Announcements – 16 Sep 2014

1. **A Cappella Auditions!** – Many of the groups in the BYU a cappella club are having a joint audition tonight at 7 pm, Varsity Theater. All parts needed, male and female. Prepare ~60 seconds of music to sing. They will also do range checks and tonal memory checks.
   → facebook page: www.facebook.com/acappellaclub

2. **Dr Colton out of town –** I'll be out of town from Sep 19-22, so I won't have my normal office hours on Monday Sep 22.

“Which of the problems from last night's HW assignment would you most like me to discuss in class today?”

Projectiles wrap-up

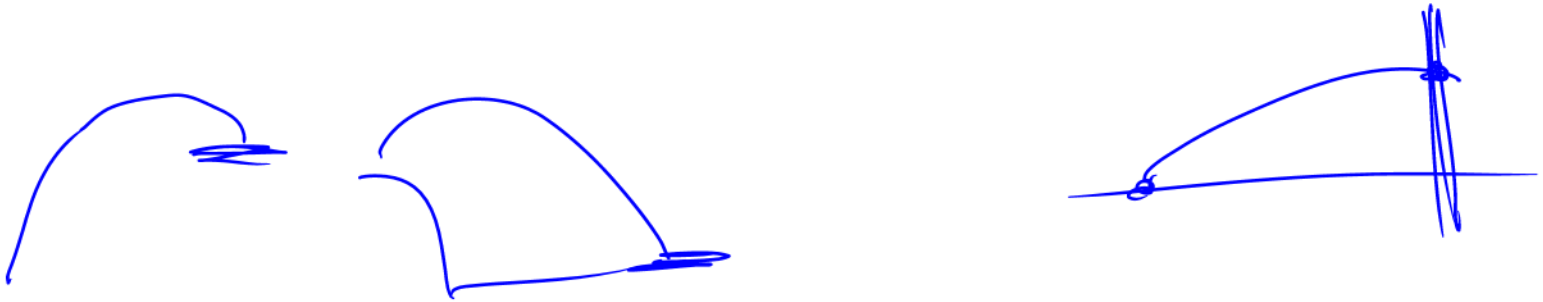
Equations $x = x_0 + v_{0x} t$

$v_y = v_{0y} - gt$

$y = y_0 + v_{0y} t - \frac{1}{2} g t^2$

$v_{fy}^2 = v_{0y}^2 - 2 g \Delta y$

Paths



What if you *do* worry about **air resistance**?

Simulation:
http://phet.colorado.edu/new/simulations/sims.php?sim=Projectile_Motion

