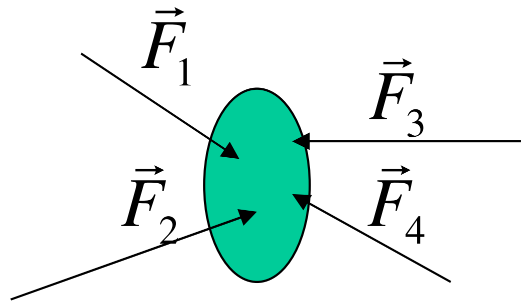
Review: Newton's Laws



Newton's First Law

The velocity of an object does not change unless a force acts on the object

Newton's Second Law: $\mathbf{F}_{net} = m\,\mathbf{a}$

The acceleration of an object is proportional to the net force on the object

Newton's Third Law

For every force an object exerts on a second object, there is an equal and opposite force exerted on the first object

These are equal and opposite forces even if you break the wall or your fist keeps going!

Today: Expanding upon Newton's 2nd Law ($F_{net} = m\,a$)

- Confirming what we know on Gravity
- Normal Force
- Tension
- Making a Free Body Diagram
- The Inclined Plane (Takes practice. Not on next quiz but following one)

Extra Practice Problems: 4.19, 4.21, 4.25, 4.33, 4.35, 4.37, 4.47, 4.51, 4.75

Weight

- Weight is the force due to gravity
- All objects on Earth with mass (nearly everything) are attracted to the surface of the Earth
- If object is close to the Earth's surface:

$$\vec{F}_G = W = m\vec{g}$$

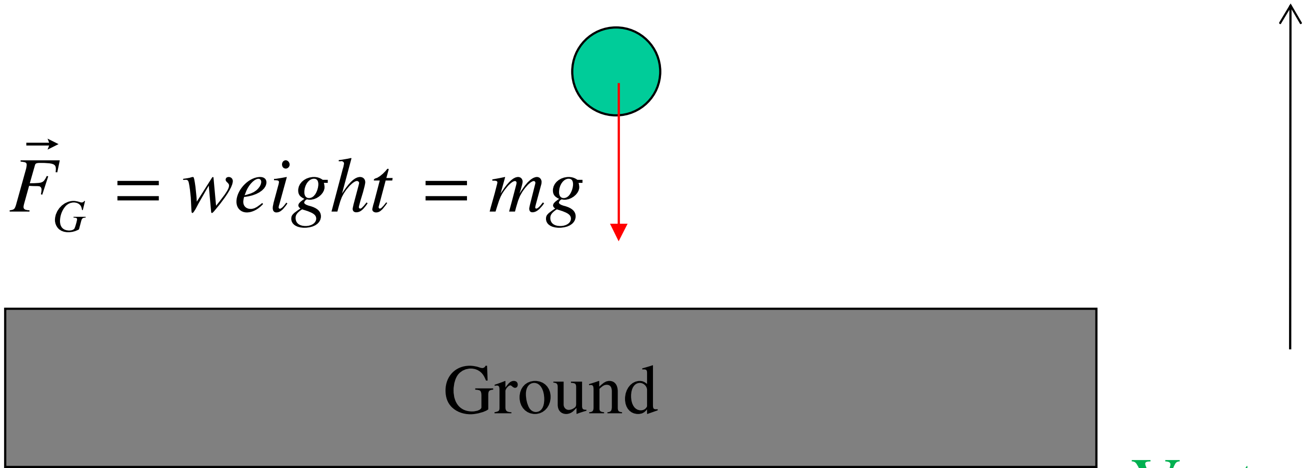
$\vec{g}$ - acceleration of gravity

g is specific to Earth (why weigh less on Mars, $a_{gravity}$ different, ~ 2 m/s^2, based on planet mass&radius)

Direction: towards ground (center of Earth)

Draw a Picture, Label Positive Direction

In other words, weight is the acceleration of a freely falling body (g on Earth) times its mass *m*



$$\vec{F}_G = weight = mg$$

$F_x = 0$ so $a_x = 0$

(same as projectile motion)

Vectors!

Newton's Second Law: $\vec{F}_{\text{net}} = m\vec{a}$ $\quad F_x=ma_x$ and $F_y=ma_y$

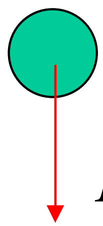
$$\Rightarrow \sum F_y = ma_y \qquad \sum F_y = -F_G = -mg$$

Why negative?

$$\Rightarrow -mg = ma_y \Rightarrow a_y = -g$$

Same as what we learned before

Free-Body Diagrams (FBDs)



$$\vec{F}_G = weight$$

If it doesn't have units of Newtons (kg m/s^2), then it doesn't belong on a FBD! (No velocity or acceleration or even m*a)

- This is known as a free-body diagram (FBD).
- A FBD labels all of the forces acting **on** (not by) an object.
- Only forces acting **on** an object will affect its motion (acceleration).
- FBDs can be much more complex than this.

Movie Physics (do not ignore air resistance)

An 80 kg movie stuntman jumps from a window of a building situated 30 m above a catching net. Assuming an air resistance of 100-N on the stuntman as he falls, determine his velocity just before he hits the net.

