SLE123 Physics for the Life Sciences

Week 1

Movement and force

DEAKIN COLLEGE
in association with
DEAKIN UNIVERSITY

Topic 1: Movement and Force

Topics:

- Forces
- Newton's laws
- What is a force?
- Types of forces
- Identifying forces

Sample question:

These ice boats sail across the ice at great speeds. What gets the boats moving in the first place? What keeps them from going even faster?

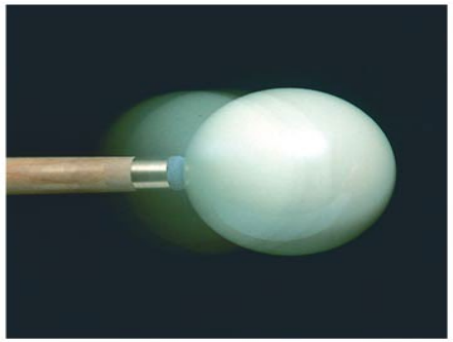
What Is a Force?

A force...

... is a push or pull.

... acts on an object.

... requires an agent.



... is a vector.

... is a contact force or a long-range force.

Newton’s first law

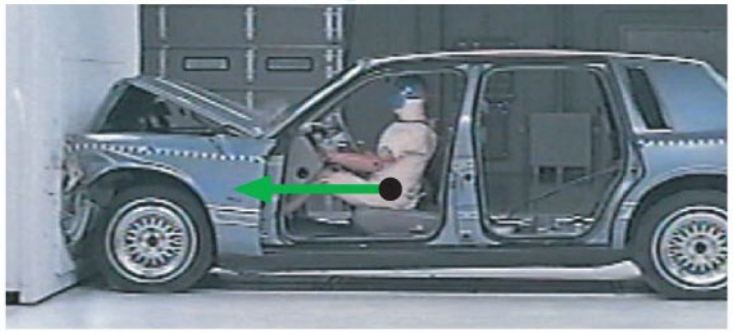
An object continues at rest or at constant velocity (constant speed in a straight line) unless an external force acts on it.

- If the object is at rest, it remains at rest (speed = 0).
- If the object is in motion, it continues to move in a straight line with the same speed (constant velocity).

Inertia is a measure of an object’s resistance to changes in its motion.

Why seatbelts are good!

These images show a direct result of Newton's First Law. An unrestrained passenger in a moving vehicle will continue to move even as the vehicle undergoes a change in velocity.

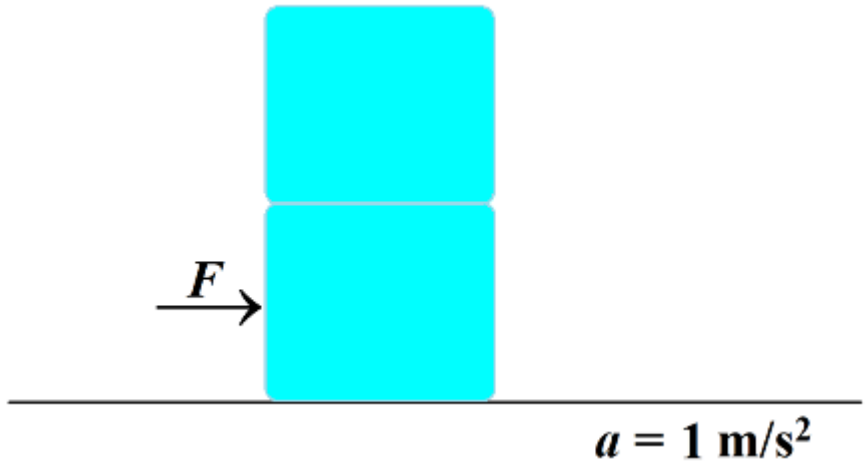


It is only when the two come into contact again will the passenger decelerate (rapidly and usually causing severe injury)

