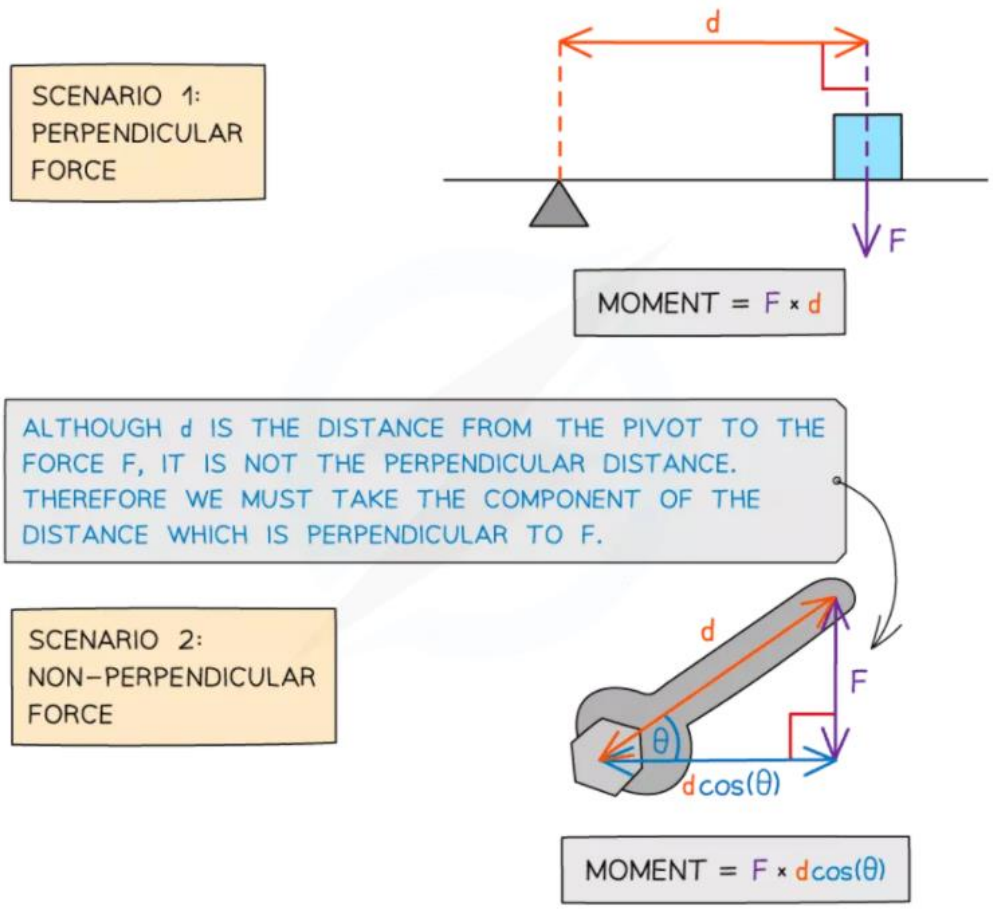
Chapter 4 Forces, density and pressure

4.1 Turning effects of forces

Candidates should be able to:	
1	understand that the weight of an object may be taken as acting at a single point known as its centre of gravity
2	define and apply the moment of a force
3	understand that a couple is a pair of forces that acts to produce rotation only
4	define and apply the torque of a couple

- The **centre of gravity** of an object is **the point at which the weight of the object may be considered to act.**
- A moment is the **turning effect of a force**
- Think of moments as a force that causes an object to **rotate** instead of moving in a straight line
- The equation for moment is
  Moment = Force x perpendicular distance from the pivot
- The **SI unit** for moment is **Nm**



4.2 Equilibrium of forces

Candidates should be able to:	
1	state and apply the principle of moments
2	understand that, when there is no resultant force and no resultant torque, a system is in equilibrium
3	use a vector triangle to represent coplanar forces in equilibrium

- The **principle of moment** states that for a system to be **balanced**, the **resultant clockwise must be equal to zero**
- **Clockwise Moment = Counter Clockwise Moment**
- Recall earlier that for a system to be in equilibrium it must satisfy **two** criteria:
  1) The resultant force must be equal to zero
  2) The resultant moment must be equal to zero

