Lecture 8
(Newton's 1st, 2nd & 3rd Laws)

Physics 160-02 Spring 2017

Douglas Fields

Exam 1 Results

10	3
9-10	7
8-9	11
7-8	4
6-7	4
5-6	8
<5	11

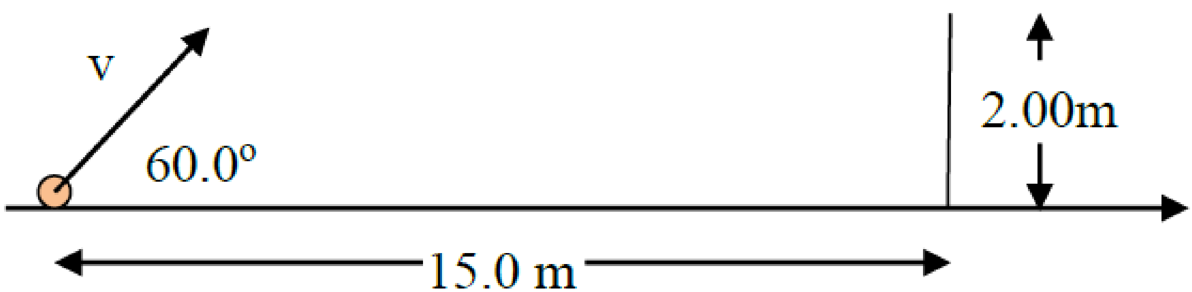
If you made less than 50%, you should strongly consider dropping this class and enrolling in Physics 110 – a class designed to help you succeed in Physics 160 next semester. You can do this without charge, or change in your total credit hours.

Problem 2

2) Find the angle in degrees between the two vectors: $\vec{A} = 2\hat{i} - 4\hat{j} + 6\hat{k}$ and $\vec{B} = 3\hat{i} + 6\hat{j} + 1\hat{k}$.

Problem 10

- A child wants to kick a ball a horizontal distance of 15.0 m over a fence 2.0 m high. They kick the ball at an angle of 60º above the horizontal. At what speed should they kick the ball so that it ***just*** passes over the fence?



Motion – Why?

- So, we now understand how to describe motion.
- But why does something move in the first place?
- Forces acting on an object cause it to move.
- More later, but what are forces?

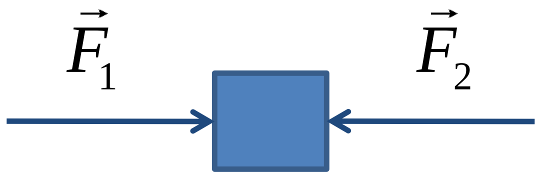
Forces

- Contact
  - Push
  - Pull
  - Tension (always pull)
  - Friction
- At a distance
  - Gravity
  - Electric/magnetic forces
  - Strong and weak nuclear forces

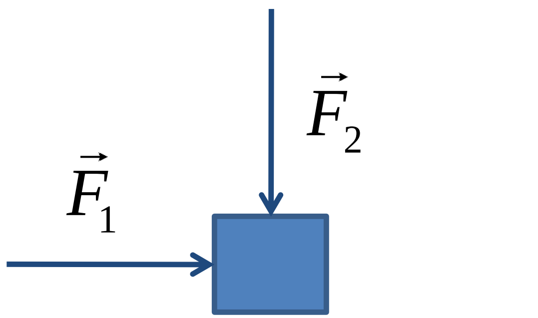
Resultant Force

- The only thing that matters for the linear motion of an object is the *net* or *resultant* force acting on it.
- Forces are vectors (it matters which way I apply a force!).
- So the resultant force is determined by vector addition of all forces acting on an object.

Examples



$$\vec{F}_{Total} = \vec{F}_1 + \vec{F}_2 = 0$$



$$\vec{F}_{Total} = \vec{F}_1 + \vec{F}_2 \neq 0$$

- The resultant (or total) force is not an independent force – it is just the vector sum of all the real forces acting on an object.

