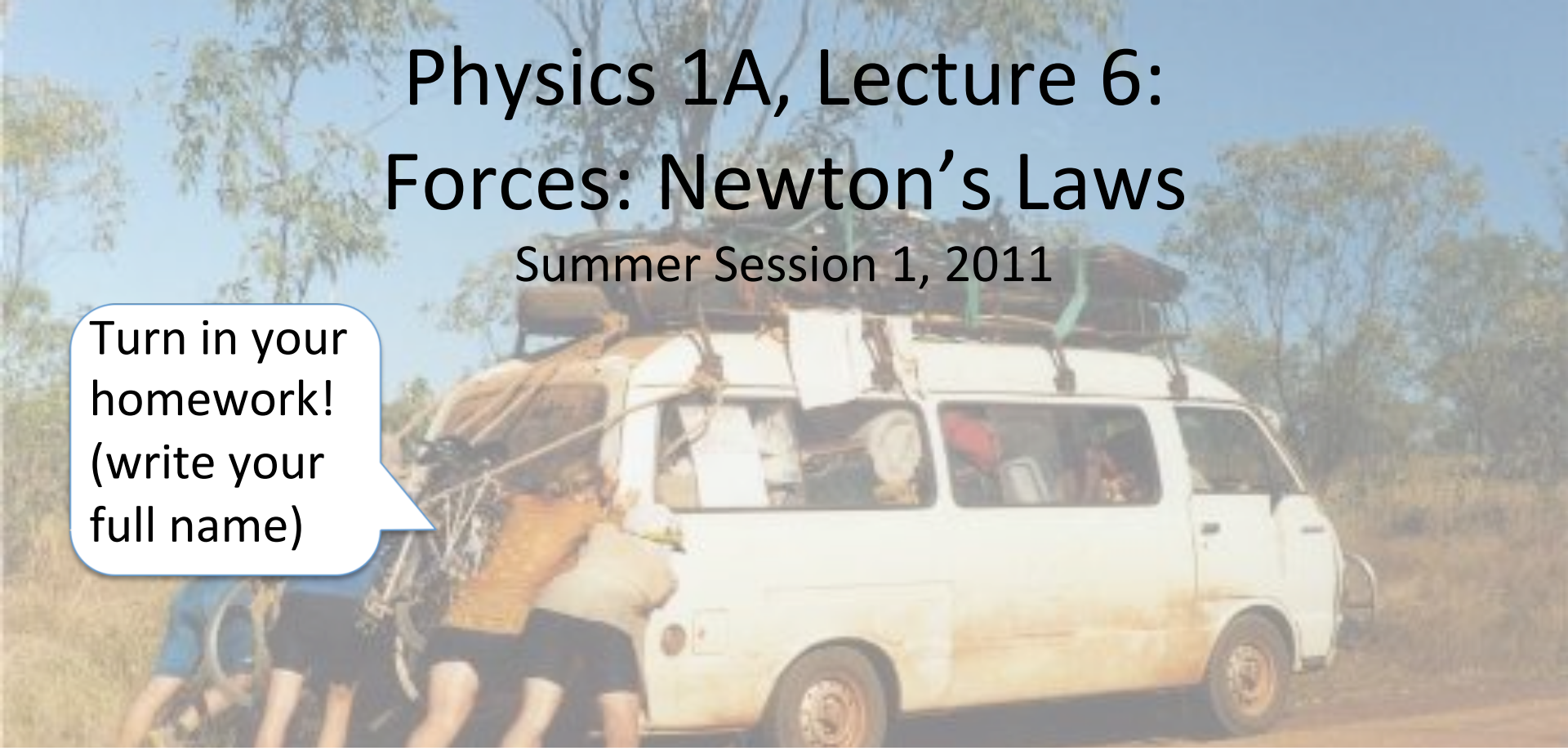
Physics 1A, Lecture 6: Forces: Newton's Laws

Summer Session 1, 2011



Your textbook should be closed, though you may use any handwritten notes that you have taken. You will use your clicker to answer these questions. If you do not yet have a clicker, please turn in your answers on a sheet of paper. The quiz will commence at 9:33 AM.

Key Questions: (Discuss with neighbors before quiz)

1) What is Newton's First Law?
2) What is inertia?
2) What is the difference between mass and weight?
3) What is the SI unit of Force?

Reading Quiz #4-2

- What is Newton's First Law?

  "An object in motion remains in motion…

A) … unless it feels like giving up"

B) … unless acted upon by a net force"

C) … if there is an internal source of energy"

D) … until it encounters an immovable object"

E) … as long as its momentum is conserved"

Reading Quiz #4-2

- What is inertia?

A) A quality that is given to an object when it is propelled

B) The tendency of an object to find its equilibrium

C) The tendency of an object to obey Newton's First Law

D) The net force on an object

E) The weight of an object

Reading Quiz #4-3

- What is the difference between mass and weight?

A) mass is a vector and weight is a scalar

B) they exactly are the same, but mass is in SI units (kg) and weight is in US conventional units (lbs)

C) mass is the same everywhere but weight depends on the planet that you are on

D) they are exactly the same

E) none of the above

Reading Quiz #4-4

- What is the SI unit of Force?

