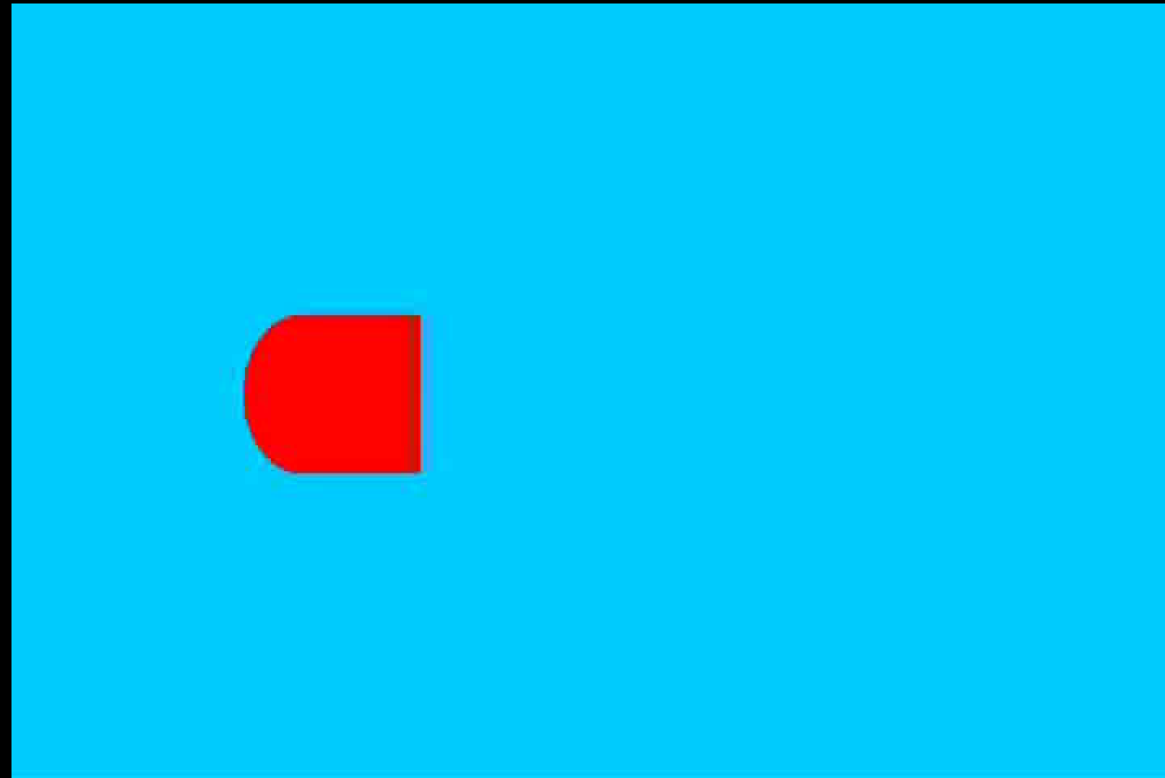
DEVIL PHYSICS
THE BADDEST CLASS ON CAMPUS
AP PHYSICS



GIANCOLI LESSON 10-3 TO 10-6

- PRESSURE IN FLUIDS
- ATMOSPHERIC PRESSURE AND GAUGE PRESSURE
- PASCAL’S PRINCIPLE
- MEASUREMENT OF PRESSURE: GAUGES AND BAROMETER

Objectives

- Know the relationship between pressure, force and area.
- Know the relationship between fluid pressure, density and height (or depth) of the fluid.
- Understand that fluid exerts a pressure in all directions.
- Understand that fluid pressure at equal depths within a uniform liquid is the same.

Objectives

- Understand that pressure exerts a pressure perpendicular to the surface it is in contact with.
- Know the difference between gauge pressure and total pressure and solve problems involving both of them.
- Apply Pascal’s principle to solve problems involving ‘mechanical advantage’.

Objectives

- Name three different pressure gauges and how they work.
- Convert different units of pressure.

Reading Activity Questions?