CPS Question 9-1

- **In which direction will the resulting motion of the (red) object acted on by the three forces shown be?**

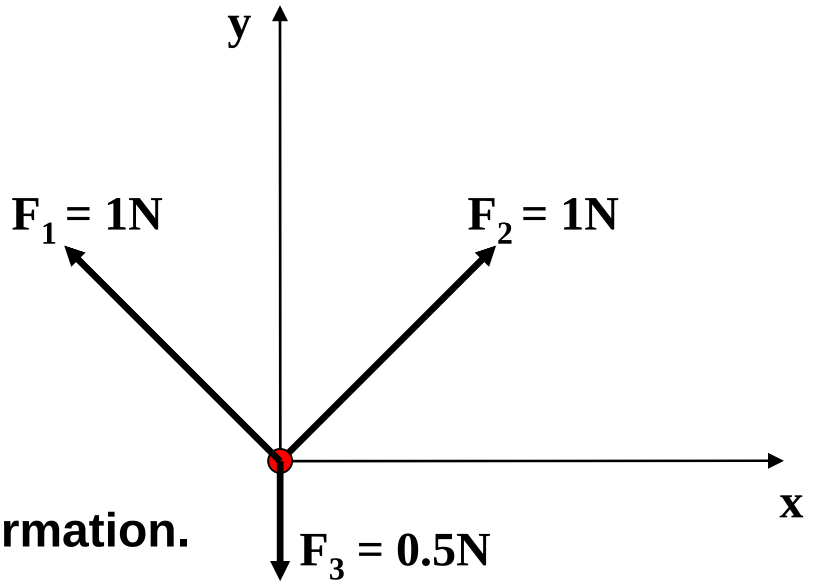
A) +x direction

B) Along F_1

C) +y direction

D) –y direction

E) Cannot determine, insufficient information.



Newton’s First Law

- A body acted on by no net force moves with zero acceleration.
- The natural resistance to change motion is called inertia.

Newton’s Second Law

- If there is a non-zero net force acting on a body, the body accelerates. The direction of acceleration is the same as the direction of the net force, and the magnitude of the acceleration is equal to the net force divided by the object’s mass.

$$\vec{a} = \frac{\vec{F}_{Total}}{m}$$

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

Units

$$\sum \vec{F} = m\vec{a} \Rightarrow$$

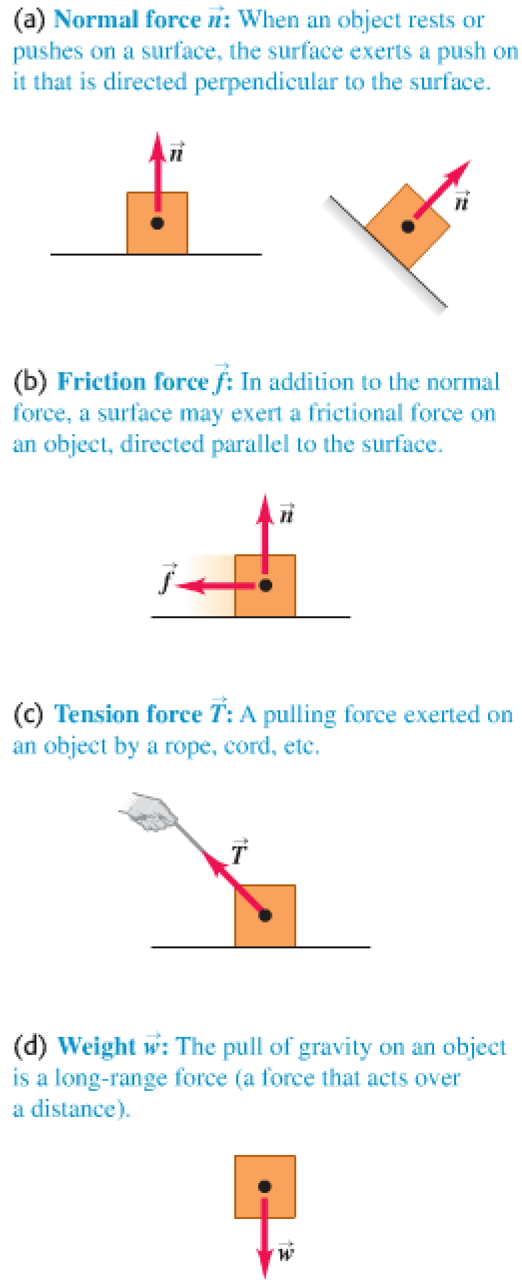
$$[N] = [kg]\left[\frac{m}{s^2}\right]$$