A) The Newton = kg m/s^2

B) The Joule = kg m^2/s^2

C) The Watt = kg m^2/s^3

D) The Aristotle = kg m/s^2

E) None of the above

Announcements

- Turn in Homework 2 by 1pm in my office hour (Mayer 5623)
  - You can pick it up at the problem session tonight
- Evan's office hours today 2pm-4pm
- Evan's problem session tonight 5-6pm (Peterson 104)
- I posted answers to the Projectile motion extra problems
- Quiz 1 is tomorrow

I will pick whichever grading rubric gives you a higher score:

- Final 40%
- Quizzes 40%
  - (drop lowest 1 of 3, each is worth 20%)
- Homework 15%
  - (out of 5, each is worth 3%)
- Reading Quizzes 5%
  - (drop lowest 4 out of 12, each is worth 0.625%)
- Clickers 5% (Extra Credit)

- Final 35%
- Quizzes 35%
  - (drop lowest 1 of 3, each is worth 20%)
- Homework 20%
  - (out of 5, each is worth 3%)
- Reading Quizzes 10%
  - (drop lowest 4 out of 12, each is worth 0.625%)
- Clickers 5% (Extra Credit)

Quiz 1 will be in class tomorrow

- It will cover everything from lecture, reading assignments, both homework assignments:
  - Math Review, Kinematics equations, Free fall, Projectile motion, Uniform Circular Motion
- You will need:
  - **Scantron, Calculator, #2 pencil**
  - **You may not use a phone as your calculator**
- An equation sheet will be provided
- It will start at 9:30am. We will not have class afterwards, so you can take the full 80 minutes
- It will be 15 multiple choice questions
- You will not be allowed to keep the questions. But if I am not able to post the grades by Friday, I will post a solution key the next day. Otherwise you will have to see solutions in office hours.

My recommendations for studying

- Try out some projectile motion problems (answers are posted on the web)
- Book problems are for the most part *much harder* than will be expected from you.
- Make sure you follow my recommendations for how to solve problems.
- Two classes of Kinematics problems:
  (1) Questions about initial/final velocity
  (2) Questions about displacement and time
- Watch out for units!

Today's anonymous poll

Approximately how long did it take you to do Homework #2?

A) Less than an hour

B) 1-2 hours

C) 2-3 hours

E) More than 3 hours

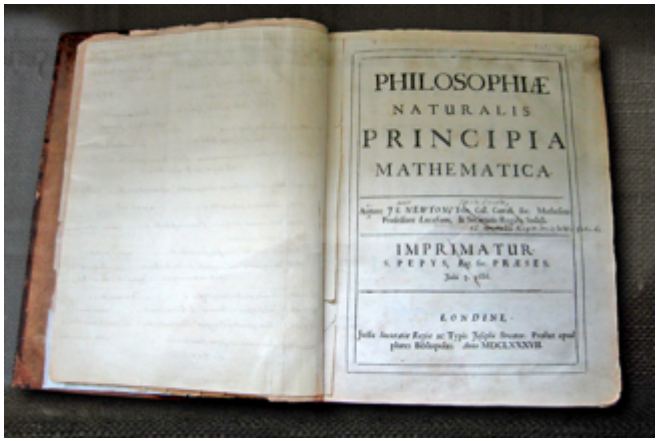
F) I couldn't finish the homework

History Lesson: Aristotle (384 BC – 322 BC)

- Aristotle's understanding of motion:
  - Force causes motion
  - Force is a quality of an object not acted on the object
  - Objects seek their "natural place"
  - Heavy bodies fall faster than lighter ones
  - Air propels things
  - Throwing an object gives it "impetus" which slows down over time
  - No concept of acceleration

History Lesson:
Issac Newton (1643 – 1727)

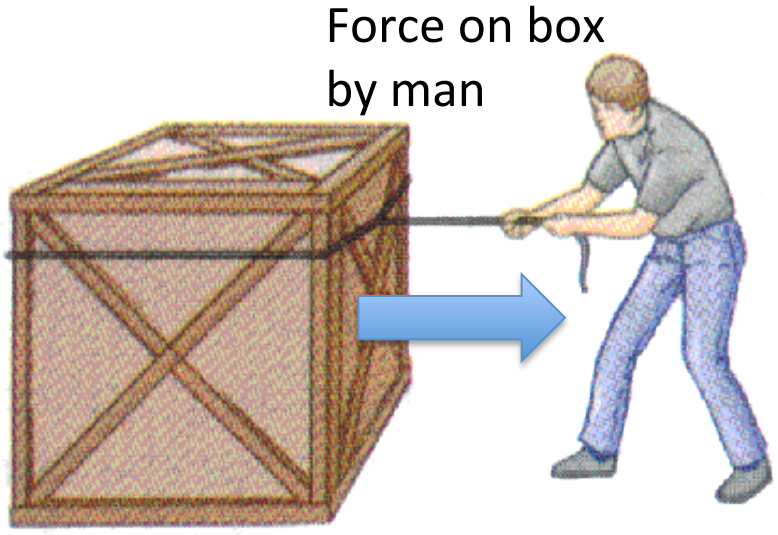
- Discovered classical mechanics as we know it



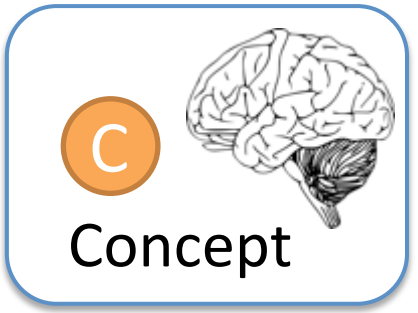
What is a force?

C Concept

- A force is a push or a pull.
- A force is a vector (magnitude and direction)
- A force can be exerted *on* an animate or inanimate object.
- A force can be exerted *by* an animate or inanimate object.

