Newton's Laws Practice

Steps:

1. Select Body
2. Draw Free Body Diagram for your selected body
3. Draw the velocity and acceleration direction if already know
4. Create x-y coordination system (Usually x-axis is same as the velocity or acceleration direction).
5. Draw both x and y components for each individual force.
6. Apply Newton's Second Law for both x and y direction:

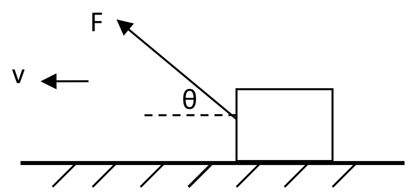
   $\sum F_x = ma_x$

   $\sum F_y = ma_y$

7. Plug all components value into the x and y direction Newton's Second Law.

Example:

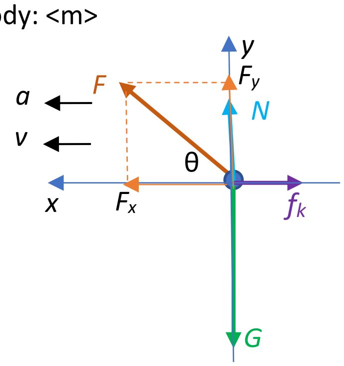
The object with mass *m* = *10 kg*, is pulled by a force *F = 20N* at an angle $\vartheta = 30o$ to the surface. The kinetic coefficient of friction between the block and the surface is $\mu = 0.2$. ($g = 10m/s^2$)



1. What's the acceleration of the object?

Solution: Step 1, 2, 3, 4, 5

Body: <m>



Step 6:

$\sum F_x = ma_x$

$\sum F_y = ma_y$

Step 7:

$F_x - f_k = F\cos\theta - f_k = ma$

$F_y + N - mg = F\sin\theta + N - mg = 0$

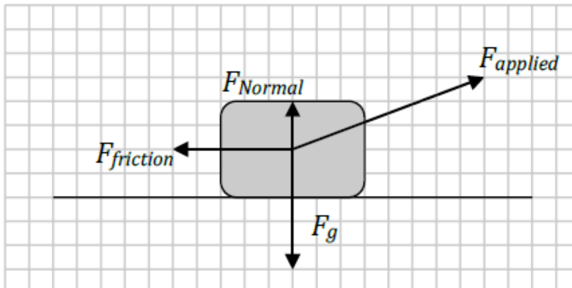
$f_k = \mu N$

Plug in all values and solve the equation.

2. The object starts from rest, what's the velocity after 5 seconds?

1. Single Object Practice

1.

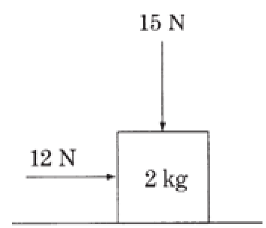


The free-body diagram shows all forces acting on a box supported by a horizontal surface, where the length of each force vector is proportional to its magnitude. Which statement below is correct?

a. The box is accelerating downwards because the force of gravity is greater than the normal force.
b. The box is accelerating to the right, but not upwards.
c. The box is accelerating upwards, but not to the right.
d. The box is accelerating upwards *and* to the right.
e. None of the statements above is correct.

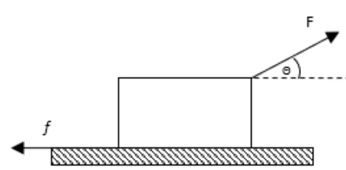
2.

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

<u>Question 3 and 4</u>: As shown in picture, a block of mass m is pulled across a rough surface by a force F exerted at an angle Θ with the horizontal. The frictional force on the block exerted by the surface has magnitude f.