Analysis

- Consider a book on a table.
- What is it’s motion described by as a function of time?
- Then, what is the Net force acting on it?
- Then, what are the forces?

Forces

- Normal force is **always** perpendicular to a surface, and pointed away from it. It's value depends upon the objects force on the surface.
- Friction is directed parallel to the surface.
- Tension is directed along the string and away from the object (you can't push with a rope!)
- Weight points in the direction of gravity (towards the center of the earth).

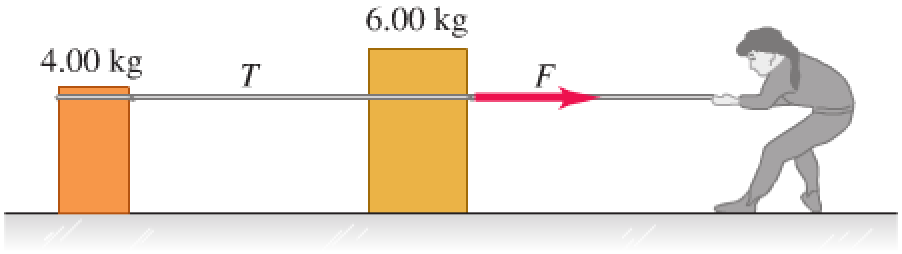


Key Points:

- What is "the object" you are analyzing? It may be actually a group of objects:

4.43 • Two crates, one with mass 4.00 kg and the other with mass 6.00 kg, sit on the frictionless surface of a frozen pond, connected by a light rope (Fig. P4.43). A woman wearing golf shoes (so she can get traction on the ice) pulls horizontally on the 6.00-kg crate with a force F that gives the crate an acceleration of 2.50 m/s^2. (a) What is the acceleration of the 4.00-kg crate? (b) Draw a free-body diagram for the 4.00-kg crate. Use that diagram and Newton's second law to find the tension T in the rope that connects the two crates. (c) Draw a free-body diagram for the 6.00-kg crate. What is the direction of the net force on the 6.00-kg crate? Which is larger in magnitude, force T or force F? (d) Use part (c) and Newton's second law to calculate the magnitude of the force F.

Figure **P4.43**

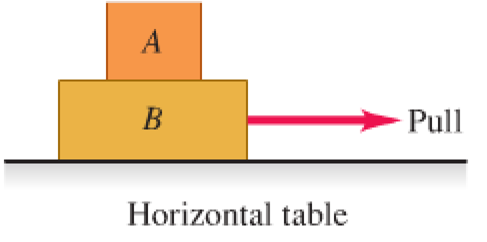


Key Points:

- Is the object accelerating?

4.28 •• A person pulls horizontally on block *B* in Fig. E4.28, causing both blocks to move together as a unit. While this system is moving, make a carefully labeled free-body diagram of block *A* if (a) the table is frictionless and (b) there is friction between block *B* and the table and the pull is equal to the friction force on block *B* due to the table.

Figure **E4.28**

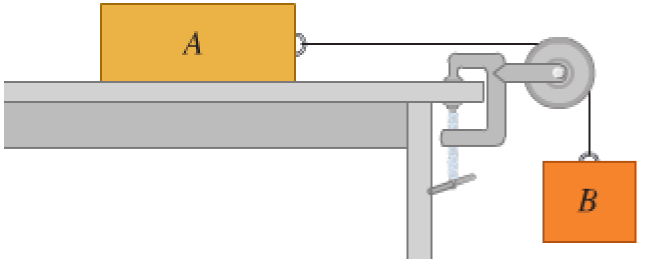


Key Points:

- Only forces acting on that body matter!

