Unit 7: Pressure

MC Textbook Chp 7

GLM Red Book Chp 6

Topics

- Definition of Pressure
- Hydraulic Press
- Liquid Pressure
- Mercury Barometer
- Manometer

Videos

- 1) Science Babe – Physics of High Heels
- http://www.youtube.com/watch?v=VIIo0SlagD8&hl=en-GB&gl=SG
- 2) Balloons and Nails – Steve Spangler
- http://www.youtube.com/watch?v=vo2iE94iAoA
- 3) Lying on Bed of Nails – Paul Hewitt
- http://www.youtube.com/watch?v=hG7lGZqWFpM

Pressure

- Symbol for Pressure: P
- S.I. Units for Pressure: Pascals (Pa)
- Other common units for pressure: atm, mmHg (more on these later)

Pressure

- Definition: Force acting per unit area
- Equation: P = F/A
- 1 Pascal = 1 Newton / 1 metre square

- For Pressure exerted by solids:
- Recall weight = mg
- Common mistake: mass/area instead of force/ area

Example 1

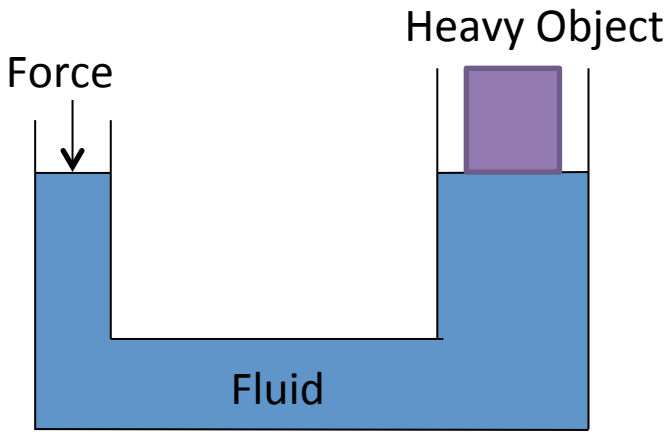
- A 1m by 1m by 1m cube has a weight of 5 kg. What is the pressure its base exerts on the ground?

Practice Task

- GLM Pg 98 Qn 3

Hydraulic Press

- A hydraulic press is a machine which allows someone to lift a heavy object using less force.
- There are two arms of a hydraulic press, one arm is used to exert force downwards, another arm is used to lift a heavy object



Hydraulic Press

- The principle behind the hydraulic press is:
- Pressure in left arm = Pressure in right arm
- Since Pressure = Force / Area
- $(Force_{left}/Area_{left}) = (Force_{right})/(Area_{right})$
- Note: Area refers to the cross-sectional area of each arm

Example

- A hydraulic press is used to lift up a car of mass 2000 kg. If the car is placed on a right piston of area 5 m^2, and the left piston has an area of 0.01 m^2, calculate the downward force on left piston required to lift the car.

- $(Force_{left}/Area_{left}) = (Force_{right})/(Area_{right})$
- $F/(0.01) = mg/(5)$
- $F/(0.01) = (2000)(10)/(5)$
- $F = 40.0$ N (3 sf)

Practice Task

- GLM Pg 103 Qn 4

Extra Info:

- (not in syllabus)
- the brakes of a car work using a modified hydraulic press
- When the brake pedal is pressed by the driver, it pushes hydraulic fluid which in turns exerts a force on the brake drum (which is attached to the wheel). The friction caused by this force causes the wheel to slow down or stop spinning (i.e. to brake)

Assignment 7A

- TYS Topic 6
- Paper 1: Qn 2, 4, 8, 9, 12, 16, 18

Normal Diving Wetsuit
up to 40 m underwater

Atmospheric Diving Suit
up to 600 m underwater

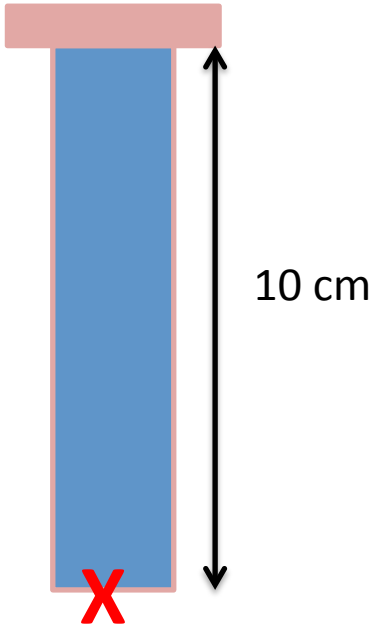
- Why can’t you wear a normal wetsuit to go deep sea diving?

