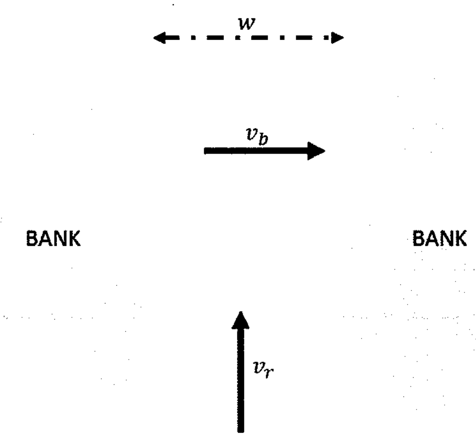
The next two questions pertain to the situation described below.

A boat is crossing a river with a speed v_b = 8.3 m/s relative to the water.

The river is flowing at a speed v_r = 2 m/s and has a width W = 750 m.



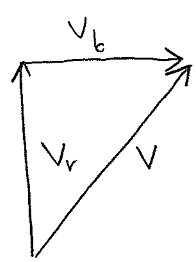
1) How much time is required to cross the river?

a. t = 93.1 s
b. t = 90.36 s
c. t = 87.85 s
d. t = 119.05 s
e. t = 72.82 s

$$d = vt \Rightarrow t = \frac{d}{v} = \frac{W}{v_b} = \frac{750\ m}{8.3\ m/s} = 90.36\ s$$

2) What is the speed of the boat relative to ground?

a. v = 10.3 m/s
b. v = 21.35 m/s
c. v = 8.54 m/s
d. v = 8.06 m/s
e. v = 6.3 m/s

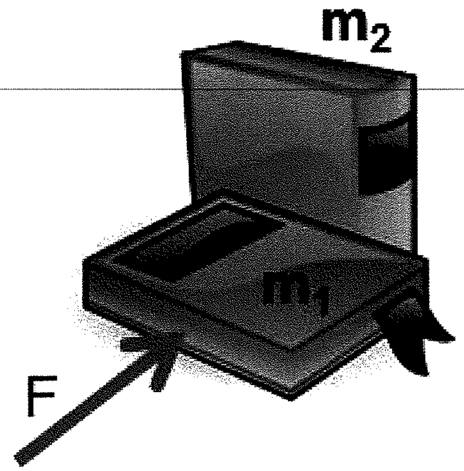


$$v \overset{?}{=} \sqrt{v_r^2 + v_b^2}$$
$$= \sqrt{(2\ m/s)^2 + (8.3\ m/s)^2}$$
$$= 8.54\ m/s$$

3) Consider two books of masses:

$m_1 = 0.3$ kg

$m_2 = 0.9$ kg



placed side by side on a frictionless horizontal surface as shown.

A force $F = 0.32$ N pushes m_1 horizontally. Both books move together.

What is the magnitude of the force exerted by the m_1 book on the m_2 book?

a. $|F_{m_2,m_1}| = 0.08$ N

b. $|F_{m_2,m_1}| = 0$ N

c. $|F_{m_2,m_1}| = 0.24$ N

d. $|F_{m_2,m_1}| = 0.96$ N

e. $|F_{m_2,m_1}| = 0.11$ N

$F = (m_1 + m_2) a \Rightarrow a = \frac{F}{m_1 + m_2} = \frac{0.32 \text{ N}}{(0.3 + 0.9) \text{ kg}}$

$= 0.2667 \text{ m/s}^2$

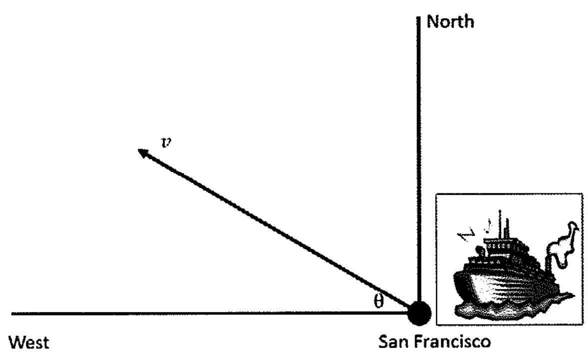
$F_{2,1} = m_2 a$

$= 0.9 \text{ kg} \times 0.2667 \text{ m/s}^2$

$= 0.24$ N

4) A passenger ship leaves San Francisco sailing at $v = 7$ m/s in a direction $\theta = 35°$ North of West as shown.

