Pressure, Hydraulics & Pneumatics

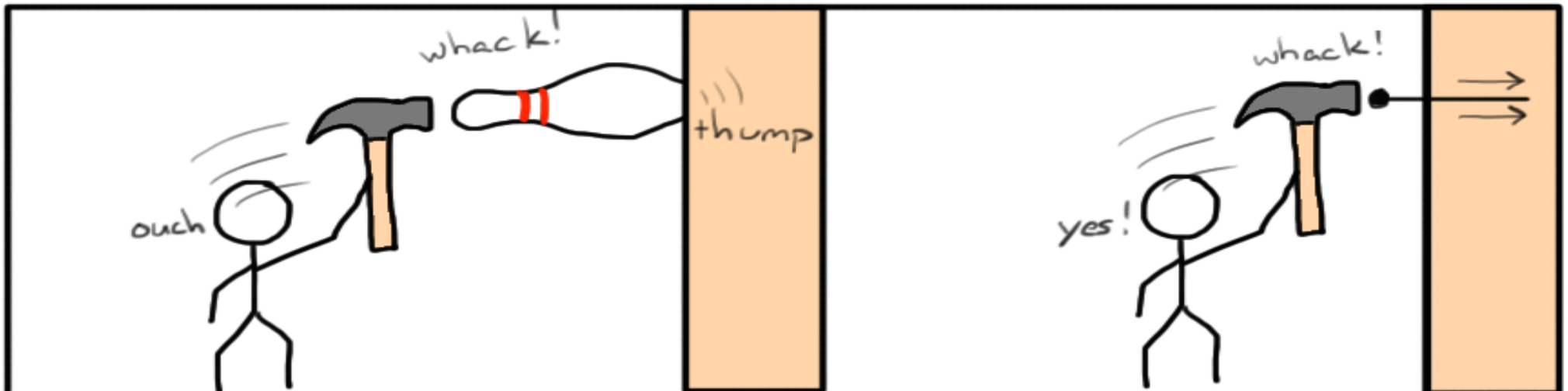
Pressure

- Many people believe that Pressure and Force are the same thing! Haha…Silly people.
- **Pressure** is a force applied over a certain area. Pressure like a 2 for 1 deal!
- P = F/A
- Pressure is measured in Pascals.
- Force is measured in Newtons.
- ***Area is always measured in m^2…NOT cm^2***

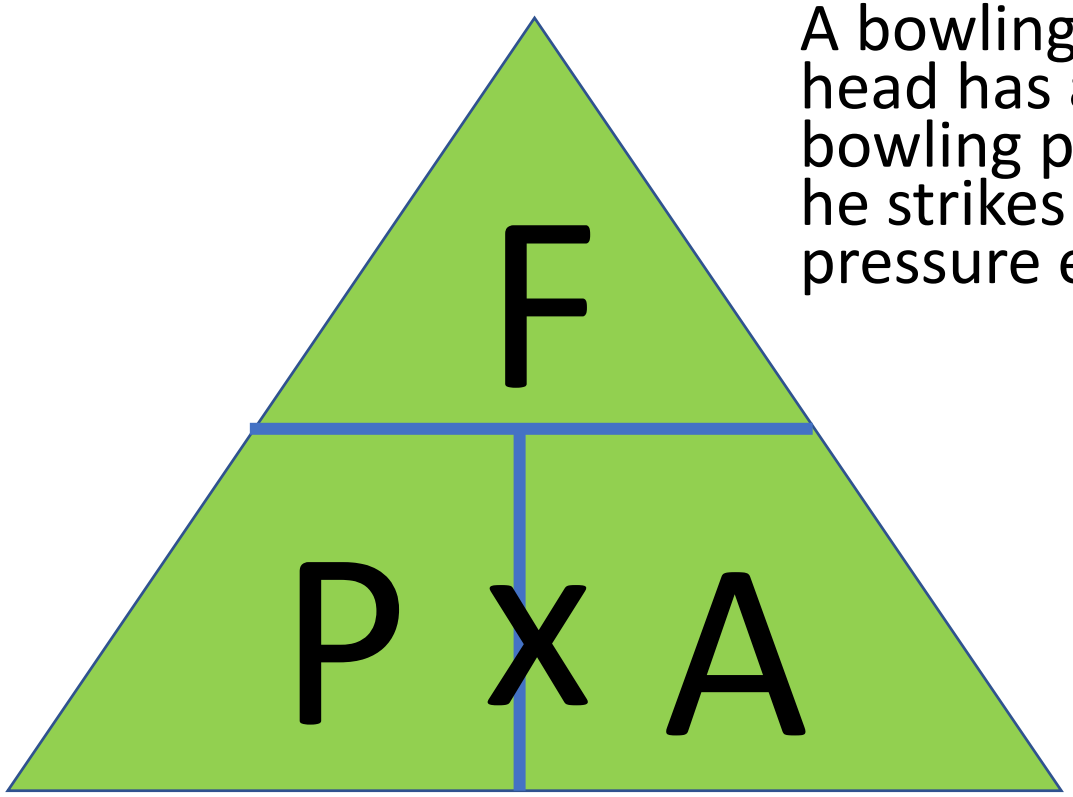
How Can Pressure Be INCREASED?

- Increase The Force.
- Decrease The Area.
- Or Do Both!!!!

- Use this logic to explain the following meme.
- Manipulated, controlled, and responding variables??