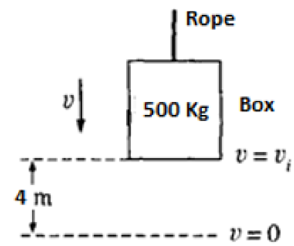
3. What is the acceleration of the block?
(A) F/m (B) FcosΘ /m (C) (F-f)/m
(D) (FcosΘ-f)/m (E) (FsinΘ-mg)/m

4. What is the coefficient of friction between the block and the surface?
(A) f/mg (B) mg/f (C) (mg-FcosΘ)/f (D) f/(mg-FcosΘ) (E) f/(mg-FsinΘ)

5. A descending box of mass 500 kg is uniformly decelerated to rest over a distance of 4 m by a rope in which the tension is 6000 N. The speed v_i of the elevator at the beginning of the 4 m descent is most nearly

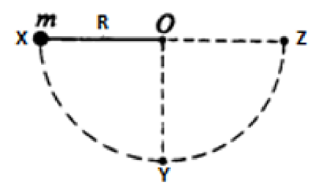
(A) 4 m/s (B) 10 m/s

(C) 12 m/s (D) 16 m/s (E) 22 m/s

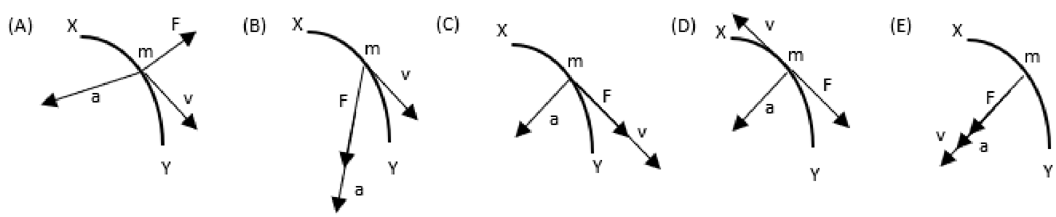


6. A rubber band ball of mass m is attached to a string of length R as shown above. The ball is released from rest from position X where the string is horizontal, swings through position Y where the string is vertical, and reaches position Z where the string is again horizontal. What are the directions of the acceleration vectors of the ball at positions Y and Z?

Position Y	Position Z
(A) Downward	Downward
(B) Downward	To the right
(C) Upward	Downward
(D) Upward	To the left
(E) To the right	To the left



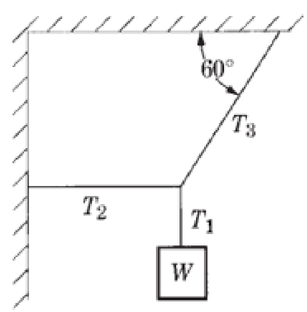
7. A mass m moves on a curved path from point X to point Y. Which of the following diagrams indicates a possible combination of the net force F on the mass, and the velocity v and acceleration a of the mass at the location shown?



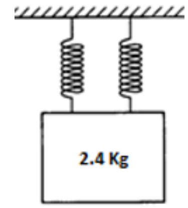
8.

A system in equilibrium consists of an object of weight W that hangs from three ropes, as shown above. The tensions in the ropes are T_1, T_2, and T_3. Which of the following are correct values of T_2 and T_3?

	T_2	T_3
(A)	$W \tan 60°$	$\frac{W}{\cos 60°}$
(B)	$W \tan 60°$	$\frac{W}{\sin 60°}$
(C)	$W \tan 60°$	$W \sin 60°$
(D)	$\frac{W}{\tan 60°}$	$\frac{W}{\cos 60°}$
(E)	$\frac{W}{\tan 60°}$	$\frac{W}{\sin 60°}$

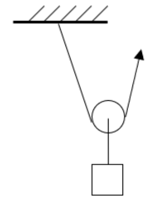


9. Two identical massless springs are hung from the ceiling. The springs suspend a block of mass 2.4 kg, as shown above. When the block is in equilibrium, each spring is stretched an additional 0.3 meters. The force constant of each spring is most nearly:



(A) 40 N/m (B) 48 N/m
(C) 60 N/m (D) 80 N/m (E) 96 N/m

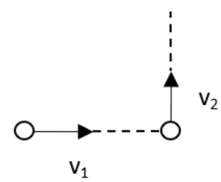
10. As shown in the diagram right. With two lifting ropes, the object remains stationary. If we increase the angle between the two ropes, the tension force of the rope will be:

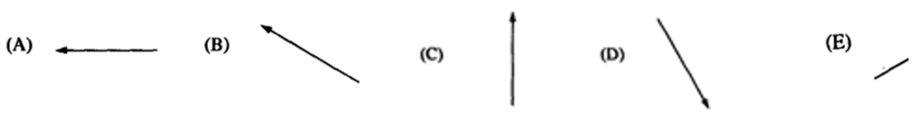


(A) keep same (B) increase
(C) decrease (D) None of the above answer is correct

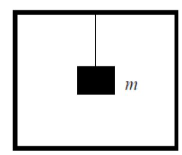
11. A ball of mass m falls in the presence of air resistance. The resistive force is represented by $F=bv^2$ where b is a constant and v represents the ball's velocity. The acceleration of the ball is most nearly
(A) mg/v (B) b-g (C) $g-bv^2/m$ (D) bv+g/m (E) bvg

12. A ball moves horizontally with an initial velocity v_1, as shown above. It is then struck by a tennis racket. After leaving the racket, the ball moves vertically with a velocity v_2, which is smaller in magnitude than v_1. Which of the following vectors best represents the direction of the average force that the stick exerts on the ball?



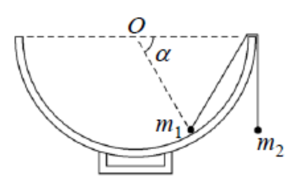


13. A mass m is suspended by a string of negligible weight from the roof of an elevator. The elevator is accelerating upwards with acceleration of magnitude a. The acceleration due to gravity is g. What is the tension in the string?



(A) mg (B) g + a (C) m(g + a)
(D) m(g – a) (E) ma

14. As shown in the figure, a hemispherical bowl is placed horizontally on a table. Point-O is the center of the hemisphere. The edge and the surface of the bowl are smooth. A particle of mass m_1 is placed in a bowl and is tied to a string with negligible mass. The other end of the string is tied to another particle of mass m_2 hanging outside the bowl. When the system is in equilibrium, the line joining the particle m1 and Point-O makes an angle $\alpha = 60^o$ with the horizontal. Find the ratio m_1/m_2.



(A) 0.71 (B) 0.87 (C) 1.15 (D) 1.41 (E) 1.73

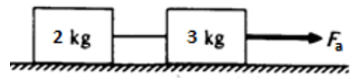
15. We have seen on TV how the astronauts were trained in weightless condition in a large airplane. To achieve weightless condition the plane should ___.
(A) Dive downwards at constant velocity
(B) Dive downwards at constant acceleration that is equal to g
(C) Accelerate in horizontal direction
(D) Move upwards at constant velocity
(E) Move upwards at constant acceleration that is equal to g

Answer:

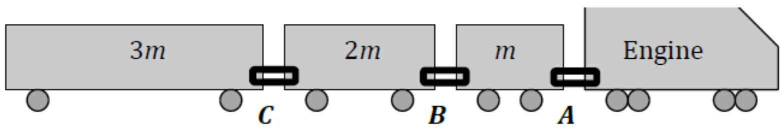
1. B
2. E
3. D
4. E
5. A
6. C
7. B
8. E
9. A
10. B
11. C
12. B
13. C
14. E
15. B

2. Multiple Objects Practice

1. When the frictionless system shown right is accelerated by an applied force of magnitude Fa, the tension in the string between the blocks is
(A) 2 Fa (B) Fa (C) (3/5) Fa (D) (2/5) Fa (E) 3 Fa



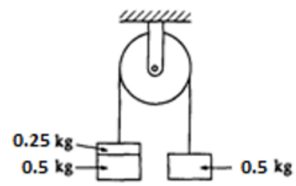
2.



A locomotive engine of unknown mass pulls a series of railroad cars of varying mass: the first car has mass m, the second car has mass $2m$, and the last car has mass $3m$. The cars are connected by links A, B, and C, as shown. Which link experiences the greatest force as the train accelerates to the right?

a. A
b. B
c. C
d. Which link depends on the mass of the engine.
e. A, B, and C all experience the same force.