How long does it take to travel 2×10^3 m West?



a. $t = 285.71$ s

b. $t = 498.13$ s

c. $t = 348.79$ s

$d = vt \Rightarrow t = \frac{d}{v} = \frac{\Delta x}{v_x} = \frac{2 \times 10^3 \text{ m}}{7 \text{ m/s} \times \cos 35°}$

$= 348.79$ s

5) A space ship is coasting through space at v_{ship} = 34 km/s in the x-direction.

The captain fires the engines to produce a constant acceleration a_{engine} = 3.4 km/s^2 in the y-direction.

How far does the ship travel during the first 20 seconds after the engine begins to fire?

a. d = 680.85 km
b. d = 36.88 km
c. d = 961.67 km
d. d = 0 km
e. d = 1360 km

$$d = \sqrt{\Delta x^2 + \Delta y^2}$$

$$\Delta x = V_x t = 34 \text{ km/s} \times 20 \text{ s} = 680 \text{ km}$$

$$\Delta y = \frac{1}{2} a_y t^2 = \frac{1}{2} 3.4 \text{ km/s}^2 (20 \text{ s})^2 = 680 \text{ km}$$

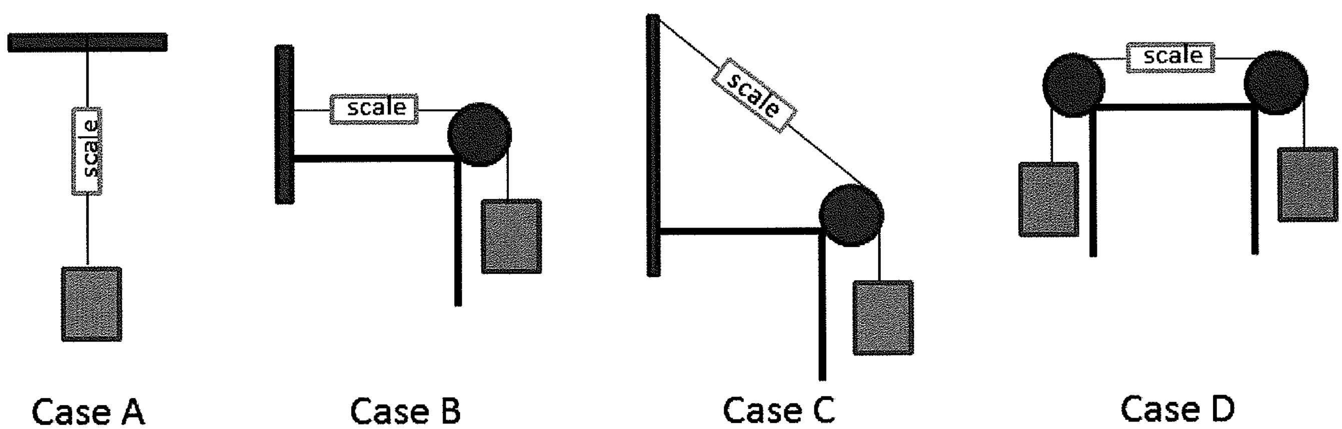
$$d = \sqrt{(680 \text{ km})^2 + (680 \text{ km})^2} = 961.66 \text{ km}$$

6) Consider the four situations shown.

All blocks are stationary and have the same weight hanging from the strings shown.

The circles are very light, frictionless pulleys. The scale measures the tension force of the string.