Problem task

Identifying situations applying Newton's 1st law

Newton's Second Law



Acceleration directly proportional to net force

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

Units of Force and Mass

$$1\ \text{N} \equiv 1\ \text{kg} \cdot \text{m/s}^2$$

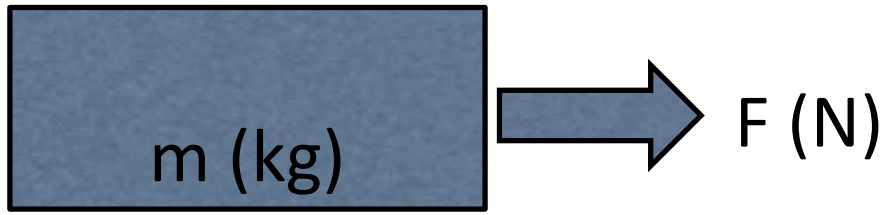
$$1\ \text{N} = 0.225\ \text{lb}$$

Table 4.1 Units of Mass, Acceleration, and Force

System	Mass	Acceleration	Force
SI	kg	m/s^2	$\text{N} = \text{kg} \cdot \text{m/s}^2$
U.S. customary	slug	ft/s^2	$\text{lb} = \text{slug} \cdot \text{ft/s}^2$

$$F=ma$$

a (m/sec^2)



Eg.

a= 2 m/sec^2

m=4 kg

F=4 x 2= 8 N

Problem solving task

Using Newton's 2nd law

Weight and mass

We often use the terms mass and weight. While they are related, they are not the same.

Mass is a measure of the matter present in an object.

Weight is a gravitational force that the object “feels” and “imparts” on other objects.

Weight and mass

How much do you weigh?

76 kg

Wrong – try again...

Weight and mass

If your mass is 76 kg

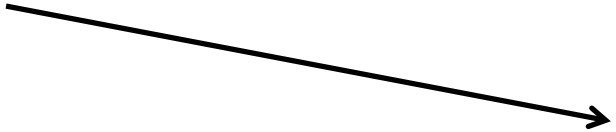
Then, your weight on earth is 76 x 9.8 = 744.8 N

weight on moon is
76 x (9.8/6) = 124.8 N

NASA/Eugene Cernan

Forces are vectors

- Forces have a **magnitude** (the strength of the force)
- And a **direction** (pointing the way the force is exerted)
- We represent a force by an arrow:



