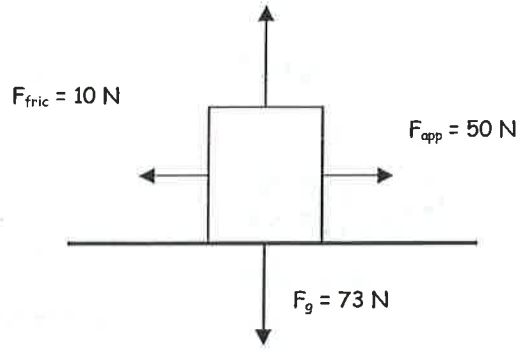
KEY

Newton's 2nd Law Practice Assessment

Part A

1. An applied force of 50 N is used to accelerate an object to the right across a frictional surface. The object encounters 10 N of friction. Use the diagram to determine the normal force, the net force, the mass, and the acceleration of the object. (Neglect air resistance).



m = 7.45 kg

a = 5.37 m/s² →

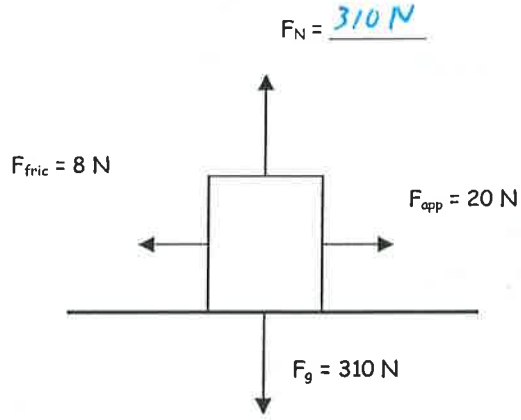
F_{net} = 50 − 10 = 40 N →

$F_g = m \cdot a_g$
$73N = m \cdot 9.8\ m/s^2$
$m = 7.45\ kg$

$F_{net} = ma$
$40N = 7.45kg \cdot a$
$a = 5.37\ m/s^2$

2. An applied force of 20 N is used to accelerate an object to the right across a frictional surface. The object encounters 8 N of friction. Use the diagram to determine the normal force, the net force, the coefficient of friction ("mu") between the objects and the surface, the mass, and the acceleration of the object. (Neglect air resistance.)

$F_g = m \cdot 9.8$
$310 = m \cdot 9.8$
$m = 31.6\ kg$



m = 31.6 kg

a = .38 m/s² →

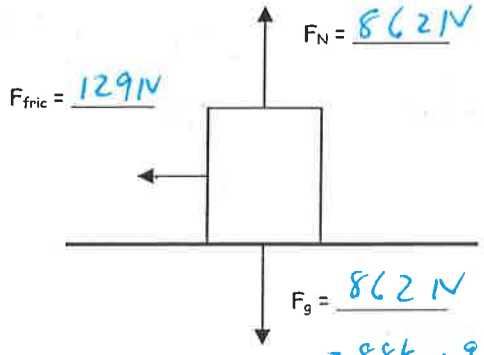
F_{net} = 20 − 8 = 12 N →

μ = .026

$\mu = \frac{F_{fr}}{F_N} = \frac{8\ N}{310\ N} = .026$

$F_{net} = ma$
$\frac{12}{31.6} = \frac{31.6\ a}{31.6}$
$a = .38\ m/s^2$

3. A 88-kg object is sliding to the right and encountering a friction force that slows it down. The coefficient of friction between the object and the surface is 0.15. Determine the force of gravity, the normal force, the force of friction, the net force, and the acceleration. (Neglect air resistance.)



μ = .15

m = 88 kg

a = 1.47 m/s² ←

F_{net} = F_{fr} = 129 N ←

$= 88kg \cdot 9.8\ m/s^2$

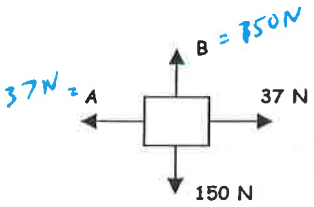
$\mu = \frac{F_{fr}}{F_N}$
$.15 = \frac{F_{fr}}{862}$
$F_{fr} = 129\ N$

$F_{net} = ma$
$129 = 88(a)$
$a = 1.47\ m/s^2$

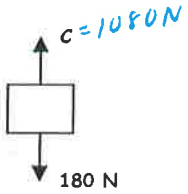
Adapted from physicsclassroom.com

4. Free-body diagrams for four situations are shown below. The net force is known for each situation. However, the magnitudes of a few of the individual forces are not known. Analyze each situation individually and determine the magnitude of the unknown forces.

