College Physics I: 1511 Mechanics & Thermodynamics

Professor Jasper Halekas
Van Allen Lecture Room 1
MWF 8:30-9:20 Lecture

Announcements

- Monday is a holiday
  - No classes on Monday
- No labs in any section all of next week
- Lecture and discussion sections meet as usual Tuesday-Friday

Announcements

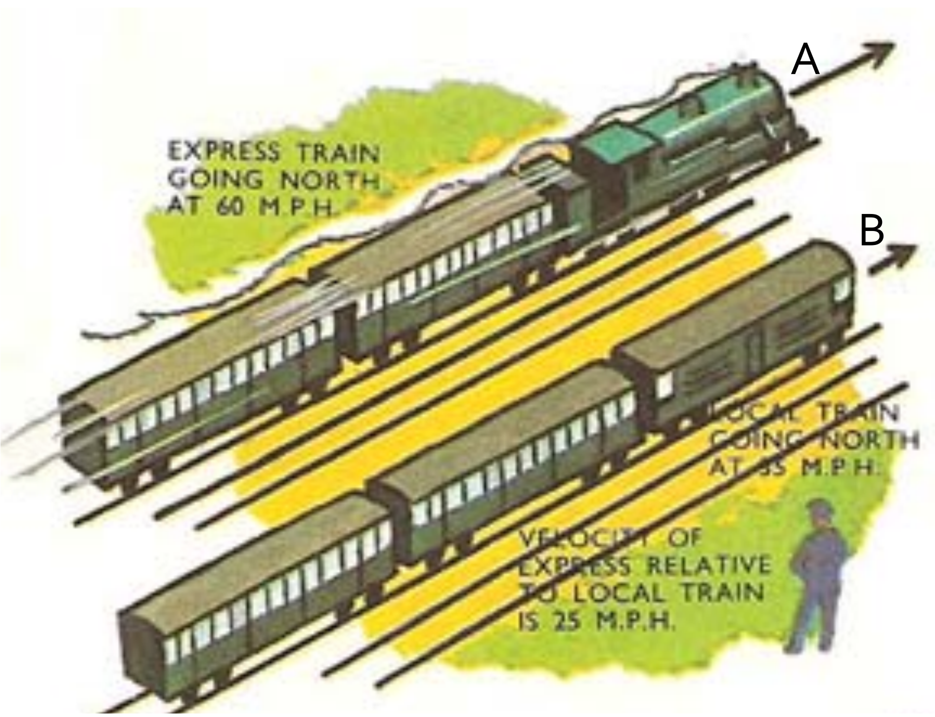
- Great job on the homework!
  - Average conceptual score 4.04
  - Average math score 4.63
- For some reason some people's grades are showing up as #/20 instead of #/10. Rest assured we've only had 10 points that count.
- If you have trouble getting the right answer in problems with angles make sure your calculator is set correctly to degrees / radians (you might need to use either depending on the problem)
- Don't forget about the 2% tolerance in Wiley Plus!

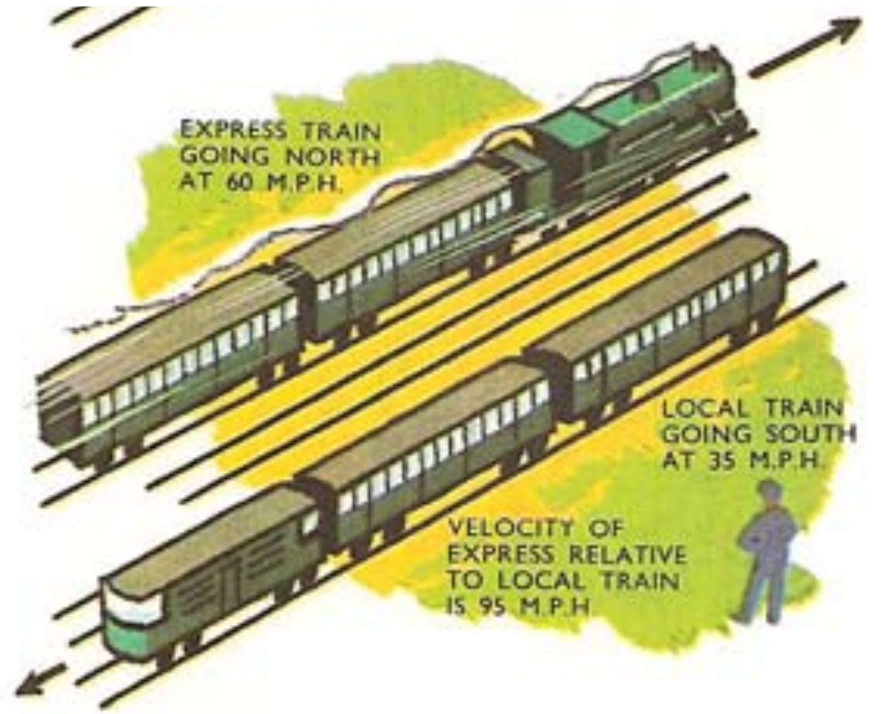
Relative Velocity

- As long as you are not accelerating:
  - Motion in a moving frame can be analyzed just like motion in a stationary frame.
  - To analyze motion in a different (moving) frame, just subtract the velocity of that frame from all the velocities in the problem

Relative Velocity: 1-d

What is v_{ab}, the velocity of train A with respect to train B?