- Length=magnitude
- Direction=where the arrow points

Problem task

Resultant forces

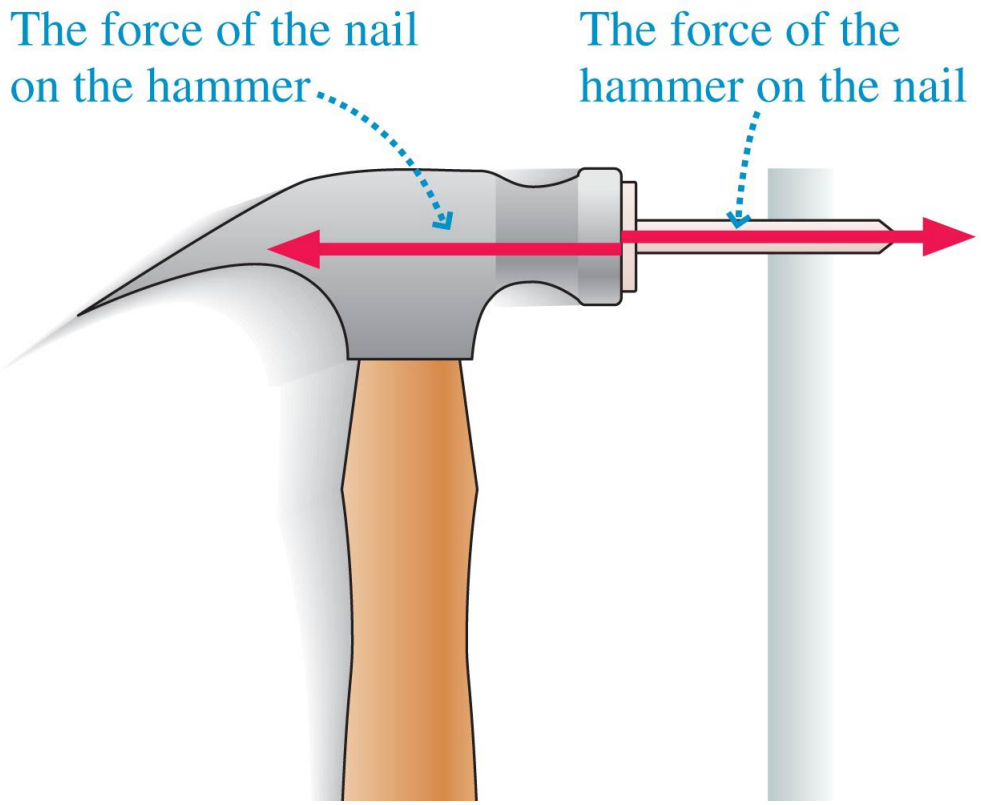
Newton's Third Law

Newton's third law

Every force occurs as one member of an action/reaction pair of forces.

The two members of an action/reaction pair act on two different objects.

The two members of an action/reaction pair point in opposite directions, and are equal in magnitude



Newton’s Third Law

For every action, there is an equal and opposite reaction.

What is meant is that every force actually occurs as one of a pair of forces of equal magnitude but in opposite directions.

An implication of this is that there are always two bodies involved in the application of forces and each applies a force to the other.

Newton's Third Law

FIGURE 4–9 If your hand pushes against the edge of a desk (the force vector is shown in red), the desk pushes back against your hand (this force vector is shown in a different color, violet, to remind us that this force acts on a different object).

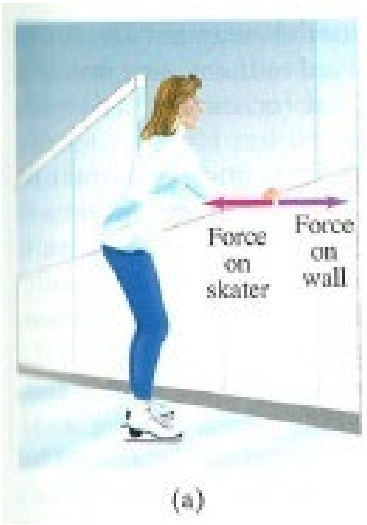


FIGURE 4–10 Two examples of Newton's third law. (a) When an ice-skater pushes against the railing, the railing pushes back and this force causes her to move away. (b) The launch of a rocket. The rocket engine pushes out the gases, and the gases exert an equal and opposite force back on the rocket, accelerating it.

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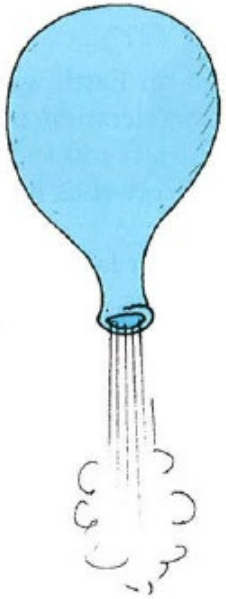
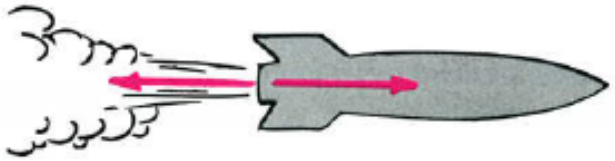
(Giancoli, *Physics for Scientists and Engineers*, 3rd edition, chap. 4)

Newton's 3rd Law



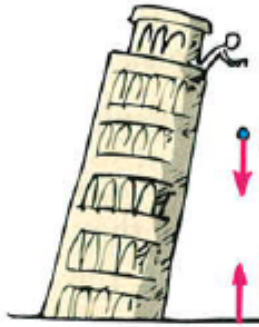
The balloon recoils from the escaping air, and it moves upward.

