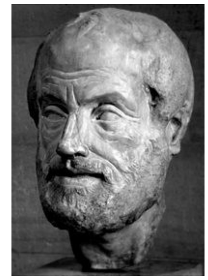
Announcements – 15 Sep 2009

1. **Exam 1 still going on…**
   a. …until tomorrow night
   b. Late fee after 1 pm tomorrow.

2. HW 4, based mainly on today's lecture, will be due Saturday night

3. Thursday afternoon email: Still 20 unregistered clickers. You've got until tomorrow afternoon to register your clicker on the class website in order to get retroactive credit. Otherwise, you'll just get credit for the quizzes you take after you finally do register.

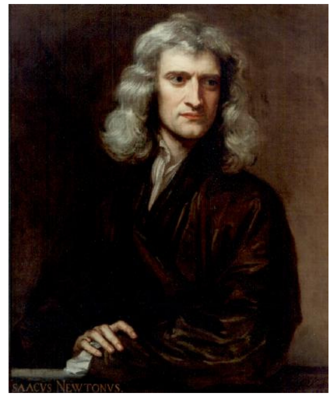
Forces and motion



Aristotle: 384 – 322 BC, Greece

- **Four elements**, two **states**
- **gravity** - earth and water want to come to rest on the ground
- **levity** - air and fire want to rise above us

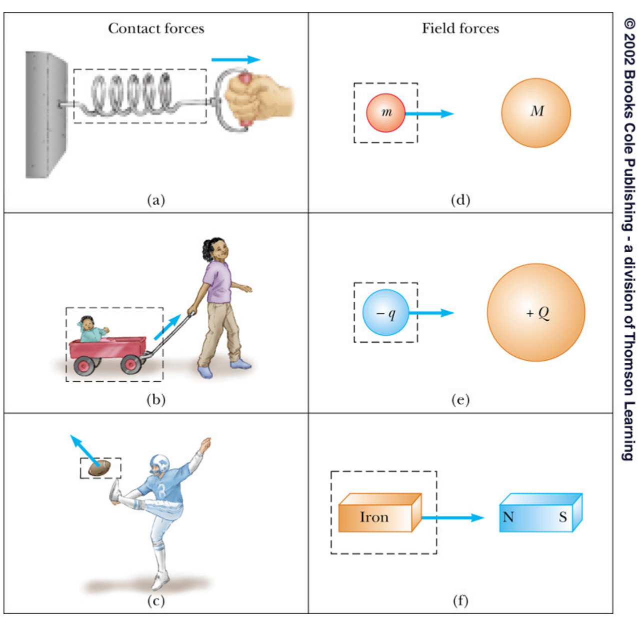
Isaac Newton: 1642 – 1727, England



- Laws of mechanics
- Law of Universal Gravitation
- Calculus
- Light and optics

Force:

A push or pull between **pairs** of objects



From warmup: Newton's first law states that, in the absence of any forces, an object in motion will
a. remain in motion forever
b. eventually come to rest

Newton's First Law: ***Inertia***

How do astronauts know which chocolate milk carton is empty?

Demo: "Inertia Balls"
Question: Which ball will move more?
a. left
b. right
c. same

Newton 1: "Objects will continue to move at *constant velocity* unless acted upon by an outside force."

→ the velocity could be zero
→ remember, velocity includes direction

Mass *m*: *"A measure of the resistance of an object to changes in its motion due to a force"*

SI unit: kilogram

Also: mass is *how much stuff there is* in the object (protons, neutrons, electrons, …)

Clicker quiz: According to Newton, the "natural state of matter" is:

a. to be at rest
b. to resist velocity
c. to resist acceleration
d. to resist displacement

Clicker quiz: The mass of an object

a. is the same as its weight
b. depends upon the forces being applied
c. is a measure of how an object resists a change in motion.

*Newton's second law: **Forces***

Newton 2: $\Sigma\vec{F} = m\vec{a}$

Forces are vectors!

$$\rightarrow \vec{a} = \frac{\vec{F}_{net}}{m}$$

Units of force:
1 Newton = 1 kg m/s^2 = 0.2248 lb
= amount of force to accelerate 1 kg at a rate of 1 m/s

Tip: We often use N2 to find the acceleration, then kinematics equations to find other quantities (distance, time, velocity)

Clicker quiz: You push your 40 kg shopping cart with a constant force of 50 N, and find there is a backwards frictional force of 20 N on it. What will be the acceleration?

a. 0.50 m/s^2
b. 0.75 m/s^2
c. 1.25 m/s^2
d. 1.33 m/s^2
e. 2.00 m/s^2

Gravity

Force of gravity: "weight", often use symbol *w*

Acceleration of "g", then…

$$F_{gravity} = w = mg$$

→ the force is still pulling down even if the object is not allowed to accelerate

1 kg = 2.2 lbs?

Weight vs. mass

→ generally weight is proportional to the mass

→ weight depends on location; mass does not

Free-body diagrams (force diagrams)

1. Draw the object by itself
   a. You can combine several objects as a single "group object" if they have the same acceleration
2. Draw forces **on the object** as arrows
   a. Start the arrows at the object.
   b. Label each arrow; use different symbols for different forces.
   c. Only draw the forces on the object! (Not the forces produced by the object.)
3. If you want to draw velocity or acceleration vectors, do so *near* the object, but not mixed in with the force vectors

Textbook, 8^{th} ed, pg 94: "The **most important step** in solving a problem by means of Newton's second law **is to draw the correct free-body diagram**."