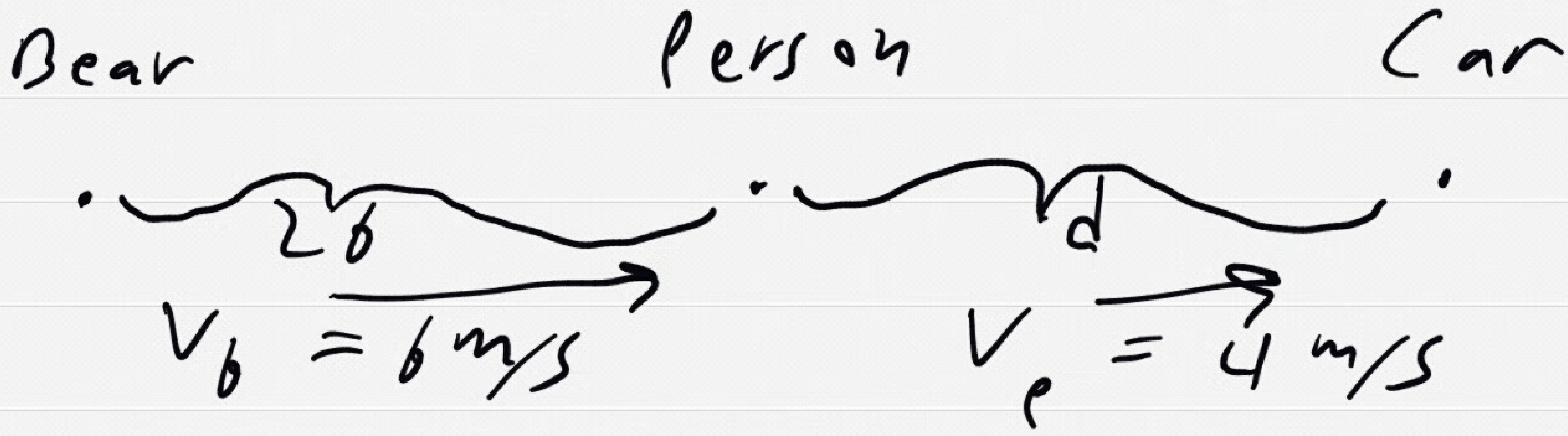




v_a = 60 mph, v_b = 25 mph, v_{ab} = 35 mph

v_a = 60 mph, v_b = -35 mph, v_{ab} = 95 mph

Relative Velocity



In frame of person:

$V_b = 2\ m/s \rightarrow \quad \leftarrow V_c = 4\ m/s$

- Car and bear reach person at same time

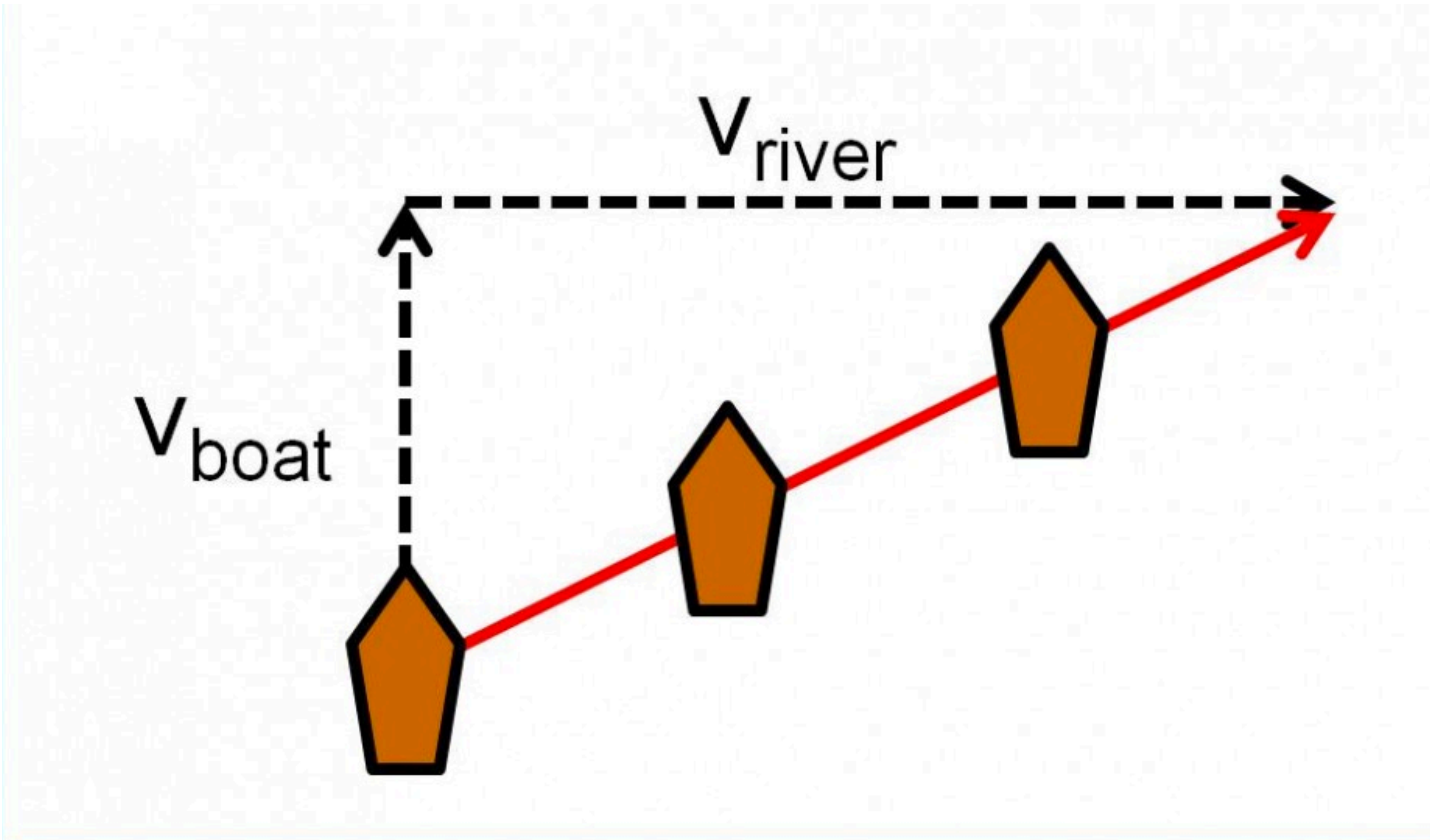
$$\Delta x = v_0 t \quad (a = 0)$$

$$\Rightarrow \quad t = \Delta x / v_0$$

$$\Rightarrow \quad \frac{\Delta x_b}{v_b} = \frac{\Delta x_c}{v_c}$$

$$\frac{26}{2} = \frac{-d}{-4} \quad \Rightarrow \quad \boxed{d = 52\ m}$$

Relative Velocity: 2-d



Concept Check

- Imagine you are sitting in a moving car (with open sunroof) traveling at constant velocity and you throw a ball straight up high into the air. Assuming no air resistance, where does it land?