F = H

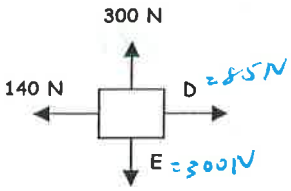


F_{net} = 0 N



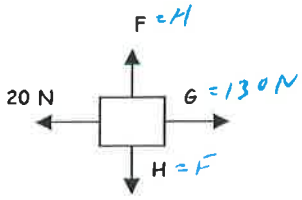
F_{net} = 900 N, up

$F_{net} = C - 180$
$900 = C - 180$
$C = 1080\ N$



F_{net} = 55 N, left

$F_{net} = 140 - D$
$55 = 140 - D$
$D = 85\ N$



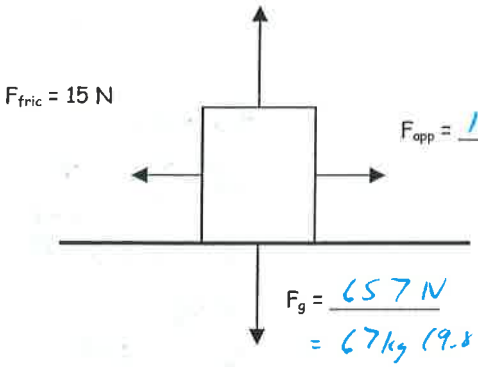
F_{net} = 110 N, right

$= G - 20$
$G = 130\ N$

5. A rightward force is applied to a 67-kg object to move it across a rough surface at constant velocity. The object encounters 15 N of frictional force. Use the diagram to determine the gravitational force, normal force, net force, and applied force. (Neglect air resistance.)

a = 0
$F_{net} = 0$

F_N = 657N

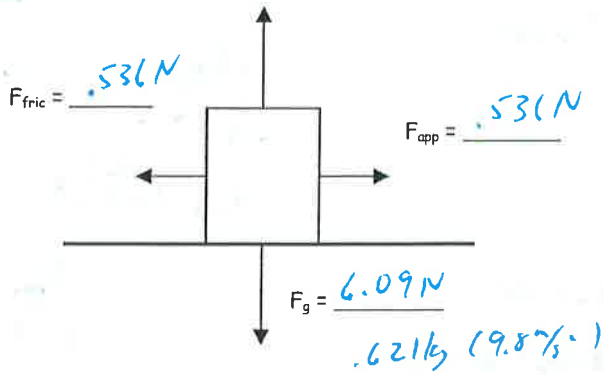


m = 67kg
a = 0
F_{net} = 0

a = 0
$F_{net} = 0$

6. A rightward force is applied to a 621-g object to move it across a rough surface at constant velocity. The coefficient of friction between the object and the surface is 0.088. Use the diagram to determine the gravitational force, normal force, applied force, frictional force, and the net force. (Neglect air resistance.)

F_N = 6.09N



m = 0.621kg
μ = .088
a = 0 m/s²
F_{net} = 0

$\mu = \frac{F_{fr}}{F_N}$

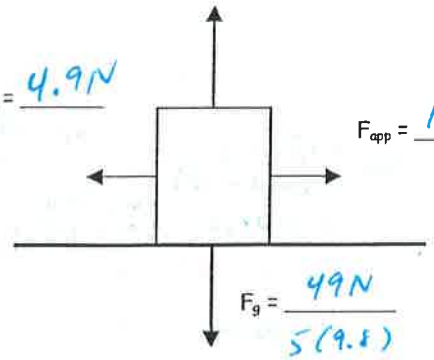
$.088 = \frac{F_{fr}}{6.09}$

$F_{fr} = .536\ N$

Adapted from physicsclassroom.com

7. A rightward force is applied to a 5-kg object to move it across a rough surface with a rightward acceleration of 2 m/s/s. The coefficient of friction between the object and the surface is 0.1. Use the diagram to determine the gravitational force, normal force, applied force, frictional force, and net force. (Neglect air resistance.)