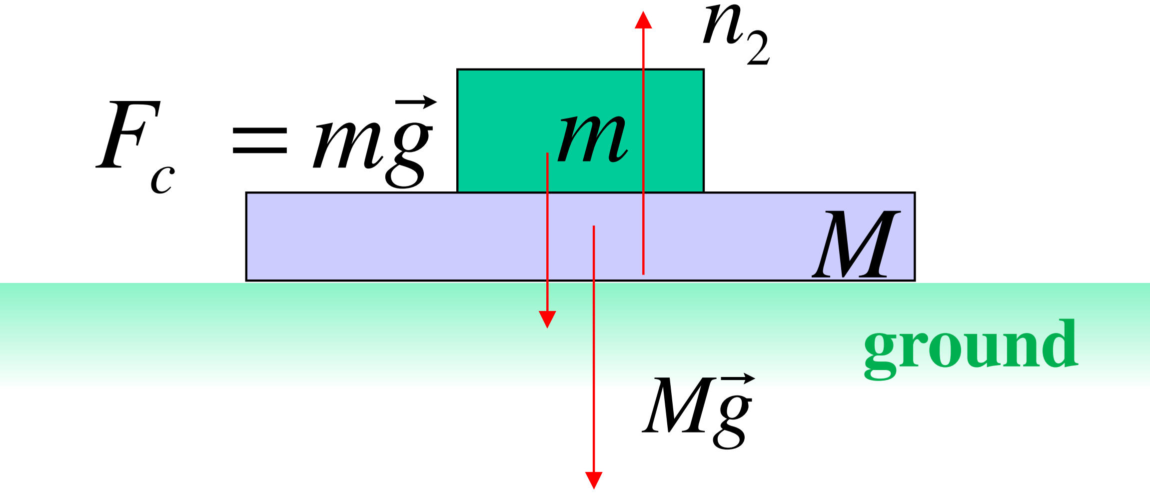
Last 2 Pro tips!
Draw a FBD and
write out $F_x = m\,a_x$ and $F_y = m\,a_y$

How should we approach this problem?

How would we have approached this problem before?

Except for gravity (and electric/magnetic fields, 102), all forces on FBD are in contact with the object.

$F_c = m\vec{g}$



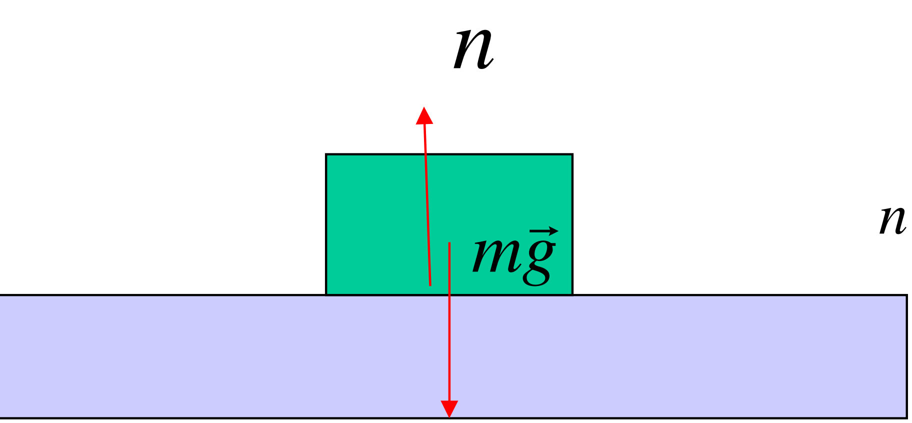
$$\vec{F}_{\text{net}} = m\vec{a}$$

$$\sum F_y = ma_y$$

Box stays at rest means $a_y = 0$

Change in velocity is zero

$$\Rightarrow \sum F_y = 0$$



$n =$ **Force of surface on box, keeps box from falling**

Normal force (**$\mathbf{F_N}$**, **n** or **N**) - contact force

Always perpendicular to surface (wall?)

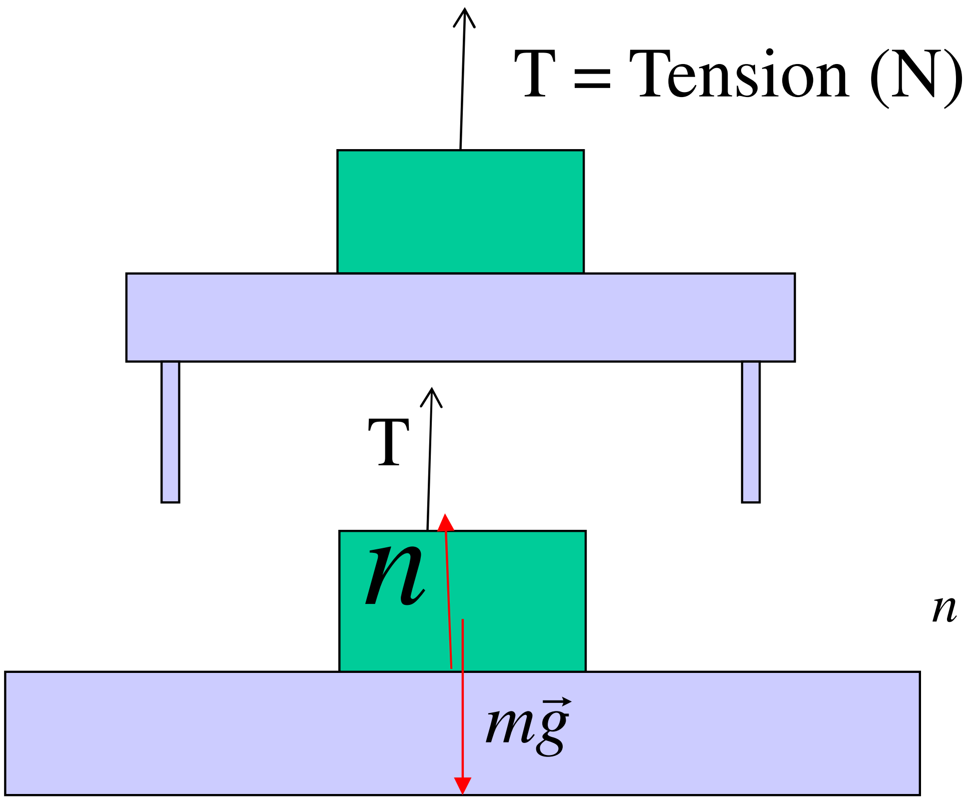
For box at rest (a=0): $\sum F_y = n - mg = 0 \quad \Rightarrow n = mg$

What should be the normal force for big box underneath?