A. In front of the car
B. Behind the car
C. In the car
D. It never lands

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Ballistic cart

Motion of ball

$$\Delta y_b = V_{y0b} t - \frac{1}{2} g t^2$$

$$\Delta x_b = V_{x0b} t$$

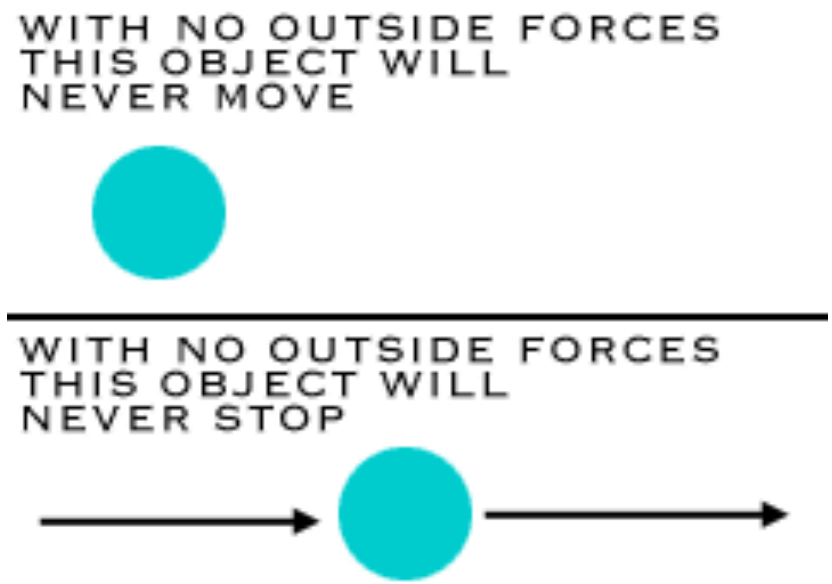
Motion of cart

$$\Delta x_c = V_{x0c} t \qquad [V_{x0c} = V_{x0b}]$$

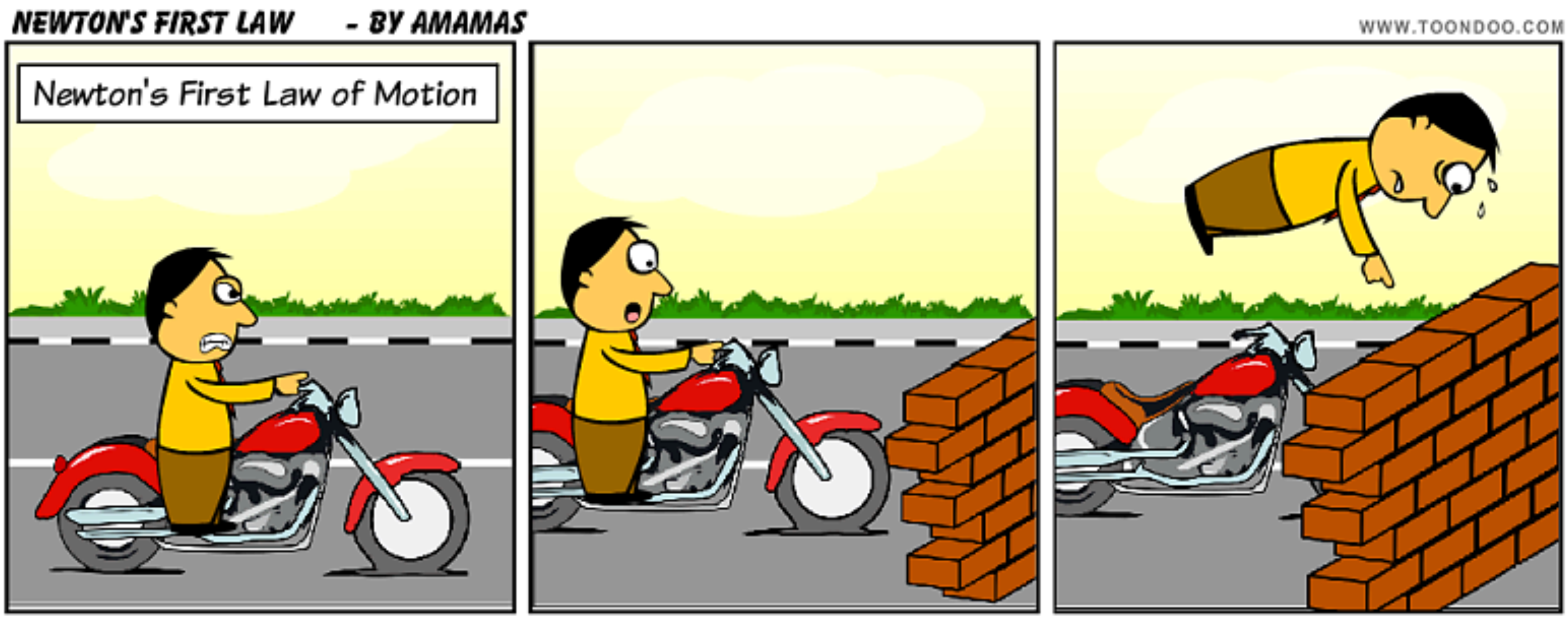
In frame of cart
$V_{xb} = 0$, just goes up
and comes down

Newton's First Law

- An object at rest stays at rest and an object in motion stays in motion with the same speed and in the same direction unless acted upon by an unbalanced force.



Applications of Newton's 1st Law



Newton's 1st Law of Parenting

What Can You Feel?

- Can you feel that you are moving when you are in a car moving at constant velocity?
  - What about when you are accelerating, or braking?