Pressure

- **Pressure, P, is defined as force per unit area where the force is understood to be acting perpendicular to the *<u>surface area</u>*, *A***

$$pressure = P = \frac{F}{A}$$

Volunteer from Audience

- ***School puts a lot of pressure on students, but how much pressure does the student exert on the school?***
  - Mass = ________________
  - F = mg = _______________
  - A_{foot} = l x w x 2 = ________
  - P = F/A = _______________

$$P = \frac{F}{A}$$

Volunteer from Audience

- ***School puts a lot of pressure on students, but how much pressure does the student exert on the school?***
  - Mass = ______70kg______
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  - P = F/A = ________________

$$P = \frac{F}{A}$$

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  - Mass = ______70kg______
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  - Mass = ______70kg______
  - F = mg = ___700N______
  - A_{foot} = l x w x 2 = _.3x.1x2_
  - P = F/A = _11,667 Pa______________

$$P = \frac{F}{A}$$

Volunteer #2 from Audience

- ***What type of fluid pressure are students under and how does it impact students?***
  - Avg Cranial Diameter = ________________
  - Radius = _______________
  - $A_{head} = \pi r^2 =$ ___________
  - $P_{atm} =$ _________________
  - F = PA = _______________

$$P = \frac{F}{A}$$

$$F = PA$$

Volunteer #2 from Audience

- ***What type of fluid pressure are students under and how does it impact students?***
  - Avg Cranial Diameter = ____0.13m______________
  - Radius = ______________
  - $A_{head} = \pi r^2 =$ ______________
  - $P_{atm} =$ ______________
  - F = PA = ______________

$$P = \frac{F}{A}$$

$$F = PA$$

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$$F = PA$$

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- ***What type of fluid pressure are students under and how does it impact students?***
  - Avg Cranial Diameter = ____0.13m______________
  - Radius = _____0.065m_________
  - $A_{head} = \pi r^2$ = ___0.0133m^2______
  - P_{atm} = ________________________
  - F = PA = ________________

$$P = \frac{F}{A}$$

$$F = PA$$

Volunteer #2 from Audience

- ***What type of fluid pressure are students under and how does it impact students?***
  - Avg Cranial Diameter = ____0.13m______________
  - Radius = _____0.065m__________
  - $A_{head} = \pi r^2 =$ __0.0133m²__________
  - $P_{atm} =$ _1.013x10⁵ N/m²________________
  - F = PA = ________________

$$P = \frac{F}{A}$$

$$F = PA$$

Volunteer #2 from Audience

- ***What type of fluid pressure are students under and how does it impact students?***
  - Avg Cranial Diameter = 0.13m
  - Radius = 0.065m
  - $A_{head} = \pi r^2 =$ 0.0133m^2
  - $P_{atm} =$ 1.013×10^5 N/m^2
  - F = PA = 7,631,903 N

$$P = \frac{F}{A}$$

$$F = PA$$

Pressure in Fluids

- **Fluid exerts a pressure in all directions**
- **Fluid pressure is exerted perpendicular to whatever surface it is in contact with**
- **Fluid pressure increases with depth**

Pressure in Fluids

- Think of a disk 5 cm (0.05 m) in diameter ($A = \pi r^2 = 1.96\ cm^2 = 0.00196\ m^2$)
- You place it in water 30 cm (0.30 m) below the surface
- The pressure on that disk is equal to the weight of a column of water that has a 5 cm diameter and is 30 cm high (*h* = height of water)

Pressure in Fluids

- Like a graduated cylinder
  - A_{disk} = 0.00196 m^2
  - The volume of the cylinder is A x h ($\pi r^2 h$) = 589 cm^3 = 5.89 x 10^{-4} m^3

$$\rho = \frac{m}{V}$$

$$\rho V = m$$

$$m = \left(1x10^3 kg / m^3\right)\left(5.89x10^{-4} m^3\right)$$

$$m = 0.589kg$$

Pressure in Fluids

- Like a graduated cylinder
  - $A_{disk} = 0.00196\ m^2$
  - $V = 5.89 \times 10^{-4}\ m^3$
  - $m = 0.589\ kg$

$$F = ma = mg$$

$$F = (0.589kg)(9.81m/s^2)$$

$$F = 5.78N$$

Pressure in Fluids

- Like a graduated cylinder
  - $A_{disk} = 0.00196\ m^2$
  - $V = 5.89 \times 10^{-4}\ m^3$
  - m = 0.589 kg
  - F = 5.78 N

$$P = \frac{F}{A} = \frac{(5.78N)}{(0.00196m^2)}$$

$$P = 2.9x10^3\ N/m^2$$

- ***That's way too much work!***
- ***How about a formula?***

Pressure in Fluids

- Like a graduated cylinder
  - $P = 2.9 \times 10^3\ N/m^2$
- *That's way too much work!*
- *How about a formula?*