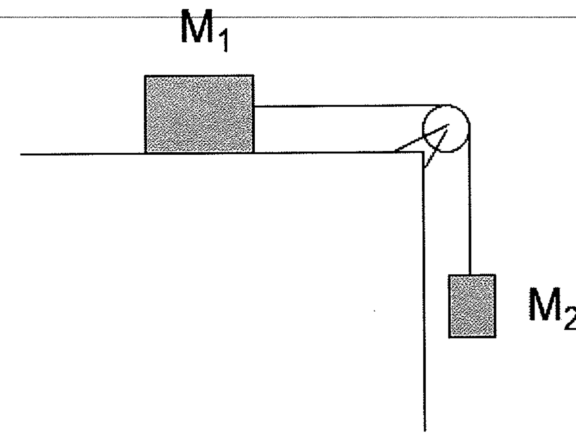
In which case does the scale measure the largest tension?



a. In case A
b. In case D
c. The scale measures the same tension in all four cases
d. In case C
e. In case B

The next three questions pertain to the situation described below.

Consider two blocks:



$M_1 = 7$ kg
$M_2 = 2.2$ kg

They are attached to each other by a string which passes over a massless, frictionless pulley.

The surface on which M_1 sits is very slippery so you can consider it frictionless.

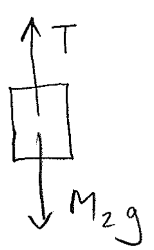
7) What is the magnitude of the acceleration of the masses when released from rest in the configuration shown in the diagram?

a. $|a| = 3.08 \text{ m/s}^2$
b. $|a| = 2.34 \text{ m/s}^2$
c. $|a| = 4.76 \text{ m/s}^2$
d. $|a| = 4.49 \text{ m/s}^2$
e. $|a| = 3.23 \text{ m/s}^2$

$$F = ma \Rightarrow a = \frac{F}{m} = \frac{M_2 g}{M_1 + M_2}$$
$$= \frac{2.2 \text{ kg} \times 9.8 \text{ m/s}^2}{(2.2 + 7) \text{ kg}}$$
$$= 2.34 \text{ m/s}^2$$

8) Which expression below best describes the tension in the string attached to M_2?

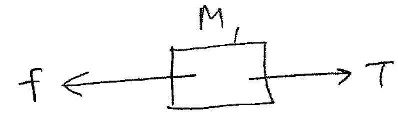
a. $T = M_2 g$
b. $T > M_2 g$
c. $T < M_2 g$



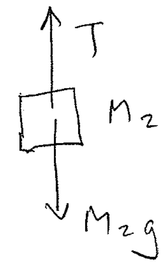
$$T - M_2 g = -M_2 a$$
$$T = M_2 g - M_2 a < M_2 g$$

9) Now suppose that the surface is sprayed with a material that creates friction between M_1 and the surface. When released, it is now observed that the system remains at rest.

Which statement(s) about the frictional force is(are) true?



- Statement A: The frictional force is equal to $\mu_s M_1 g$
- Statement B: The frictional force is equal to the tension in the string
- Statement C: The frictional force is equal to $M_2 g$



a. Among Statements A, B and C, only two of them are true - B and C

b. All three statements above are true

c. Statement C

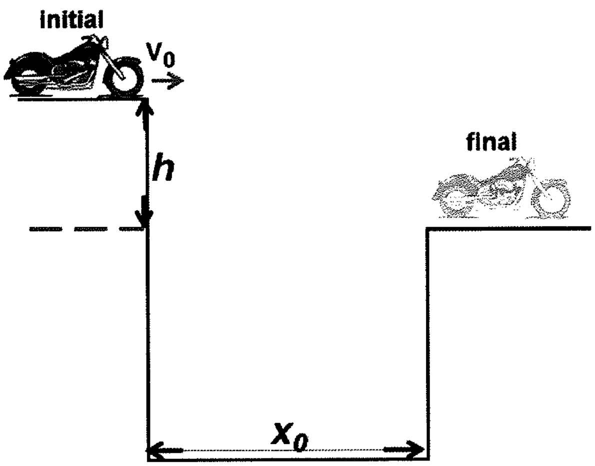
d. Statement A

e. Statement B

$T = M_2 g$

The next two questions pertain to the situation described below.