The Magic Triangle



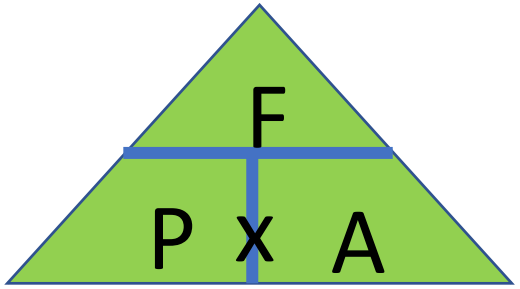
A bowling pin has a surface area of 0.04 m^2, whereas a nail head has a surface area of 0.000001 m^2. A man strikes the bowling pin against a wooden board with 200 N force. Then he strikes the nail with the same force. Calculate the pressure exerted by each.

What happens to the pressure when the area is smaller?

Human Body Connection

The human heart is an excellent pump. It distributes blood throughout the body, creating pressure in the blood vessels. Normal maximum blood pressure for a healthy person is 16 000 Pa. The artery carrying the blood from the heart has an average radius of 1.5 cm. Calculate the force supplied by the heart to produce normal blood pressure.

Always convert to meters (÷ by 100)



Pop Cans with Buttons?

- When I was a kid, pop cans had buttons.
- Each can had a **small button** and a **large button**.
- Pop cans have tremendous gas pressure pushing outwards against the tab. So that means it takes a lot of pressure to puncture them.

- Which button do you think you can create enough pressure with your thumb? _____ Why? _____
- The next secret is that when that first tab was opened, gas would exit making the second button easier to pop open.

Can You Lift A Car Using Only Your Pinky Finger?

- Yes you can!
- But unless you are superman, you are going to need some mechanical advantage

.....using the power of Hydraulics.

Welcome To Hydraulics (Liquid Power)

- Pistons (think syringes) can create mechanical advantage when they are **different sizes**. Hop into the Time Machine!

- Blaise (prounounced “Blasé”) Pascal, discovered that if you squeezed a water balloon, the balloon bulges in all the directions.
  - No kidding, right?
  - Well, this was a ground-breaking discovery because it proved that liquids **cannot** be compressed.

Not convinced? Try squeezing an air filled ---sealed---water bottle vs. a liquid-filled ---sealed ---water bottle. Observations?

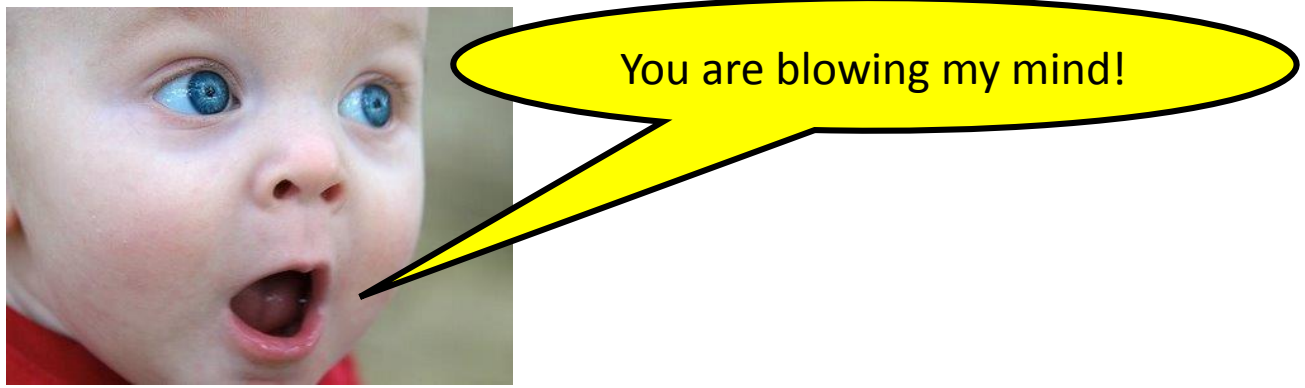
Fluids Are Incompressible!

- What? Really?!! So if fluids are “incompressible”, how will they react if we **TRIED** to compress them?

- The liquid will push away from you equally in all directions.

- What happens when you push one piston down?

- The liquid moves away from it causing the other piston to rise up.

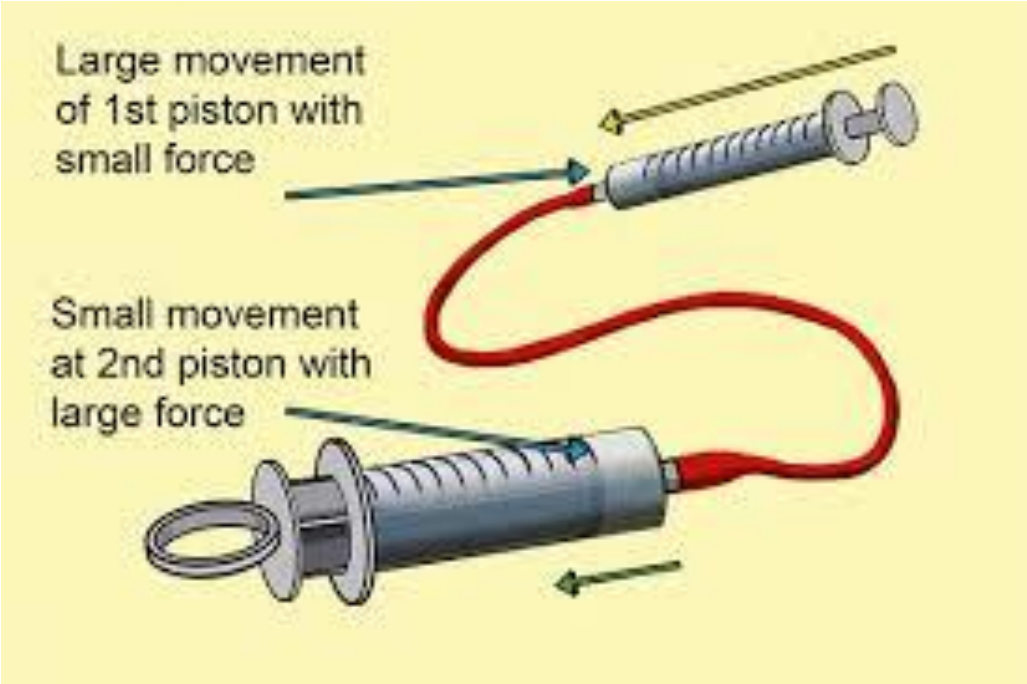


Giant pistons filled with liquids can generate enough force to make cars bounce. *(watch in full screen)*