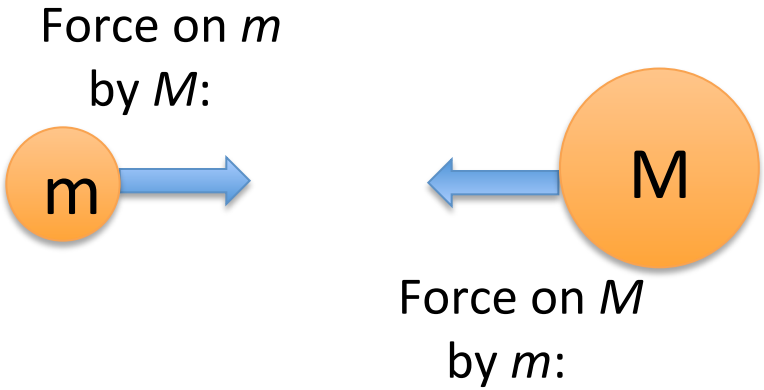


What is a force?



- A force is either between two objects *in contact* OR it is due to a *field force*.

- Only *field forces* can create action at a distance:
  - Gravity force (1A)
  - Electric force (1B)
  - Magnetic force (1B)
  - Nuclear force



What is a force?

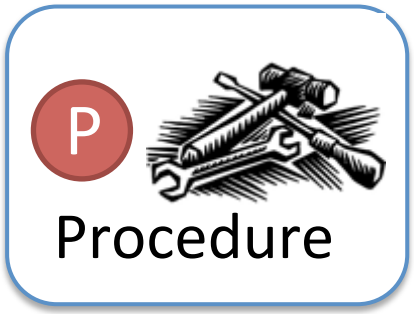
C Concept

- A force is either between two objects *in contact* OR it is due to a *field force*.

- A contact force exists only when two objects are IN CONTACT:



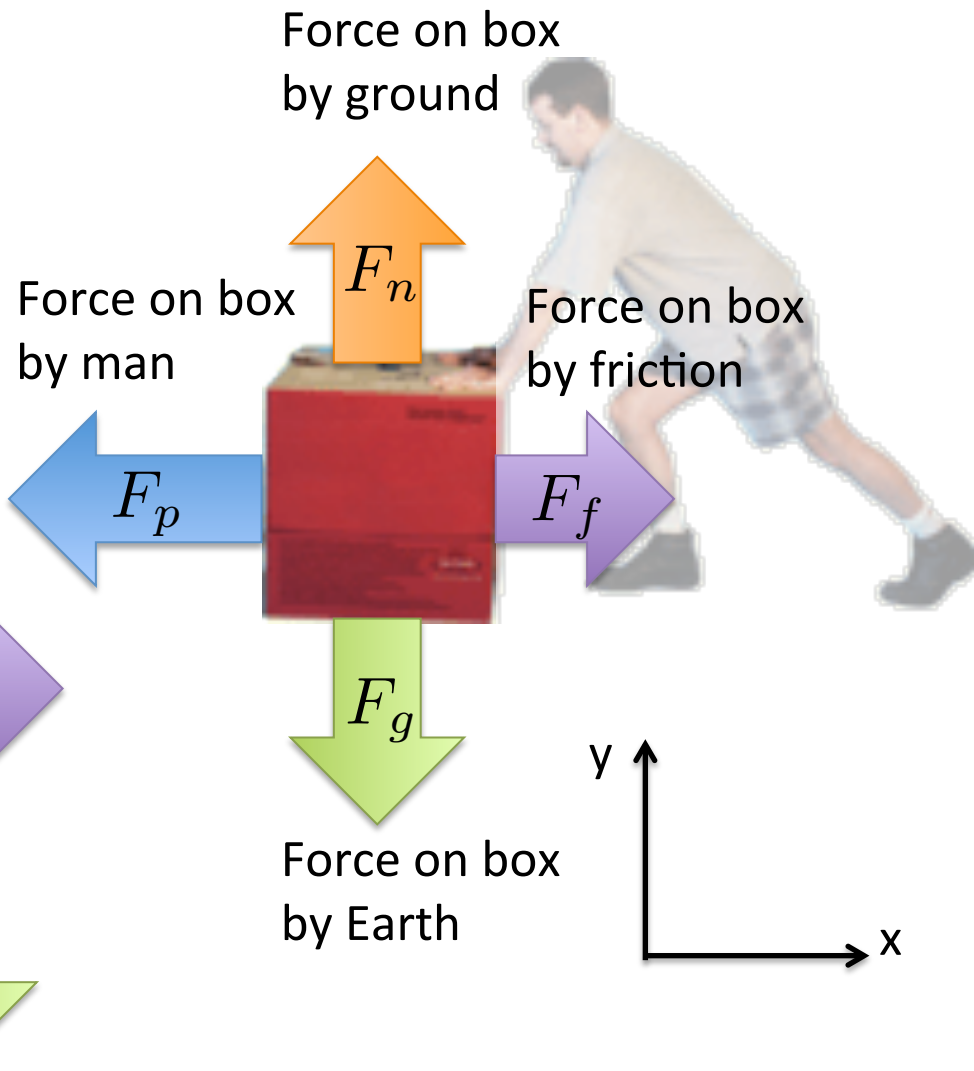

Free body diagrams and Net Force, ΣF



- To find the net force on an object:
  - Draw a picture with a coordinate system
  - Draw arrows going away from the object to represent the forces
  - Deal with each axis separately:

$$\sum \vec{F}_x = F_p + F_f$$

$$\sum \vec{F}_y = F_n + F_g$$



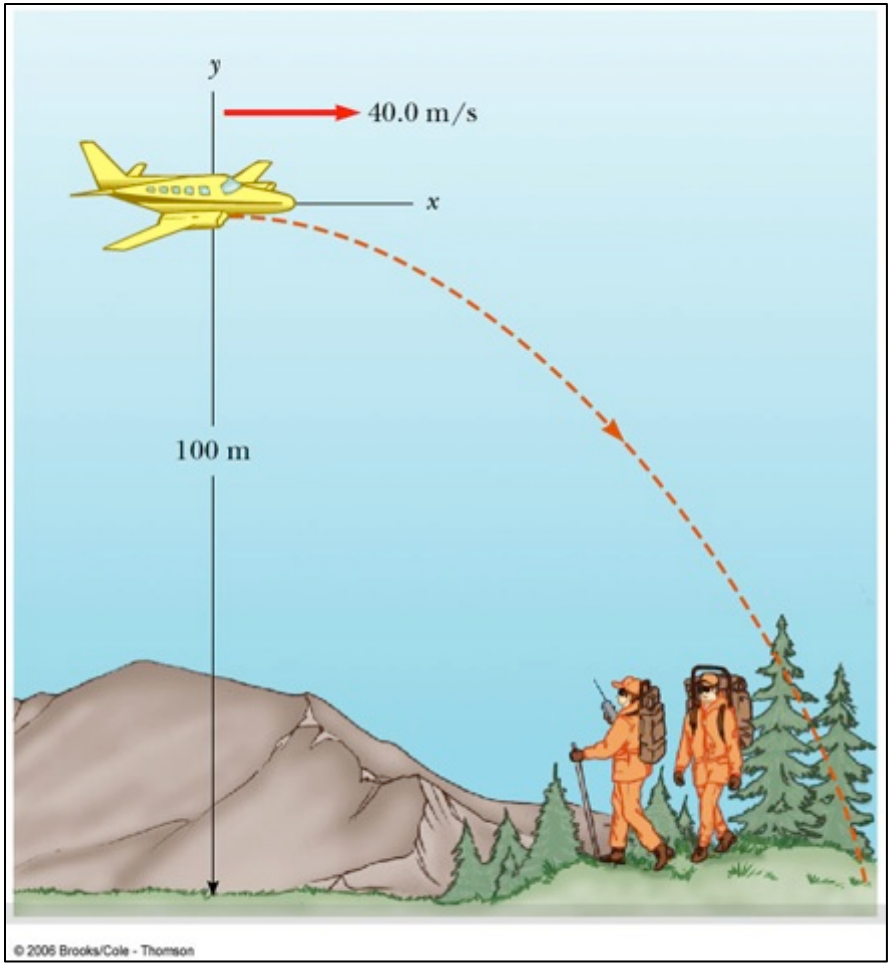
Newton's First Law

An object continues in a state of rest or in a state of motion at a constant speed along a straight line, unless compelled to change that state by a net force.

-which means-

An object does not need need to be under the influence of a force to be in motion!

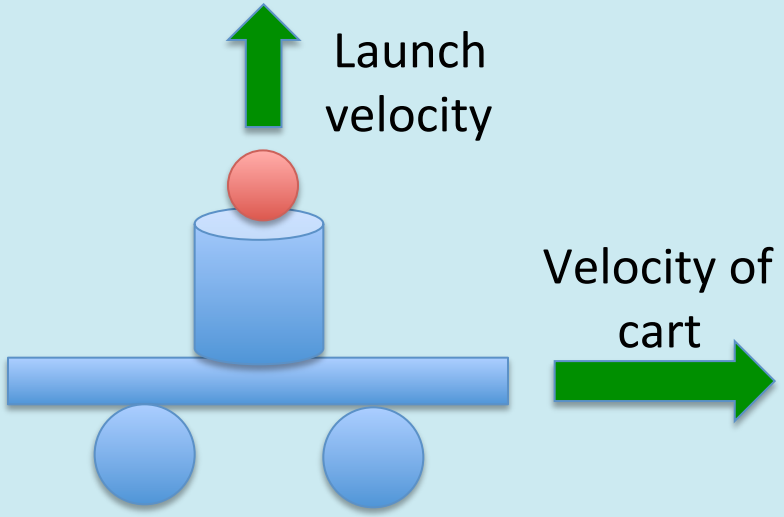
Consequences of Newton's First Law



Clicker Question 6-1
"The Ballistic Cart"

A cart moves with a constant velocity. The cart has a ball launcher that is aimed straight upward. If the cart launches a ball straight upward (at least in the cart's perspective), where does the ball land if the cart continues along with constant velocity and if we can neglect air resistance?

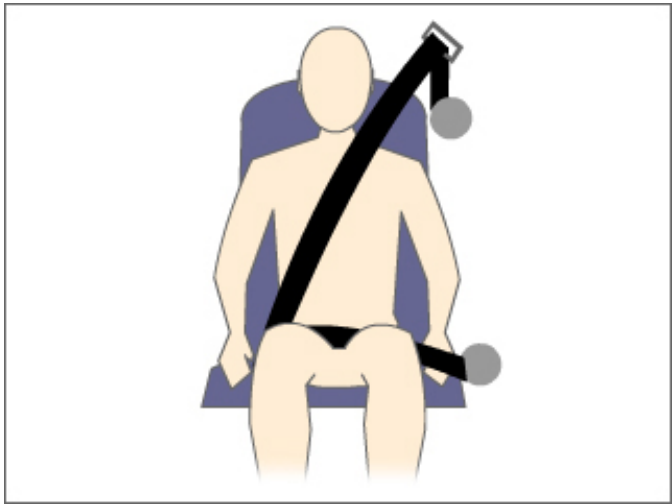
A) in front of the cart
B) behind the cart
C) on the cart



Inertia

C Concept

- One word summary of Newton's First Law
- The tendency of an object to retain its state of motion unless acted on by an external force.
- One major consequence of inertia: SEAT BELTS
- The more massive something is, the more it resists changes to its velocity



Clicker Question 6-2

- A hockey player shoots puck gently across the ice but it comes to a stop halfway down the ice rink. Why does this happen?

