PHY 211 Lecture 7

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Exam recap

- Overall
- A bit longer than we intended
- Remember grades are B 65-80, A 80+

Some specifics

- Be very careful about positive and negative signs on vector components!
- When you draw a vector include the arrow for the direction
- Don't assume things are triangles if you don't know for sure

Moving forward

- Biggest lesson I hope to reinforce: walk us through the problem solving method you are using
- Trying to memorize a ton of special cases, hoping you can pluck the right answer on the exam out of the mix, does not work well
  - This means it is usually a bad idea to rely on formulas for specific cases like $\Delta v^2 = 2a\Delta x$ or the range formula
  - This is not how physics works, and it's not what we want to teach
- You will get points on an exam for doing things like:
  - Drawing meaningful diagrams, with clearly labeled axes, and clearly labeled $t = 0$ points
  - Being explicit about your initial and final conditions
  - Writing down a sentence that says what you are going to solve before you do it

Forces

- So far we have talked about motion with constant acceleration
- Now, we want to talk about why things accelerate

$$\frac{\text{Sum of forces}}{\text{mass}} = \text{acceleration}$$

What's a force?

- The casual definition works pretty well – pushes and pulls are forces
- And we will have to think hard about when something is pushing or pulling

Question

- Can an inanimate object (floor, wall, table, etc.) cause a force?
  (a) Yes (b) No

Question

- Do you really believe that?
  (a) Yes
  (b) No

Visualizing push and pull

- It's easy to imagine the force that you apply to an object since we do this all the time to manipulate the environment
- Instead we need to imagine the force the environment applies on us
- Let's start with springs

Examples of forces

Springs

Examples of forces

Normal (perpendicular) force

Examples of forces

Tension

Contact forces

- These forces are all contact forces
- They happen because one thing is touching or attached to another
- Almost all forces we will deal with involve contact of one kind or another

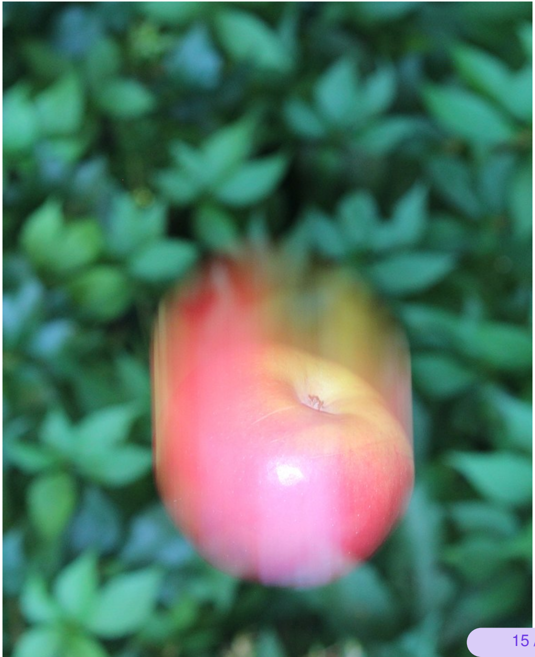
Pre-lecture question 1

- A rock is thrown straight up. At the top of the trajectory, the velocity is momentarily zero. The force on the object is also zero.

  (a) True (b) False

Examples of forces

Gravity: the only non-contact force in this class



Pre-lecture question 2

- A hockey puck slowly comes to a stop on a sheet of ice. In which of these directions, if any, is there a force on the puck?

A. In the direction of velocity.

B. Opposite the direction of velocity.

C. Along the ice surface, perpendicular to the velocity

D. None of the above

Examples of forces

Friction

Force vector

- We know force has to be a vector
  - It has a magnitude (you can push or pull harder)
  - It has a direction
- Adding up forces is very important – you can have many different sources of force, and often they can even cancel out completely!

External and internal forces

- Without forces, nothing would stick together
- We don’t need to write them all down to do problems
- Think about projectile problems – we just used the acceleration of gravity for all of them, we didn’t care how they were stuck together
- We need to identify the system we care about, and separate it from the environment
- Then find all the places the system contacts the environment, and identify the external forces from those contacts