$$P = \frac{F}{A}$$

$$P = \frac{mg}{A}$$

$$P = \frac{\rho V g}{A}$$

$$P = \frac{\rho A h g}{A}$$

$$P = \rho g h$$

Pressure in Fluids

- **Like a graduated cylinder**
  - **P = 2.9 x 10^3 N/m^2**

$$P = \rho g h$$

$$P = \left(1.0x10^3\, kg/m^3\right)\left(9.81 m/s^2\right)\left(0.3m\right)$$

$$P = 2.9x10^3\, N/m^2$$

$$P = \rho g h$$

Pressure in Fluids

- **Pressure at equal depths within a uniform liquid is the same**

$$P = \rho g h$$

- **IMPORTANT: The pressure the water exerts on an object at a certain depth is the same on all parts of a body.**
- ***In other words, if you hold a cube 30cm under water, each side of that cube will feel the same pressure exerted on it – not just the top, but the bottom and all four sides!!!***

Pressure in Fluids

- **It follows from this that a change in depth is directly proportional to a change in pressure**

$$P = \rho g h$$

$$\Delta P = \rho g \Delta h$$

- **Note:** ***An important assumption here is that the fluid is incompressible, because if it were compressible, the density would change with depth!***

Pressure in Fluids

$$\Delta P = \rho g \Delta h$$

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- Let's say you had a water tank 15m in diameter and was 20m tall. What would be the pressure at the bottom of the tank?

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- Let's say you had a water tank 15m in diameter and was 20m tall. What would be the pressure at the bottom of the tank?

$$\Delta P = \rho g \Delta h$$

$$\Delta P = \left(1.0x10^3\right)\left(9.81\right)\left(20\right)$$

$$\Delta P = 1.96x10^5\,Pa$$

Pressure in Fluids

$$\Delta P = \rho g \Delta h$$

- Let's say you had two pipes attached to the tank, one 18 cm in diameter and the other 12 cm in diameter. What would be the difference in pressure between the two pipes?

$$\Delta P = 1.96x10^5 \, Pa$$

Pressure in Fluids

$$\Delta P = \rho g \Delta h$$

- Let's say you had two pipes attached to the tank, one 18 cm in diameter and the other 12 cm in diameter. What would be the difference in pressure between the two pipes?

$$\Delta P = 1.96x10^5 \, Pa$$

- ***No difference***

Pressure in Fluids

$$\Delta P = \rho g \Delta h$$

- Let's say you had a second tank that could hold twice as much water but was the same height. What would be the difference in pressure between the two tanks?

$$\Delta P = 1.96x10^{5}\,Pa$$

Pressure in Fluids

$$\Delta P = \rho g \Delta h$$

- Let's say you had a second tank that could hold twice as much water but was the same height. What would be the difference in pressure between the two tanks?