Action: tire pushes on road Reaction: road pushes on tire



Action: rocket pushes on gas Reaction: gas pushes on rocket

Action: man pulls on spring Reaction: spring pulls on man



Action: earth pulls on ball

Reaction: ball pulls on earth

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P. Hewitt, *Conceptual Physics* 10e, p. 76

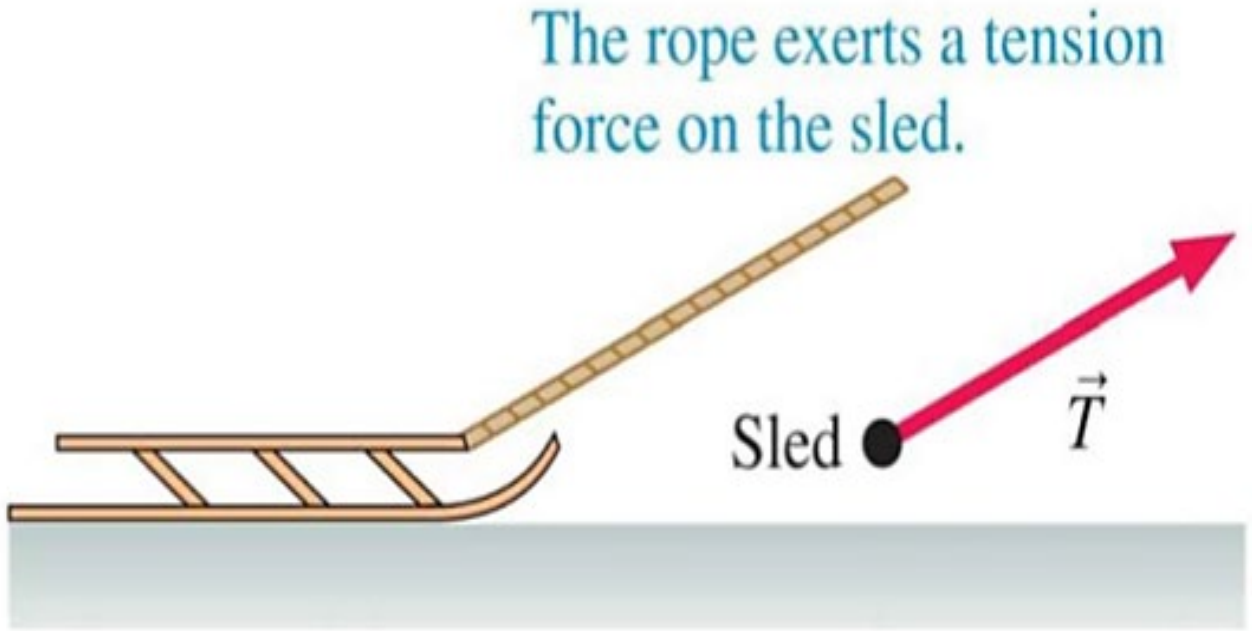
Problem task

Newton's 3rd law

Types of Forces

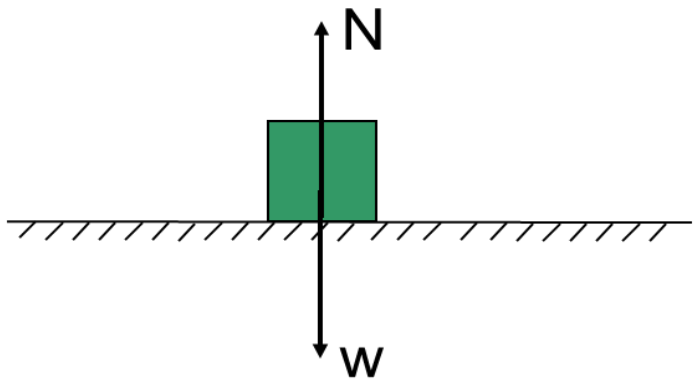
Tension force

- When a string, rope or wire pulls on an object, it exerts a tension force
- The direction of the force is always in the direction of the rope/string
- Symbol is T