$F_N =$ 49N



$F_{fric} =$ 4.9N

$F_{app} =$ 14.9N

$F_g =$ 49N
5(9.8)

m = 5kg

μ = .1

a = 2 m/s²

$F_{net} =$ 10 N

$F_{net} = ma$
$= 5(2)$
$= 10\ N$

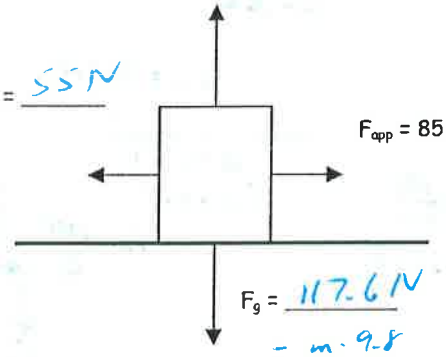
$F_{net} = F_A - F_{Fr}$
$10 = F_A - 4.9$
$F_A = 14.9\ N$

$\mu = \frac{F_{Fr}}{F_N}$

$.1 = \frac{F_{Fr}}{49}$ $F_{Fr} = 4.9\ N$

8. A rightward force of 85 N is applied to a 12 kg object to move it across a rough surface with a rightward acceleration of 2.5 m/s/s. Use the diagram to determine the gravitational force, normal force, frictional force, net force, and the coefficient of friction between the object and the surfaced. (Neglect air resistance.)

$F_N =$ 117.6 N



$F_{fric} =$ 55 N

$F_{app} =$ 85 N

$F_g =$ 117.6 N
$= m \cdot 9.8$
$= 12(9.8) = 117.6\ N$

m = 12kg

μ = .47

a = 2.5 m/s²

$F_{net} =$ 30 N

$F_{net} = ma$
$= 12(2.5)$
$F_{net} = 30\ N$

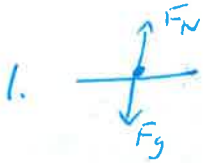
$F_{net} = F_A - F_{Fr}$
$F_{net} = 85 - F_{Fr}$
$30 = 85 - F_{Fr}$
$F_{Fr} = 55\ N$

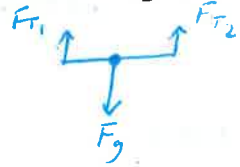
$\mu = \frac{F_{Fr}}{F_N} = \frac{55\ N}{117.6\ N} = .47$

Part B

Draw a free body diagram for the following:

1. A book is at rest on a tabletop. Diagram the forces acting on the book.
2. A girl is suspended motionless from a bar that hangs from the ceiling by two ropes. Diagram the forces acting on the girl.
3. An egg is free falling from a nest in a tree. Neglect air resistance. Diagram the forces acting on the egg as it is falling.
4. A flying squirrel is gliding (no wing flaps) from a tree to tree at a constant velocity. Consider air resistance. Diagram the forces acting on the squirrel.
5. A rightward force is applied to a book in order to move it across a desk with a rightward acceleration. Consider frictional forces. Neglect air resistance. Diagram the forces acting on the book.

1. 

2. 

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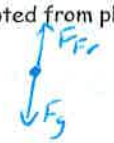
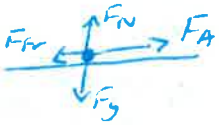
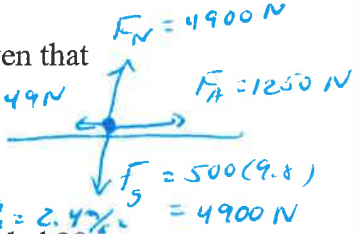
4. 

5. 

Sliding Mass Problems

Draw a force diagram and label the known information for each problem. Use your diagrams to write a valid equation for Newton's Second Law and solve for the unknowns. You will need to use other equations (form Chapter 5) to solve.