A) The force that he gave the puck was drained away by friction

B) Hockey players don't obey Newton's Laws of Motion

C) The force of friction between the puck and the ice acted on the puck to slow it down.

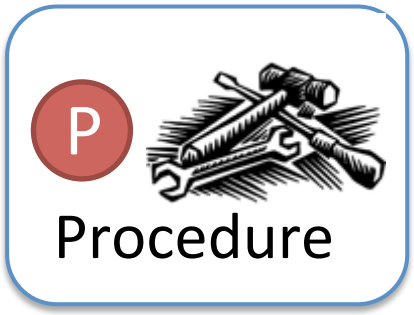
D) The force that he hit the puck with has to be proportional to the distance The puck travels.

Newton's Second Law

A net force (ΣF) on an object of mass (m) results in an acceleration (a) according to the following formula:

$$\Sigma F = ma$$

ΣF=ma



- y direction:

$$\sum \vec{F}_y = \vec{F}_n + \vec{F}_g$$

$$= 0$$

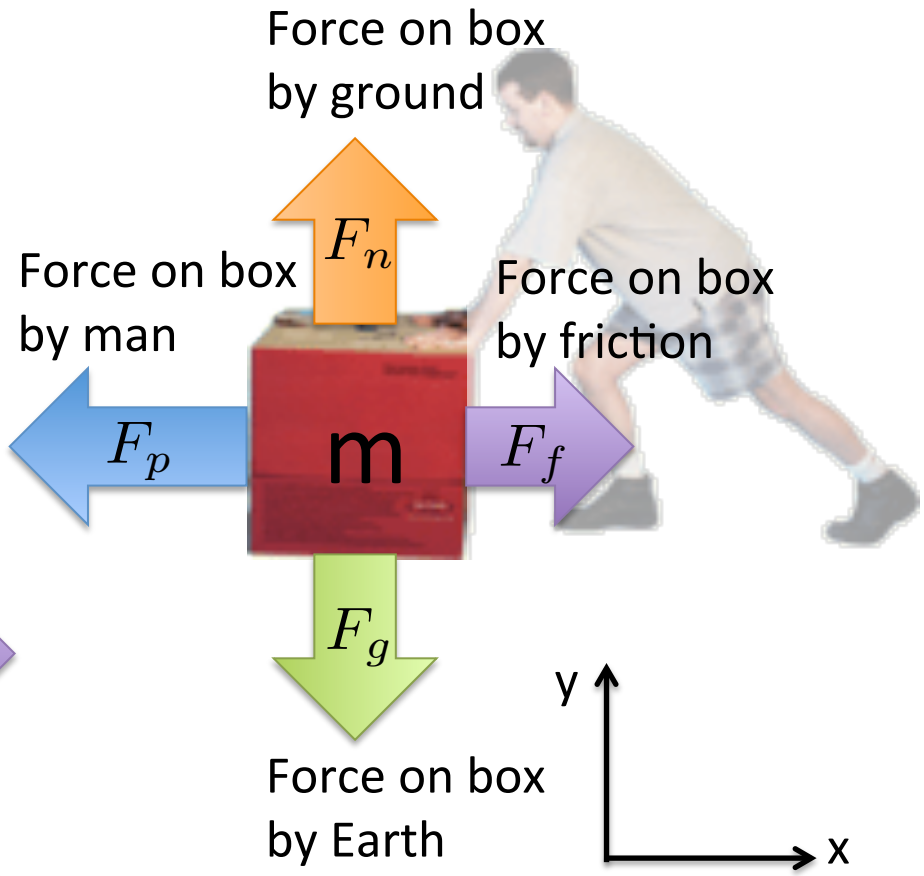
– Equilibrium in y!

- x direction:

$$\sum \vec{F}_x = \vec{F}_p + \vec{F}_f$$

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

– Acceleration in x!



Clicker Question 6-2

Which one of the following statements about forces is correct?

A) If there's no net force on an object, the object is at rest or will immediately come to rest.

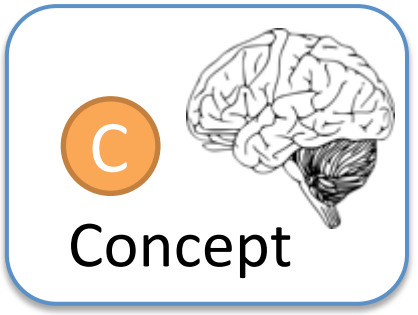
B) An object that remains at rest could have a net force that is non-zero.

C) An object that is continually moving must have a net force on it.