For big box underneath: $\sum F_y = n_2 - mg - Mg = 0 = n_2 - (M + m)g$

Draw a Free-Body Diagram

- Example: box at rest on a surface with a string lightly pulling up on it, but not lifting it off



$$\vec{F}_{\mathbf{net}} = m\vec{a}$$

$$\sum F_y = ma_y$$

Box at rest means $a_y = 0$

$$\Rightarrow \sum F_y = 0$$

$n =$ **Force of table on box, keeps box from falling**

Normal (perpendicular) force - type of contact force

For box at rest: $\sum F_y = T + n - mg = 0$ $\Rightarrow n = mg - T$

What happens if I pull with a tension greater than mg?

Another thing FBDs are good for: Inclined Planes

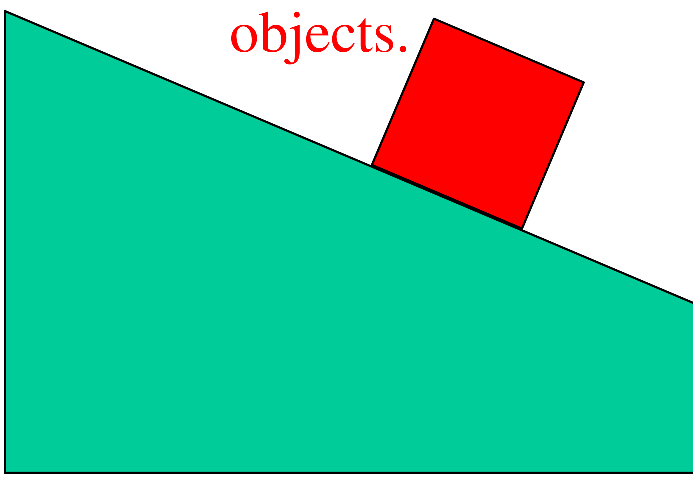
Physics is infamous for sliding blocks down inclined planes

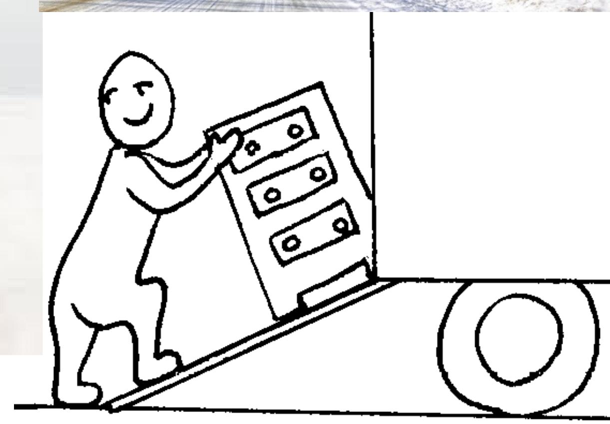
How boring! Why do we study it?

Many things we do involve inclines.

Blocks are an easy way to simplify many complex objects.

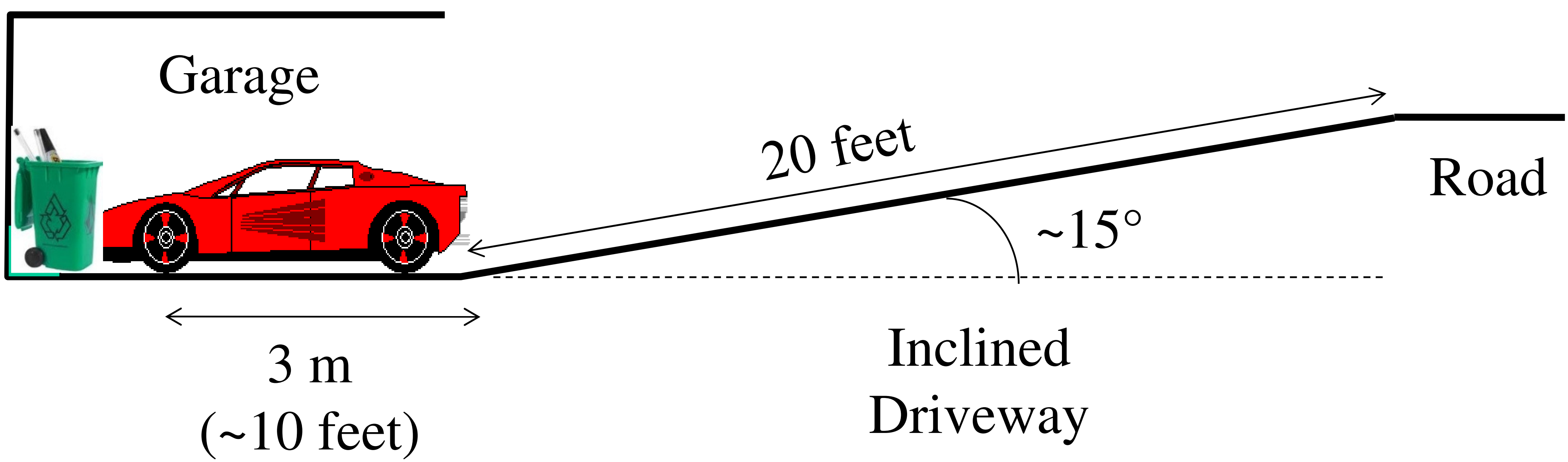
In physics, we approximate things as blocks or round objects.