Example FBD: Dr Colton trying to move a fridge

Turning in FBDs

Starting with HW 5, some homework problems will require you to turn in FBDs.

1. **Read "Free-body diagrams" section of the syllabus**
2. Turn them in to the "turn in" boxes near N357 ESC (closed boxes on bottom left)
3. If you can't get to campus: Sara (the grader) said it would be OK for you to scan & email her your FBDs.
   a. Due at the same time (11:59 pm)
   b. Don't expect to get as much feedback

Solving Newton's 2nd Law problems

1. Draw the correct free-body diagram
2. Apply N2 to both the x- and y-components:

   $\Sigma F_x = ma_x$ and $\Sigma F_y = ma_y$

   → m is the mass of the object
   → Be careful with positive directions; forces are vectors
3. Use these equations as **blueprints**
   → Fill in the blueprints with the information you're given, to get the "real equations"

Multiple objects:

- Draw a free-body diagram and write eqns for each object
- If objects are connected, you can treat them as group

Demo: Ping-pong ball cannon (2^{nd} Law)

Clicker quiz: how fast do you think the ping pong ball will come out?
a. Less than 100 m/s
b. 100 – 200
c. 200 – 300
d. More than 300 m/s

Worked Problem. A 2.7-gram (0.0027 kg) ping-pong ball is pushed 3 meters along a tube by a constant force of 54 N from air behind it. What is the exit velocity?

Answers: $a = 20{,}000$ m/s^2; $v_f = 346.4$ m/s

From warmup: The engine on a fighter airplane can exert a force of 105,840 N. The take-off mass of the plane is 16,875 kg. If you mounted this aircraft engine on your car, what acceleration would you get? (1400 kg car)
a. less than 10 m/s
b. between 10 and 100 m/s
c. between 100 and 200 m/s
d. more than 200 m/s

Clicker quiz: A monkey starts to slide down a rope. As it speeds up, it tightens its grip, until it slides at a constant velocity down the rope. Which of these choices is true in this situation?

a. The gravitational force is equal to the frictional force.
b. The gravitational force is greater than the frictional force.
c. The gravitational force is less than the frictional force.

Answer: 75.6 m/s^2

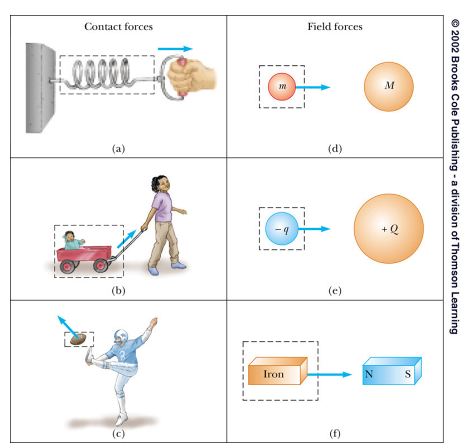
*Newton's Third Law: **Equal & Opposite***

"For every *force*, there is an equal and opposite *force*"

Forces always come in *pairs*

$$\vec{F}_{1-2} = -\vec{F}_{2-1}$$

The forces in a pair always act on ________________.
The magnitudes of the forces are always _________, and their direction is ______________.



Video: Reaction gliders, equal masses

Clicker quiz: What will happen to the first cart?

a. It will stay still
b. It will move left
c. It will move right

Are the ***acceleration*** magnitudes of the two objects always the same?

Video: Reaction gliders, unequal masses

Clicker quiz: What will happen to the gliders now?

a. The heavier glider will move faster
b. The heavier glider will move slower
c. The heavier glider will move at the same speed

From warmup: Ralph is driving his car and a bug hits his windshield. The bug is totally smashed, but the windshield is unaffected. Doesn't this mean that the force exerted by the windshield on the bug is greater than the force exerted by the bug on the windshield?

Answer from the class:

From warmup: If I push on an object which is at rest (like the wall), then the force exerted by my hand on the object will be equal to the force exerted by the object on my hand. However, if I push on an object, causing it to accelerate, then the force exerted by my hand on the object will be

a. greater than
b. less than
c. still equal to

the force exerted by the object on my hand.

Clicker quiz: A hammer hits a nail, and the nail is driven into the board. The magnitude of the force of the nail on the hammer is ___________ the force of the hammer on the nail.

a. less than
b. the same as
c. more than

Partner forces are <u>always</u> equal in magnitude! $|F_{12}|$ equals $|F_{21}|$!

A car is at rest on a road. Identify the forces on the car, and their partner forces on other objects.

Clicker quiz: What force on the car causes it to accelerate when the gas pedal is pushed?

a. the car pushing backward on the road
b. the car pushing forward on the road
c. the road pushing forward on the car
d. the road pushing backward on the car

Elevators (if we have time)

Worked Problem: Rex has a mass of 40 kg (weight = 392 N), and stands on a SI-unit scale in the elevator.

a. The elevator is at rest. What does the scale read?

b. The elevator accelerates **downward** at 2 m/s^2. What does the scale read now?

c. After a while the elevator moves down at a constant speed of 8 m/s. What does the scale read now?

Try it out! The elevators in the Eyring building (sometimes) have scales in them!

Summary

N1:

N2:

N3:

Weight = force of gravity pulling down