

### NEWTON'S THIRD LAW OF MOTION:

Words: EVERY action has an EQUAL and OPPOSITE reaction.  
(all forces) (in strength) (in direction)

$$\text{Math: } F_{AB} = - F_{BA} \quad F_{AB} = - F_{BA}$$

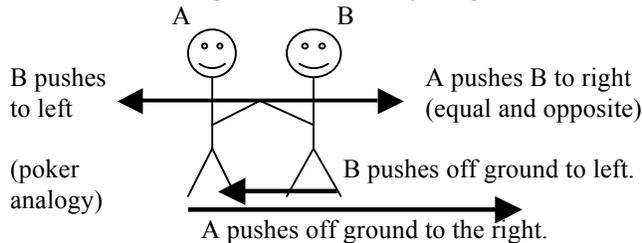
Action equal opposite reaction

EQUAL All action / reaction pairs are exactly equal in strength. But one object is usually better at dealing with the force. (When you punch someone in the face your hand is hit just as hard as they are. Your fist can handle it. Their nose cannot.)

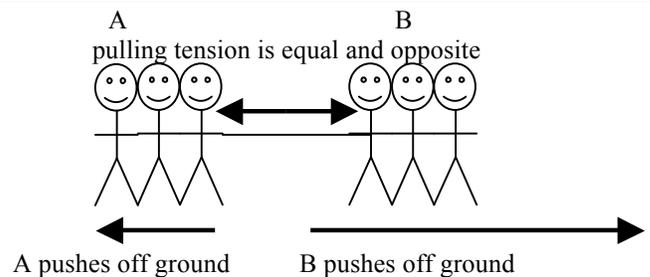
Bob crashes his motorcycle head on with a semi truck. BAM!! Which was hit harder, Bob or the semi?  
SAME!! Bob's frail little body couldn't handle it. The truck could.

Karate Kate chops a block of wood in half with her hand. Hi Ya!! Which was hit harder, the wood or her hand?  
SAME!! The wood couldn't handle it. Her bones could.

Arm Wrestle & Tug of War Free Body Diagrams



A wins because he gets more outside help from the ground and B can't handle that much force without moving.



B wins because they get more outside help from the ground and A can't handle that much force without moving.

OPPOSITE Sentence: If A does this to B, then B does the same thing to A but in the other direction.

If a gun shoots a bullet forward, then the bullet will also shoot the gun backward.  
(called kick back)

If the Earth pulls a skydiver DOWN with its gravity then the skydiver pulls the Earth UP.  
(Gravity pulls BOTH ways. The earth is just so big it doesn't move very much.)

If Bob's foot kicks a soccer ball forward with 20 N of force, then the soccer ball

**kicks his foot backward with 20 N.**

If a tow truck pulls a car forward with 1200 N of force, then the car **pulls the truck backward with 1200 N.**  
(Luckily the tow truck has more help from static friction than the little car so he wins.)

If a magnet pulls a paperclip up with 2 N of force, then the paperclip **pulls the magnet up with 2 N.**

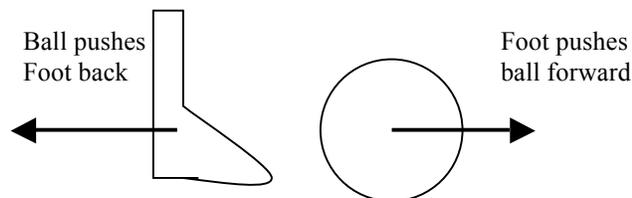
If Bob's teeth push in on a juicy apple with 7 N of force, then the apple **pushes his teeth out with 7 N.**  
(His teeth can handle it. . . . the apple can't. Crunch!!)

If Bob's teeth push in on a metal nail with 50 N of force, then the nail **pushes his teeth out with 50 N.**  
(This time, Bob's teeth will probably break before the nail does. Hello chipped tooth!)

