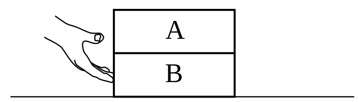
Physics 160-02 Spring 2017   Exam #2

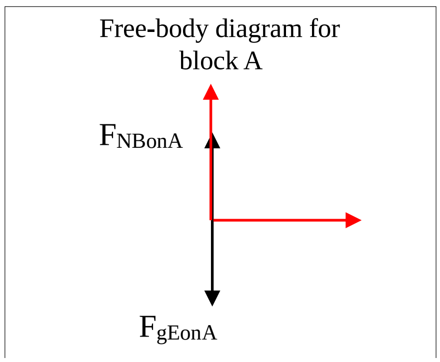
Name:______________________________

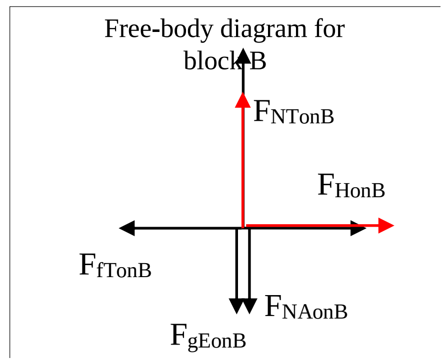
1) Two identical blocks of mass *m* are stacked as shown at right. A hand exerts a constant force to the right on block B. The blocks move to the right with **constant speed**, and block A does not move relative to block B.

Constant speed



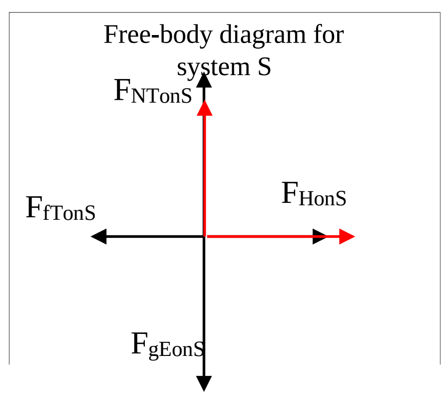
In the spaces provided, draw separate free-body diagrams for blocks A and B. **Clearly label each of the forces in your diagrams, identifying the type of force, the object on which the force is exerted, and the object exerting the force. Both direction and relative magnitude of the force arrows will be graded.**



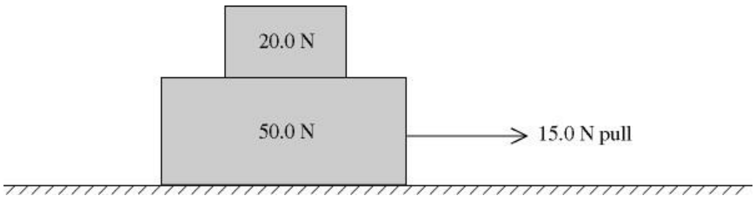


Consider system S, which consists of both blocks together.

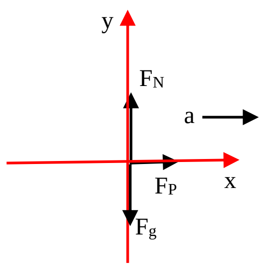
In the space provided, draw and label a free-body diagram for system S.



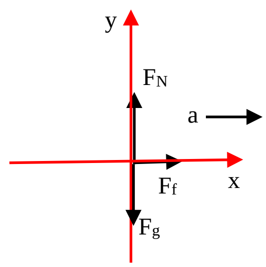
2) A 20.0-N box rests on a 50.0-N box on a perfectly smooth horizontal floor. When a horizontal 15.0-N pull to the right is exerted on the lower box, both boxes move together. Find the magnitude of the net external force on the upper box.



For both blocks together:



For the top block:



For both blocks together,

$$\sum F_x = F_P = Ma_x = \left(\frac{20N + 50N}{9.8\frac{m}{s^2}}\right) a_x \Rightarrow$$

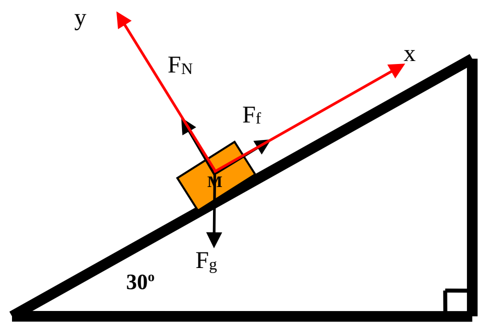
$$a_x = \frac{15N}{70N}\left(9.8\frac{m}{s^2}\right) = 2.1\frac{m}{s^2}$$

For the top block,

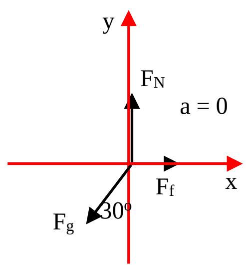
$$\sum F_x = F_f = Ma_x = \frac{20N}{9.8\frac{m}{s^2}}\left(2.1\frac{m}{s^2}\right) \Rightarrow$$

$$F_f = 4.3N$$

3) A block of mass M sits on an inclined plane with a coefficient of static friction of μ_s. What is the force of friction on the block?