Liquid Pressure

- Equation for liquid pressure
  - **$P = \rho gh$**
- Liquid pressure is dependent on 3 things:
  - density of the liquid (ρ)
  - gravitational field strength ($g = 10\ ms^{-2}$)
  - height/depth of the liquid (h)
- Note: liquid pressure does NOT depend on volume of liquid, only the height/depth of the liquid

Example 2a

- A measuring cylinder is filled with water (density = 1000 kgm^{-3}) and is quickly turned upside down and placed on a table. If the height of the column of water is 10 cm, determine the liquid pressure at the bottom of the water.

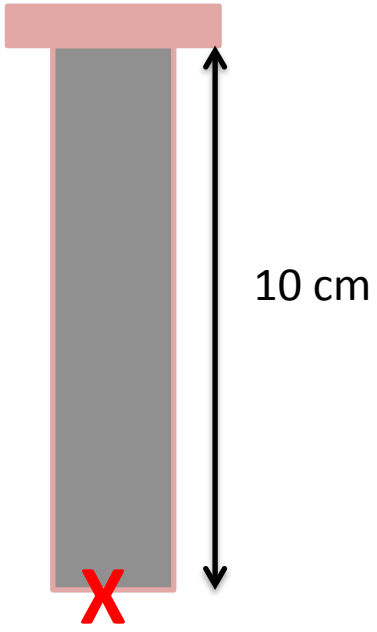


- $P = \rho gh$
- $= (1000)(10)(0.10)$
- $= 1000$ Pa

Example 2b

- The same setup is repeated except that instead of water, liquid mercury (13 500 kgm^{-3})is used to fill the measuring cylinder. What is the pressure at the bottom of the mercury?

  - $P = \rho gh$
  - $= (13500)(10)(0.10)$
  - $= 13500$ Pa



Practice Task

- GLM Pg 103 Qn 2(a)
- GLM Pg 103, Qn 3(a)
- GLM Pg 110 Qn 7

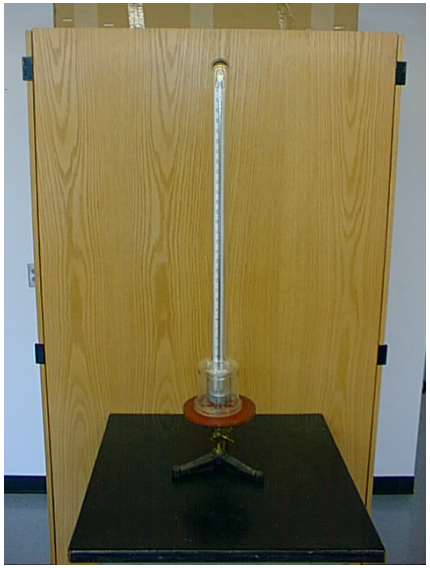
Atmospheric Pressure

- When you are surrounded by liquid (e.g. underwater) you will be under liquid pressure
- Similarly, when you are surrounded by air, you are under air pressure
- Right now, air is pushing against you and your skin!!
- Atmospheric air pressure is approximately 10^5 Pa, sometimes referred to as “1 atm”
- Air pressure varies with height (at the top of Mount Everest, air pressure is only 30 000 Pa)

Mercury Barometer

- A device which measures air pressure is called a barometer
- For your syllabus, you are required to know how a very low-tech barometer works – the <u>mercury barometer</u>
- [not in syllabus] because of the poisonous nature of mercury, mercury barometers are no longer produced since 2007