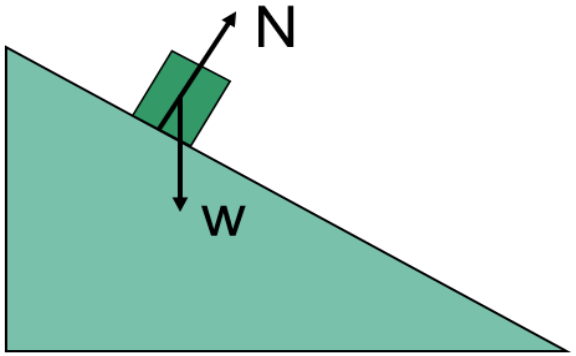
Types of Forces

Normal force: this force acts in the direction perpendicular to the contact surface.



Example: normal force of the ground on the box acts upward (perpendicular to the horizontal surface).

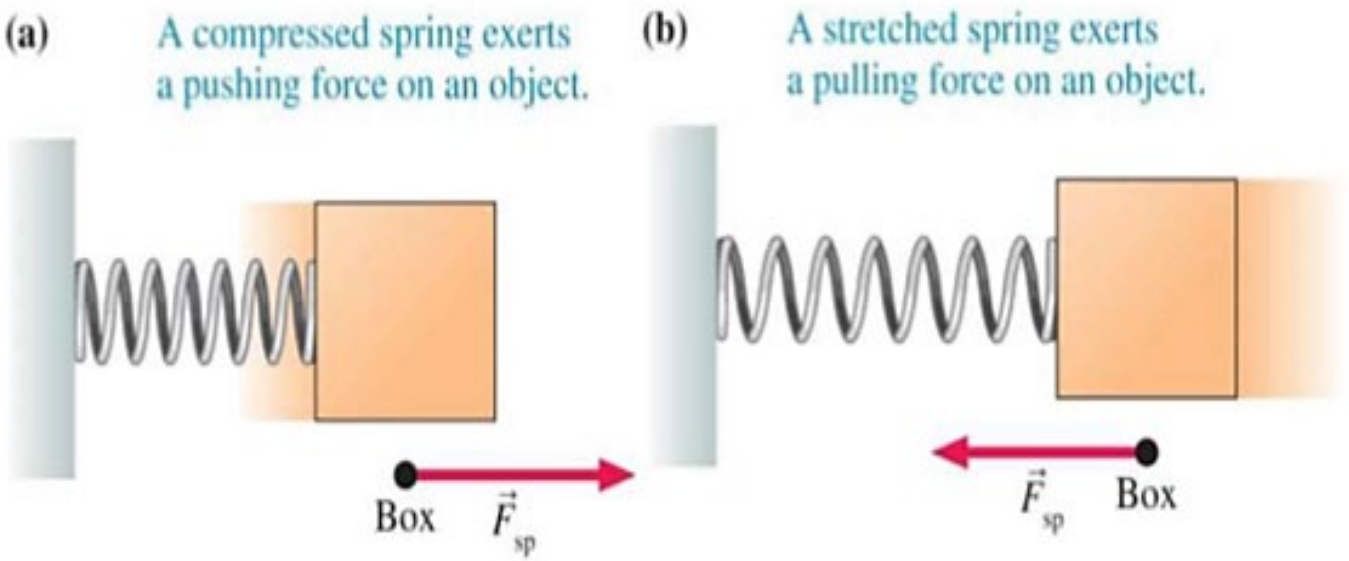
Example: normal force of the inclined ramp on the box acts at an angle (perpendicular to the surface of the ramp).