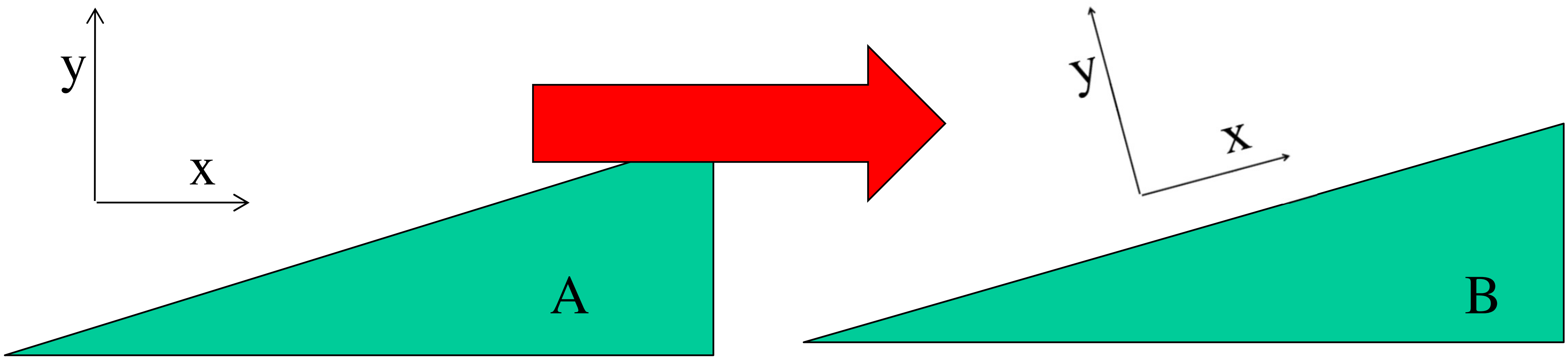
A real example: My Icy Driveway

When my driveway is a sheet of ice (ignore friction), how fast do I need to be driving to get to the top of my driveway?



Making 2 dimensions only 1!

Better, unless if going around an inclined curve (Ch. 7)



Why would I change x and y?

In Case A, need v_x, v_y, Δx, Δy?

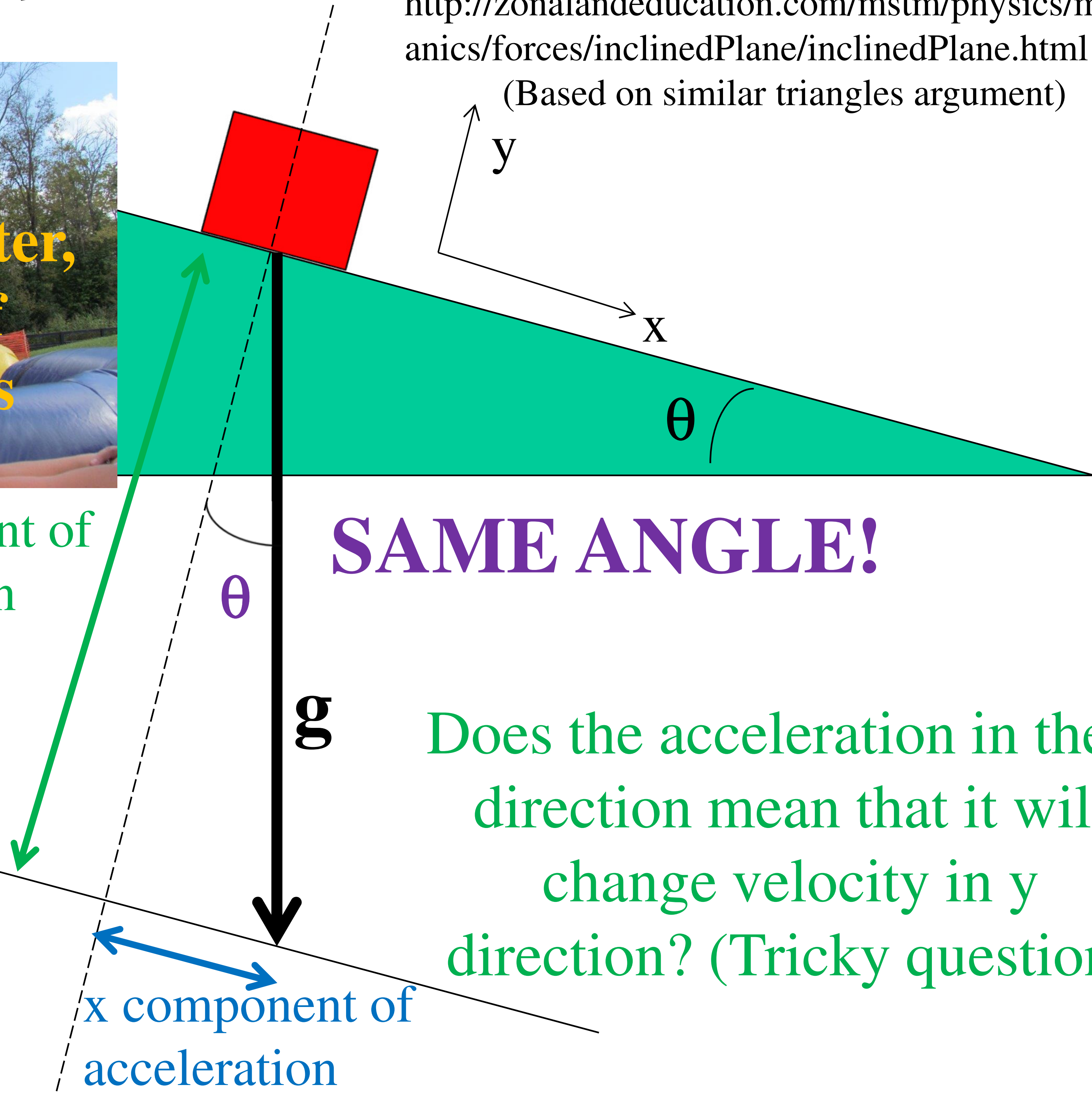
Have to break up the vector components

In Case B: $\Delta y=0$, $v_y=0$

Acceleration changes though: $a_x=\pm 9.8 \sin\theta$

Why $a_{g,x} = \pm 9.8 \, \mathrm{Sin}\theta$?