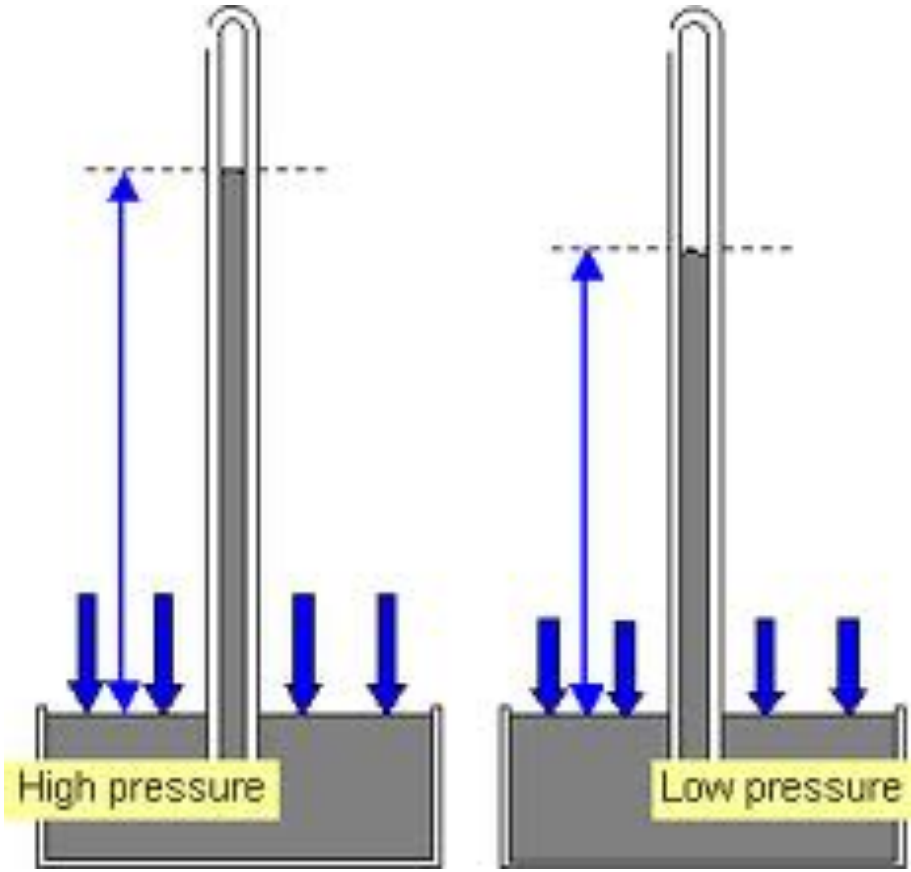
Modern weather barometer



Mercury Barometer

Mercury Barometer

- works using the principle of liquid pressure, $P = \rho gh$
- Atmospheric pressure is calculated using ρgh where h is the height of the column of mercury in the glass
- Note that the space in the tube above the mercury is compete vacuum (i.e. absolutely nothing, no air)
- Atmospheric pressure is around 760 mm (76 cm) of height of mercury

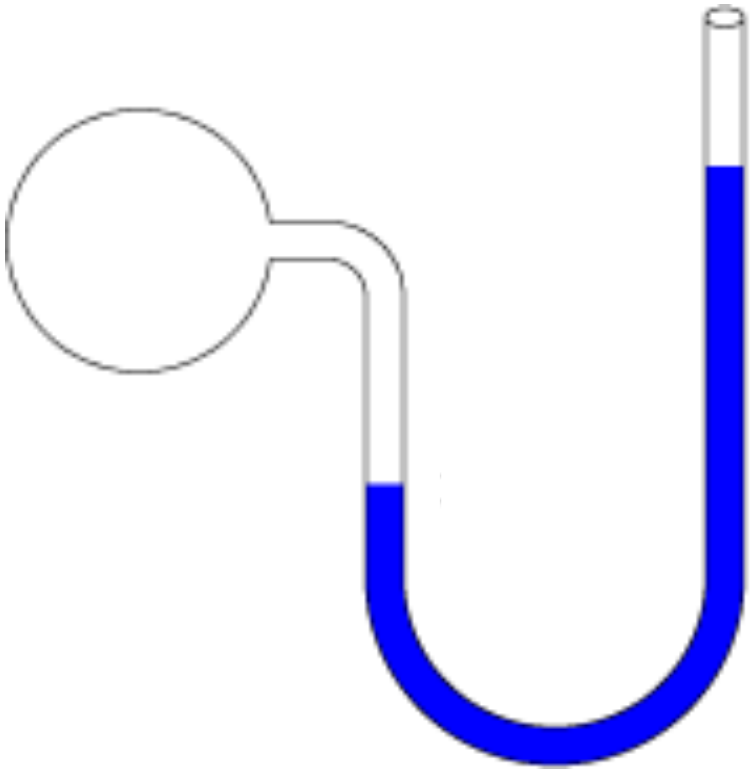


Practice Task

- GLM Pg 109 Qn 1-2
- GLM Pg 107 Qn 1

Manometer

- A manometer is a measuring instrument which measures the pressure of an enclosed gas
- It is made of a U-shaped tube with some liquid inside
- It has two arms – one attached to the enclosed gas and another left exposed (to atmospheric pressure)