Pre-lecture question 3

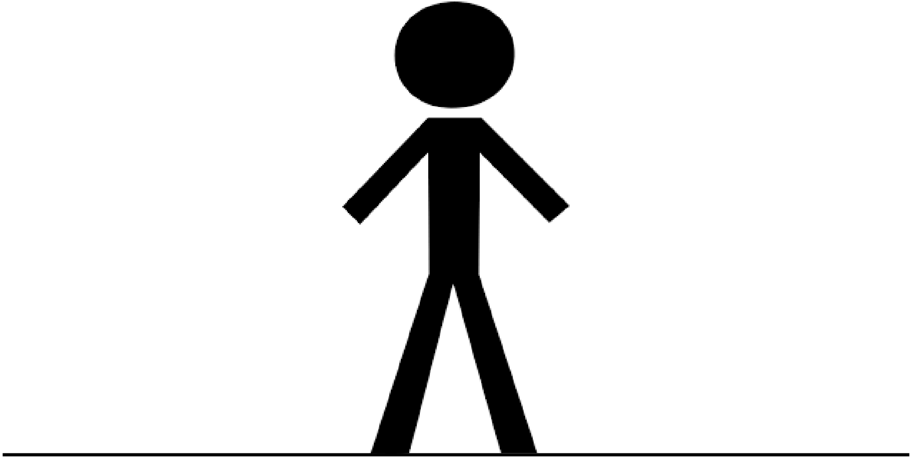
A weight is sitting on the floor. Which of the following forces is acting on the weight?

- A Friction
- B Normal force
- C Tension
- D No forces are acting on the weight.

Identifying external forces

A simple example

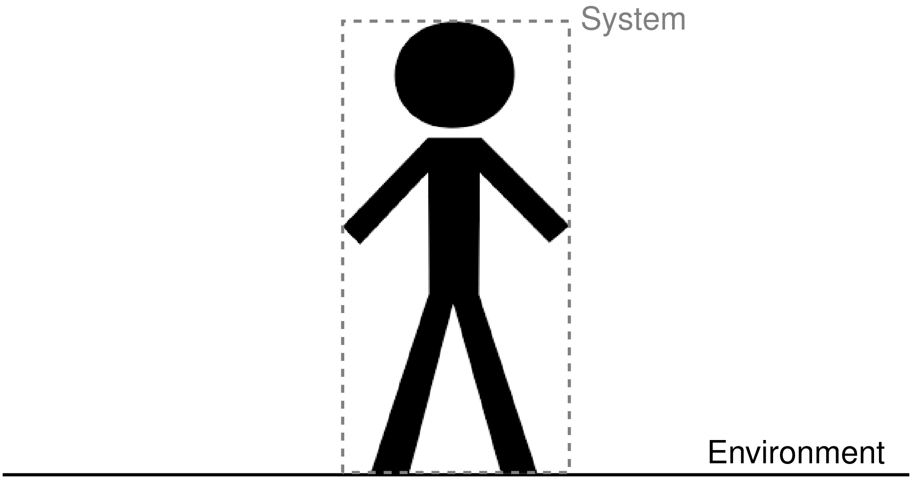
- Consider a person standing still on the ground



Identifying external forces

A simple example

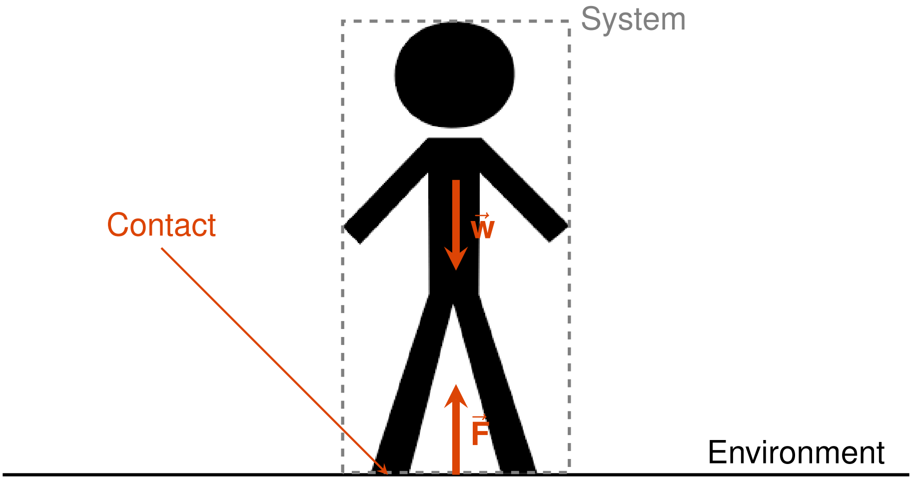
- Consider a person standing still on the ground