http://zonalandeducation.com/mstm/physics/mechanics/forces/inclinedPlane/inclinedPlane.html
(Based on similar triangles argument)



Breaking up vector components:

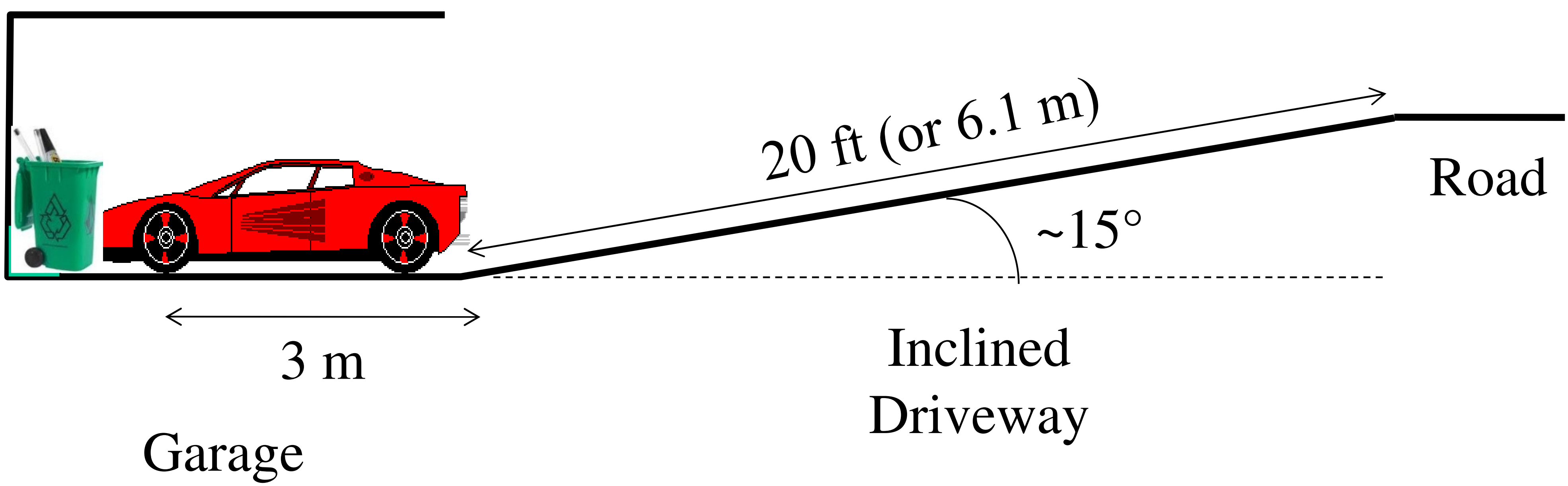
Draw a line parallel to y axis from start of the vector

Draw a line parallel to x axis from end of vector

Does the acceleration in the y direction mean that it will change velocity in y direction? (Tricky question)

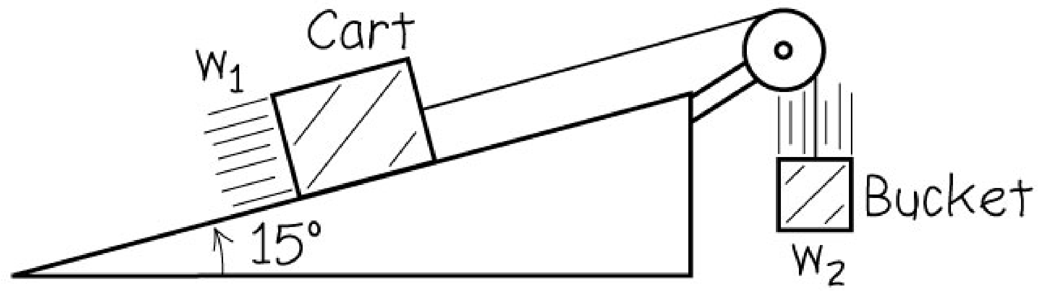
My Icy Driveway

When my driveway is a sheet of ice (ignore friction on slope), (a) how fast do I need to be driving to get to the top of my driveway? (b) Is this feasible on an icy day? (c) Is it feasible if my car was not in a garage?