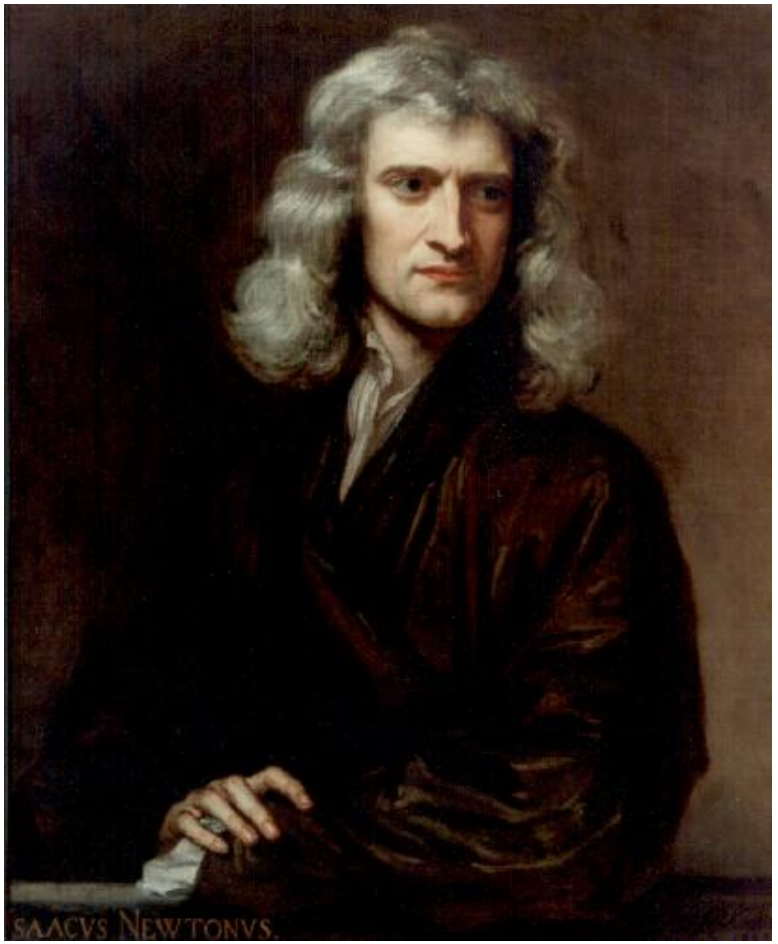
Clicker quiz

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

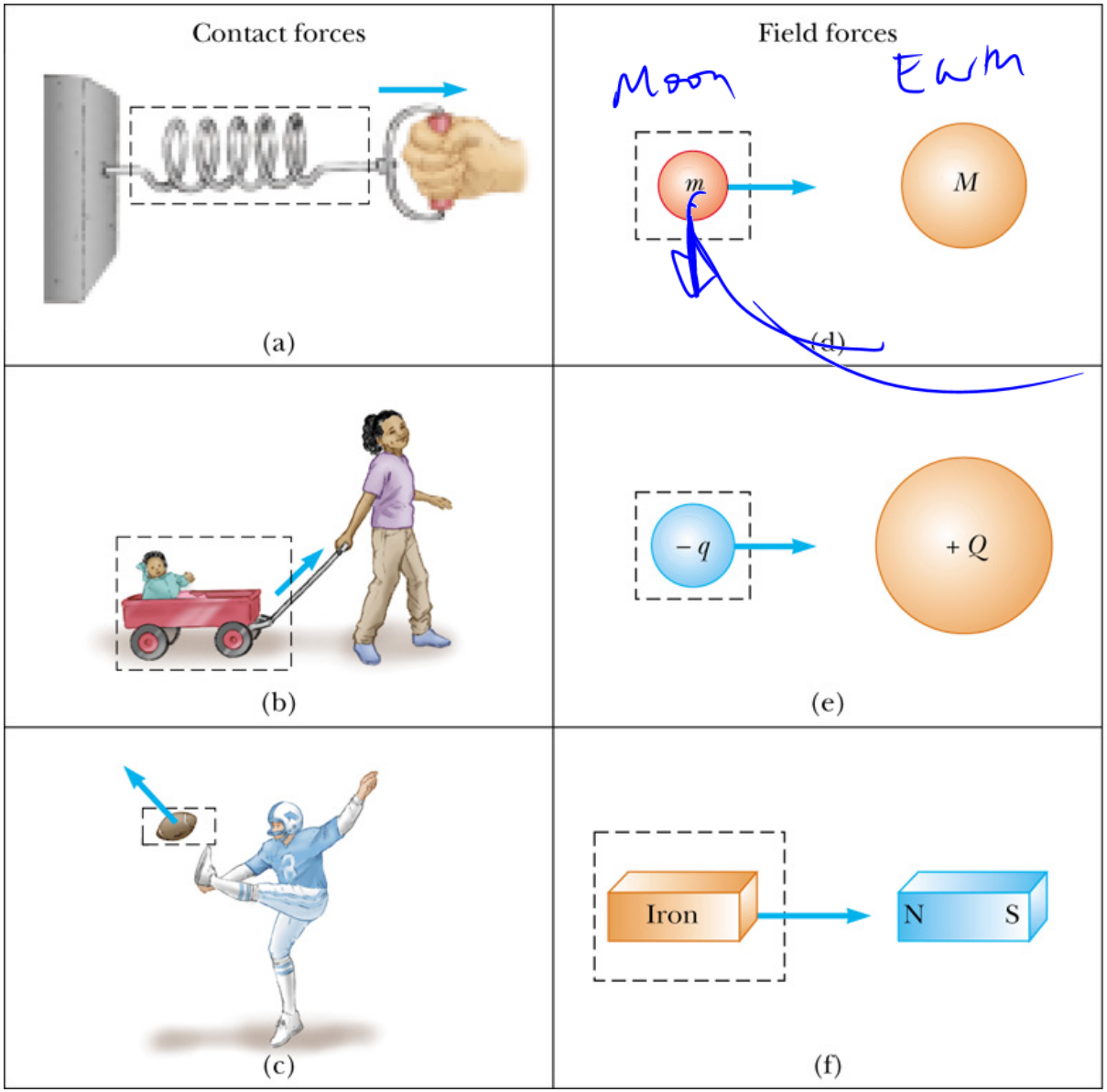
Isaac Newton, 1642 - 1727

- Laws of mechanics
- Law of universal gravitation
- Integral/differential calculus
- Variational calculus
- Light and optics
- Heat flow
- Much more



Force

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



Electricity

Magnetism

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

Clicker quiz

The mass of an object

a. depends upon the forces being applied
b. is a measure of how an object resists a change in motion
c. is measured in Newtons
d. is the same as its weight
e. more than one of the above

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 (total mass of protons, neutrons, electrons, …)

Newton's second law: **Forces**

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

Forces are vectors!

$(1\,kg)(1\,m/s^2)$

What's this symbol? Sigma

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

Unit of force:

1 Newton = 1 kg m/s^2 = 0.2248 lb

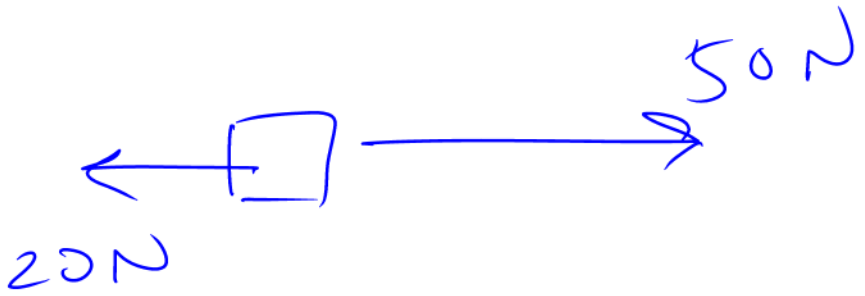
= amount of force to accelerate 1 kg at a rate of 1 m/s^2

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



$F_{net} = 50 - 20\ N$

$= 30\ N$

$\Sigma F = ma$

$30\ N = 40\ kg \cdot a$

$a = \frac{3}{4}\ m/s^2$

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?

$= (1\text{kg}) \cdot (9.8\ \text{m/s}^2) = 9.8\ \text{N}$

Weight vs. mass

→ generally weight is proportional to the mass

→ weight depends on location; mass does not

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

Clicker quiz: how fast do you think the ping pong ball will come out?

a. Less than 50 m/s
b. 50 – 100
c. 100 – 150
d. 150 – 200
e. More than 300 m/s

$100 \frac{m}{s} = 220 mph$

$v \simeq 340 m/s$

15%

What was the average force on the ball as it accelerated?

(What do we need to know?)

Worked Problem

A 2.7-gram ping-pong ball is accelerated along a 3 meter tube by the air pushing on it. It emerges at 340 m/s. What was the average force on the ball?