Identifying external forces

A simple example

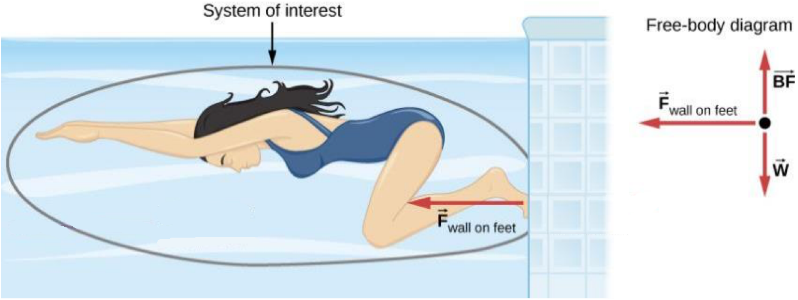
- Consider a person standing still on the ground



Free body diagrams

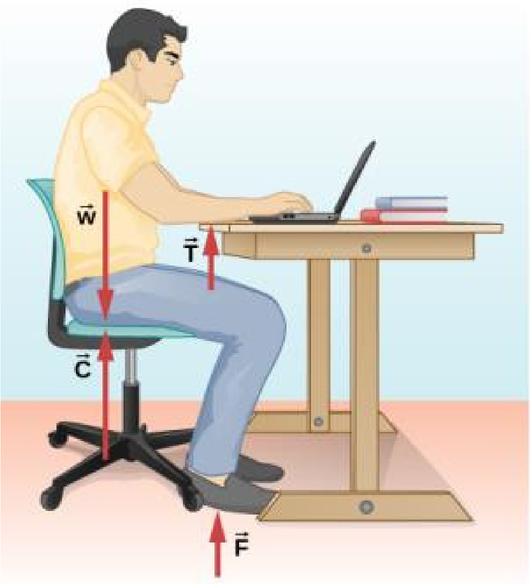
- To aid with force calculations, we can take all of the forces on one system and move the vectors so they start at one point
- The point represents the system
- You should only ever draw forces that act on the system
- Draw all forces, even if another one cancels it
- Don't add up the forces and draw the sum on the diagram

Pushing off a wall



More external forces

- What are the external forces on the student?
- What about the chair?
- What about the student–chair system?



Hover car

- What force keeps the hover car moving?
- A Force of motion
- B Force of gravity
- C Force of friction
- D None

Newton's first law of motion

A body at rest remains at rest or, if in motion, remains in motion at constant velocity unless acted on by a net external force.

This just says that forces cause acceleration, not velocity

Inertia

- The natural state of things is no acceleration not no velocity
  - Historically it took a long time to realize this!
- We all are used to the fact that an object that's not moving won't suddenly start moving on its own
- The reason we are used to everything coming to a stop is friction which acts to slow everything down – but friction is a force because it causes an acceleration

Newton's second law

- The main formula for this class

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

- I like to write it this way because it shows that the forces cause the acceleration

Units of force

- We combine acceleration and mass (kilograms)
- The units for force are called Newtons

A Newton

$$1\,\mathrm{N} = 1\,\mathrm{kg}\,\mathrm{m}/\mathrm{s}^2$$

Newton's third law

- When one object exerts a force on another, there is an equal and opposite force exerted by the latter on the former

Mathematically

$$\vec{\mathbf{F}}_{\text{by A, on B}} = -\vec{\mathbf{F}}_{\text{by B, on A}}$$

- Just because two forces are equal and opposite, does not mean they are action–reaction
  - The reaction to the normal force holding you up is the force you push down on the ground

People on two carts

- Who will move?
- A One pushing
- B One being pushed
- C Neither
- D Both

Question

- What applies the force that makes a rocket accelerate?

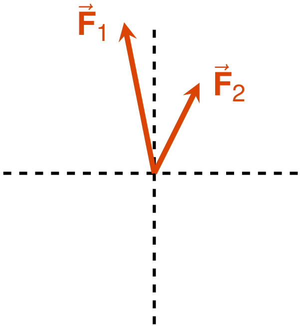
A. The Earth
B. The surrounding air
C. It's exhaust
D. Nothing

Thrust

- Engine applies a force to expel gas from the back
- By Newton's third law we know that the engine (and the car) then have a reaction force acting on them from the gas

Summing forces

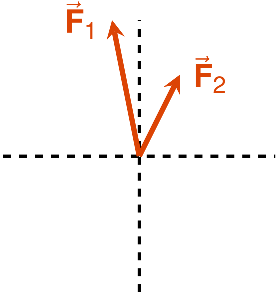
- Many problems we do will have forces that point in different directions at different angles
- And not always just up-and-down, left-and-right!



$\vec{\mathbf{F}}_{\text{tot.}} = ?$

Question

- Which way will it go?



(a) Down the middle

(b) Towards $\vec{\mathbf{F}}_1$

(c) Towards $\vec{\mathbf{F}}_2$

(d) Some other direction