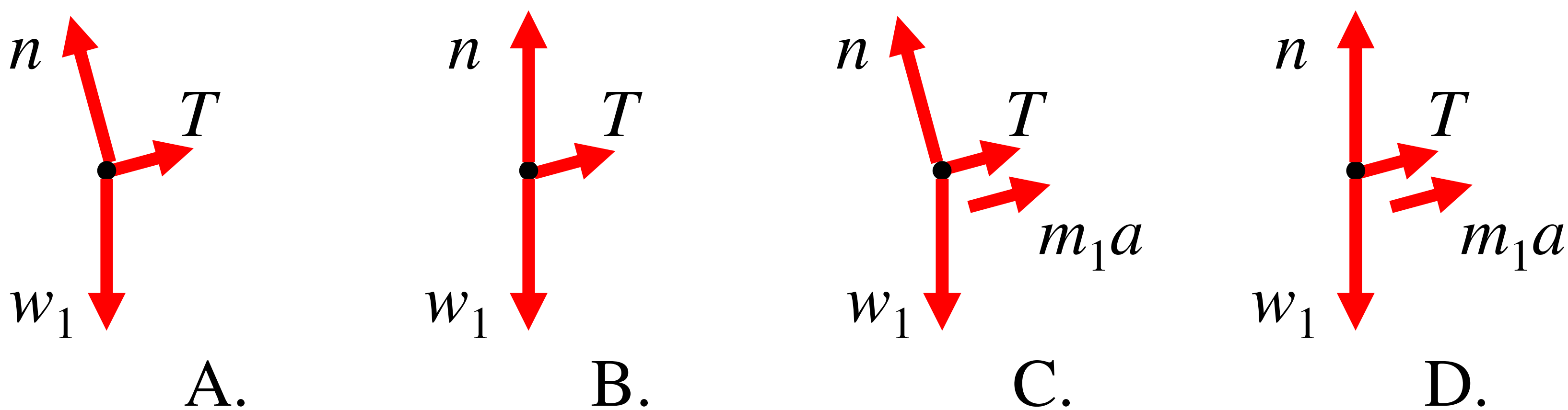
Acceleration of starting for a typical car is only 0.5g. So, how could I get out of my driveway?

A cart (weight w_1) is attached by a lightweight cable to a bucket (weight w_2) as shown. The ramp is frictionless.



When released, the cart accelerates up the ramp.

Which of the following is a *correct* free-body diagram for the *cart?*



Q44

A car engine is suspended from a chain linked at *O* to two other chains. Which of the following tensions *should* be included in the free-body diagram for the engine?

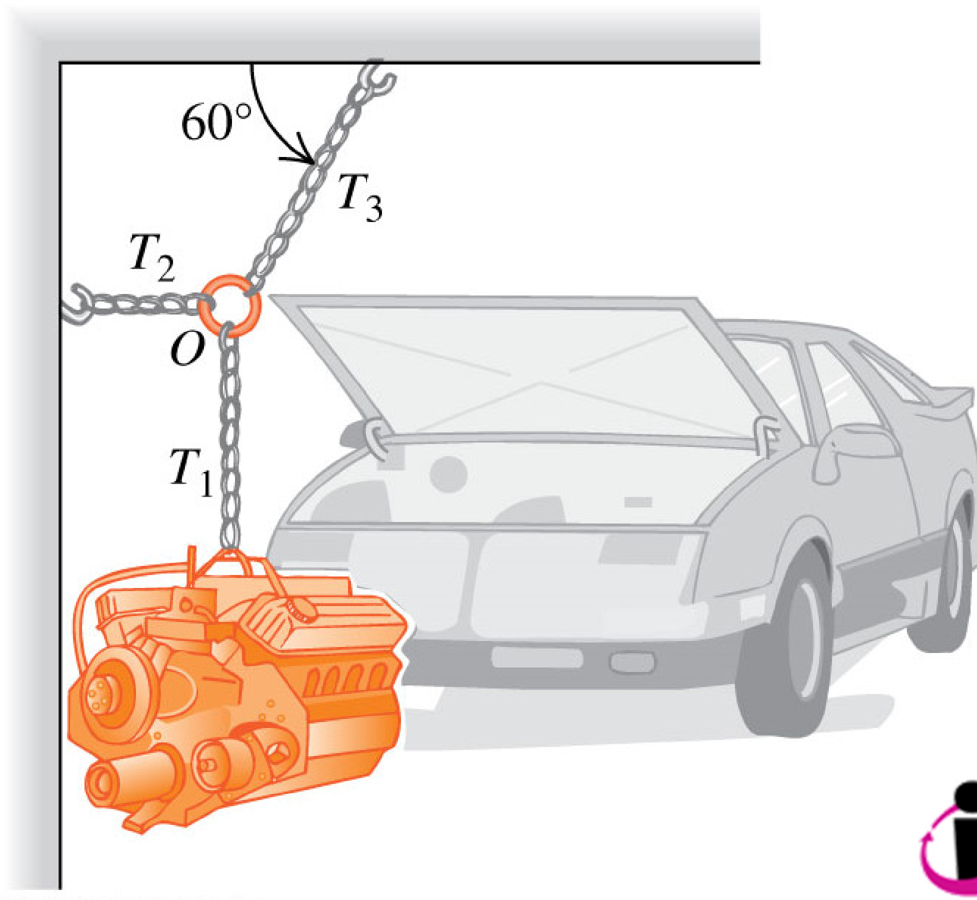
A. tension T_1

B. tension T_2

C. tension T_3

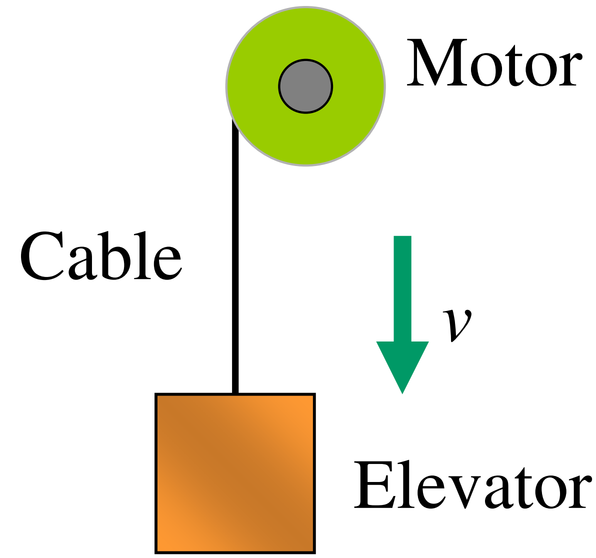
D. two of the above

E. T_1, T_2, and T_3



Q36

An elevator is being lowered at a **constant speed** by a steel cable attached to an electric motor. There is no air resistance, nor is there any friction between the elevator and the walls of the elevator shaft.



