Spring 2014

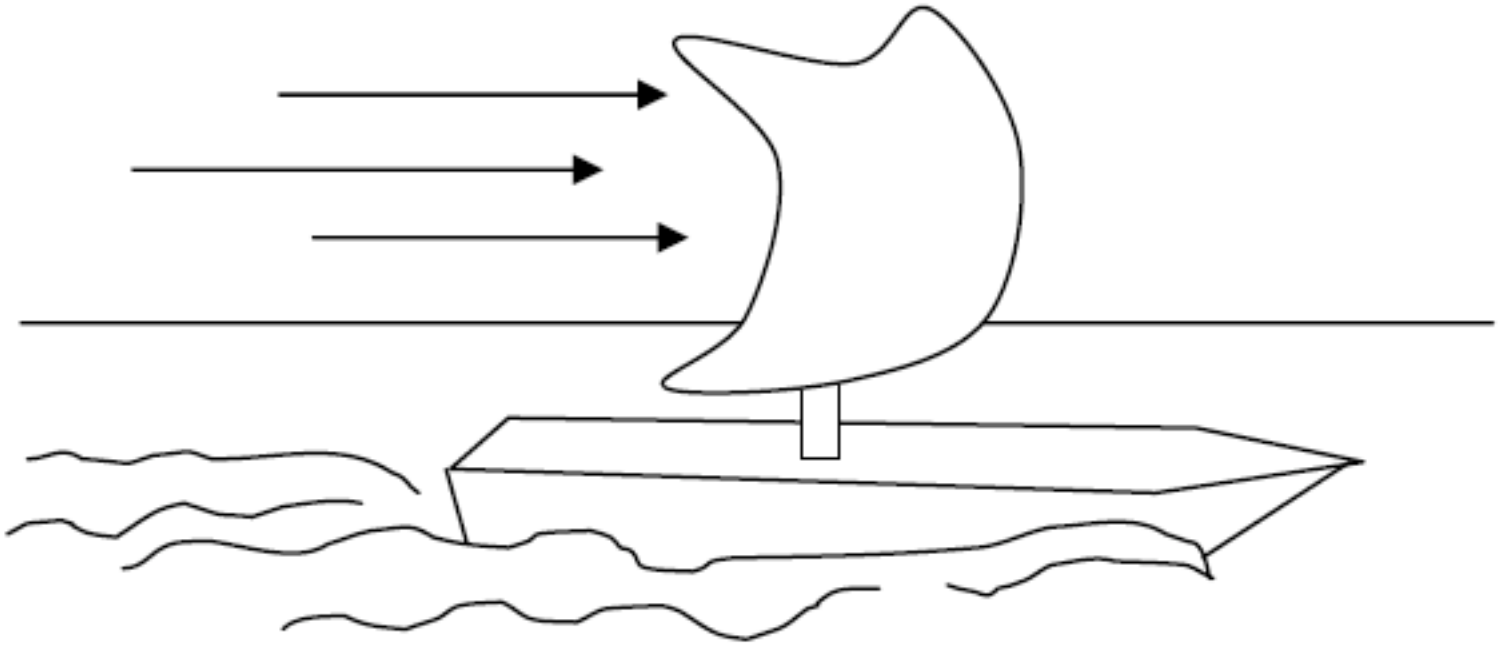
PHYS-2010

Lecture 14

Clicker Question

Room Frequency BA

A sailboat is being blown across the sea at a constant velocity.
What is the direction of the net force on the boat?