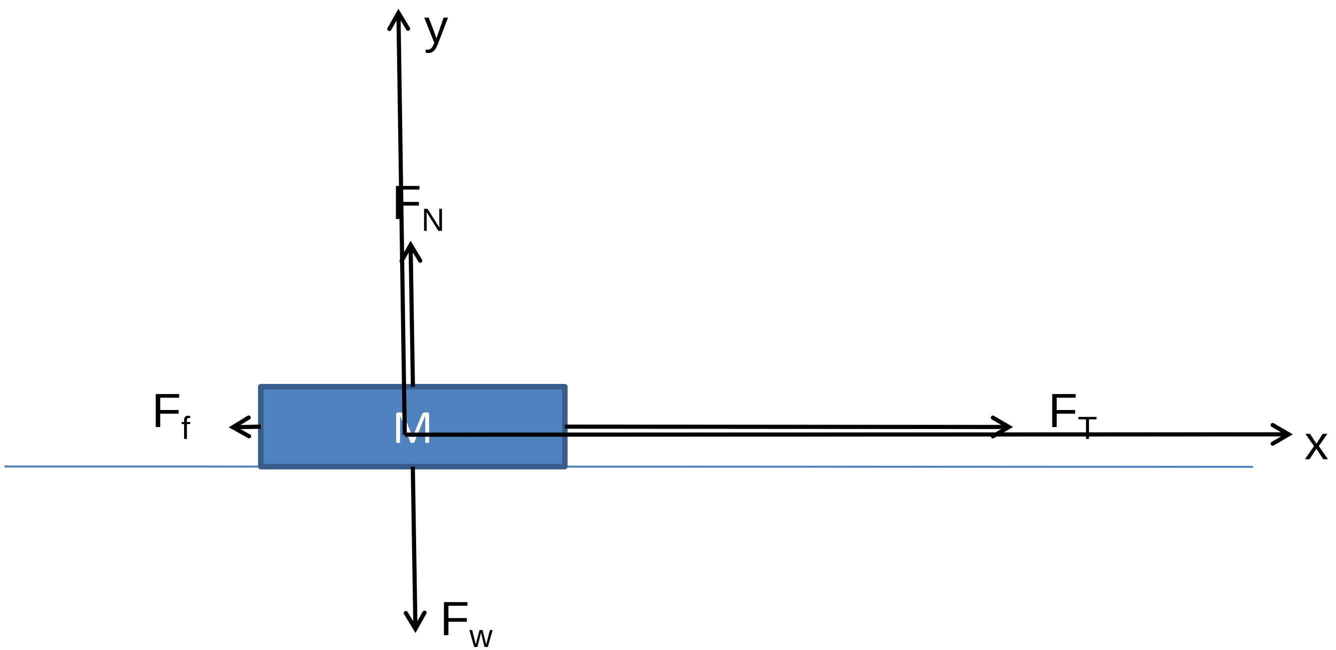
5.34 •• Consider the system shown in Fig. E5.34. Block *A* weighs 45.0 N and block *B* weighs 25.0 N. Once block *B* is set into downward motion, it descends at a constant speed. (a) Calculate the coefficient of kinetic friction between block *A* and the tabletop. (b) A cat, also of weight 45.0 N, falls asleep on top of block *A*. If block *B* is now set into downward motion, what is its acceleration (magnitude and direction)?