Pistons of DIFFERENT Sizes

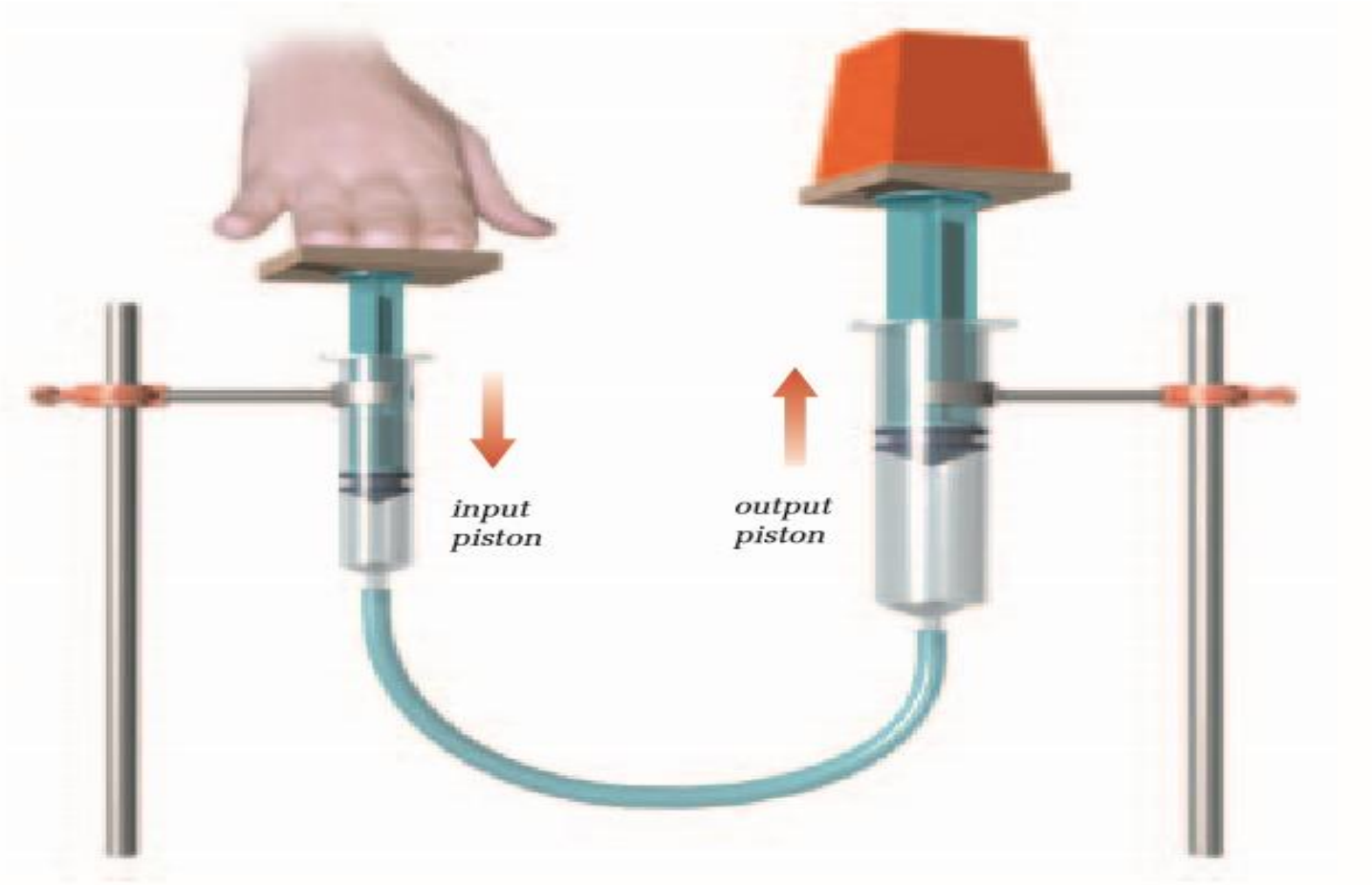
- Creates mechanical advantage.

$$M.A = \frac{\text{Area or diameter of OUTPUT Piston}}{\text{Area or Diameter of INPUT Piston}}$$



*Nothing is for free. The cost of receiving extra force is that you must move a greater distance. Wouldn't you take that kind of deal?

$$M.A = \frac{\text{Area or diameter of OUTPUT Piston}}{\text{Area or Diameter of INPUT Piston}}$$



Why is the M.A 25?