1. A loaded snow sled is pulled by six huskies with a force of 1,250 N. Given that the mass of the sled is 500 kg and μ is 0.01, determine:
   A. Normal force 4900 N
   B. Force of friction 49 N
   C. Acceleration of the sled 2.4 m/s²
   D. Given that it started at rest what would be its velocity after it traveled 20 seconds 48 m/s
   E. How far did it travel in the first 20 seconds? 480 m



$F_{net} = F_A - F_{Fr} = 1250 - 49 = 1201\ N$

$F_{net} = ma$

$1201 = 500\,a$

$a = 2.4\ m/s^2$

$\mu = \frac{F_{Fr}}{F_N}$

$.01 = \frac{F_{Fr}}{4900}$

$F_{Fr} = 49N$

D. $v_i = 0\ m/s$, $a = 2.4\ m/s^2$, $t = 20s$, $\Delta x = ?$, $v_f = ?$

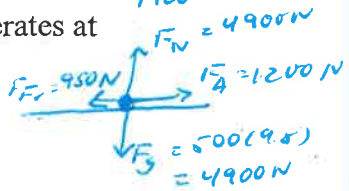
$v_f = v_i + at$

$v_f = 0 + 2.4(20) = 48\ m/s$

E. $\Delta x = v_i t + \frac{1}{2}at^2$

$\Delta x = 0 \cdot \frac{1}{2}(2.4)(20)^2 = 480\ m$

2. A person pushes a 500 kg crate with a force of 1200 N and the crate accelerates at 0.5 m/s², determine:
   A. Friction force 950 N
   B. Normal force 4900 N
   C. μ (coefficient of friction) .194
   D. What would be the velocity at 10 seconds (given it started at rest)? 5 m/s
   E. How far did it travel in the first 10 seconds? 25 m



$\mu = \frac{F_{Fr}}{F_N} = \frac{950}{4900}$

$\mu = .194$

$F_{net} = ma$

$F_A - F_{Fr} = 250N$

$1200 - F_{Fr} = 250$

$F_{Fr} = 950N$

$v_i = 0\ m/s$, $a = .5\ m/s^2$, $t = 10s$, $v_f = ?$, $\Delta x = ?$

$v_f = v_i + at$

$v_f = 0 + .5(10)$

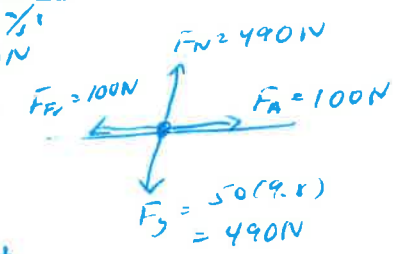
$v_f = 5\ m/s$

$\Delta x = v_i t + \frac{1}{2}at^2$

$\Delta x = 0 + \frac{1}{2}(.5)(10^2)$

$\Delta x = 25\ m$

3. A 50 kg sled is pulled by a force of 100 N that produces a constant velocity of 2.5 m/s, determine:
   A. the acceleration 0 m/s²
   B. force of friction 100 N
   C. the net force 0 N
   D. μ .204
   E. F_N 490 N

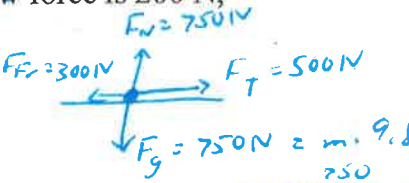


$a = 0\ m/s^2$

$F_{net} = 0N$

$\mu = \frac{F_{Fr}}{F_N} = \frac{100}{490} = .204$

4. A 750 N crate is pulled by a rope with a tension of 500 N. If the new force is 200 N, determine:
   A. Force of friction 300 N
   B. μ .4
   C. acceleration 2.6 m/s²



$F_{net} = F_T - F_{Fr}$

$200 = 500 - F_{Fr}$

$F_{Fr} = 300N$

$\mu = \frac{F_{Fr}}{F_N} = \frac{300}{750} = .4$

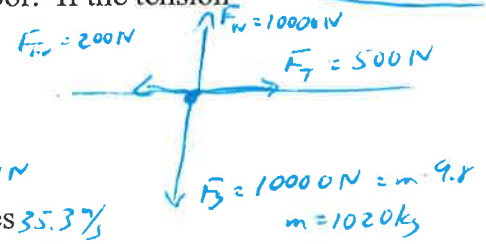
$m = \frac{750}{9.8} = 76.5\ kg$

$F_{net} = ma$

$200 = 76.5a$

$a = 2.6\ m/s^2$

5. The coefficient of sliding friction is 0.02 between a crate and the floor. If the tension force pulling the crate is 500 N and the net force is 300 N, determine:
   a. force of friction 200 N
   b. normal force 10000 N
   c. mass of crate 1020 kg
   d. acceleration of the crate .294 m/s²
   e. what is the velocity of the crate (if it started from rest) after 2 minutes 35.3 m/s