Figure **E5.34**



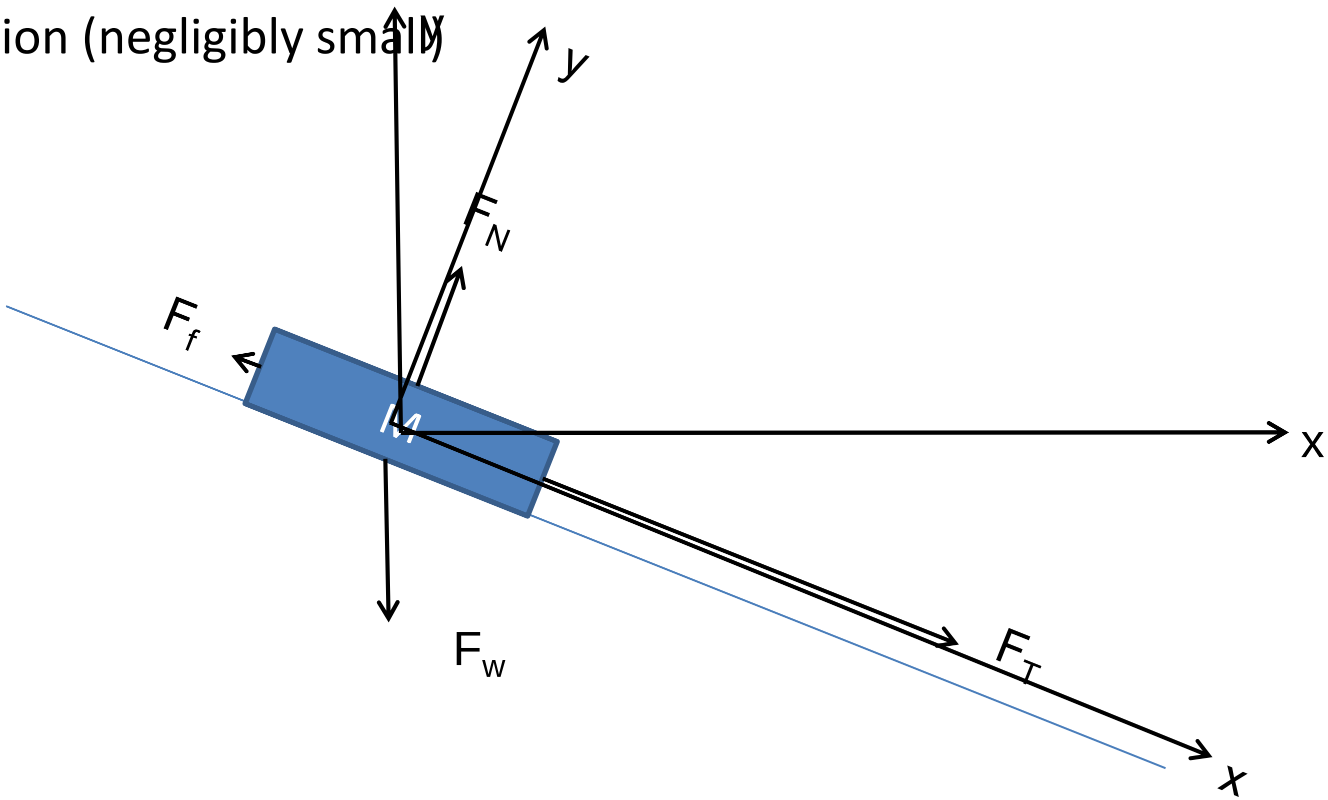
Demonstration

- Forces on pulled object:
  - Tension in string
  - Gravity
  - Normal Force
  - Friction

