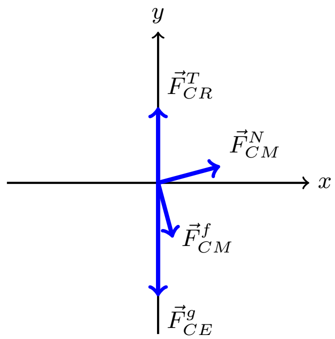
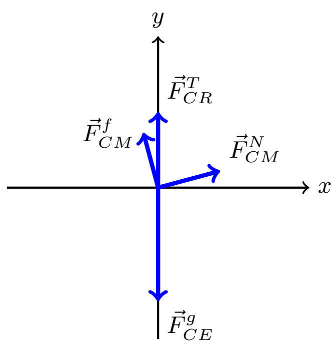
Friction is always parallel to the surface of contact, so (C) and (G) are the only possible answers. If we pick (G) and look at the free-body diagram,



we find that the x-component of the net force is positive, which would make the climber accelerate. We need friction to go in direction (C) if we want to balance the forces in the x-direction.

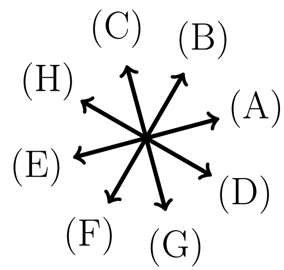


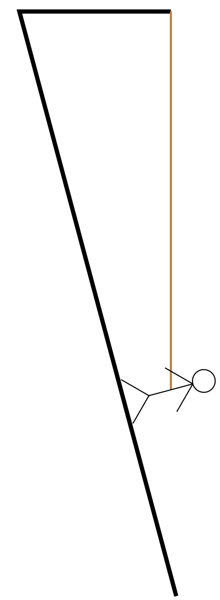
This FBD is out of scale, as the y-components of the tension, normal force, and friction clearly add to be larger than the force of gravity, and we need the x-components of friction and the normal force to be equal in magnitude to cancel out.

Lecture 8: Free-Body Diagrams

Warm-Up Activity

What direction is the force of friction in the Mountain Climbing activity from Get-Ready #5?





Free-Body Diagrams and Systems

- Choose a system.
  - Make sure you know what is internal to your system and what is external to your system.
- Identify and describe each external force:

$$\vec{F}^{\,\text{type}}_{\text{on,by}}$$

  - Say what kind of force it is.
  - Determine the object the force is being acted on.
  - Determine the object that is exerting the force.
  - Write a symbolic version of the force that includes the information above.
  - Represent all the forces acting on a single object or system using a **free-body diagram**.
    * All forces on the same free body diagram should act on the same thing (same first subscript).

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(Newton's) Laws of Motion

(1) An object in motion (or at rest) stays in motion (or at rest) unless a net external force acts on it.

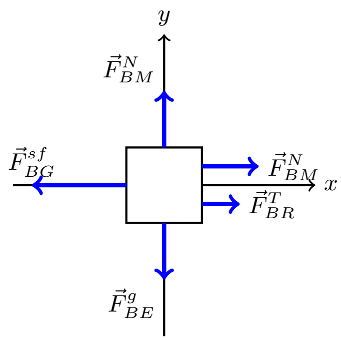
(2) The net force on an object is equal to the object's mass times its acceleration.

$$\vec{F}^{net} = m\vec{a}$$

Idenfity All Forces

- Mike is pushing directly into the side of the box, so we need a normal force on the box by Mike: $\vec{F}^N_{BM}$.
- The box has mass, so we need a force of gravity on the box from Earth: $\vec{F}^g_{BE}$.
- The rope held by Lucas is pulling on the box (Lucas himself is not directly touching it), so we need a force of tension on the box by the rope: $\vec{F}^T_{BR}$.
- The box is sitting on the ground and not budging, so we need a normal force on the box from the ground, and a force of static friction on the box from the ground: $\vec{F}^N_{BG}$ and $\vec{F}^{sf}_{BG}$.

Free-Body Diagram



L8-1: Moving a Box

Mike and Lucas are attempting to move a box, which does not move.

- Identify all forces acting on the box.
- Draw a free-body diagram for the box.
- Indicate the acceleration.

L8-2: Moving a Box II

El pushes the box with her mind, and it begins to speed up.

- Modify your free-body diagram.
- Indicate the acceleration.
- Write a symbolic expression for the acceleration.

Main Ideas

- Forces arise from interactions between objects.
- There are many different kinds of forces that we can analyze differently.
- Objects can only change their motion when acted upon by an external force.
- The net force on an object is equal to its mass times its acceleration.