$\mu = \frac{F_{Fr}}{F_N} = \frac{200}{F_N} = .02$

$F_N = \frac{200}{.02} = 10000\ N$

$F_{net} = ma$

$300 = 1020kg \cdot a$

$a = \frac{300}{1020} = .294\ m/s^2$

$v_i = 0$

$t = 120s$

$a = .294\ m/s^2$

$v_f = ?$

$v_f = v_i + at$

$v_f = .294(120) = 35.3\ m/s$

$F_{net} = F_T - F_{Fr}$

$300N = 500N - F_{Fr}$

$F_{Fr} = 200N$

TYPICAL NUMERIC QUESTIONS FOR PHYSICS I REGULAR -

QUESTIONS TAKEN FROM CUTNELL AND JOHNSON

CONTENT STANDARD IC, ID

FORCES

1. When the net force that acts on a hockey puck is 10 N, the puck accelerates at a rate of 50 m/s^2. Determine the mass of the puck.
A) 0.2 kg B) 1.0 kg C) 5 kg D) 10 kg E) 50 kg

$F_{net} = ma$
$10\,N = m \cdot 50\,m/s^2$

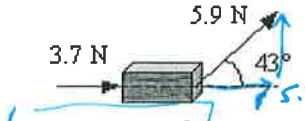
2. A 15-N net force is applied for 6.0 s to a 12-kg box initially at rest. What is the speed of the box at the end of the 6.0-s interval?
A) 1.8 m/s B) 15 m/s C) 3.0 m/s D) 30 m/s E) 7.5 m/s

$F_{net} = ma$
$15\,N = 12\,kg\ a$
$a = 1.25\,m/s^2$
$v_i = 0\,m/s$
$t = 6\,s$
$v_f = v_i + at$

3. A 810-kg car accelerates from rest to 27 m/s in a distance of 120 m. What is the magnitude of the average net force acting on the car?
A) 740 N B) 2500 N C) 91 N D) 1300 N E) 7900 N

$v_i = 0\,m/s$
$v_f = 27\,m/s$
$\Delta x = 120\,m$
$m = 810\,kg$
$a = ?$
$a = 3.04\,m/s^2$
$v_f^2 = v_i^2 + 2a\Delta x$
$27^2 = 0 + 2a(120)$
$F_{net} = ma = 810(3.04) = 2462.4\,N$

4. Two forces act on a 4.5-kg block resting on a frictionless surface as shown. What is the magnitude of the horizontal acceleration of the block?

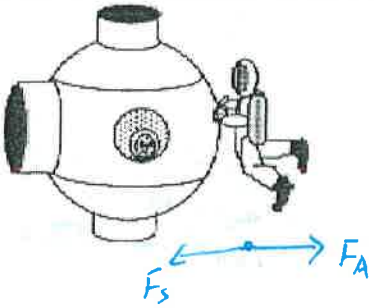


$5.9\cos 43 = 4.3\,N$
$F_{net} = 3.7 + 4.3\,N$
$= 8\,N \rightarrow$
$F_{net} = ma$
$8 = 4.5\,a$
$a = 1.78\,m/s^2$

A) 1.8 m/s^2 B) 1.2 m/s^2 C) 0.82 m/s^2 D) 3.2 m/s^2 E) 8.9 m/s^2

Use the following to answer question 5:

A 70.0-kg astronaut pushes to the left on a spacecraft with a force **F** in "gravity-free" space. The spacecraft has a total mass of 1.0×10^4 kg. During the push, the astronaut accelerates to the right with an acceleration of 0.36 m/s^2