The upward force exerted on the elevator by the cable is

A. greater than the downward force of gravity.

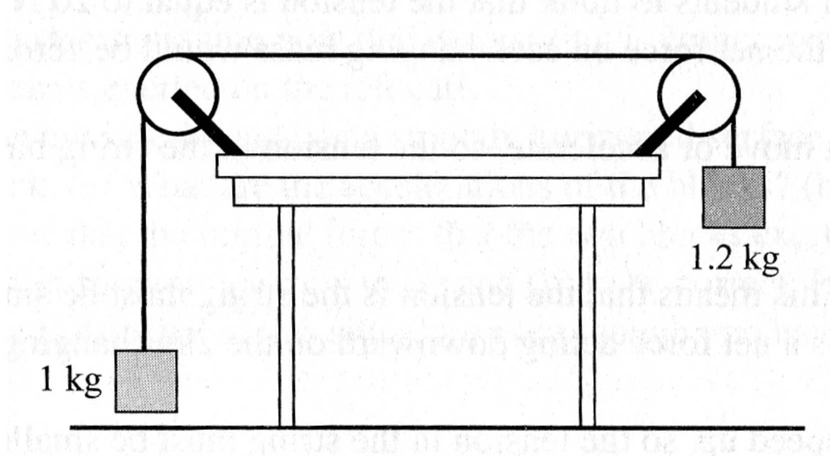
B. equal to the force of gravity.

C. less than the force of gravity.

D. any of the above, depending on the speed of the elevator.

Q37

Two blocks are arranged as shown and kept at rest by holding the 1-kg block in place.



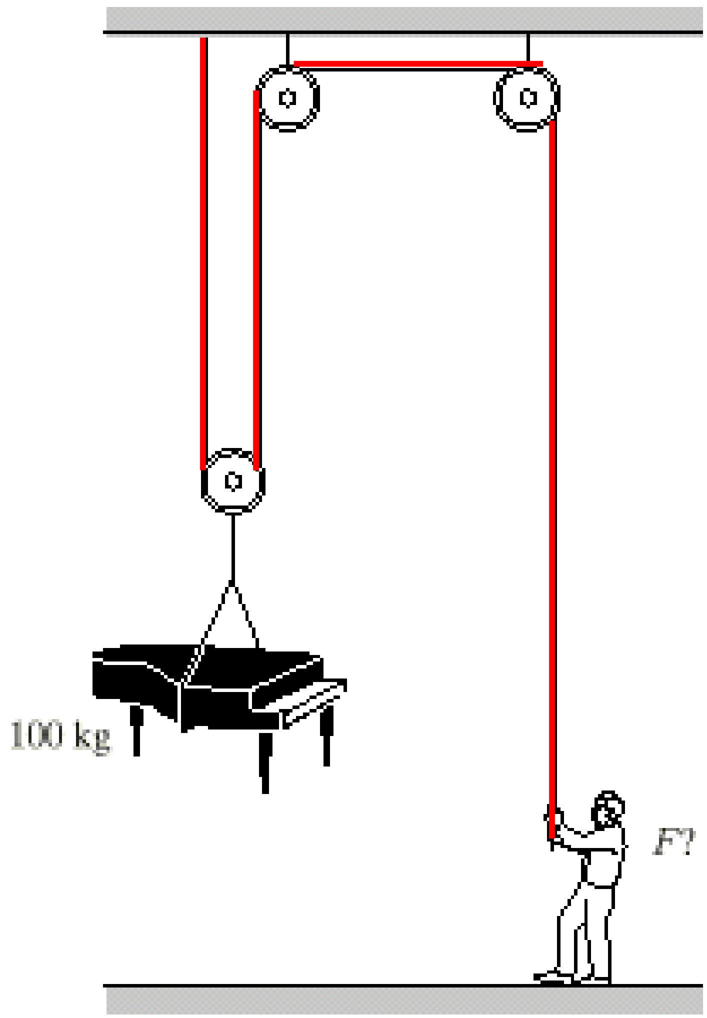
The tension force in the string is *closest* to:

A. 10 N
B. 11 N
C. 12 N
D. 10 N at the left end; 12 N at the right
E. Smoothly varying from 10 N by the left block to 12 N by the right block

Q38

What is the tension in the string closest to if we instead hold the 1.2-kg block?

A piano mover raises a 100-kg piano at a constant rate using the frictionless pulley system shown here. With how much force is he pulling on the rope? Ignore friction and assume $g = 10\ m/s^2$.



A. 2000 N

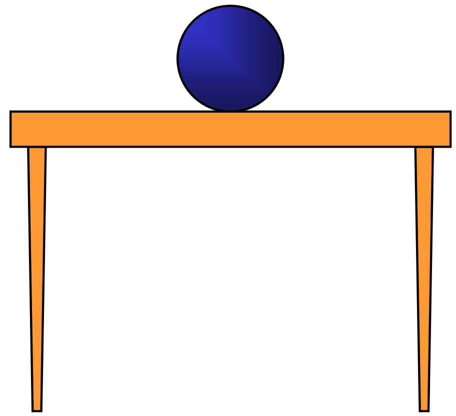
B. 1500 N

C. 1000 N

D. 750 N

E. 500 N

Q39



Consider this ball at rest on the table. We can conclude that the downward gravitational pull of Earth on the ball and the upward contact force are equal and opposite because of which fact:

A) the two **forces** form an action/reaction pair

B) the net force on the ball is zero

Q40

You are standing at rest and begin to walk forward. What force pushes you forward?