A) Left ←
B) Right →
C) Net force is zero
D) Down ↓
E) Up ↑

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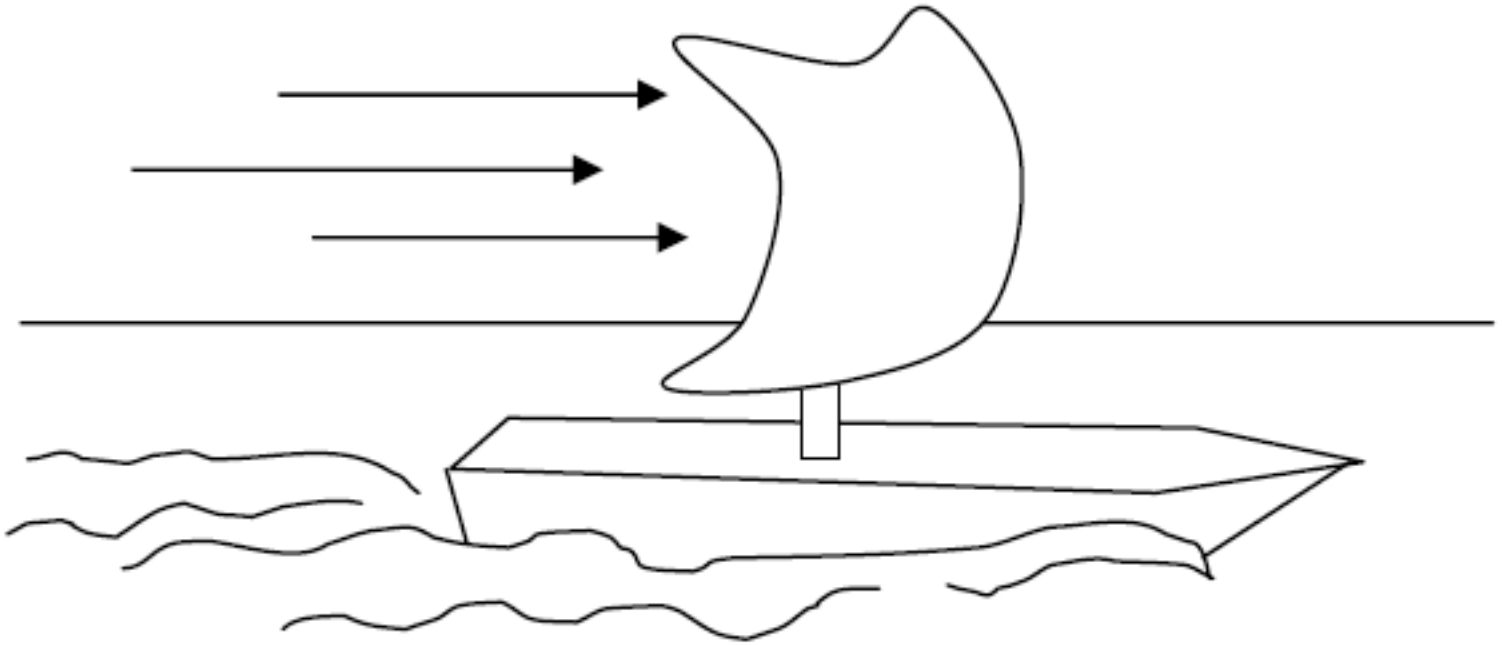

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Announcements

- Read Giancoli Chapter 4 (sections 4.1-4.6).
- **CAPA # 5** is due next Tuesday at 11 pm.
- **Written homework # 3** due today at 4 pm.
- Reminder: there are several links to various useful **resources** on the course website (under the right-most tab "Resources"):
  - Giancoli Textbook website;
  - PhET simulations;
  - Thinkwell;
  - Prof. Dubson's Notes (under "Lecture Info" tab)

We want to know why what causes accelerations (forces).

Dynamics

Newton's Three Laws

Newton's Laws (as stated) hold in an "Inertial Reference Frame" (non-rotating / non-accelerating):

I. "Law of Inertia": Every object continues in its state of rest or uniform motion (constant velocity along a straight line), as long as ***no net force*** acts on it.

II. Acceleration is proportional to force and inversely proportional to mass. Famous $\vec{F}_{\text{net}} = m\vec{a}$ equation.

III. Whenever one object exerts a force on a second object, the second exerts an equal force in the opposite direction on the first. $\vec{F}_{\text{AB}} = -\vec{F}_{\text{BA}}$

Newton's Second Law

Acceleration is proportional to force and inversely proportional to mass.

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

Knowing the forces acting on an object of mass (*m*), we can calculate the accelerations.

Then we can use these accelerations to calculate the kinematics (motion).

Note that the direction of the acceleration is the same as the direction of the net force vector.

The **unit of force** in the SI system is the **Newton (N)**:

1 N = 1 kg m/s^2

TABLE 4–1
Units for Mass and Force

System	Mass	Force
SI	kilogram (kg)	newton (N) $(= \text{kg} \cdot \text{m/s}^2)$
cgs	gram (g)	dyne $(= \text{g} \cdot \text{cm/s}^2)$
British	slug	pound (lb)

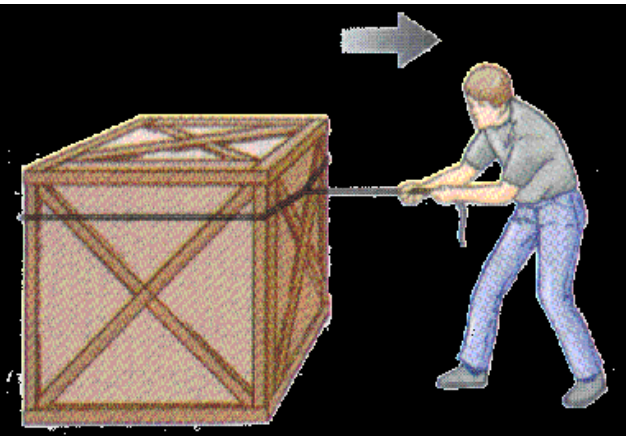
Conversion factors: 1 dyne $= 10^{-5}$ N; 1 lb $\approx$ 4.45 N.