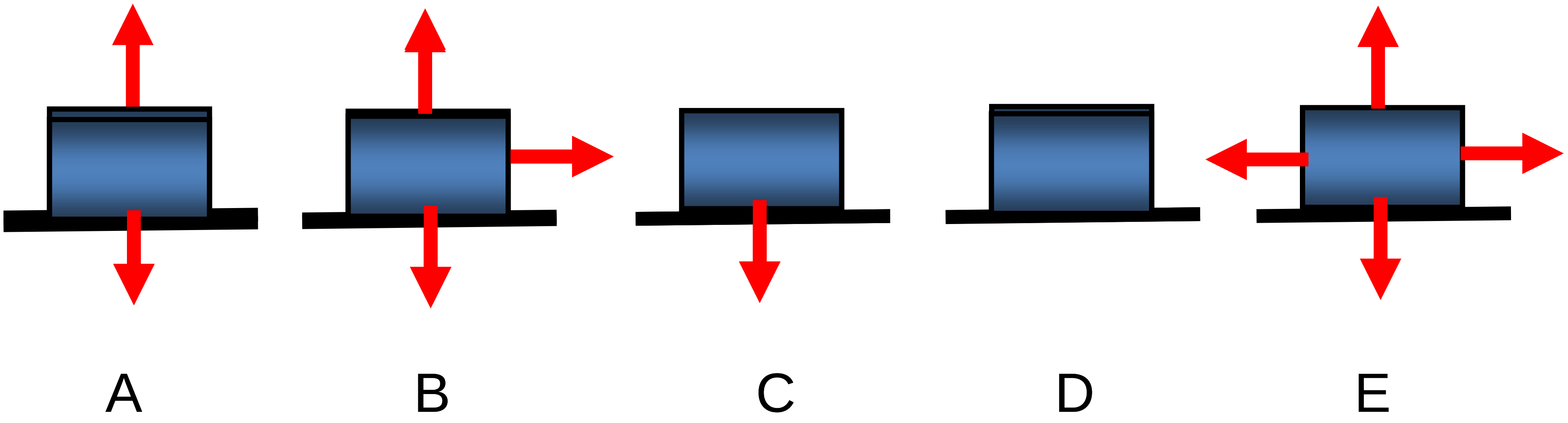


Demonstration

- If we tilted the table:
  - Tension in string
  - Gravity
  - Normal Force
  - Friction (negligibly small)

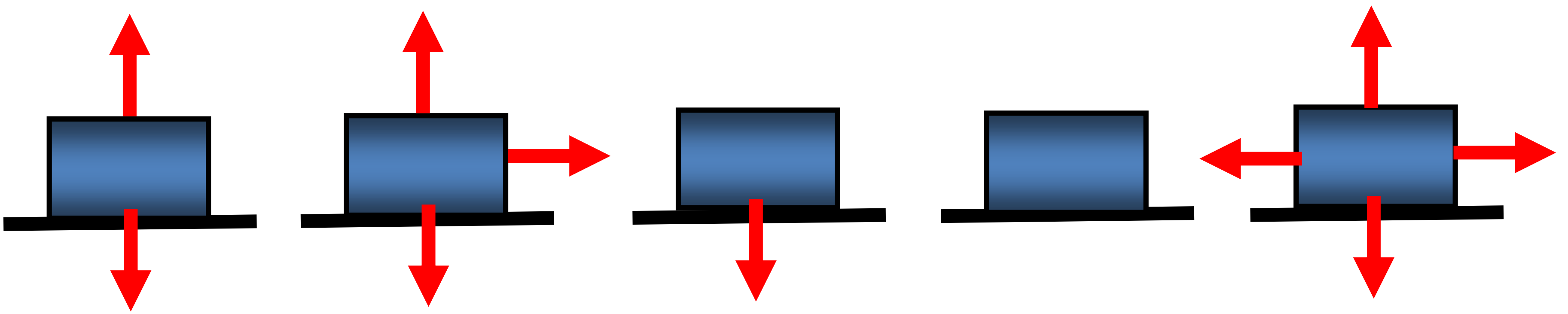


A block sits ***at rest*** on a frictionless surface. Which of the following sketches most closely resembles the correct freebody diagram for all forces acting on the block? Each red arrow represents a force. Observe their number and direction, but **ignore their lengths**.