Manometer

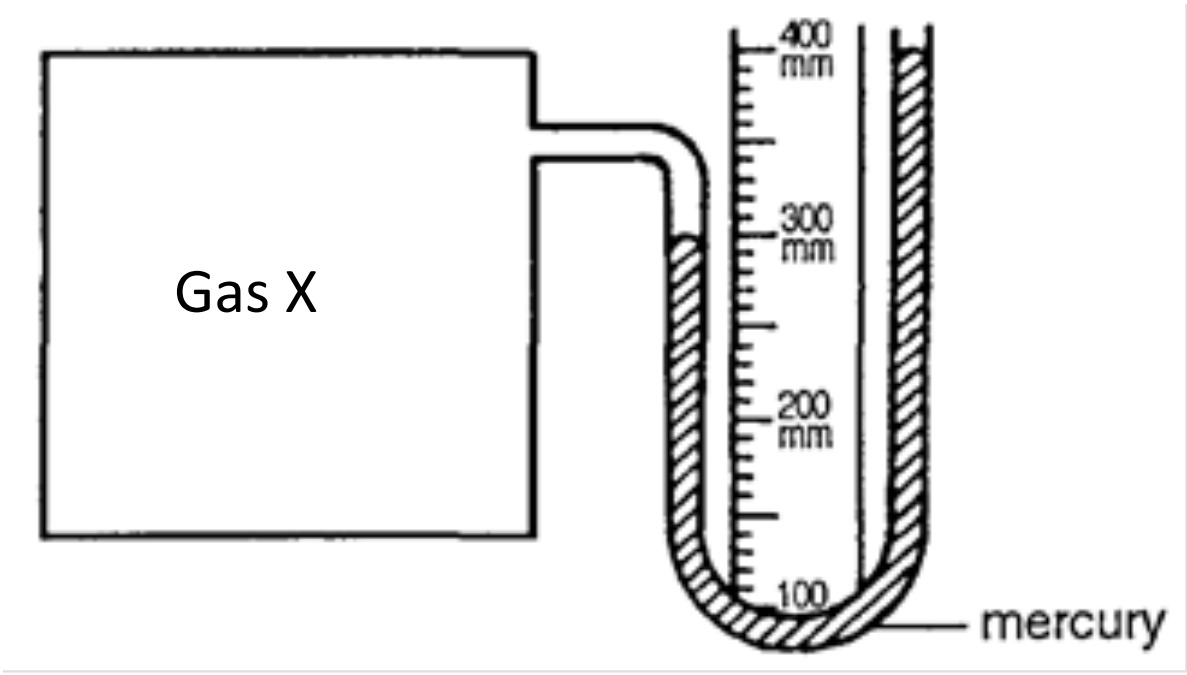
- If pressure of gas is same as atmospheric pressure, the liquid level in left arm = liquid level in right arm
- If pressure of gas is higher than atmospheric pressure, the liquid level in left arm is lower than liquid level in right arm
- If pressure of gas is lower than atmospheric pressure, the liquid level in left arm is higher than liquid level in left arm

Manometer

- Principle of manometer – *at the same height*, total pressure in left arm is same as total pressure in right arm
- Total pressure of left arm = pressure of enclosed gas + ρgh (if any)
- Total pressure of right arm = atmospheric pressure + ρgh (if any)
- The difference in pressure between enclosed gas and atmospheric pressure = ρgh

Example 3

- If atmospheric pressure is 760 mm Hg, what is the pressure of gas X in terms of mm Hg?



Example 3

- If the density of mercury is 13 500 kgm^{-3}, calculate the pressure of gas X in terms of Pascals.

- Answer to 4(a): 860 mm Hg
- h = 860 mm = 0.86 m
- ρgh = (13500)(10)(0.86) = 116 000 Pa (3 sf)

Practice Task

- GLM Pg 110 Qn 4 (typo, "gas supply" not "water supply")
- GLM Pg 108 Qn 3
- GLM Pg 109 Qn 4

Summary

- Pressure is Force per unit Area; $P = F/A$
- In a hydraulic press,
  - pressure in left arm = pressure in right arm
  - $F_L/A_L = F_R/A_R$
- Liquid Pressure; $P = \rho gh$
- Mercury Barometer
- Manometer
  - Difference in pressure (btn left arm and right arm) = ρgh

Quiz 7

Assignment 7b

- TYS Topic 6
- Paper 1 Qn 1, 5, 7, 11, 13, 14, 17, 19
- Paper 2 Qn 1 (sketch all diagrams on foolscap paper, but indicate markings clearly)