$F_S = F_A$

$10000\ a = 70kg\,(.36\ m/s^2)$

$a = .00252\ m/s^2$

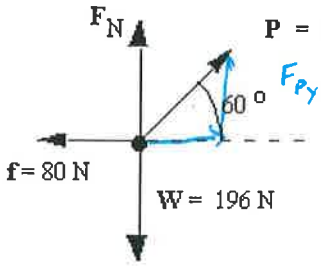
5. Determine the magnitude of the acceleration of the spacecraft.
   A) 51.4 m/s^2
   B) 0.36 m/s^2
   C) 2.5×10^{-3} m/s^2
   D) 7.0×10^{-3} m/s^2
   E) 3.97×10^{-4} m/s^2

6. A 44-kg child steps onto a scale and the scale reads 430 N. What is the magnitude of the normal force acting on the child?
   A) 44 N B) 215 N C) 430 N D) 645 N E) 860 N

$F_S = F_N$

Use the following to answer question 7:

A force **P** pulls on a crate of mass *m* on a rough surface. The figure shows the magnitudes and directions of the forces that act on the crate in this situation. **W** represents the weight of the crate. $\mathbf{F}_N$ represents the normal force on the crate, and **f** represents the frictional force.



$F_{Py} = 160 \sin 60 = 139N$

$F_S = F_{Py} + F_N$

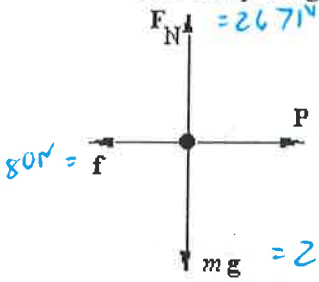
$196 = 139 + F_N$

$F_N = 57N$

7. What is the magnitude of $\mathbf{F}_N$, the normal force on the crate?
   A) 57 N B) 80 N C) 160 N D) 196 N E) 230 N

Use the following to answer question 8:

A block is pulled along a rough level surface at constant speed by the force **P**. The figure shows the free-body diagram for the block.



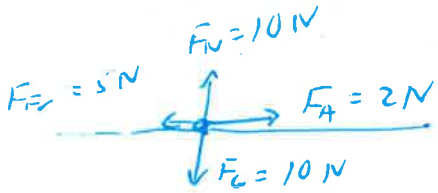
$F_N = F_g$

$\mu = \frac{F_{fr}}{F_N}$

$.3 = \frac{80\,N}{F_N}$ $F_N = \frac{80}{.3} = 267\,N$

$\mathbf{F_N}$ represents the normal force on the block; and **f** represents the force of kinetic friction.

8. If the coefficient of kinetic friction, μ_k between the block and the surface is 0.30 and the magnitude of the frictional force is 80.0 N, what is the weight of the block?
   A) 1.6 N B) 4.0 N C) 160 N D) 270 N E) 410 N



Use the following to answer questions 9-10:

A 2.0-N force acts horizontally on a 10-N block that is initially at rest on a horizontal surface. The coefficient of static friction between the block and the surface is 0.50.

$\mu = .5 = \frac{F_{fr}}{F_N}$

$.5 = \frac{F_{fr}}{10}$

$F_{fr} = 5\,N$

9. What is the magnitude of the frictional force that acts on the block?
   A) 0 N B) 2 N C) 5 N D) 8 N E) 10 N

$a = 0$ $F_{net} = 0$

10. Suppose that the block now moves across the surface with constant speed under the action of a horizontal 3.0-N force. Which statement concerning this situation is *not* true?
    A) The block is not accelerated.
    B) The net force on the block is zero newtons.
    C) The frictional force on the block has magnitude 3.0 N.
    D) The coefficient of kinetic friction between the block and the surface is 0.30.
    E) The direction of the total force that the surface exerts on the block is vertically upward.

11. A small plane climbs with a constant velocity of 250 m/s at an angle of 28° with respect to the horizontal. Which statement is true concerning the magnitude of the *net force* on the plane?
A) It is equal to zero newtons.
B) It is equal to the weight of the plane.
C) It is equal to the magnitude of the force of air resistance.
D) It is less than the weight of the plane but greater than zero newtons.
E) It is equal to the component of the weight of the plane in the direction of motion.