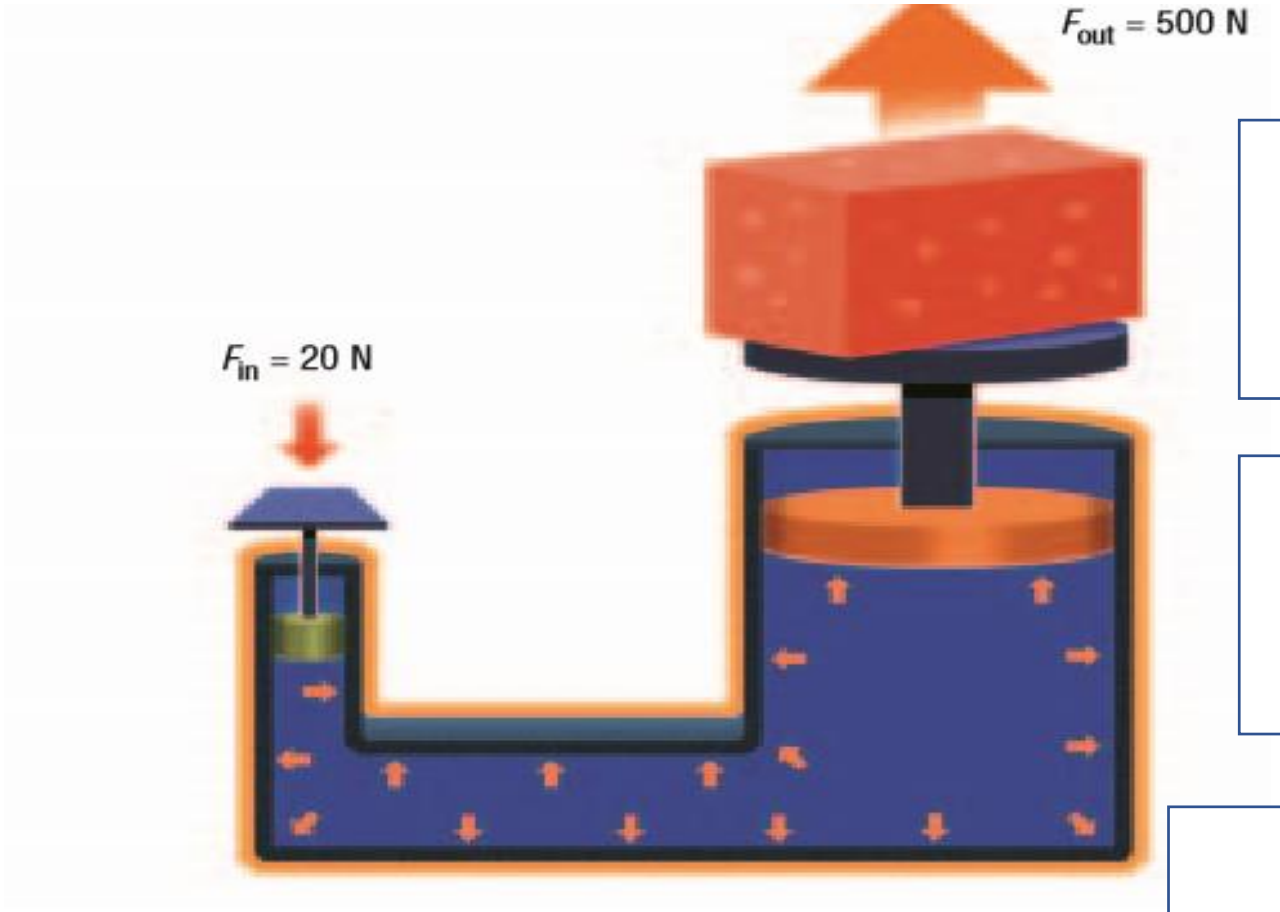
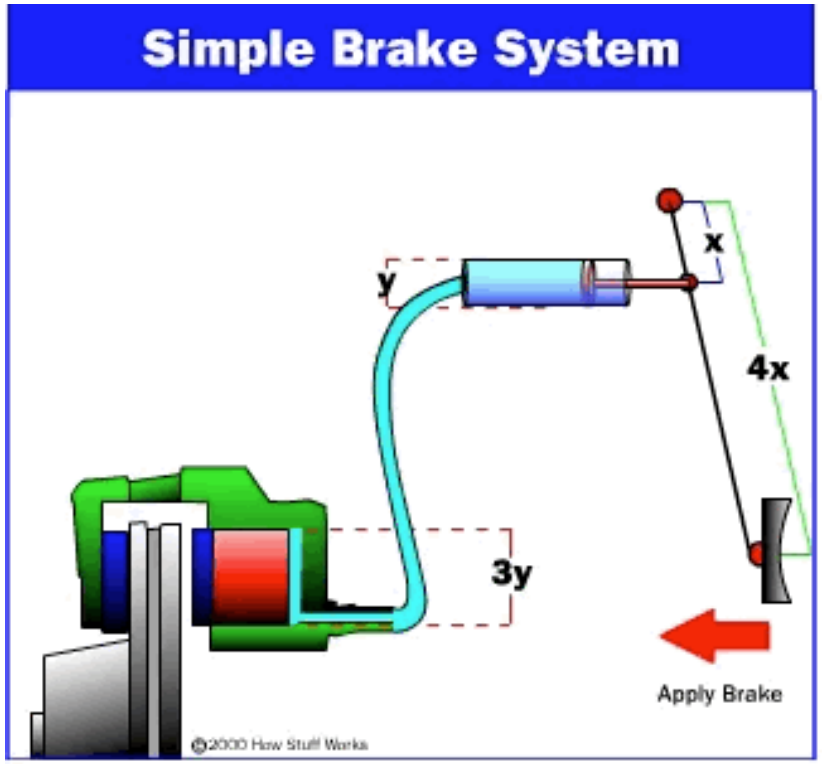


Figure 2.19 This hydraulic jack has a mechanical advantage of 25.