Types of Forces

Spring force

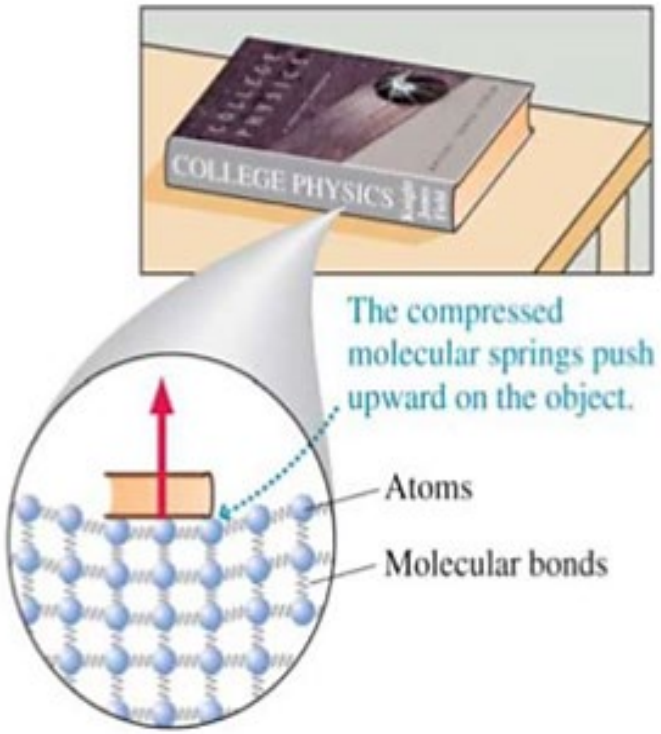
- Also known as elastic force
- Can either push or pull
- Symbol is F or F_{sp}

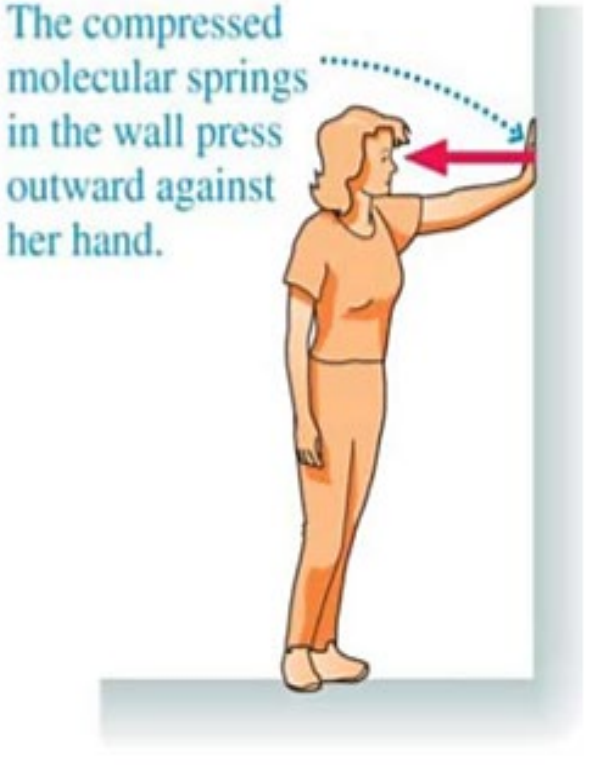


Types of Forces

Friction

- The *normal force* is the force exerted by a surface (the agent) against an object that is pressing against the surface
- Always acts perpendicular to surface
- Symbol is n