$$v_f^2 = v_0^2 + 2a\Delta x$$

$$a = \frac{v_f^2}{2\Delta x} = \frac{340^2}{2(3)} = 19266\ m/s^2$$

$$F = ma = (.0027kg)(\ \uparrow\ )$$

$$= \boxed{52\ N}$$

Answer: F_{ave} = 52 N

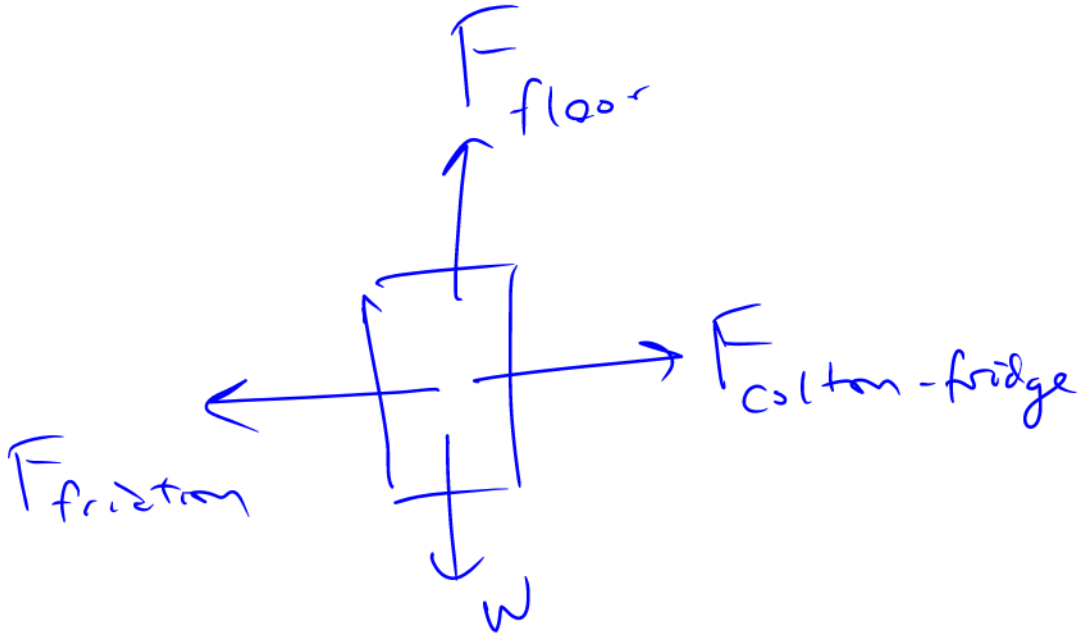
Free-body diagrams (force diagrams)

1. Draw the object by itself
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

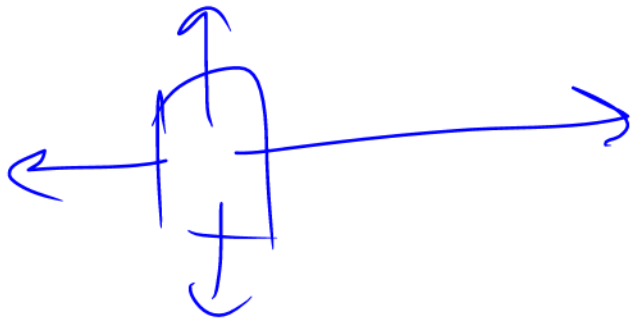
Textbook, 8th ed, pg 94:
"The **most important step** in solving a problem by means of Newton's second law **is to draw the correct free-body diagram**."

Example FBDs

Dr Colton trying to move a fridge



Dr Colton *actually* moving a fridge (i.e. causing it to accelerate)



Turning in FBDs

Starting with HW 6 (due Monday Sep 22), 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)
    a. Sorted by CID

You'll get them back in the open boxes right near there, sorted by CID.

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 vs. negative; forces are vectors!

3. Treat 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, separately
- If objects are connected, you can treat them as group

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

Answer: 75.6 m/s^2

Clicker quiz

A monkey starts to slide down a rope. It adjusts 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.