E - None of the above

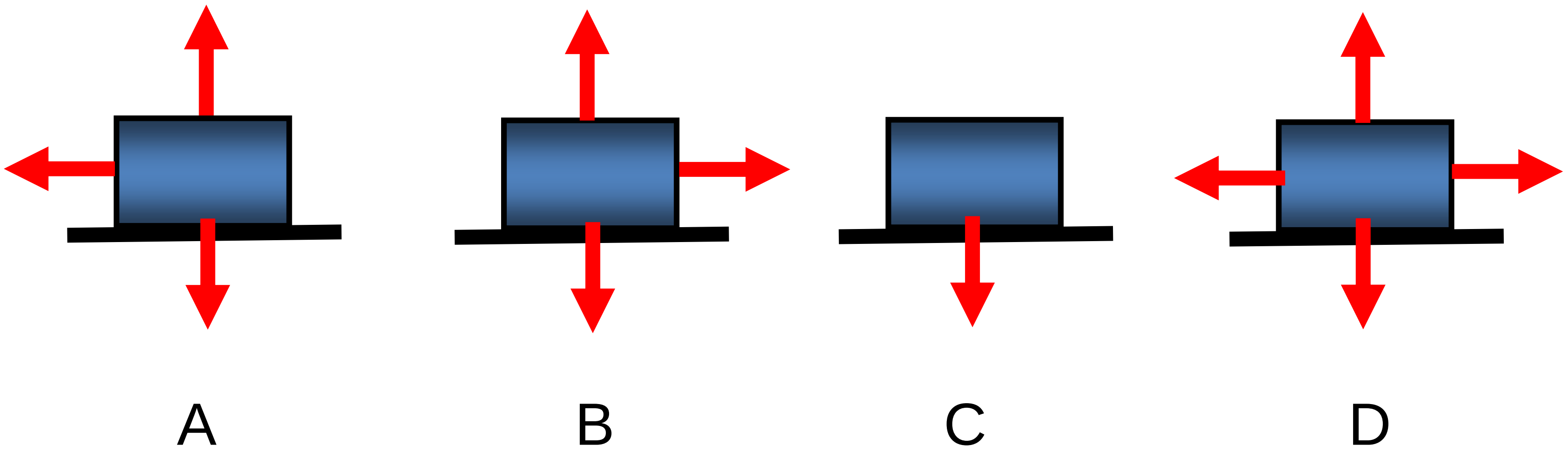
Now, the same block moves with a **constant velocity to *the right on the frictionless surface***. Which of the following most closely resembles the correct freebody diagram for all forces acting on the block?



A B C D E

E - None of the above

Now, the block moves with a **constant** velocity ***to the right*** on a surface ***that has friction***. Which of the following most closely resembles the correct freebody diagram for all forces acting on the block?



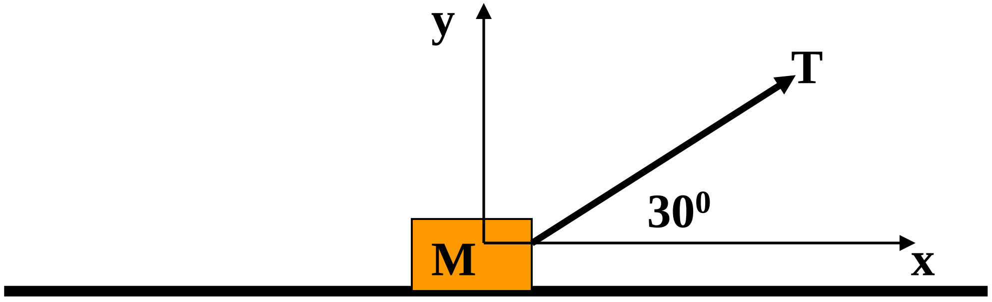
E - None of the above

Weight and Mass

- Weight is a FORCE given by w=mg.
- Mass is a property of an object.
- An object of mass 10kg, and weight mg=(10kg)(9.8m/s^2)=98N, will still have mass 10kg on the moon, but will have a lower weight on the moon (since the pull of the moon's gravity on an object is less than that of the earth's).

CPS Question 10-1

- **A block of mass M sits on a horizontal plane. A rope pulls on the block to the right with a force T at an angle of 30^o with the horizontal. What is the best way to describe the normal force N of the table on the block?**



A) Mg in the + y-direction.

B) Mg + T sin(30) in the + y-direction.

C) Mg - T cos(30) in the + y-direction.

D) Mg - T sin(30) in the + y-direction.

E) Mg in a direction 30^o to the left of the block.

Newton’s Third Law

- If a body A exerts a force on body B, then body B exerts a force on body A. These two forces have the same magnitude, but are opposite in direction.

Demonstrations