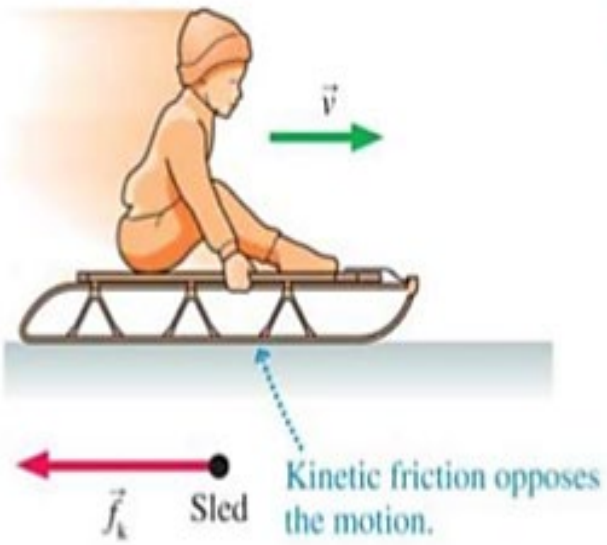


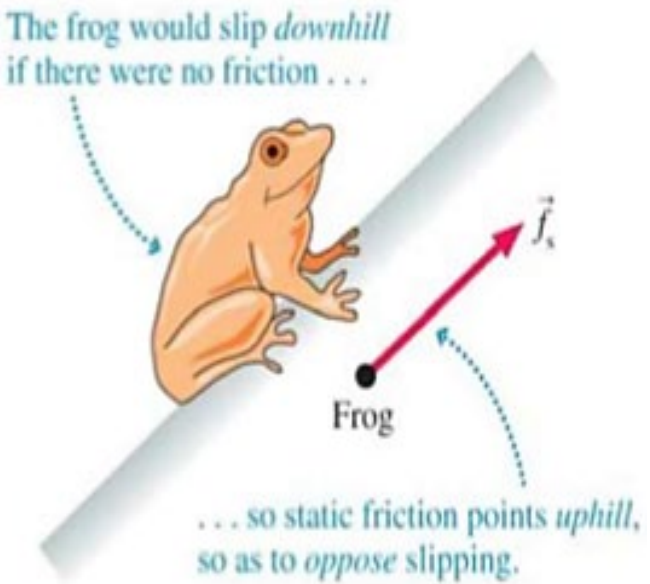


Types of Forces

Friction force

- Is exerted by a surface
- Is always *parallel* to the surface
- Kinetic friction, f_k, acts as an object slides across a surface.
- Static friction, f_s, is the force that keeps an object stuck on a surface.



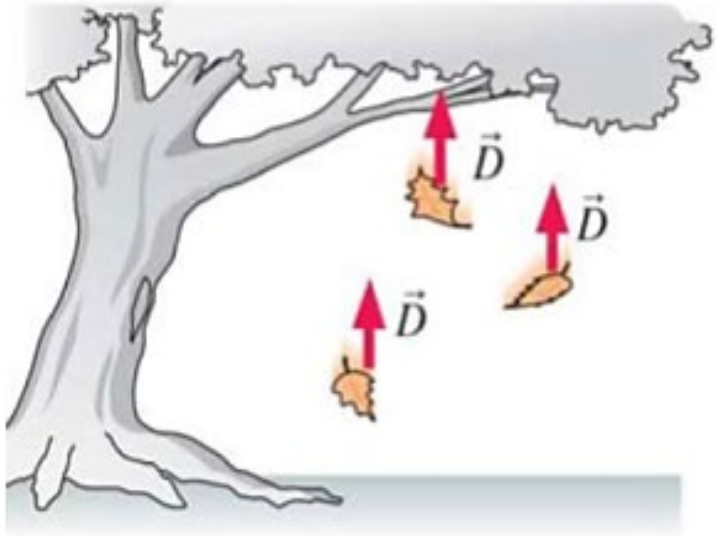


Types of Forces

Drag force

- Drag, like is air friction, is a resistive force.
- Drag opposes motion through fluids - gases (like air) and liquids (like water).
- Symbol is D

Air resistance is a significant force on falling leaves. It points opposite the direction of motion.



End of class

See the study guide for practice problems, with extra problems at the end of the study guide