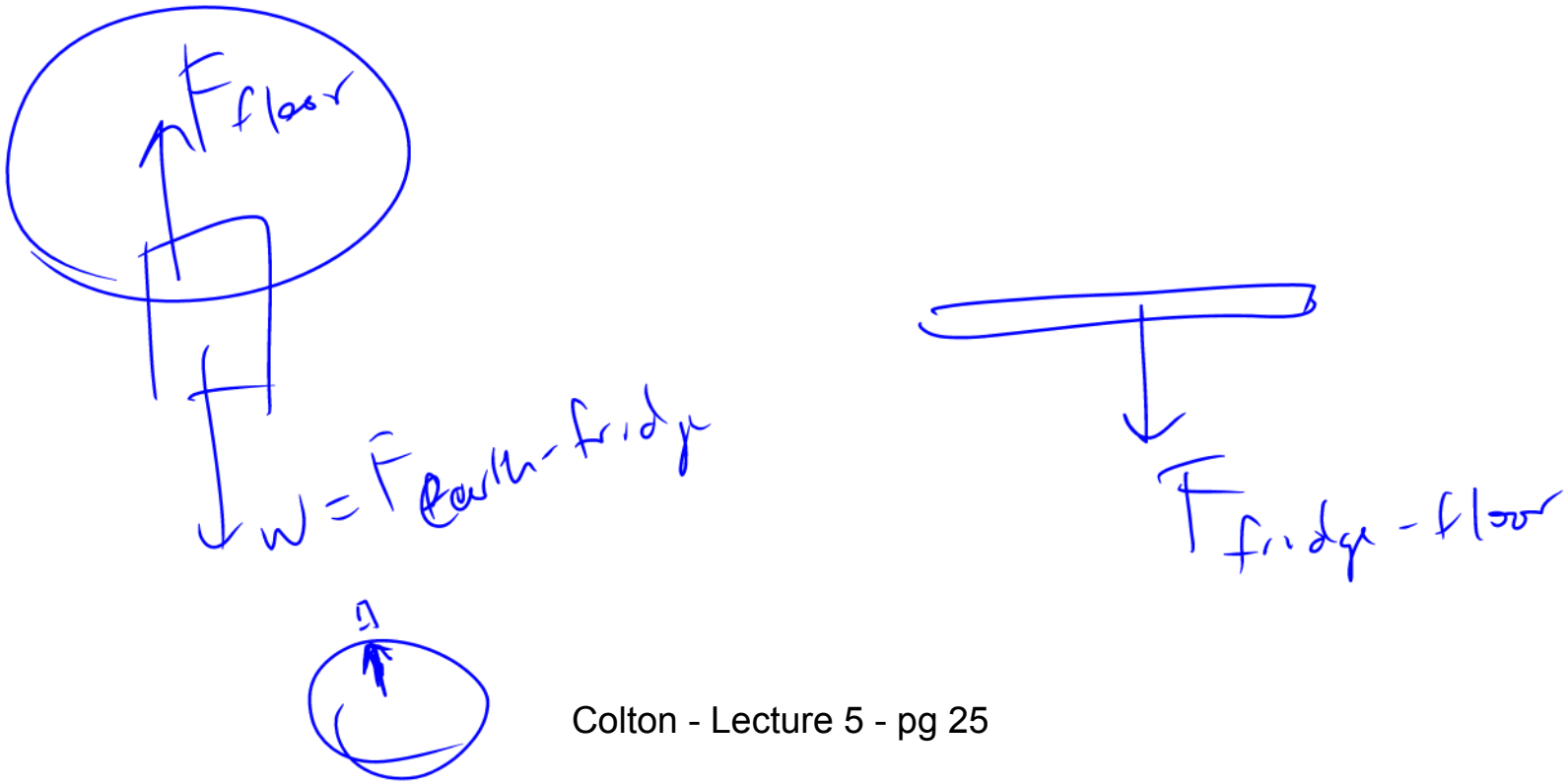
Newton's Third Law: **Equal & Opposite**