Consider a motorcycle jumping between two buildings separated by a distance $x_0 = 16$ m. The difference in heights of the buildings is $h = 6$ m.



10) What initial horizontal velocity v_0 must the motorcycle have to just make it to the other building?

$$d = vt \Rightarrow x_0 = v_0 t$$

$$y = y_0 - \frac{1}{2} g t^2 \Rightarrow y - y_0 = -h = -\frac{1}{2} g t^2$$

a. $v_0 = 14.46$ m/s
b. $v_0 = 9.56$ m/s
c. $v_0 = 18.07$ m/s
d. $v_0 = 10.84$ m/s
e. $v_0 = 12.65$ m/s

$$h = \frac{1}{2} g \left(\frac{x_0}{v_0}\right)^2$$

eliminate t

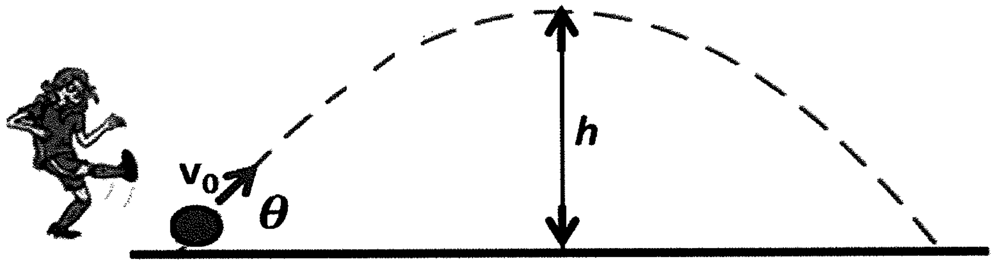
$$\Rightarrow v_0 = \sqrt{\frac{1}{2} g \frac{x_0^2}{h}} = \sqrt{\frac{1}{2}\, 9.8\, \mathrm{m/s^2}\, \frac{(16\ \mathrm{m})^2}{6\ \mathrm{m}}} = 14.46\ \mathrm{m/s}$$

11) The final horizontal speed on impact (when motorcycle lands on lower building) is

a. smaller than v_0
b. the same as v_0
c. larger than v_0

The next three questions pertain to the situation described below.

A soccer player kicks the soccer ball with an initial speed v_0 = 9 m/s at an angle $\theta = 37^\circ$ with respect to the horizontal as shown.



12) Find the maximum height h of the ball's trajectory

$$v_y^2 = v_{y_0}^2 - 2gh \Rightarrow h = \frac{v_{y_0}^2}{2g} = \frac{(9\ m/s\ \sin 37^\circ)^2}{2 \times 9.8\ m/s^2}$$
$v_y = 0$
$$= 1.5\ m$$

a. h = 4.13 m
b. h = 2.64 m
c. h = 1.5 m

13) What is the speed of the ball v at the maximum height

$$V = V_{x_0} = 9\ m/s\ \cos 37^\circ = 7.19\ m/s$$

a. v = 7.19 m/s
b. v = 5.42 m/s
c. v = 6.3 m/s
d. v = 9 m/s
e. v = 7.79 m/s

14) The direction of the velocity of the ball v at the maximum height is

a. vertical
b. part vertical, part horizontal
c. horizontal

The next two questions pertain to the situation described below.