4.3 Density and pressure

Candidates should be able to:	
1	define and use density
2	define and use pressure
3	derive, from the definitions of pressure and density, the equation for hydrostatic pressure $\Delta p = \rho g \Delta h$
4	use the equation $\Delta p = \rho g \Delta h$
5	understand that the upthrust acting on an object in a fluid is due to a difference in hydrostatic pressure
6	calculate the upthrust acting on an object in a fluid using the equation $F = \rho g V$ (Archimedes' principle)

- **Density** is the **mass per unit volume** of an object

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

- The **SI unit** for density is **kg/m^3**
- **Pressure** is defined as **force per unit area**

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

- The **SI unit** for pressure is **N/m^2** or **Pa**
- **Hydrostatic pressure** is the pressure exerted by a fluid at equilibrium at a given point within the fluid, due to the force of gravity
- The magnitude of the pressure depends on the depth (h) the object is submerged in the fluid, the density of the fluid (ρ) and the gravitational acceleration (g)

- The equation of hydrostatic pressure is given by

$$p = h\rho g$$

- The derivation is shown below:

  Rewrite the pressure formula in terms of *ρ, h and g.*

  Hint 1 Write out the "original" pressure formula

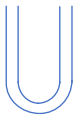
  Hint 2 What is the equation for weight (or force)?

  Hint 3 Mass is equal to density x volume

  Hint 4 Volume is equal to area x height of the fluid.

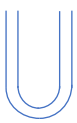
  Hint 5 Assume both area are the same.

- You can measure pressure by using a manometer
  When both arms are not connected to anything



  When one arm is connected to a gas supply and the gas pressure > atmospheric pressure

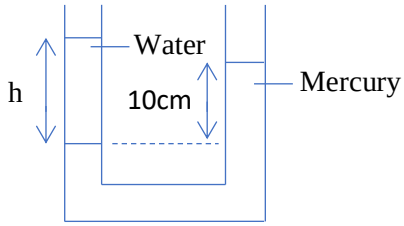
  When one arm is connected to a gas supply and the gas pressure < atmospheric pressure



There are several steps in order to find pressure using a manometer.

Step 1 Draw equal pressure lines. Remember the pressure is only the same for same
fluids.
Step 2 Draw arrows showing the direction of force caused by the weight of the Fluids on the equal pressure lines.
Step 3 Write the relevant equations down.
Step 4 Solve the problem

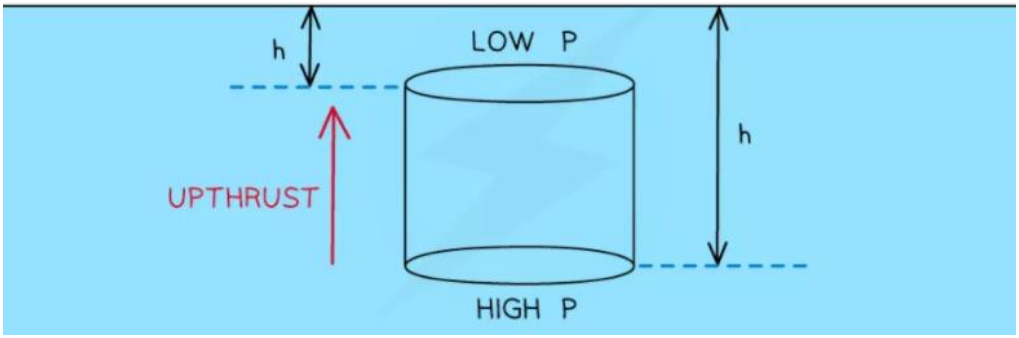
- Don't forget that
  Total pressure = Hydrostatic pressure + Atmospheric pressure (101325 Pa)
  Try the problem below using the steps above:



The manometer consists of water and mercury. You are asked to find *h*.

Step 1 Draw equal pressure lines. *Hint: It's obvious this time.*
Step 2 Draw arrows showing the direction of force caused by the weight of the fluids
Hint: Both arms are exposed to the atmosphere
Step 3 Write the relevant equations down. *Hint: P = hρg*
Step 4 Solve the problem

- Upthrust is a force which pushes upwards on an object submerged in a fluid
- Think boat or submarine
- Another name for upthrust is buoyancy force
- Buoyancy is caused by the difference in hydrostatic pressure at the top and bottom of a submerge vessel



- **Archimedes' principle** states that an **object submerged in a fluid at rest has an upthrust equal to the weight of the fluid displaced by the object.**

$$F = \rho g V$$

- An example is shown below