$$\Delta P = 1.96x10^5\,Pa$$

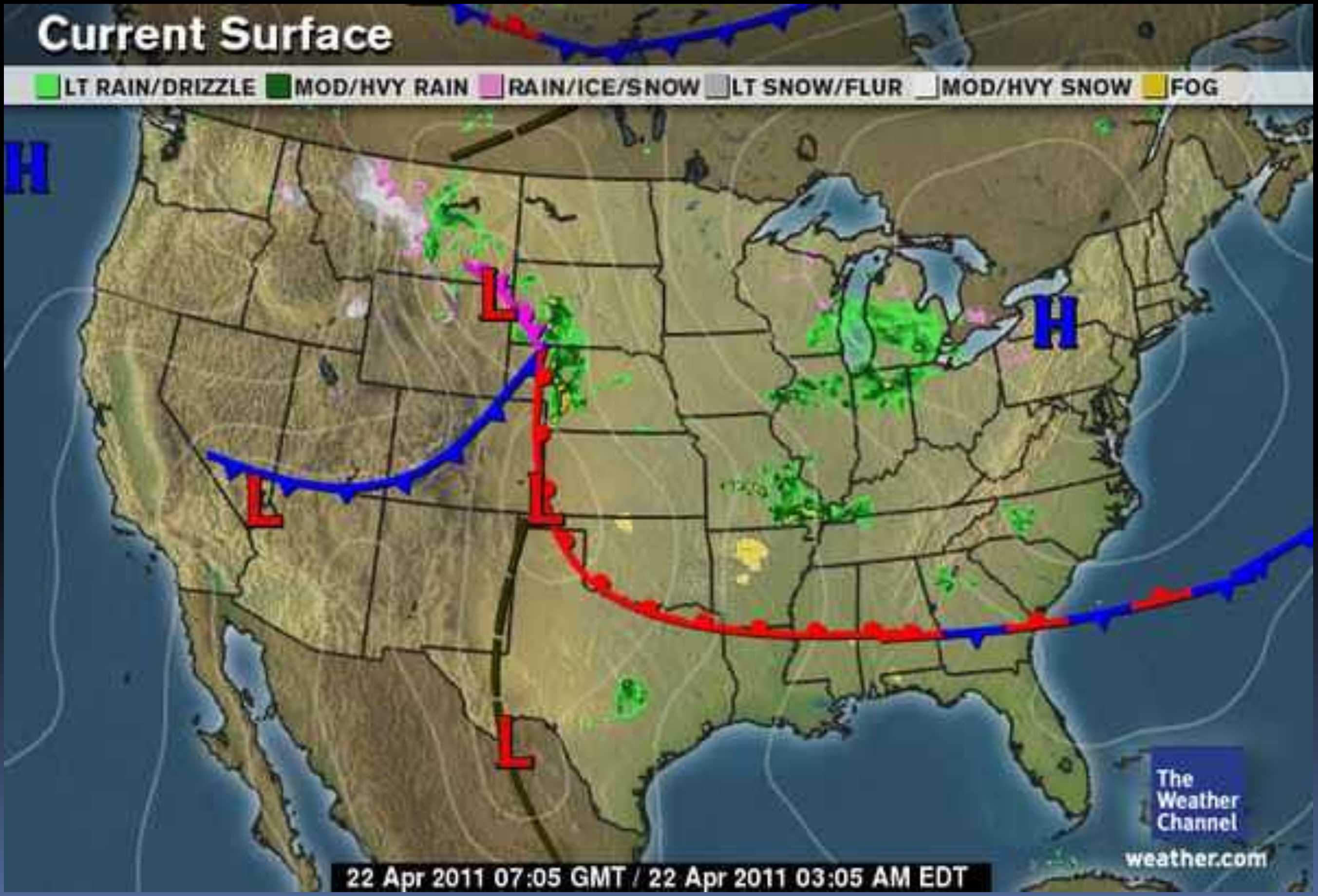
- ***No difference***

Atmospheric Pressure and Gauge Pressure

- Atmospheric pressure is a function of elevation and weather conditions
  - Elevation
    - Higher elevation smaller column of air above
    - Lower elevation larger column of air above
  - Weather
    - High temp = less dense
    - High humidity = more dense

Atmospheric Pressure and Gauge Pressure

- Atmospheric pressure is a function of elevation and weather conditions



Atmospheric Pressure and Gauge Pressure

- Average atmospheric pressure is, well, 1 atmosphere, hence the name

$$1atm = 1.013x10^5 N/m^2 = 101.3kPa$$

Atmospheric Pressure and Gauge Pressure

- Units for pressure

ABLE 10-2

nversion Factors Between Different Units of Pressure

In Terms of 1 Pa = 1 N/m^2	Related to 1 atm
1 atm = 1.013×10^5 N/m^2	1 atm = 1.013×10^5 N/m^2
= 1.013×10^5 Pa = 101.3 kPa	
1 bar = 1.000×10^5 N/m^2	1 atm = 1.013 bar
1 dyne/cm^2 = 0.1 N/m^2	1 atm = 1.013×10^6 dyne/cm^2
1 lb/in^2 = 6.90×10^3 N/m^2	1 atm = 14.7 lb/in^2
1 lb/ft^2 = 47.9 N/m^2	1 atm = 2.12×10^3 lb/ft^2
1 cm-Hg = 1.33×10^3 N/m^2	1 atm = 76 cm-Hg
1 mm-Hg = 133 N/m^2	1 atm = 760 mm-Hg
1 torr = 133 N/m^2	1 atm = 760 torr
mm-H_2O (4°C) = 9.81 N/m^2	1 atm = 1.03×10^4 mm-H_2O (4°C)

Atmospheric Pressure and Gauge Pressure

- Most pressure gauges read pressure over and above the atmospheric pressure
- Total pressure is then equal to gauge pressure plus atmospheric pressure

$$P = P_g + P_a$$

- Pressure limits correspond to the gauge readings

Atmospheric Pressure and Gauge Pressure

$$P = P_g + P_a$$

- ***You put a tire gauge to your car tire and it reads 35 psi. What is the total pressure in your tire?***