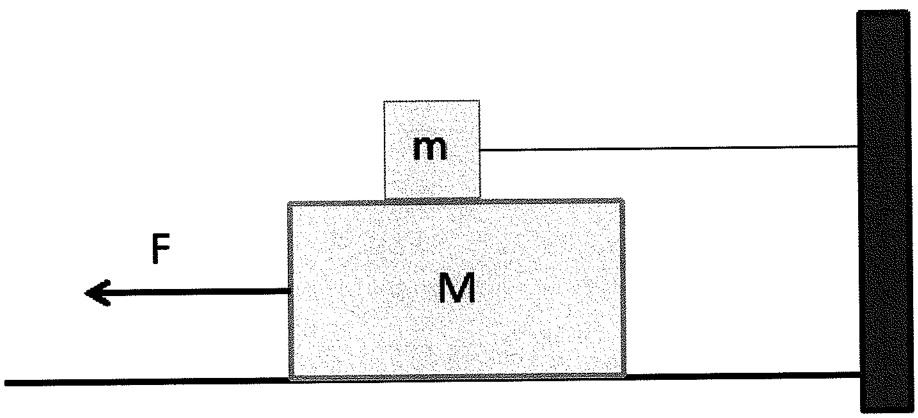
Consider the situation shown.

Block M is pulled toward the left with a force of F = 70 N and <u>moves at a constant speed</u>.

There is no friction at the surface between the two masses **but there is friction** between M and the floor.

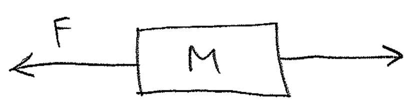
Block m does not move since it is attached to a wall by a string. Use

m = 11 kg
M = 17 kg.



15) What is the coefficient of kinetic friction between M and the floor?

a. 0.26
b. 0.42
c. 0.026
d. 0.65
e. 0.039



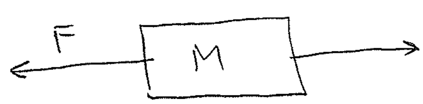
$f = \mu_K N = \mu_K (M+m) g$

$F = \mu_K (M+m) g \Rightarrow \mu_K = \dfrac{F}{(M+m) g} = \dfrac{70\ N}{(17+11)\ kg \times 9.8\ m/s^2} = 0.26$

16) Suppose now that there is no friction between M and the floor but that there is friction at the surface between m and M.

How would the coefficient of kinetic friction between the two blocks now compare to the value you found between M and the floor in the previous problem?

a. $\mu_{now} > \mu_{previous}$
b. $\mu_{now} < \mu_{previous}$
c. $\mu_{now} = \mu_{previous}$



$f = \mu_{now} N = \mu_{now} mg$

$F = \mu_{now} mg$ vs. $F = \mu_{previous} (M+m) g$

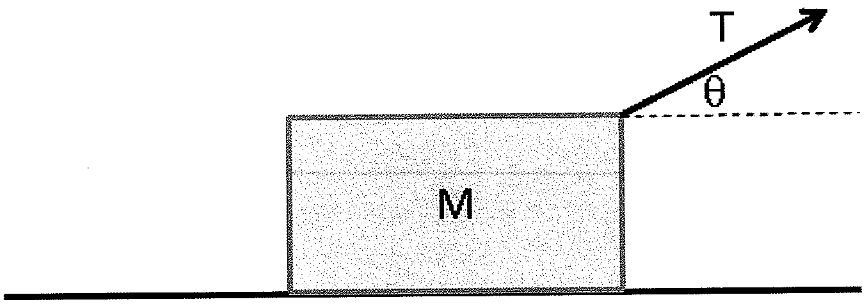
$\Rightarrow \mu_{now} > \mu_{previous}$

The next two questions pertain to the situation described below.

A crate sits on a frictionless surface and a tension force is applied to it.

The tension (by means of a string) is applied at an angle $\theta = 30^0$ to the horizontal.

The magnitude of the tension force is T=18 N, and the crate has mass M=35 kg.



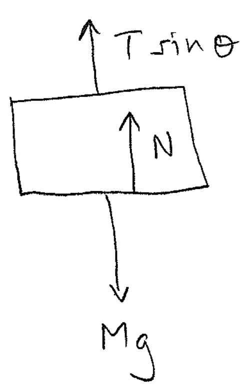
17) What is the magnitude of the acceleration of the crate?