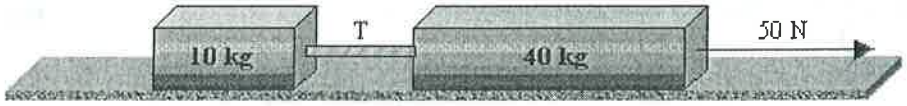
12. A woman stands on a bathroom scale in an elevator that is not moving. The scale reads 500 N. The elevator then moves downward at a constant velocity of 5 m/s. What does the scale read while the elevator descends with constant velocity? $F = 0$
A) 100 N B) 250 N C) 450 N D) 500 N E) 750 N

13. A rope connects boat A to boat B. Boat A starts from rest and accelerates to a speed of 9.5 m/s in a time $t = 47$ s. The mass of boat B is 540 kg. Assuming a constant frictional force of 230 N acts on boat B, what is the magnitude of the tension in the rope that connects the boats during the time that boat A is accelerating?
A) 160 N B) 1270 N C) 230 N D) 860 N E) 340 N

omit

Use the following to answer question 14:

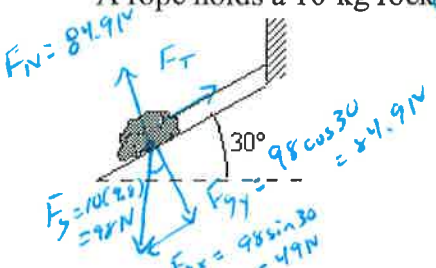
A 10-kg block is connected to a 40-kg block as shown in the figure. The surface on which the blocks slide is frictionless. A force of 50 N pulls the blocks to the right.



14. What is the magnitude of the acceleration of the 40-kg block?
A) 0.5 m/s^2 B) 1 m/s^2 C) 2 m/s^2 D) 4 m/s^2 E) 5 m/s^2

Use the following to answer questions 15-16:

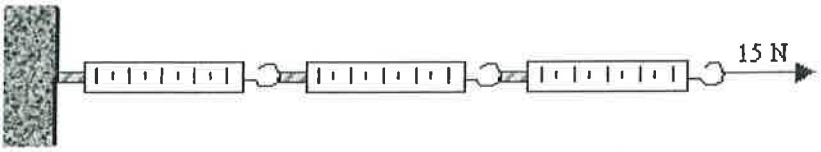
A rope holds a 10-kg rock at rest on a *frictionless* inclined plane as shown.



15. Determine the tension in the rope.
A) 9.8 N B) 20 N C) 49 N D) 85 N E) 98 N

16. Which one of the following statements concerning the force exerted *on* the plane *by* the rock is true?
A) It is 0 N.
B) It is 98 N.
C) It is greater than 98 N.
D) It is less than 98 N, but greater than zero newtons.
E) It *increases* as the angle of inclination is *increased*.

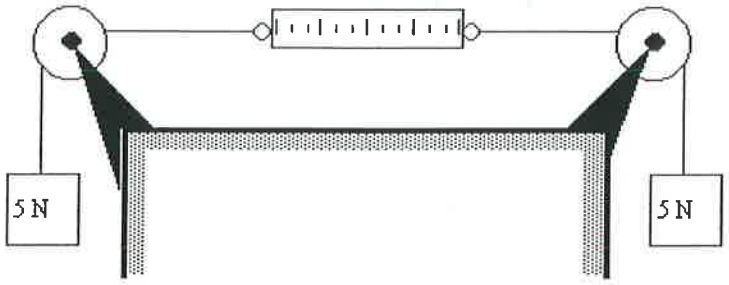
17. Three spring scales are attached along a straight line as shown. The scale on the left is attached to a wall. A force of 15 N is applied to the scale at the right.



What is the reading on the middle scale?
A) 0 N B) 45 N C) 10 N D) 5 N E) 15 N

Use the following to answer questions 18-19:

Two 5-N boxes are attached to opposite ends of a spring scale and suspended from pulleys as shown.



omit

18. What is the reading on the scale?
A) 0 N B) 2.5 N C) 5 N D) 10 N E) 25 N

19. Suppose that the system were placed in an elevator that accelerated downward at 2 m/s^2. What would the scale read?
A) 0 N B) 4 N C) 6 N D) 8 N E) 10 N