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

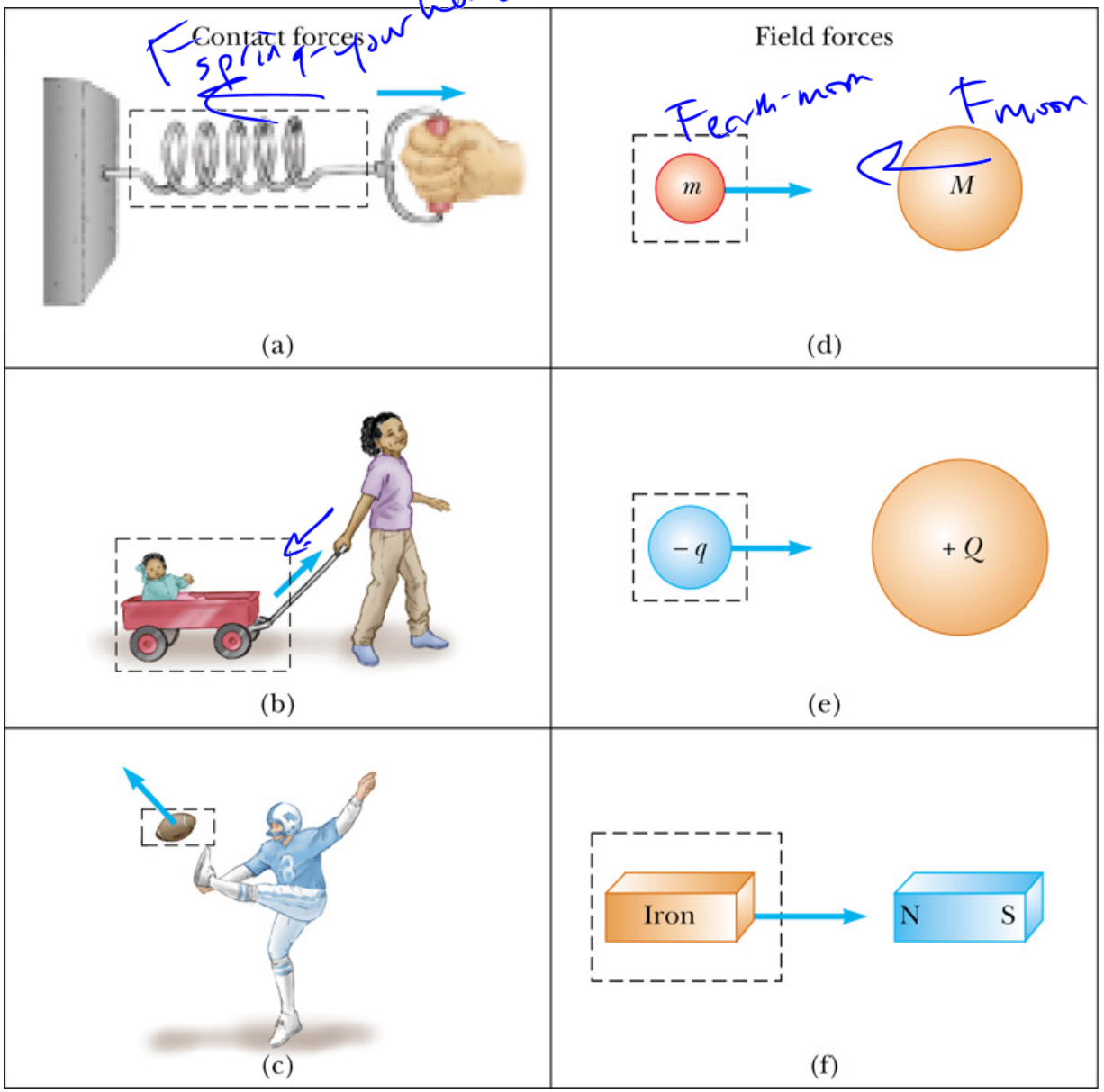
Forces always come in *pairs*

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

The forces in a pair always act on different objects.



What are the opposing forces?



Video: Reaction gliders, equal masses

Clicker quiz: What will happen to the first cart?

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

Question

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 two gliders 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?

“Think-pair-share”

- Think about it for a bit
- Talk to your neighbor, find out if he/she thinks the same as you
- Be prepared to share your answer with the class if called on

Clicker: I am now ready to share my answer if randomly selected.

a. Yes

Note: you are allowed to "pass" if you would really not answer.

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

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 _____ the force exerted by the object on my hand.

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

Partner forces are always equal in magnitude!

$$\vec{\mathbf{F}}_{12} = -\vec{\mathbf{F}}_{21}$$

$$\left|F_{12}\right| = \left|F_{21}\right|$$

Question

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

Worked Problem

Rex has a mass of 70 kg (weight = 686 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?

Answers: 686 N, 546 N

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

d. Finally, the elevator starts slowing down as it reaches the bottom, at a rate of 3 m/s^2. What does the scale read?

Answers: 686 N, 896 N

On Your Own

Try it out! The south elevators in the Eyring Science Center (usually) have scales in them!

Summary

N1: inertia, objects resist $\Delta \vec{v}$

N2: $\sum \vec{F} = m\vec{a}$

N3: $\vec{F}_{1,2} = -\vec{F}_{2,1}$

Weight = force of gravity pulling down