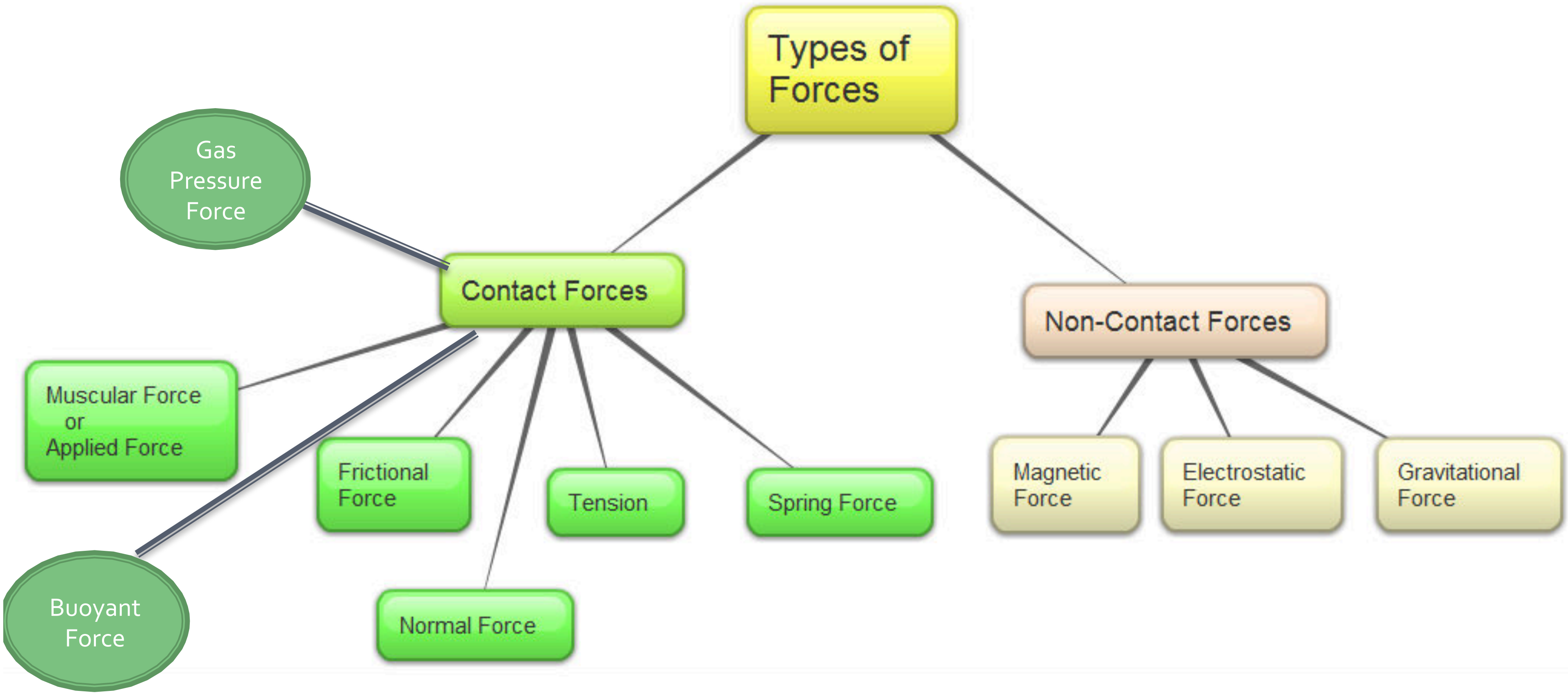
- Can you feel that you are moving when you are in an elevator going up?
  - What about when it first starts moving?

Definition: Force (Newton's 2nd Law)