How Car Brakes Work

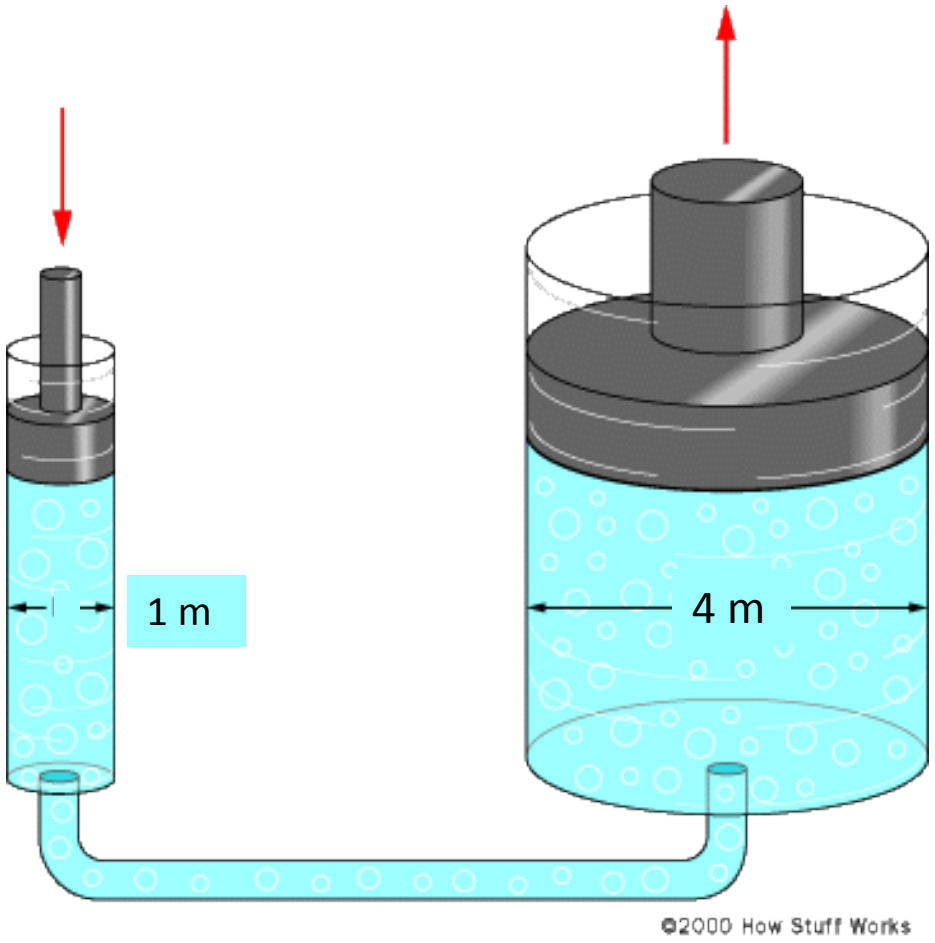


Make sure you are in full screen mode to see the animation.

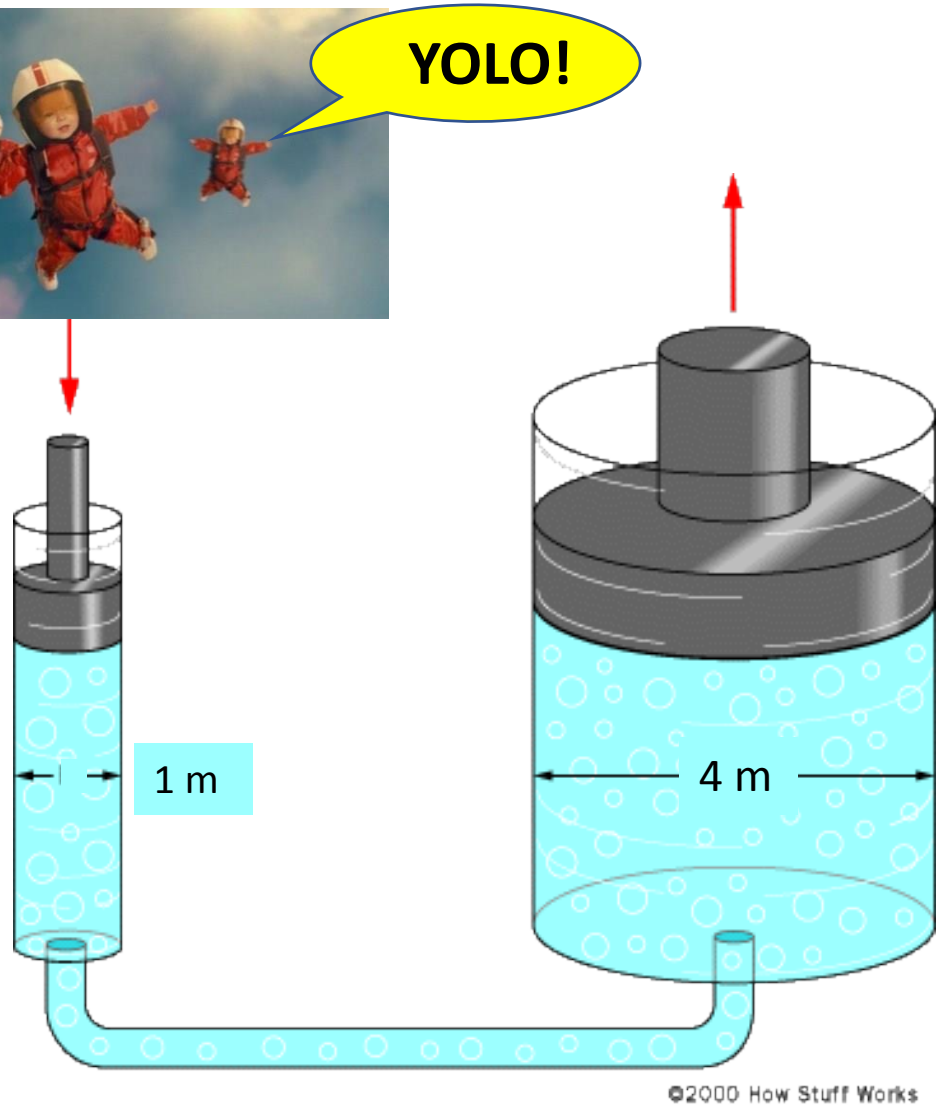
- Break pedal is a lever that pushes a small piston.
- Small Piston pushes fluid.
- Fluid pushes a larger piston.
- Large piston clamps on the wheel with tremendous force.....way more force than you applied on to the brake lever with your foot.