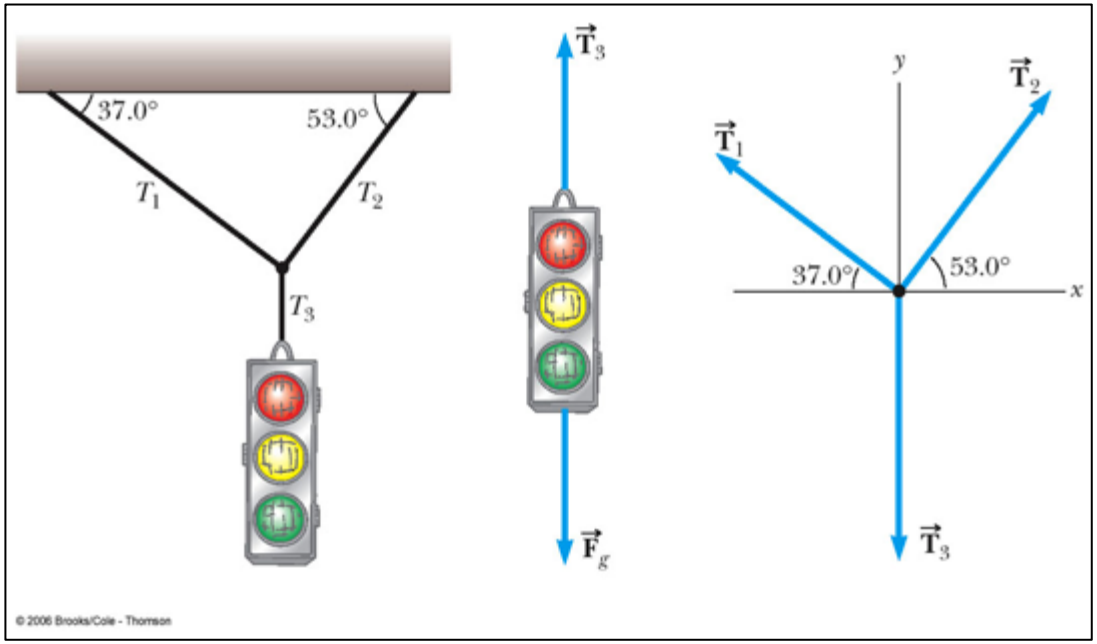
D) In general, force is proportional to velocity.

E) All of the above statements are incorrect.

Equilibrium



- When something is not in motion, the **NET** force must be zero. (This is also true for something moving with a constant velocity)



Newton's Third Law

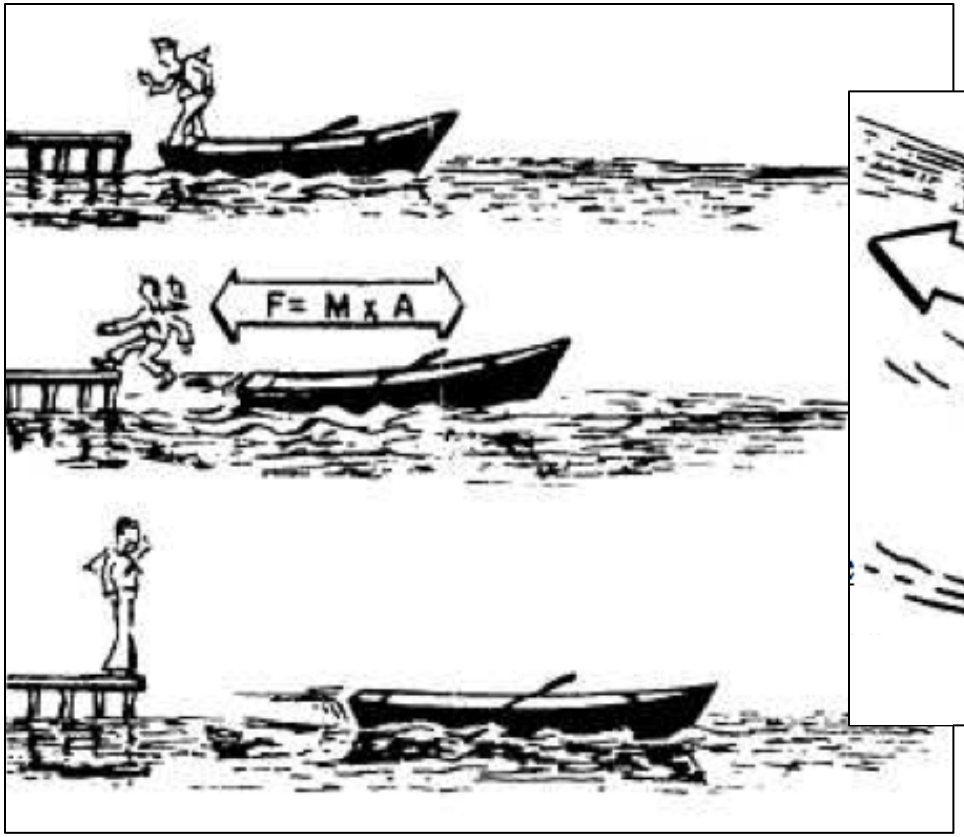
If two object interact, the force exerted by object 1 on 2 is equal in magnitude and opposite in direction to the force exerted by object 2 on 1 :

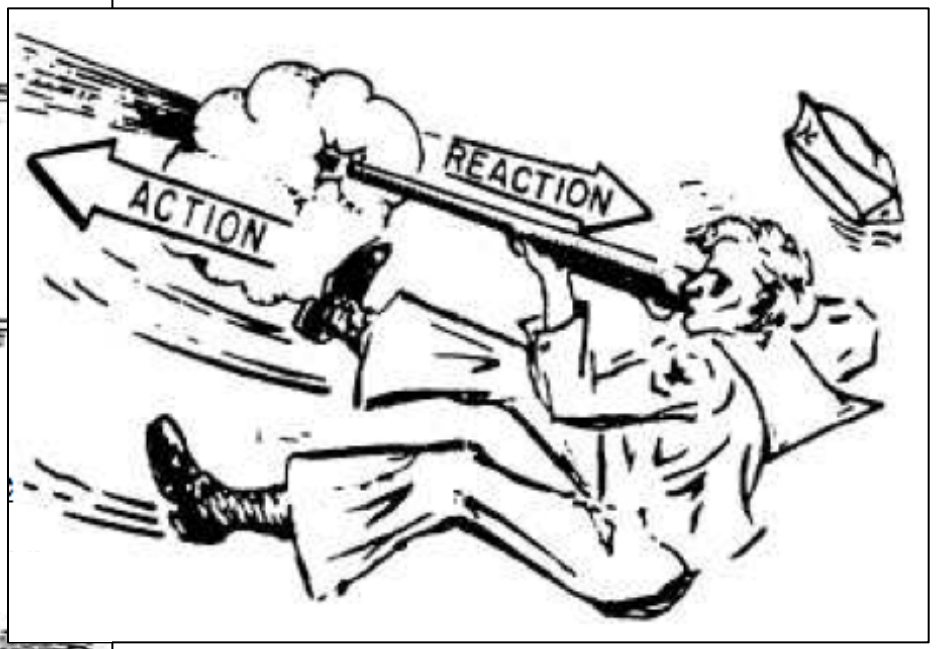
$$\mathcal{F}_{12} = -\mathcal{F}_{21}$$