3. Two 0.5-kilogram blocks are connected by a string that passes over a frictionless pulley, as shown above. The blocks are initially held at rest. If a third block with a mass of 0.25 kilograms is added on top of one of the 0.5-kilogram blocks as shown and the objects are released, the magnitude of the acceleration of the 0.25-kilogram object is most nearly



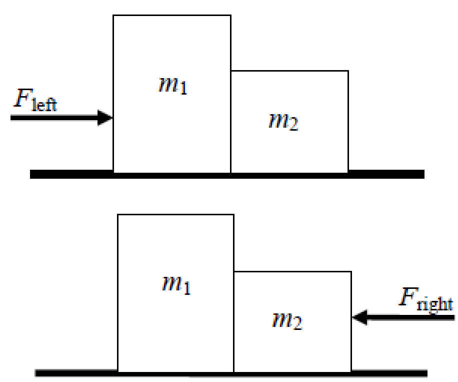
(A) 10.0 m/s^2 (B) 6.0 m/s^2 (C) 4.0 m/s^2 (D) 2.0 m/s^2 (E) 1.0 m/s^2

4. As shown, two blocks are pushed along a horizontal frictionless surface by a 30 newton force to the right. The force that the 4-kilogram block exerts on the 6-kilogram block is

(A) 8 newtons to the left (B) 8 newtons to the right
(C) 10 newtons to the left (D) 12 newtons to the left (E) 12 newtons to the right

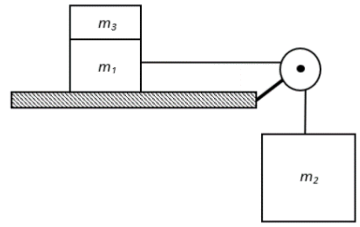
5.

Two blocks with masses m_1 and m_2, with $m_1 > m_2$, are on a horizontal frictionless surface so that they are in contact with each other as shown. A horizontal force is applied from either the left or the right. The magnitudes of the forces are the same so that the result is a horizontal acceleration of the two blocks to the right or to the left. The magnitude of the contact force between the blocks m_1 and m_2 is



(A) larger when the force is from the right.
(B) larger when the force is from the left.
(C) the same in both cases.
(D) impossible to determine from the information given.

Questions 6-9



The system above consists of three blocks, m_1, m_2 and m_3 where m_1 and m_2 are attached to a virtually massless cord and m_3 sits on top of m_1. The system is attached to a massless pulley and accelerates downward. There is no friction between the surface and m_1, however there is friction between the m_1 and m_3. The coefficient of kinetic friction is μ however the coefficient of static friction is not given. Block m_3 does not slide off of block m_1.

6. Find the acceleration of m2
(A) $m_1g/(m_2+m_3)$ (B) $(m_1+m_2+m_3)/m_2g$ (C) $m_2g/(m_1+m_2+m_3)$
(D) $(m_1+m_3)g/m_2$ (E) $(m_1+m_3)/m_2g$

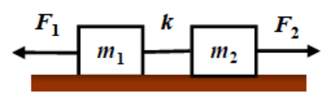
7. What coefficient of static friction must there be in order for m_3 not to slide off of block m1?
(A) $m_2/(m_1+m_2+m_3)$ (B) $m_1/(m_2+m_3)$ (C) $(m_1+m_3)/m_2$
(D) $(m_1+m_2+m_3)/m_2$ (E) $m_3/(m_1+m_2+m_3)$

Now block m_3 begins to slide off block m_1.