Essentially, a small piston caused a large piston to move with tremendous force.

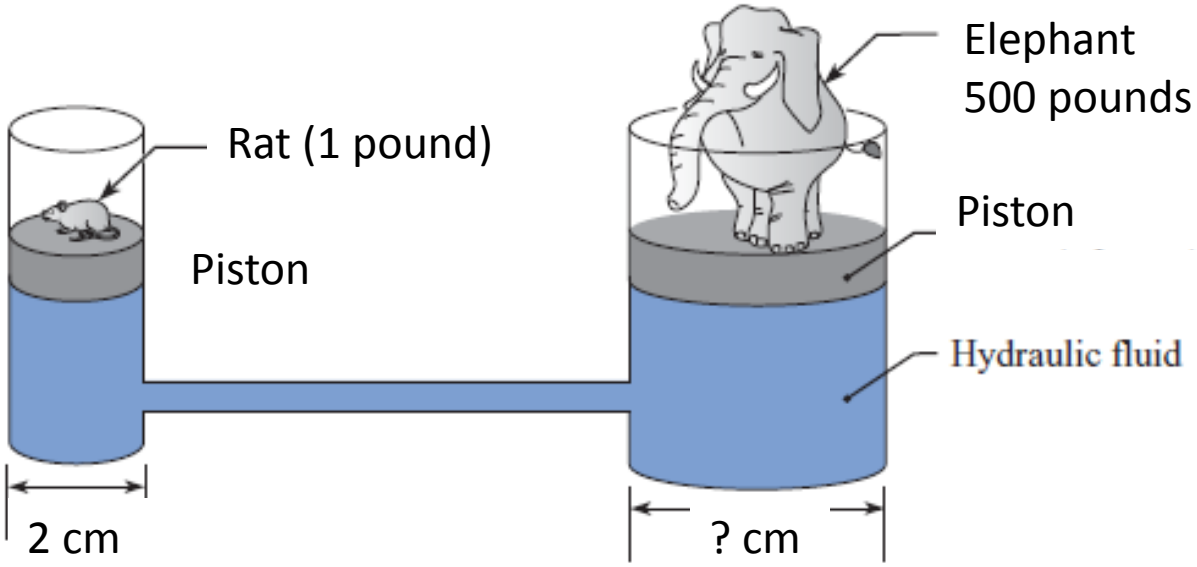
If the small piston has a diameter of 1 m and the larger piston has a diameter of 4 m, what is the mechanical advantage of the system if the small piston is the driver?



If a 10 pound baby dropped on top of the small piston, how heavy of a rock would it be able to lift on the big piston……and at what cost?



Can a 1 pound rat lift a 500 pound baby elephant? Figure out the size of the **large piston** to make this work. ..But at what cost?



Think Tank

Hydraulic Pumps: The Good & …..The Ugly

Pros

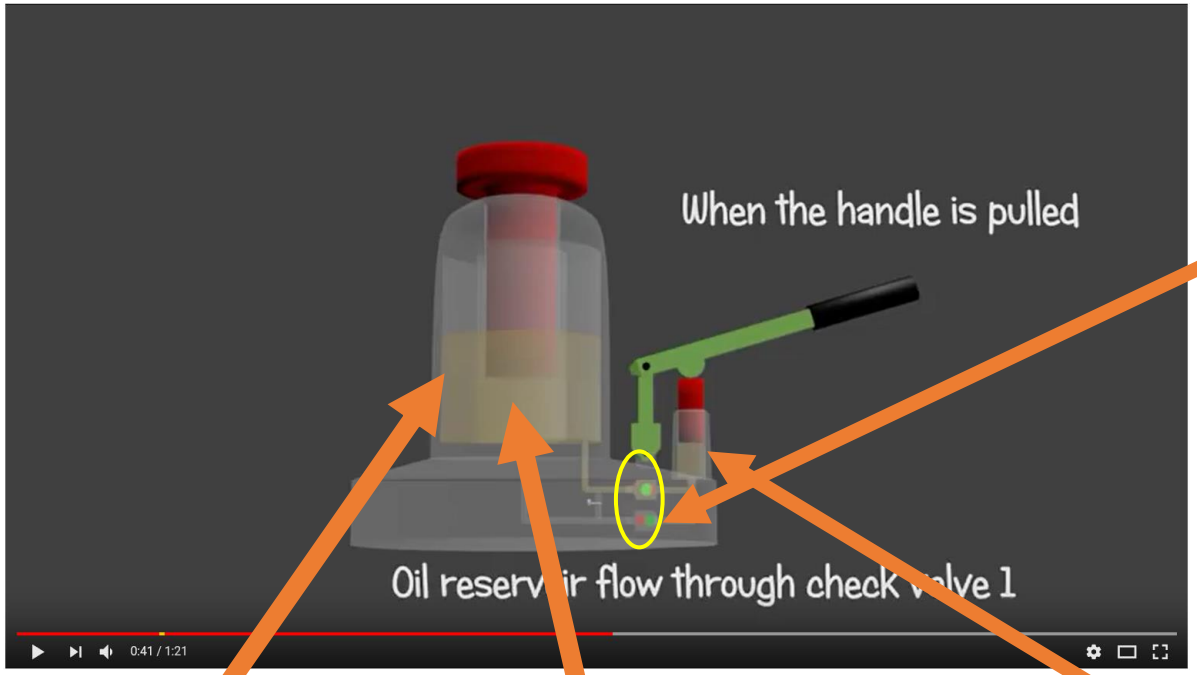
- You can move or lift **tremendous** loads.
- Sensitive to manual touch because liquids are incompressible. The liquid responds instantly

Cons

- Not good for generating super high speeds (ex. Jackhammer, dentist power drills)
- Because oil is used (to avoid rust), if a leak happens it can cause an environmental hazard.