A. the force of your feet on the ground

B. the force of the ground on your feet

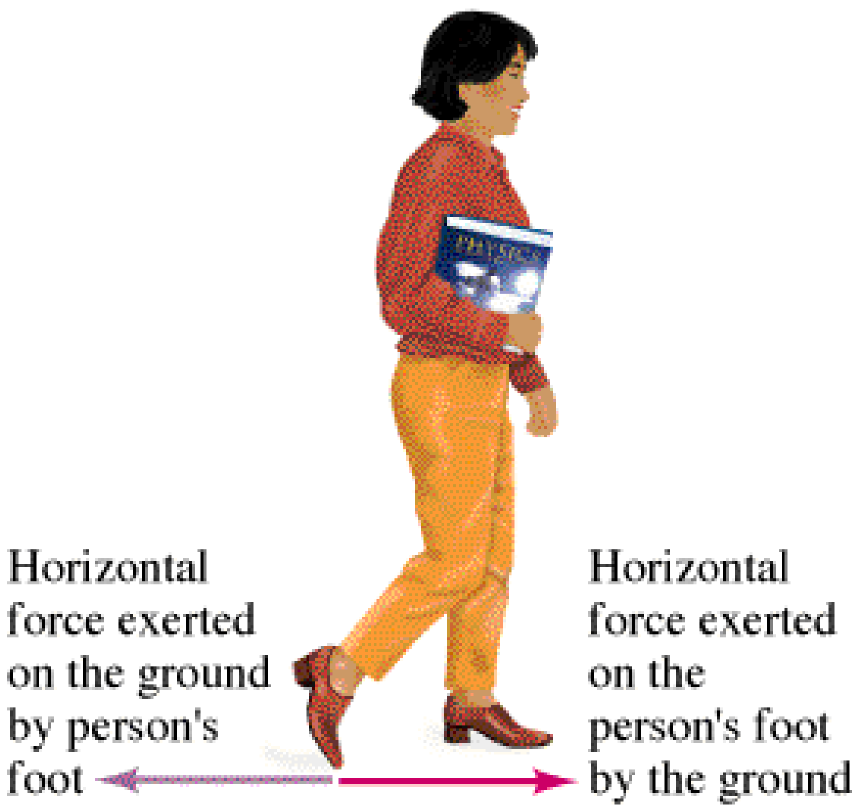
C. the force of your acceleration

D. the force of your velocity

E. the force of your momentum

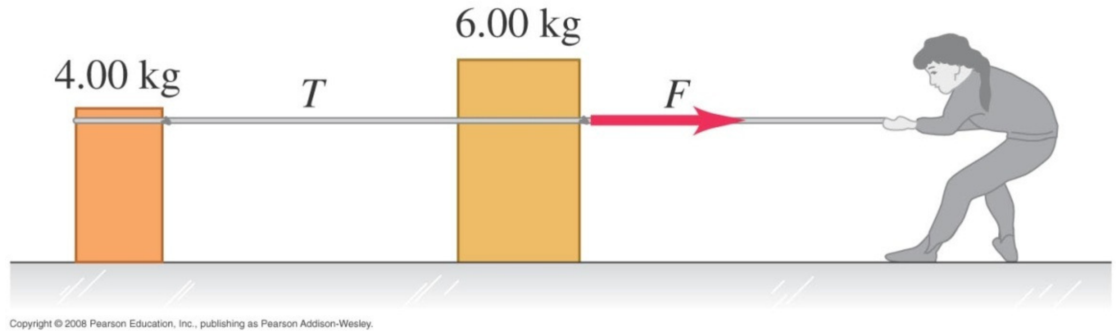
Q41

Only forces that act **on** you affect your motion and belong on your free body diagram



Note: $\mathbf{F}_{PG}$ propels person forward
$\mathbf{F}_{GP}$ affects ground (Earth) -
does not affect person

A woman pulls on a 6.00-kg crate, which in turn is connected to a 4.00-kg crate by a light rope. The light rope remains taut.



If the two crates are *accelerating to the right*,

A. the 6.00-kg crate exerts more force on the 4.00-kg crate than the 4.00-kg crate exerts on the 6.00-kg crate.

B. the 6.00-kg crate exerts less force on the 4.00-kg crate than the 4.00-kg crate exerts on the 6.00-kg crate.

C. the 6.00-kg crate exerts as much force on the 4.00-kg crate as the 4.00-kg crate exerts on the 6.00-kg crate.

Q42

A lightweight crate (*A*) and a heavy crate (*B*) are side by side on a frictionless horizontal surface. You are applying a horizontal force *F* to crate *A*. Which of the following forces *should* be included in a **free-body diagram for crate *B***? *(Not all possible forces are necessarily listed.)*

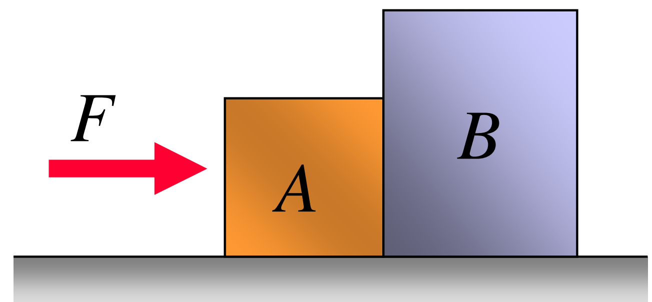
A. the weight of crate *B*

B. the force of crate *B* on crate *A*

C. the force *F* that you exert

D. the acceleration of crate *B*

E. more than one of the above



Q43

Clicker Answers

Chapter/Section: Clicker #=Answer

Today: 36=A, 37=B, 38=C, 39=E, 40=B, 41=B, 42=C, 43=A, 44=A