8. Find the acceleration of block m_3.
(A) $\mu g(m_1+m_2+m_3)/m_3$ (B) $\mu m_3g/m_1$ (C) μg
(D) $\mu g(m_1+m_3)/m_2$ (E) $\mu g m_3/(m_1+m_2+m_3)$

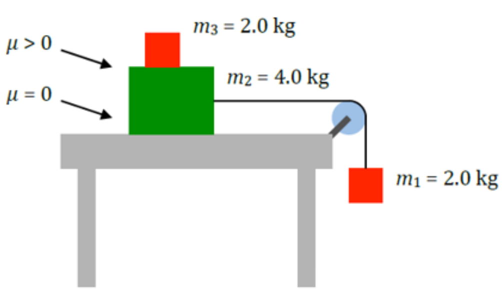
9. What is the acceleration of block m_2?
(A) $(m_2-\mu m_3)g/(m_1+m_2)$ (B) $m_2g/\mu(m_1+m_3)$ (C) $(m_1+m_2+m_3)\mu/3m_1g$
(D) $(m_1+m_3)\ \mu g$ (E)$(m_1+m_3)g/\mu(m_1+m_2+m_3)$

10. As shown in the figure, two blocks of masses m1 and m2 are connected by a light spring and are placed on a horizontal smooth surface. Forces of magnitude F1 and F2 act on them respectively, causing them to move linearly. The force constant of the light spring is k, and F1 > F2. What is the extension x of the light spring?



(a) $\dfrac{F_1m_1+F_2m_2}{k(m_1+m_2)}$ (b) $\dfrac{F_1m_2+F_2m_1}{k(m_1+m_2)}$ (c) $\dfrac{|F_1m_2-F_2m_1|}{k(m_1+m_2)}$ (d) $\dfrac{|F_1m_1-F_2m_2|}{k(m_1+m_2)}$ (e) $\dfrac{F_1m_1+F_2m_2}{k|m_1-m_2|}$

11.



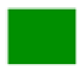
Blocks $m_1 = 2.0$ kg and $m_2 = 4.0$ kg are connected by a thin, light cord which is draped over a light pulley so that mass m_1 is hanging over the edge of the pulley as shown. The surface between m_2 and the table is essentially frictionless, but there is friction between m_2 and m_3, which has a mass of 2.0 kg and is resting on top of m_2.

a. Block m_2 is initially held so that it doesn't move. What is the Tension in the cord attached to m_1?

b. Block m_2 is now released, and it accelerates so that m_3 does not slip, and remains in place atop m_2.

   i. What is the acceleration of mass m_2?

   ii. Draw a free-body diagram of mass m_2, with vector arrows originating at the location where the force is applied.



   iii. What is the Tension in the cord attached to m_1 now as the system accelerates?

   iv. What is the minimum static coefficient of friction that can exist between m_2 and m_3 based on this situation? Explain your reasoning.

   v. If the coefficient of static friction between m_2 and m_3 is 0.50, what is the maximum mass that m_1 can have so that m_3 will accelerate without sliding?

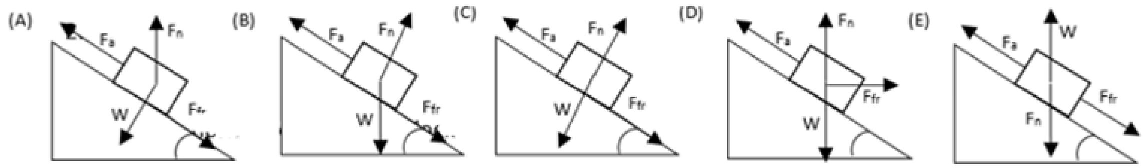
Answer:

1. D
2. A
3. D
4. D
5. A
6. C
7. A
8. C
9. A
10. B
11. a. 19.6N
    b. i. $2.45 m/s^2$
       ii. 5 forces
       iii. 14.7N
       iv. 0.25
       v. 6kg

3. Object on the Slope Practice

A 60-newton force is pushing a 5 kg box is being pushed up an incline at a 53° angle (cos53°=0.6, sin53°=0.8). The coefficient of kinetic friction is 0.5. (Questions 1 - 3)

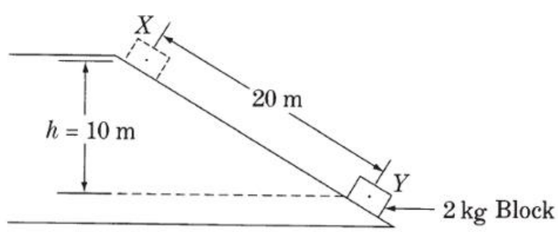
1. Which diagram best represents the block's weight W, normal force F_n and the friction force F_r on the block?