How does a hydraulic lift (car jack) work (click video)

https://www.youtube.com/watch?v=lXmp9gUueI4



1 way valves prevent backflow.

Lifting handle pulls oil in from reservoir and into the small piston.

Pushing the handle down forces the oil into the large piston.

Repeating process over and over and over again makes the large piston rise.

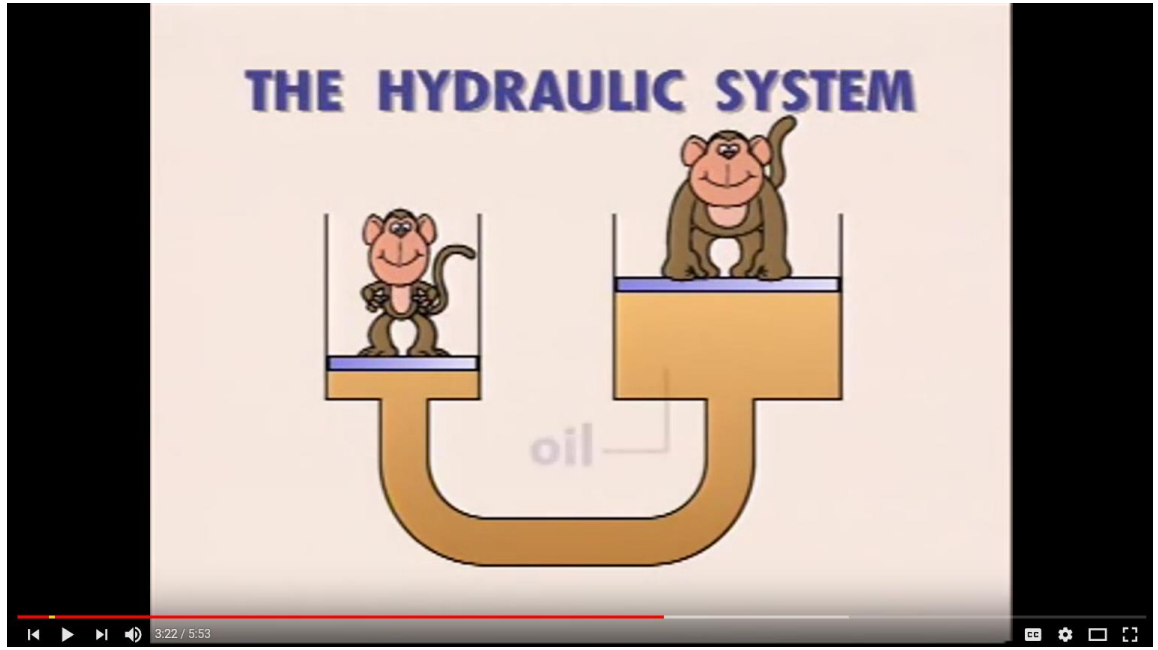
What's the trade off for producing such Large Force?

Reservoir Chamber

Large Piston chamber

Small Piston chamber

Hydraulics vs Pneumatics



https://www.youtube.com/watch?v=YlmRa-9zDF8&list=PLXWEn3x45oSi9IIsRVzcLpZpWYlCRreH3

https://www.youtube.com/watch?v=UuK3ESGgbqk&index=2&list=PLXWEn3x45oSi9IIsRVzcLpZpWYlCRreH3

Write down the key things that you learn.

Pneumatics

- Similar design to hydraulic pumps except that Air is used instead of liquid.

- Pneumatic systems are not totally sealed like they are in hydraulics. The reason for that is that these setups allow air to enter and then leave very quickly.
- Air rushes inside a pneumatic device to push a piston up and down quickly (jack hammer..2000rpm) or rotate a turbine (Dental Drill..300,000 rpm).

- Gusts of air blow out of pneumatic devices. Super loud.

Pneumatic Pumps: The Good &….The Bad

Pros

- Highly compressed bursts of air are designed for creating speed. (think dentist drills 300,000 rpm, jack hammers (2000 rpm)
- Although leaks easily happen, it is only air so no environmental hazard.

Cons

- Very noisy.
- Since there is air inside these pumps and air holds moisture, condensation can build up inside the pump, if used in cold environments, and this can cause rusting.
- Not very sensitive to slight motions of the pump because air will compress before it starts to move.
- Cannot be used under water, because it requires air to enter and exit.

How To Build A Mouse Trap Car (Video)

https://www.youtube.com/watch?v=b7zWwo9dbiU

Use the next page to write down all the factors that will decide if your car goes super fast vs super far.

Long Distance Car

Write your notes below

Super Fast Car

Write your notes below

Catapult

- A catapult is a machine that uses lever action to launch cats into the air. Actually not! Launching cats into the air is not a laughing matter.