Atmospheric Pressure and Gauge Pressure

- ***You put a tire gauge to your car tire and it reads 35 psi. What is the total pressure in your tire?***

$$P = P_g + P_a$$

$$P_g = 35 psi = 35 lb/in^2$$

$$P_a = 14.7 lb/in^2$$

$$P = 35 + 14.7 = 49.7 lb/in^2 (psi)$$

Atmospheric Pressure and Gauge Pressure

$$P = P_g + P_a$$

- ***While we're on tires, why does it say "Max Cold Inflation 35 psi" on the side?***

Atmospheric Pressure and Gauge Pressure

$$P = P_g + P_a$$

- *While we're on tires, why does it say "Max Cold Inflation 35 psi" on the side?*
- *Because if it were written on the bottom, you couldn't read it AND it would eventually wear off.*

Atmospheric Pressure and Gauge Pressure

$$P = P_g + P_a$$

- *While we're on tires, why does it say "Max Cold Inflation 35 psi" on the side?*
- *Another reason is that as the tire heats up the pressure will increase and filling a cold tire to more than 35 psi, then getting the tire hotter could cause it to either explode or at least blow a bead.*

Atmospheric Pressure and Gauge Pressure

$$P = P_g + P_a$$

- ***One last tire question: The average car tire is inflated to 35-45 psi. What is the air pressure in a NASCAR vehicle or drag racer?***

Atmospheric Pressure and Gauge Pressure

$$P = P_g + P_a$$

- *One last tire question: The average car tire is inflated to 35-45 psi. What is the air pressure in a NASCAR vehicle or drag racer?*
- *They both use about 12 psi cold for two reasons:*
  - *The tires heat up a lot and raise the pressure*
  - *Keeping them somewhat flat to increase the amount of tire in contact with the track to give them more grip and avoid spinning the tires*

Pascal's Principle

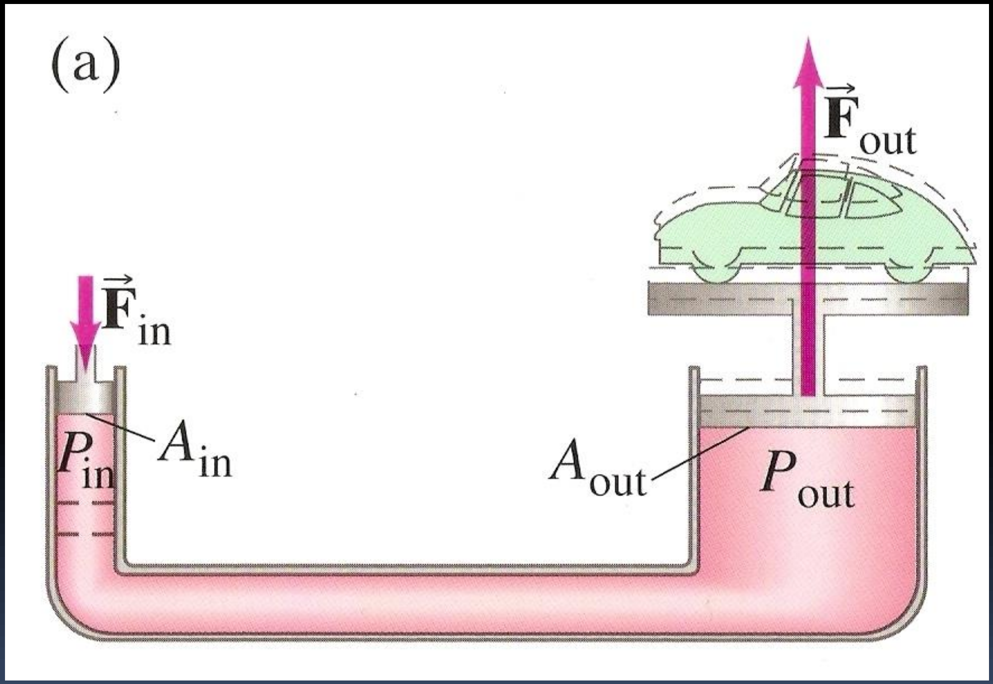
- ***The pressure applied to a confined fluid increases the pressure throughout the fluid by the same amount.***
- Examples
  - A cube at the bottom of a bucket of water. It has the pressure of the water acting on it, but also the atmospheric pressure pushing on the water.
  - The brake system in a car. You apply pressure via the brake pedal and that pressure gets transmitted via a fluid to the brake pads on the wheel