$F = ma \Rightarrow a = \frac{F}{m} = \frac{T_x}{M} = \frac{18\ N \cos 30}{35\ kg} = 0.445\ m/s^2$

a. 0.257 m/s^2
b. 0.514 m/s^2
c. 0.642 m/s^2
d. 0.445 m/s^2
e. 0.321 m/s^2

18) Which relationship below best describes the magnitude of the normal force that the surface exerts on the crate?

a. $N = Mg$
b. $N > Mg$
c. $N < Mg$

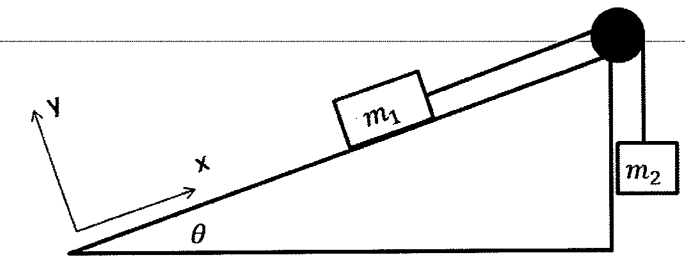


$N + T\sin\theta = Mg$

$N = Mg - T\sin\theta < Mg$

19) The two blocks shown are not moving.

~~There is friction between m_1 and the incline~~ surface.



Which statement below most accurately describes the direction of the friction force on m_1?

a. The friction force on m_1 points up the plane (along the positive x-axis)

b. The friction force on m_1 could point up the plane or down the plane, depending on the value of the masses, m_1 and m_2.

c. The friction force on m_1 points down the plane (along the negative x-axis)

20) You stand on a scale inside of an elevator.

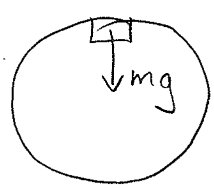
In which of the following situations is the reading on the scale the lowest?

a. The elevator is going up and is slowing down
b. The elevator is going up and is speeding up
c. The elevator is going at a constant speed

21) Simone (mass 50 kg) is riding on a roller coaster. The roller coaster moves at constant speed throughout the ride.

Unfortunately, the attendant forgot to lock her in before the roller coaster departed, and now she is headed for a loop of radius R= 20 m.

What is the minimum speed of the roller coaster on top of the loop such that Simone does not fall out at the top of the loop? (Hint: The normal force between Simone and her seat is 0 N at the top of the loop!)



$$F = ma = \cancel{m}\frac{v^2}{R} \Rightarrow v = \sqrt{gR}$$

$$\cancel{m}g$$

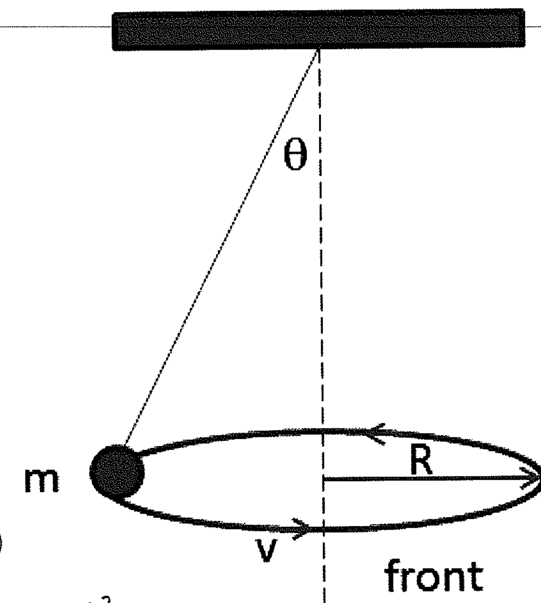
$$= \sqrt{9.8\ m/s^2 \times 20\ m}$$

$$= 14\ m/s$$

a. v = 14 m/s
b. v = 0.7 m/s
c. v = 2.04 m/s

The next two questions pertain to the situation described below.