For the Block



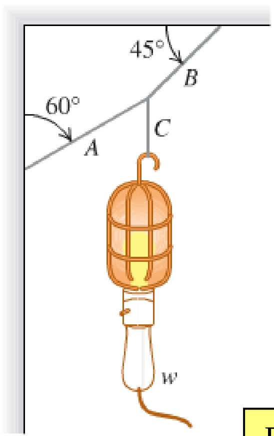
For the block,

$$\sum F_x = F_f - F_g \sin 30^0 = Ma_x = 0$$

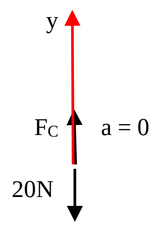
So,

$$F_f = F_g \sin 30^o = Mg \sin 30^o$$

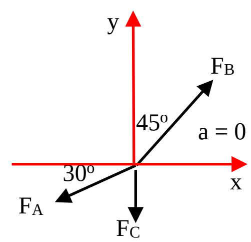
4) Find the tension in each chord in the figure below if the weight of the suspended object is 20N.



For the lamp



For the knot



First, for the lamp, we have only on relevant direction:

$$\sum F_y = F_C - 20N = 0 \Rightarrow$$

$$F_C = 20N$$

Then, for the knot,

$$\sum F_x = F_B \sin 45^0 - F_A \cos 30^0 = ma_x = 0$$

$$\sum F_y = F_B \cos 45^0 - F_A \sin 30^0 - F_C = 0$$

So, from the first of these,

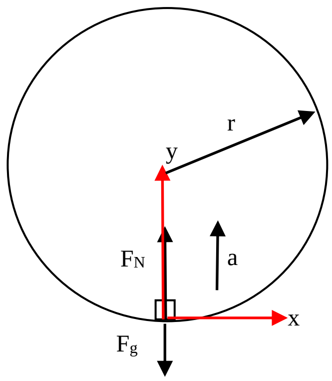
$$F_B = \frac{F_A \cos 30^o}{\sin 45^o} \Rightarrow$$

$$\frac{F_A \cos 30^o}{\sin 45^o} \cos 45^o - F_A \sin 30^o - F_C = 0 \Rightarrow$$

$$F_A = \frac{F_C}{\left[\cos 30^o \cot 45^o - \sin 30^o\right]} = \frac{20N}{0.366} = 54.6N$$

$$F_B = \frac{54.6N \cos 30^o}{\sin 45^o} = 66.9N$$

5) A Ferris wheel (vertical circular ride) has a diameter of 50m and completes one revolution every 45s. If a rider has a mass of 65kg, what is the magnitude of the normal force acting on the rider at the bottom of the ride?

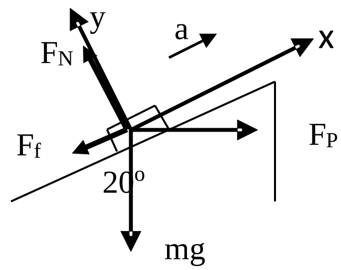


$$\sum F_y = F_N - mg = ma = m\frac{v^2}{r}$$

$$F_N = mg + m\frac{v^2}{r} = mg + m\frac{\left(\frac{2\pi r}{T}\right)^2}{r} = mg + m\frac{4\pi^2 r}{T^2}$$

$$F_N = 65kg\left(9.8\frac{m}{s^2} + \frac{4(3.14)^2\,25m}{(45s)^2}\right) = 670N$$

6) In the figure below, a 100kg box is pushed up a 20° ramp by a ***horizontal*** force F_P. The coefficient of kinetic friction between the ramp and the box is 0.3. If the box is accelerating up the ramp with a = 1m/s², what is the magnitude of the force, F_P?



$$\sum F_x = F_P \cos 20^0 - mg \sin 20^0 - \mu_k F_N = ma_x$$
$$\sum F_y = F_N - mg \cos 20^0 - F_P \sin 20^0 = 0$$
$$F_N = mg \cos 20^0 + F_P \sin 20^0 \Rightarrow$$
$$F_P \cos 20^0 - mg \sin 20^0 - \mu_k \left(mg \cos 20^0 + F_P \sin 20^0 \right) = ma_x$$
$$F_P \left[\cos 20^0 - \mu_k \sin 20^0 \right] = ma_x + mg \sin 20^0 + \mu_k mg \cos 20^0 \Rightarrow$$
$$F_P = \frac{ma_x + mg \sin 20^0 + \mu_k mg \cos 20^0}{\cos 20^0 - \mu_k \sin 20^0}$$
$$F_P = \frac{100kg \cdot 1 m/s^2 + 100kg \cdot 9.8 m/s^2 \cdot \sin 20^0 + 0.3 \cdot 100kg \cdot 9.8 m/s^2 \cdot \cos 20^0}{\cos 20^0 - 0.3 \cdot \sin 20^0}$$
$$F_P = 850N$$

7) A car is going around an un-banked curve of radius 400m when it starts skidding off the road. The policeman at the scene had taken a physics class and knew that the coefficient of static friction between the car and the road was 0.75. What was the speed that the car when it started skidding?

The car is in circular motion, so its acceleration is v^2/r directed towards the center of the arc. The force creating that acceleration is the frictional force between the car and the road, F_f, which can have a maximum value of $\mu_s F_N = \mu_s mg$. So,

$$\Sigma \vec{F} = m\vec{a}$$

$$\mu_s mg = m\frac{v^2}{r} \Rightarrow$$

$$v^2 = \mu_s r g$$

Solving for the velocity gives v = 54.2 m/s.