2. The normal force on the block is
   (A) 10 N (B) 20 N (C) 30 N (D) 40 N (E) 50 N

3. Calculate the block's acceleration as it moves up the incline
   (A) 0.5 m/s^2 (B) 1.0 m/s^2 (C) 2.9 m/s^2 (D) 3.5 m/s^2 (E) 4.2 m/s^2

Question 4 and 5



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.

4. 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

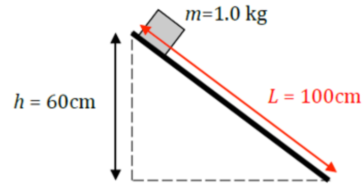
5. The speed of the block at point Y is most nearly

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

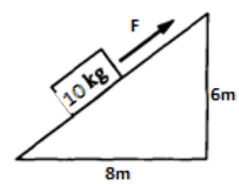
6.

To determine the coefficient of friction between a block of mass 1.0kg and a 100cm long surface, an experimenter places the block on the surface and begins lifting one end. The block just begins to slip when the end of the surface has been lifted 60cm above the horizontal. The static coefficient of friction between the block and the surface is most nearly

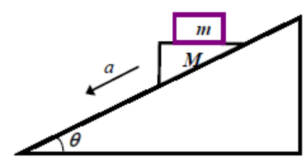
a. 0.60
b. 0.75
c. 0.90
d. 1.05
e. 1.20



7. A 10 kilogram block lies on an inclined plane, as shown above. The incline is 8 meters wide and 6 meters tall. The coefficient of friction between the plane and the block is 0.3. The magnitude of the force F necessary to move the block up the plane with constant speed is most nearly
(A) 64 N (B) 76 N (C) 82 N (D) 90 N (E) 108 N

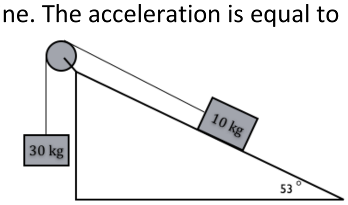


8. As shown in the figure, a wedge of mass M is placed on a smooth inclined ramp that makes an angle ϑ to the horizontal. An object of mass m rests on top of the wedge. The system is sliding down the ramp at acceleration a. Determine the apparent weight of the object as it slides down. Note that there is friction between the object and the wedge so that the object remains relatively at rest on the wedge.



(a) $mg\cos\theta$ (b) $mg\cos^2\theta$ (c) $mg\sin\theta\cos\theta$ (d) $mg\tan\theta$ (e) mg

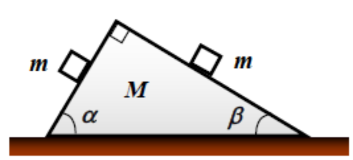
A 30 kg block and 10 kg block are set up on an incline plane using a pulley system (Friction is not negligible). The 30 kg block accelerates downward while the 10 kg block is accelerating up the incline. The acceleration is equal to 2m/s2. (Question 8 & 9)



9. Determine the tension in the string.
(A) 200 N (B) 210 N (C) 220 N
(D) 230 N (E) 240 N

10. Determine the friction force acting on the 10 kg block.
(A) 75 N (B) 100 N (C) 140 N (D) 160 N (E) 175 N

11. As shown in the figure, a triangular wooden block of mass M is fixed on a horizontal table. Its top angle is 90°, and the base angles are α and β. Two small pieces of wood, each of mass m, are located on the inclined smooth surfaces. When the wood pieces slide down the inclined surfaces, what is the normal force acting on the table by the triangular block?



(A) Mg (B) 2mg (C) Mg+mg (D) Mg+2mg (E) Mg+mg(sin α + sin β)

Answer:

1. B
2. C
3. B
4. E
5. C
6. B
7. C
8. B
9. E
10. C
11. C