Force is a vector, so **Newton's 2nd Law** is a vector equation:

$$\vec{F} = m\vec{a} \longrightarrow \begin{cases} F_x = ma_x \\ F_y = ma_y \end{cases}$$

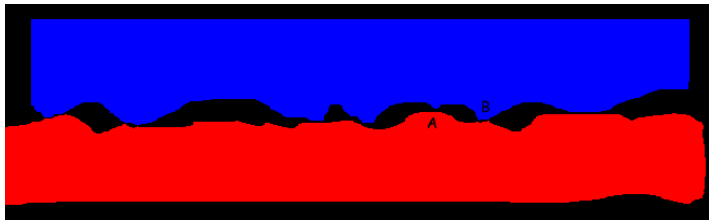
All Kinds of Forces

Pulling / Pushing



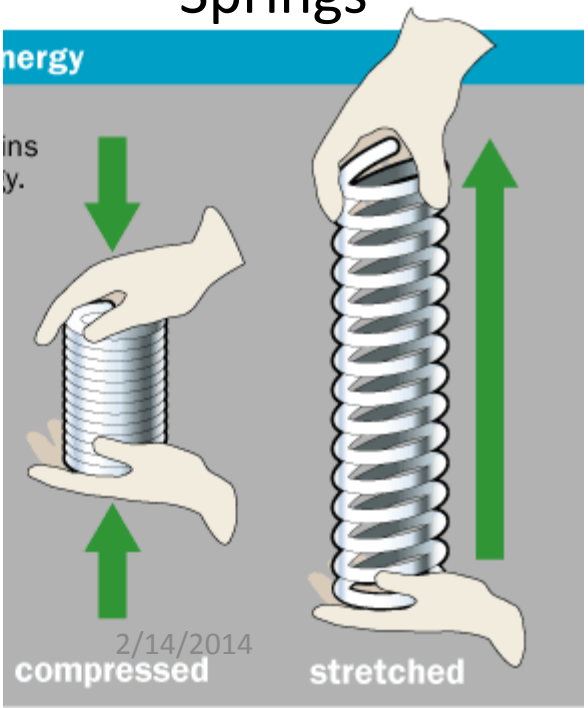
Gravity

Friction



Air Resistance / Drag

Springs



Lots of others too (electric, magnetic, etc.)

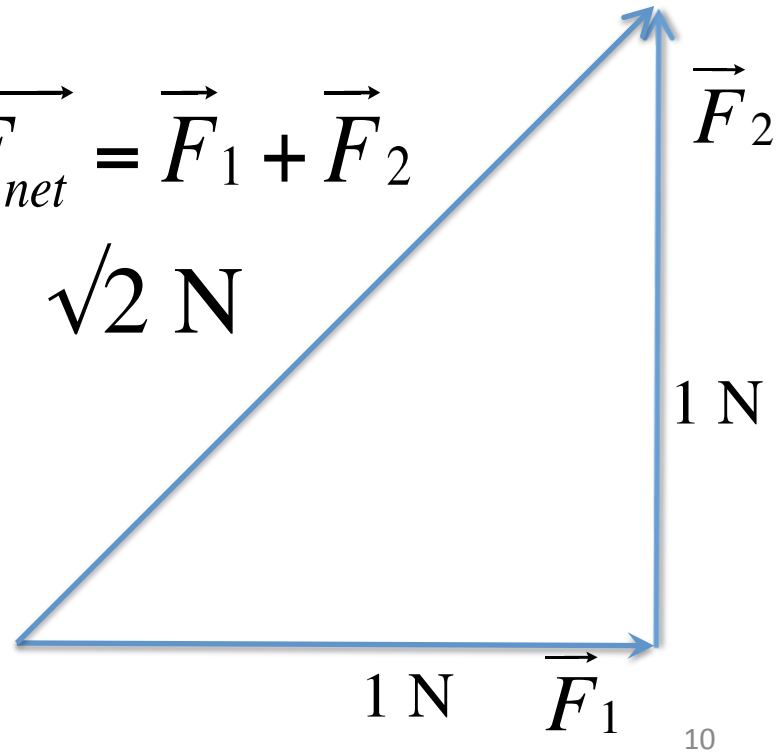
Clicker Question

Room Frequency BA

Forces add like vectors, not like scalars.

Consider two forces, $\vec{F}_1$ and $\vec{F}_2$, both of magnitude 1 N.
One points to the right and other straight up.
What's the magnitude and direction of the net force?