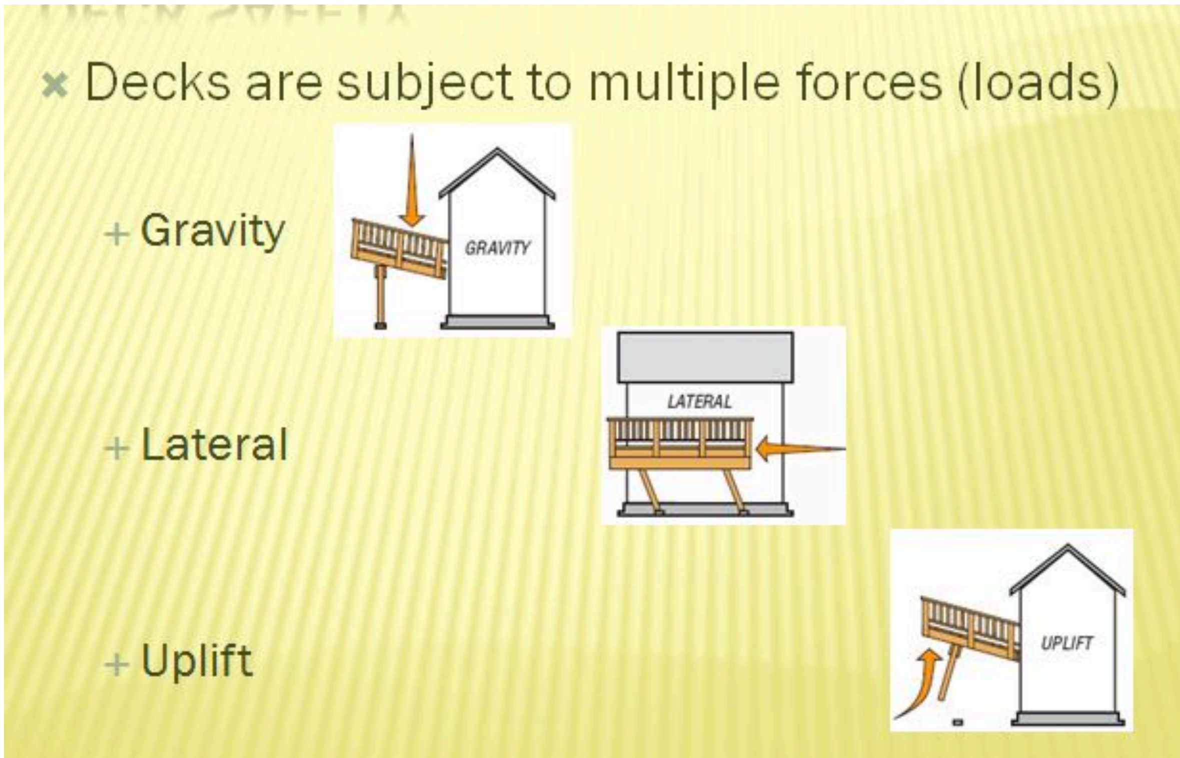
$$\vec{F} = m\vec{a}$$

Net Force [Newtons = kg m/s²] = Mass [kg] * Acceleration [m/s²]
Vector = Scalar * Vector

Forces


Types of Forces
Contact Forces
Non-Contact Forces
Gas Pressure Force
Muscular Force or Applied Force
Buoyant Force
Frictional Force
Normal Force
Tension
Spring Force
Magnetic Force
Electrostatic Force
Gravitational Force

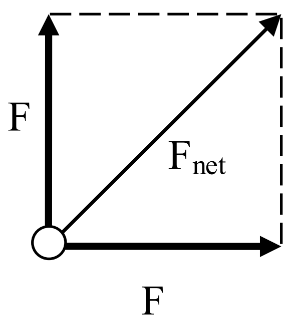
Force Vs. Acceleration (1)



$$\vec{\mathbf{a}} = \frac{\sum \vec{\mathbf{F}}}{m} \qquad \sum \vec{\mathbf{F}} = m\vec{\mathbf{a}}$$

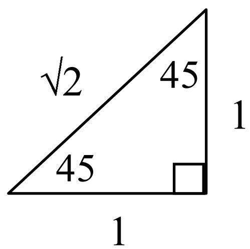
Vector Nature of Force

Example: Two forces, labeled $\mathbf{F}_1$ and $\mathbf{F}_2$, are both acting on the same object. The forces have the same magnitude $|\vec{F}_1| = |\vec{F}_2| = F$ and are 90° apart in direction:



$$\vec{F}_{net} = \vec{F}_{total} = \sum \vec{F} = \vec{F}_1 + \vec{F}_2$$

($\sum \vec{F}$ means "sum of all the forces on the object")



$$\Rightarrow F_{net} = \sqrt{2}\, F \qquad \text{(NOT 2F)}$$

Free-Body Diagrams

Rules for drawing "Free-body diagram" or force diagram :

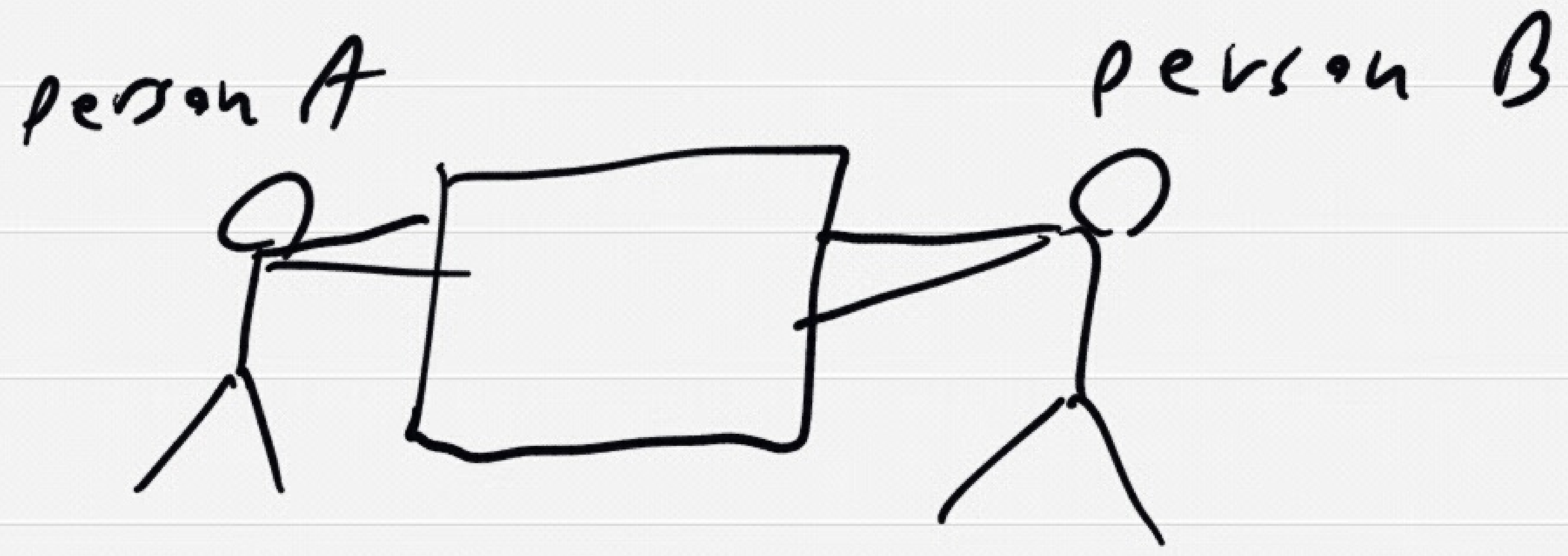
0) Draw a blob representing the object.