-In other words-

For every action there is an equal and opposite reaction.

Consequences of Newton's Third Law





Clicker Question 6-3

Which one of the following objects can exert a force on another object?

A) A table.

B) A person.

C) Air.

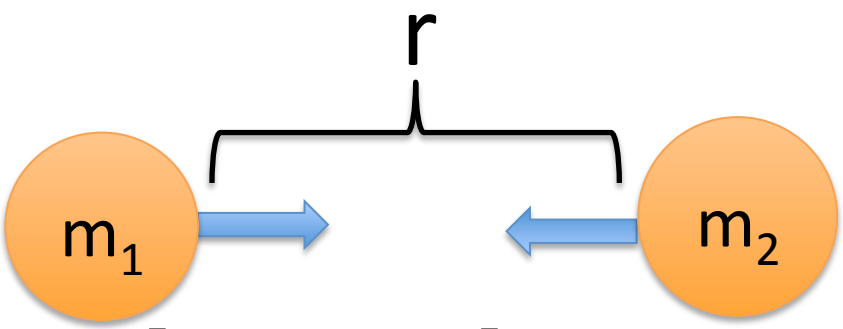
D) All of the above can exert a force on another object.

E) Only choices A and B are correct.

Newton's Third Law

C Concept

- Field forces obey Newton's Third Law:



Force on m_1 by m_2:

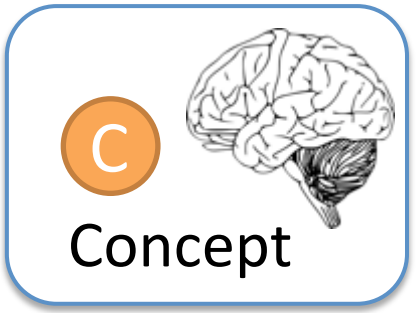
Force on m_2 by m_1:

$$\left|\vec{F}_{12}\right| = G\frac{m_1 m_2}{r^2}$$

$$G = 6.67 \times 10^{-11}\,\frac{\mathrm{N\ m^2}}{\mathrm{kg^2}}$$

The gravitational constant

Newton's Third Law



- Force of gravity:

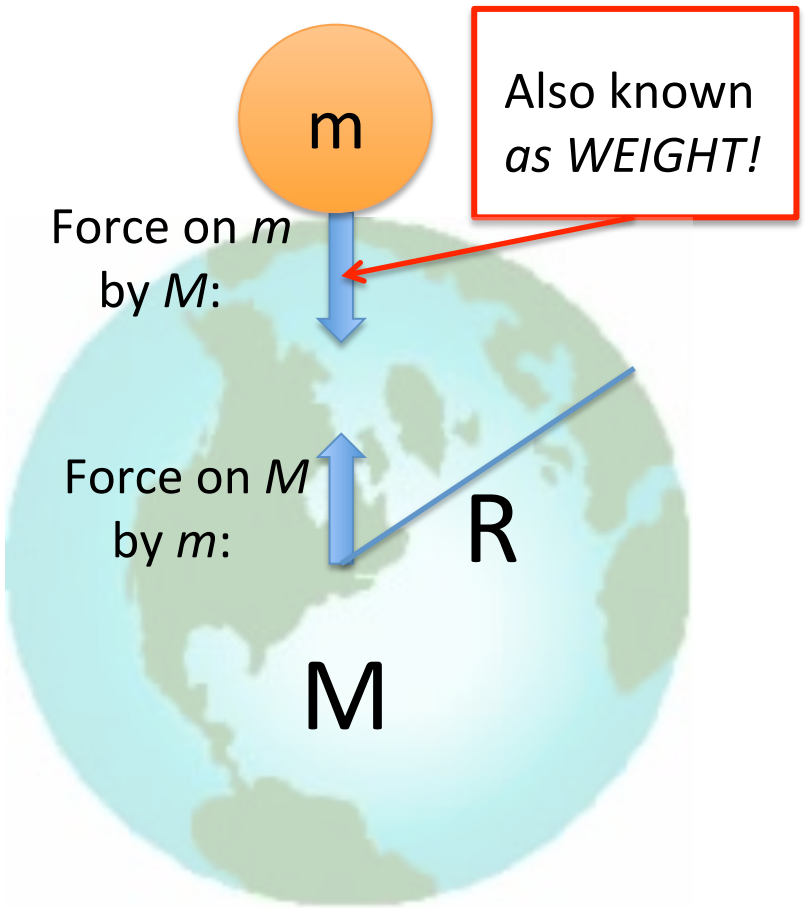
$$\left|\vec{F}_{12}\right| = G\frac{m_1 m_2}{r^2}$$

$$\left|\vec{F}_g\right| = G\frac{Mm}{R^2} = mg$$

$$\left|\vec{F}_g\right| = mg$$

Acceleration due to gravity at the Earth's surface

$$g = \frac{GM}{R^2} \approx 9.8\frac{\mathrm{m}}{\mathrm{s}^2}$$



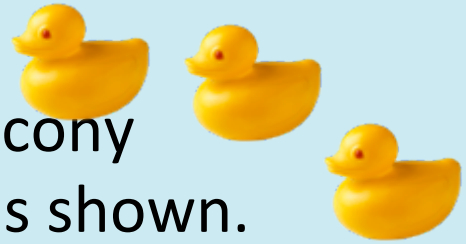
Clicker Question 6-3

If gold was sold by weight, where would you rather purchase it?