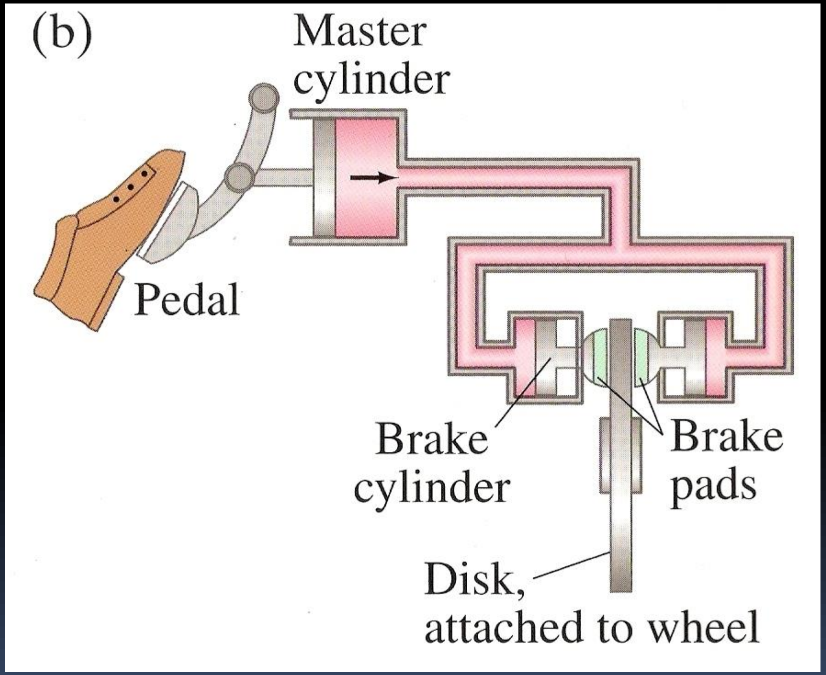
Pascal's Principle

- Demo Time

Pascal’s Principle

- Examples





Pascal's Principle

- ***The pressure applied to a confined fluid increases the pressure throughout the fluid by the same amount.***

$$P_{in} = P_{out}$$

$$\frac{F_{in}}{A_{in}} = \frac{F_{out}}{A_{out}}$$

$$\frac{F_{in}}{F_{out}} = \frac{A_{in}}{A_{out}}$$

$$\frac{F_{out}}{F_{in}} = \frac{A_{out}}{A_{in}}$$

Pascal's Principle

- ***If I want the force applied to my brakes to be 10 times the force I apply to the pedal, by what factor would the diameter of the piston at the brakes exceed that of the piston at the brake pedal?***

$$\frac{F_{out}}{F_{in}} = \frac{A_{out}}{A_{in}}$$

Pascal's Principle

- ***If I want the force applied to my brakes to be 10 times the force I apply to the pedal, by what factor would the diameter of the piston at the brakes exceed that of the piston at the brake pedal?***

$$\frac{F_{out}}{F_{in}} = \frac{A_{out}}{A_{in}}$$

$$\frac{10xF_{in}}{F_{in}} = \frac{\pi(xr)^2}{\pi r^2}$$

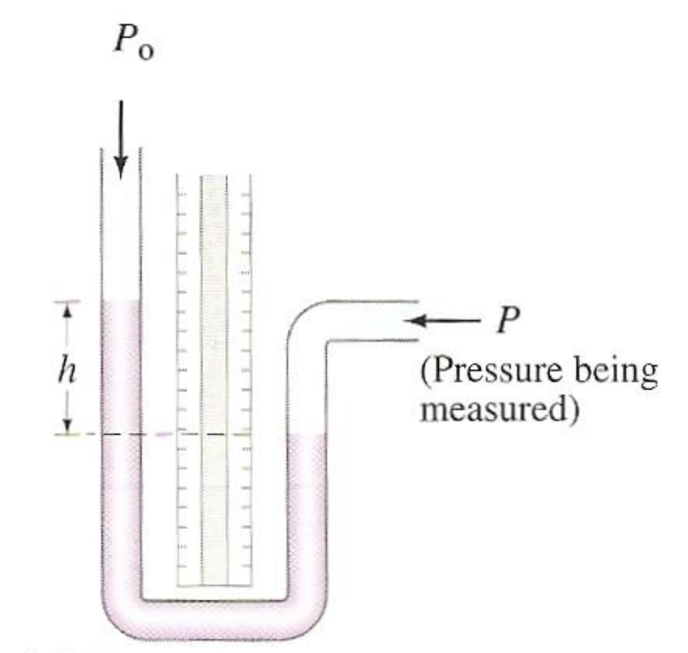
$$10 = x^2$$

$$x = 3.16$$

Pressure Gauges

- Manometer
  - U-shaped tube partially filled with liquid
  - Difference in fluid height represents pressure measurement by