A) 2 N, straight up.
B) $\sqrt{2}$ N, straight up.
C) 0 N.
D) $\sqrt{2}$ N, up and right.
E) $-\sqrt{2}$ N, left.

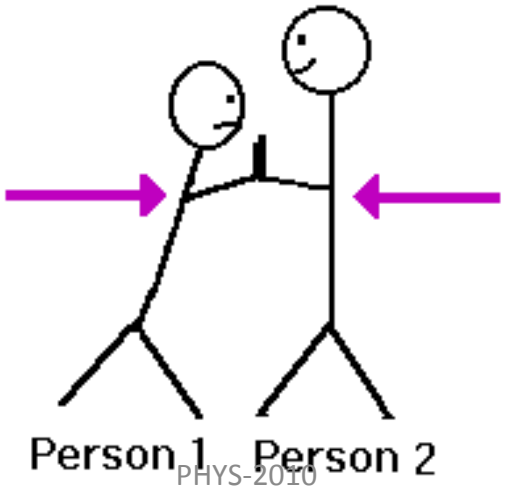


Newton's Third Law

Whenever one object exerts a force on a second object, the second object exerts an equal and oppositely directed force on the first:

$$\vec{F}_{AB} = -\vec{F}_{BA}$$

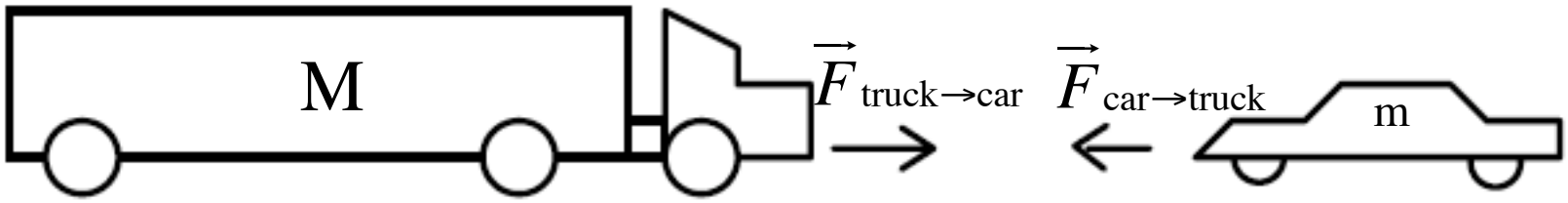
(action equals reaction)



Clicker Question

Room Frequency BA

A moving truck collides with a sports car in a high-speed head-on collision. *Crash!*



During the impact, the truck exerts a force with magnitude $F_{\text{truck->car}}$ on the car and the car exerts a force with magnitude $F_{\text{car->truck}}$ on the truck. Which of the following statements about these forces is true:

A) The magnitude of the force exerted by the truck on the car is the same size as the magnitude of the force exerted by the car on the truck: $F_{\text{truck->car}} = F_{\text{car->truck}}$

B) $F_{\text{truck->car}} > F_{\text{car->truck}}$

C) $F_{\text{truck->car}} < F_{\text{car->truck}}$

Guaranteed by Newton's Third Law

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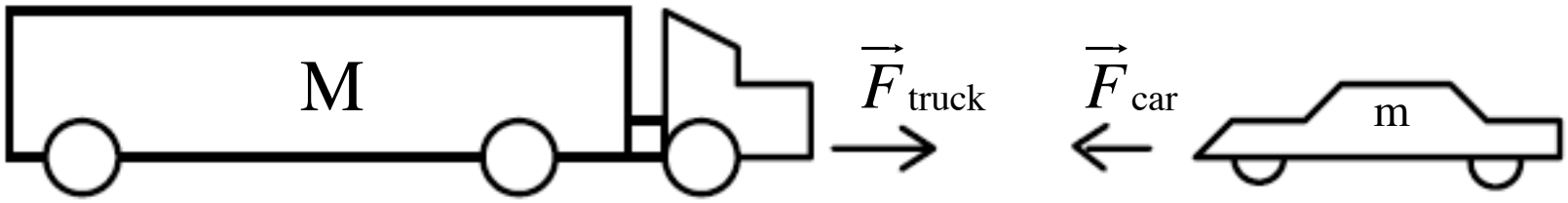

During the collision, the imposed forces cause the truck and the car to undergo accelerations with magnitudes a_{truck} and a_{car}. What is the relationship between a_{truck} and a_{car}?

A) $a_{\text{truck}} > a_{\text{car}}$

B) $a_{\text{car}} > a_{\text{truck}}$

C) $a_{\text{truck}} = a_{\text{car}}$

D) Indeterminate from information given.

Newton's Second Law: $F = ma$

Newton's Third Law Demonstrations

$$\vec{F}_{AB} = -\vec{F}_{BA}$$