A) Denver

B) Death Valley

Clicker Question 6-2



A child throws his rubber ducky off a balcony sideways. The ducky's motion diagram is shown.

After the child has let go of the bear, identify all the forces on the bear. You may neglect air resistance.

A) The force of gravity downward and the horizontal force of the fall.

B) The force of gravity downward and the upward force of the fall.

C) The force of gravity downward.

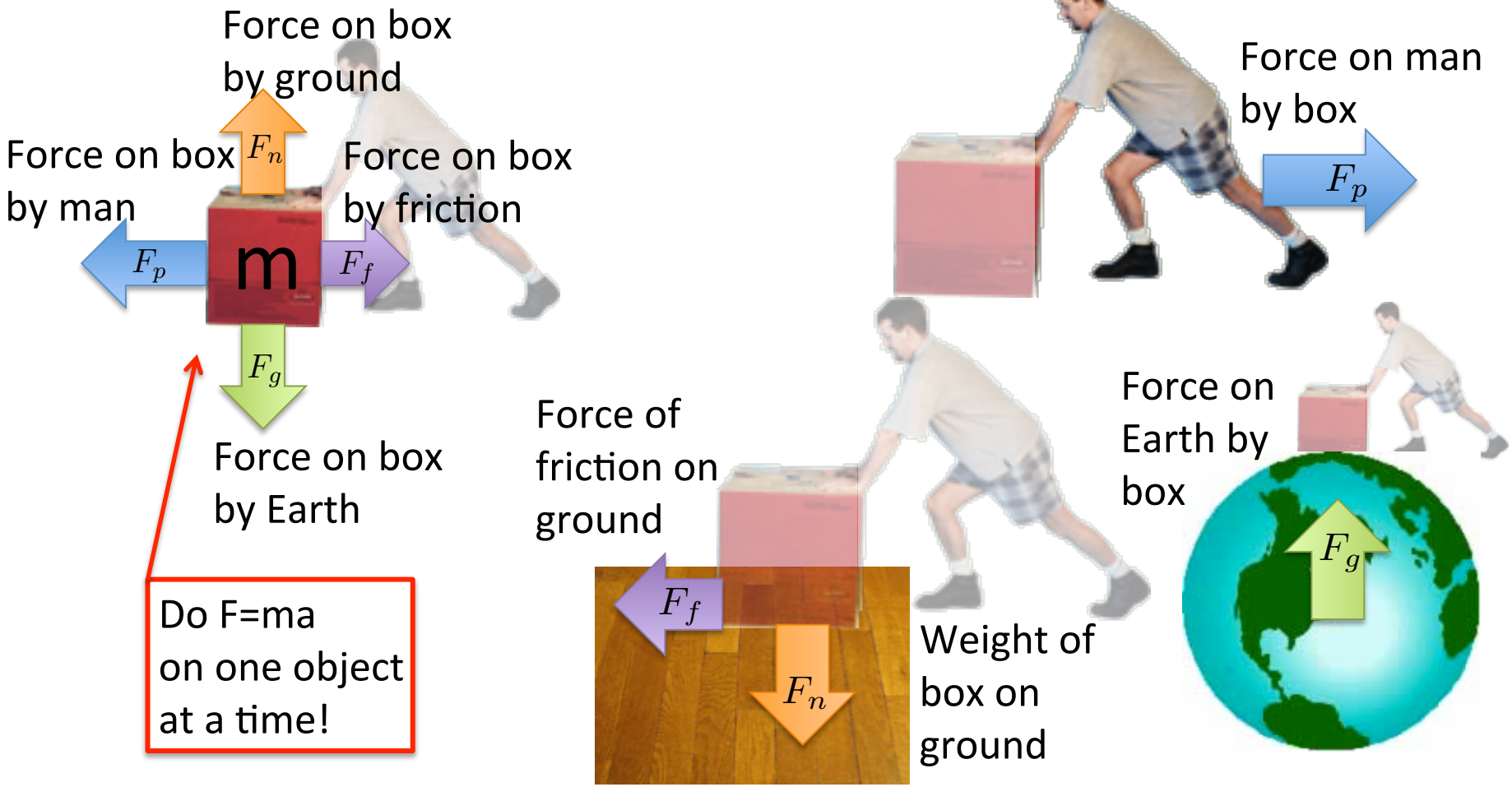
D) The force of gravity downward and the horizontal force of the child's hand.

E) The force of gravity downward and the upward force of the child's hand.

Newton's Third Law

C Concept

- Contact forces also obey Newton's Third Law:



Homework

- Turn in Homework #2 by 1pm in office hours
- Quiz #1 will be tomorrow
- Monday's reading assignment and Homework #3 will be posted by tomorrow at 5pm
- Quiz #1 grades or solutions will be posted Friday so that you can make a decision about dropping.