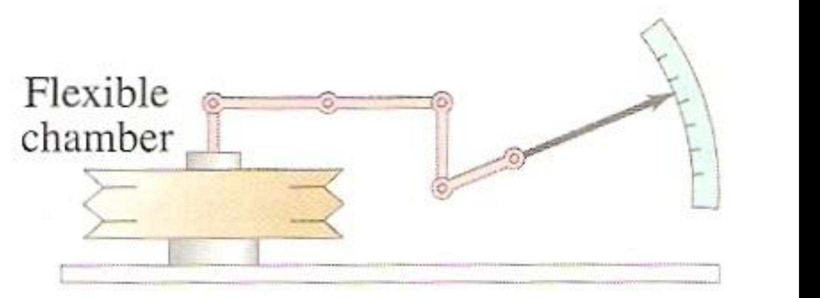
$$P = P_0 + \rho g h$$



(a) Open-tube manometer

Pressure Gauges

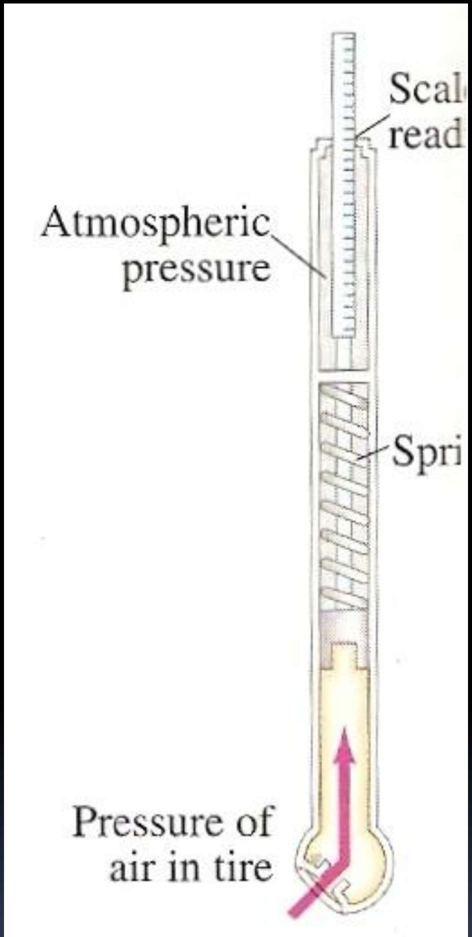
- Aneroid Gauge
  - Pointer attached to a flexible chamber
  - Changes in outside pressure will compress or expand the chamber which moves the pointer



(b) Aneroid gauge (used mainly for air pressure and then called an aneroid barometer)

Pressure Gauges

- Tire Gauge
  - When pressed against the tire valve stem, air pressure compresses the calibrated spring moving the scale bar ***(F = kx)***
  - Scale bar remains in place after pressure removed until manually reset



(c) Tire gau

Barometers

- Closed-End Mercury Manometer
  - Standard atmospheric pressure will support a column of 76cm of mercury
  - Changes in pressure calculated as deviations from this height

Summary Review

- Do you know the relationship between pressure, force and area?
- Do you know the relationship between fluid pressure, density and height (or depth) of the fluid?
- Do you understand that fluid exerts a pressure in all directions?
- Do you understand that fluid pressure at equal depths within a uniform liquid is the same?

Summary Review

- Do you understand that pressure exerts a pressure perpendicular to the surface it is in contact with?
- Do you know the difference between gauge pressure and total pressure and solve problems involving both of them?
- Can you apply Pascal’s principle to solve problems involving ‘mechanical advantage’?

Summary Review

- Can you name three different pressure gauges and how they work?
- Can you convert different units of pressure?

QUESTIONS?

Homework

#7-17

STOPPED HERE 4/10/14