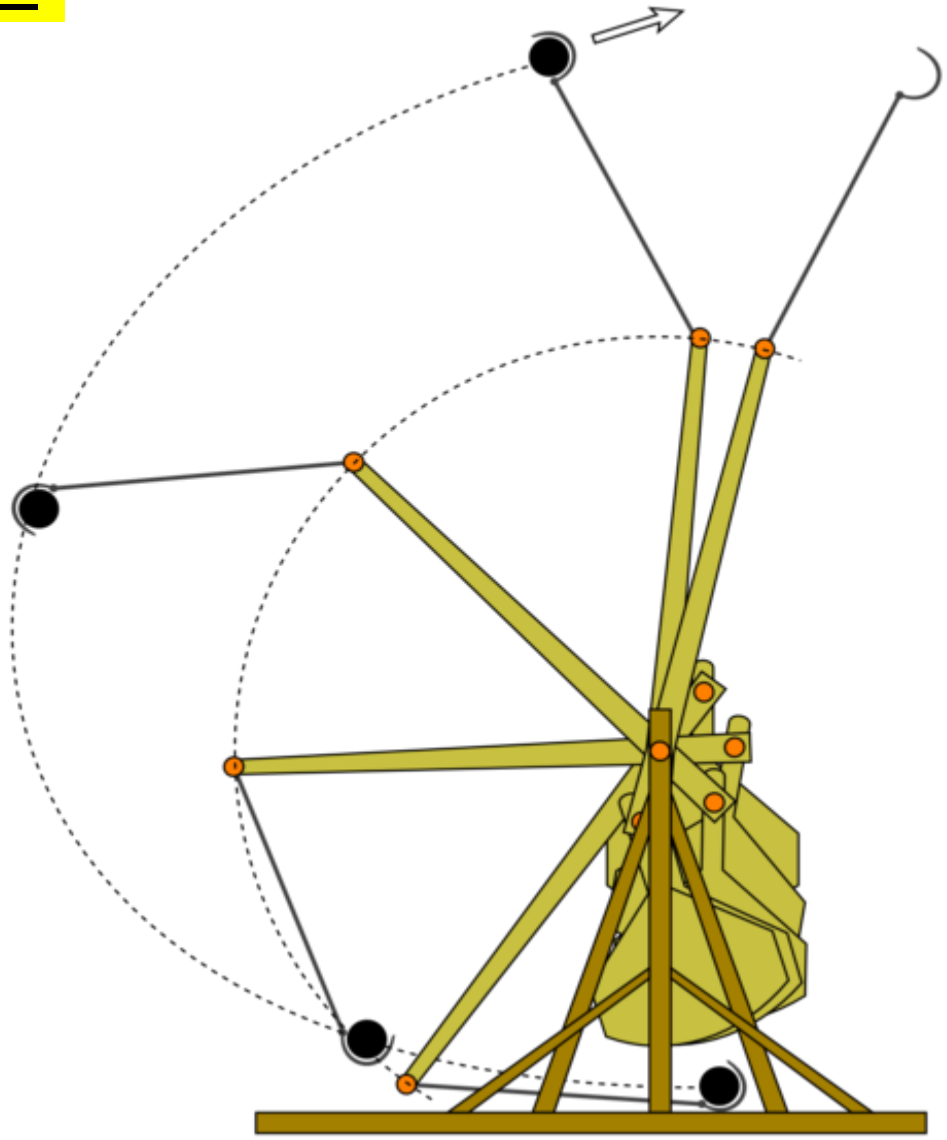
- During medieval times, Catapults were designed to launch weapons and diseases over castle walls.

- The arm that holds the load (weapon) is generally super long so that it can generate enough distance.

Trebuchet

- The problem with catapults is that there is a limit to how much distance you can generate with the load arm. Usually you only get between 45^{o} and 60^{o} of arc.

- Trebuchets are essentially catapults with a rope extension tucked underneath the load arm. This rope creates extra arc which creates tons of extra sling distance. Its no contest.

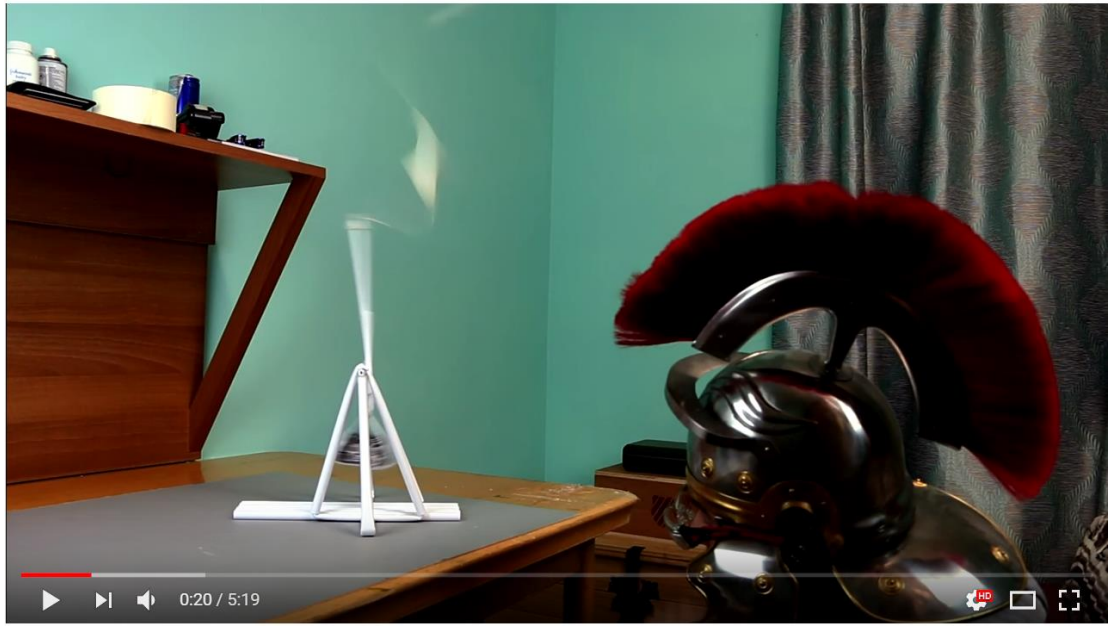


Building a Catapult vs Trebuchet

Catapult

https://www.youtube.com/watch?v=WpLFC_SOpXs

Trebuchet



https://www.youtube.com/watch?v=1NzrokQejzw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memegenerator.net