A ball of mass m = 4 kg is attached to a string. The other end of the string attached to a ceiling. The ball is set in motion in such a way that it traces a horizontal circle. The ball moves at a constant speed of v = 1.7 m/s, as shown in the diagram. The string makes an angle of $\theta = 40^\circ$ with the vertical causing a tension T in the string.



x: $F = ma = m\frac{v^2}{R}$

$\parallel$

$T\sin\theta$ so $T\sin\theta = m\frac{v^2}{R}$

y: $mg = T\cos\theta$ so $T\cos\theta = mg$

$\tan\theta = \frac{v^2}{gR} \Rightarrow R = \frac{v^2}{g\tan\theta} = \frac{(1.7\ m/s)^2}{9.8\ m/s^2 \tan 40} = 0.35\ m$

22) What is the radius of the circle traced out by the mass?

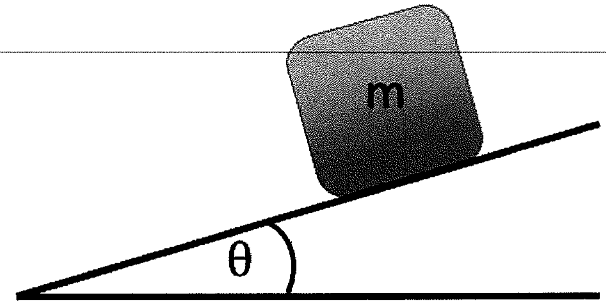
a. R = 1.09 meters
b. R = 0.23 meters
c. You need the length of the string to be able to determine the radius, R.
d. R = 0.19 meters
e. R = 0.35 meters

23) Which statement below is equal to the net force acting on the mass?

a. $F_{net} = mv^2/R$
b. $F_{net} = T - mg$
c. $F_{net} = T$

The next two questions pertain to the situation described below.

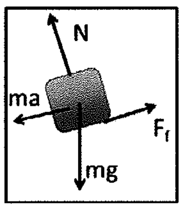
A block of mass m = 4 is initially at rest on a ramp that makes an angle of $\theta = 20^{o}$ with the horizontal, as shown.

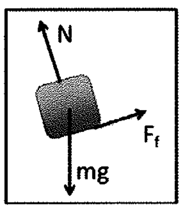


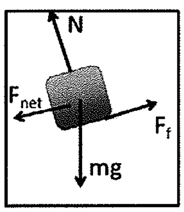
The coefficients of friction between the box and the ramp:

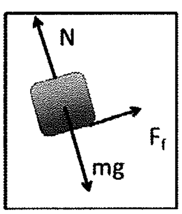
coefficient of kinetic friction: $\mu_k = 0.35$
coefficient of static friction: $\mu_s = 0.7$.

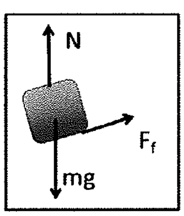
24) Which of the following is the correct free-body diagram of the situation?

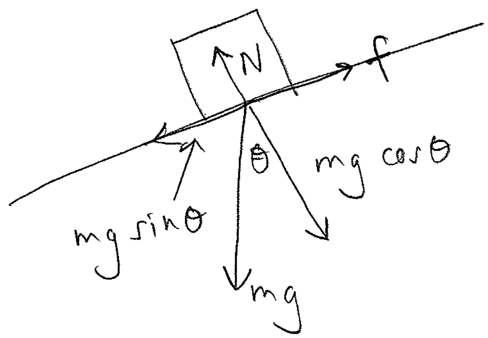
a.


(b)


c.


d.


e.




$f_s^{max} = \mu_s N = \mu_s mg \cos\theta$ Is this enough to prevent block from sliding?

Is $\mu_s \cancel{mg} \cos\theta > \cancel{mg} \sin\theta$?

$\mu_s > \tan\theta$?

$0.7 > \tan 20 = 0.36$ Yes!

So block stays at rest

25) What is the magnitude of the force of friction while the block is at rest on the incline?

a. 25.79 N
b. 13.72 N
c. 12.89 N
d. 27.44 N
e. 13.41 N

$f_s = mg \sin\theta$

$= 4\,kg \times 9.8\,m/s^2 \sin 20$

$= 13.41\,N$