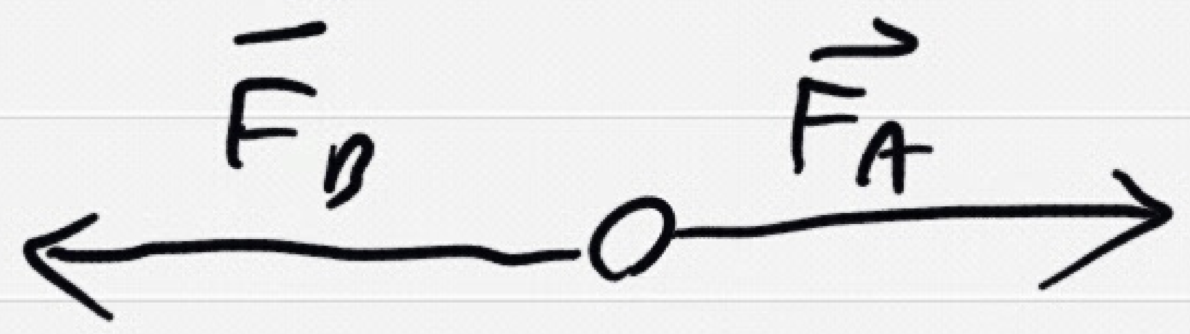
1) Draw only the forces acting **on** the object (not the forces which the object exerts on others).

2) Indicate strength and direction of forces on the object by drawing arrows coming out of the object.

3) Use symbols to represent the magnitudes of the forces (Don't worry about +/- signs. The forces arrows show the directions of the forces already.)