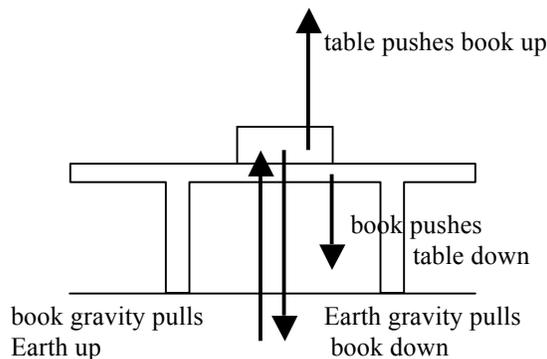
Bob is trying to do a pull up on a bar. If Bob pulls down on the bar with 700 N of force, then **the bar pulls Bob up with 700 N.**

Bob is trying to do a push up. If Bob pushes down on the floor with 400 N of force, then **the floor pushes bob up with 400 N.**

Why don't pair forces cancel each other out? Because pair forces always act on two different objects.



You can't cancel out a push on a ball by applying a Push to a foot! (The only way to stop the ball is to apply a force to the ball itself.)



Even though they are equal and opposite, the normal force and gravity are NEVER pair forces with each other!!!

### The weakest link.

The strongest force that can ever be exerted between two objects is always limited by the **weakest object**

Once you reach the limit of the weakest object it will either break or move

EXAMPLES: Hardest you can push in an arm wrestle depends on the weakest contestant.  
Hardest you can pull in a tug of war depends on the weakest team.  
Hardest you can push on a window depends on the strength of the glass (not your arm.)  
Hardest you can push on a paper is pathetic. . . . it runs away before you generate any pressure.

### DAY 1 HOMEWORK: TO BE COMPLETED ON A SEPARATE SHEET OF PAPER

1. What is Newton's Third Law of Motion?
  - ▶ EVERY action has an EQUAL and OPPOSITE reaction.
2. If a golf club hits a golf ball forward with 55 N of force, then **THE GOLF BALL HITS THE GOLF CLUB BACKWARD WITH 55 N OF FORCE.**
3. Bob is trying to climb up a rope. If Bob pulls down on the rope with 650 N of force, then **THE ROPE PULLS UP ON BOB WITH 650 N OF FORCE.**
4. Bob smashes a watermelon with his hammer. Both of the following statements are true. "Today a watermelon was hit by a hammer." "Today a hammer was hit by a watermelon." Which one was hit harder? Why did the watermelon explode while the hammer escaped unhurt?
  - ▶ They were both hit the SAME!
  - ▶ The watermelon was the weakest object and couldn't handle the force, but the hammer could
5. There is a proverb that says "Whether the china (glass plate) hits the rock or the rock hits the china, it is going to be bad for the china." Explain how this relates to Newton's Third Law.
  - ▶ The china plate is the weakest object and will break even though both the plate and the rock feel the same force.

6. Explain how runners and swimmers both use Newton's Third Law to move their bodies forward.
  - ▶ It is just like walking or ice-skating. They push in the opposite direction they want to go.
  
7. Brain Teaser 1: An astronaut is floating in space with nothing except his suit and a fire extinguisher. (Why? Why not?) He starts to drift away from his spaceship. How can he get safely back? (You can't "swim" back to the ship by flapping your arms because there is no air up there silly!)
  - ▶ Like the movie WALLE. Point the fire extinguisher in the opposite direction you want to go and then shoot it.
  
8. Brain Teaser 2: James Bond is in a canoe in a lake of acid. (Why? Somebody is trying to kill him.) He has no paddles. How can he get the canoe safely back to shore?
  - ▶ Walking the opposite way from the shore in the canoe can get him back to the shore safely.
  - ▶ Breathing the opposite way from the shore can get him back to the shore safely.
  
9. Brain Teaser 3: There is an Asian story about a greedy man on a bridge that notices a bag of gold sitting on the ice below him. He jumps down to get it, but finds that the ice is so slippery he can't get back to shore and he freezes. If the man hadn't been so greedy, how could he have gotten safely back to the shore?
  - ▶ He could have pushed the gold in the opposite direction of the shore.
  - ▶ Pushing the gold away from the shore would cause him to move toward the shore
  
10. Brain Teaser 4: A horse is pulling a wagon across the prairie. If the horse pulls the wagon forward just as hard as the wagon pulls the horse backward, then how on earth does the horse ever get the wagon to move?
  - ▶ The horse gets more outside help from his legs (like the tug of war and arm wrestle examples).