Free-body Diagrams





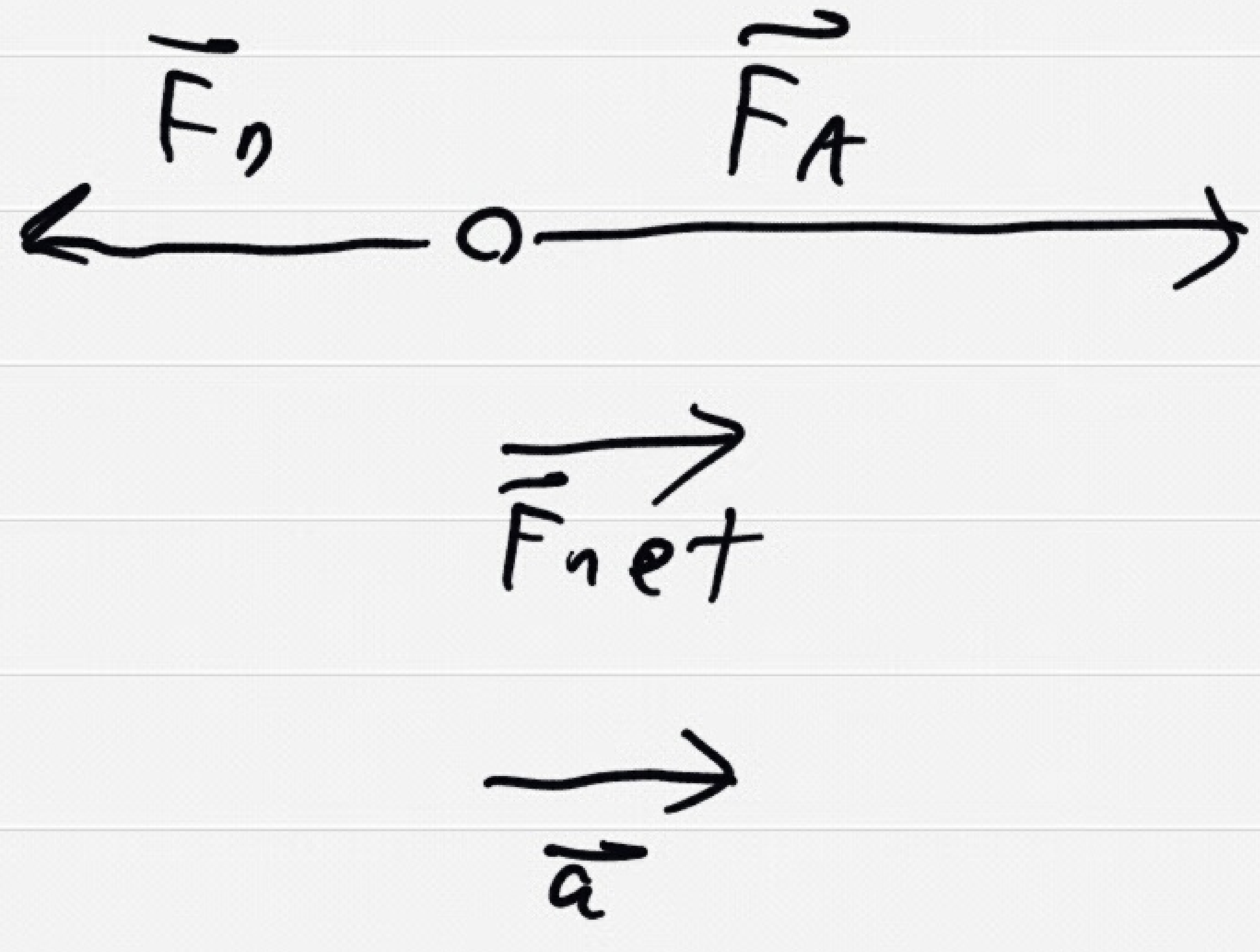
If $|\vec{F}_A| = |\vec{F}_B|$ then $\vec{F}_{net} = 0$

$\Rightarrow$ stationary or moving w/ constant velocity

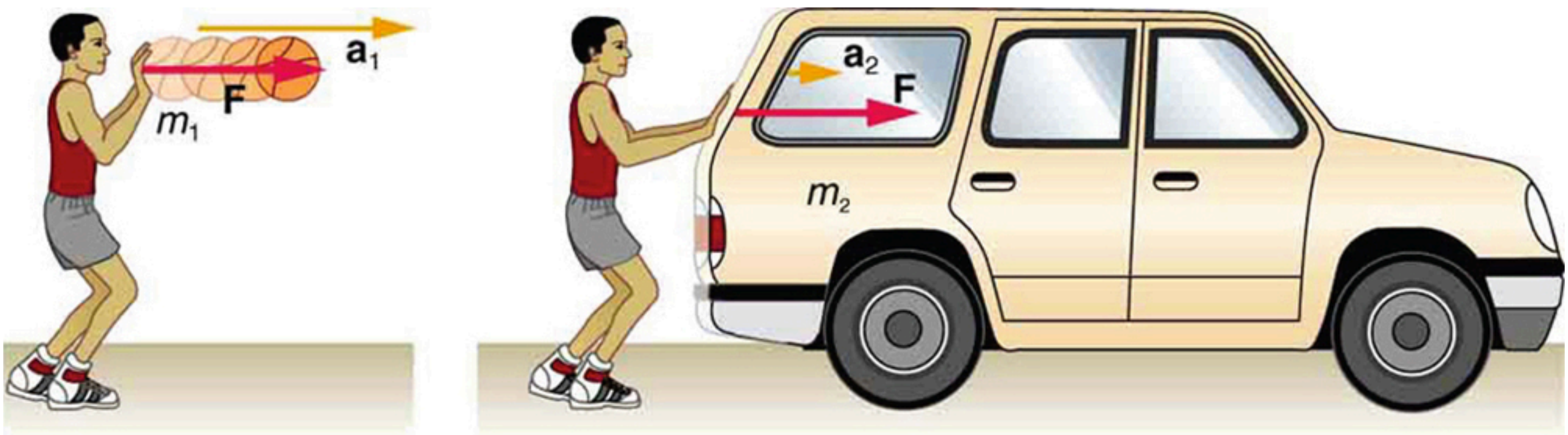
If $|\vec{F}_A| \neq |\vec{F}_B|$ then $\vec{F}_{net} \neq 0$

$\Rightarrow$ accelerating in direction of $\vec{F}_{net}$

e.g.



Force Vs. Acceleration (2)



(a) (b)