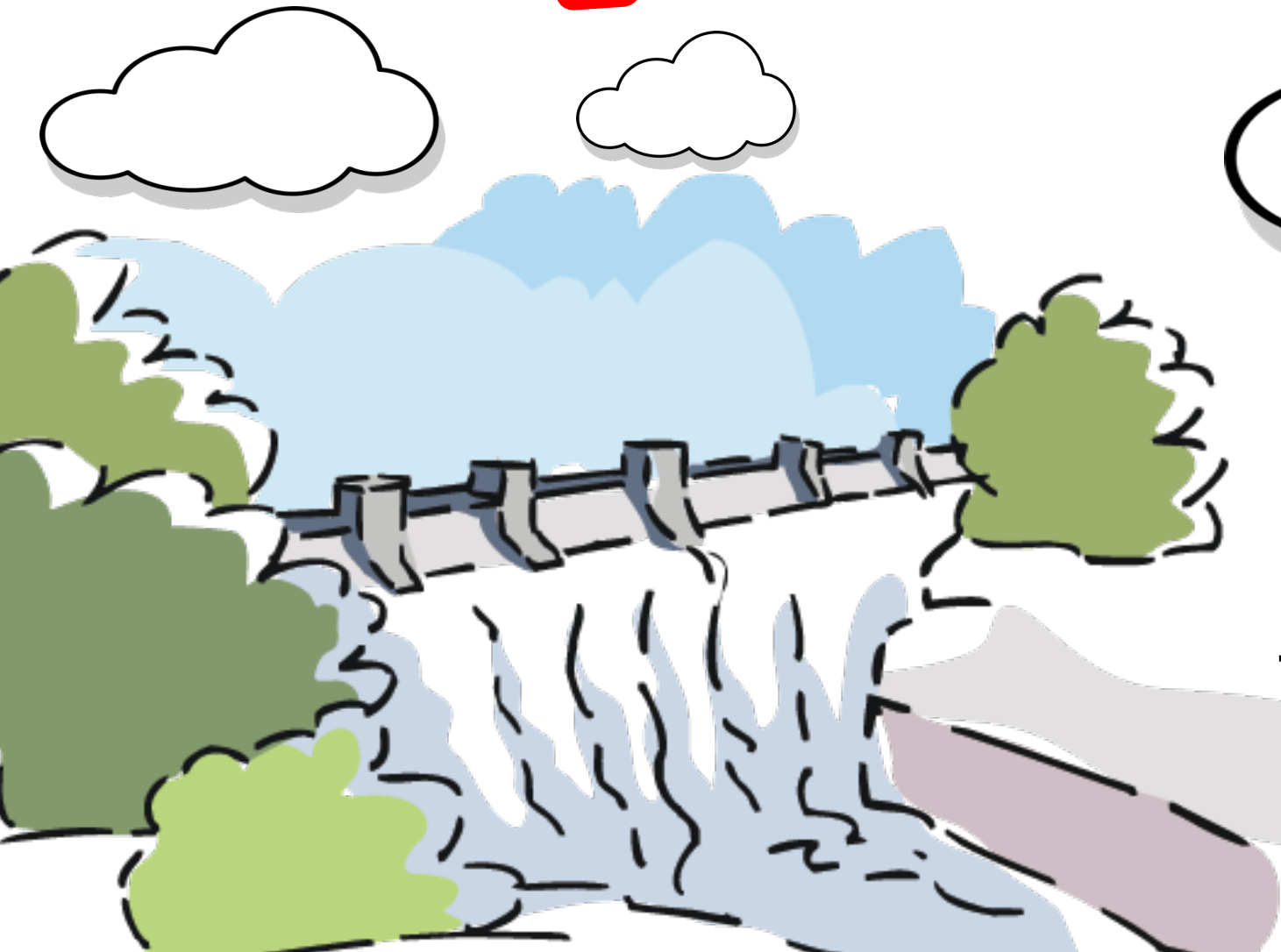


PRESSURE



The **Difference** Is
The **EXPERIENCE**

DREAM BIG...AIM HIGH...NEVER GIVE UP

The pressure due to the weight of the liquid acting per unit area on the liquid surface

LIQUID PRESSURE

Assume that a vertical column of liquid with a density ρ and a horizontal area A .

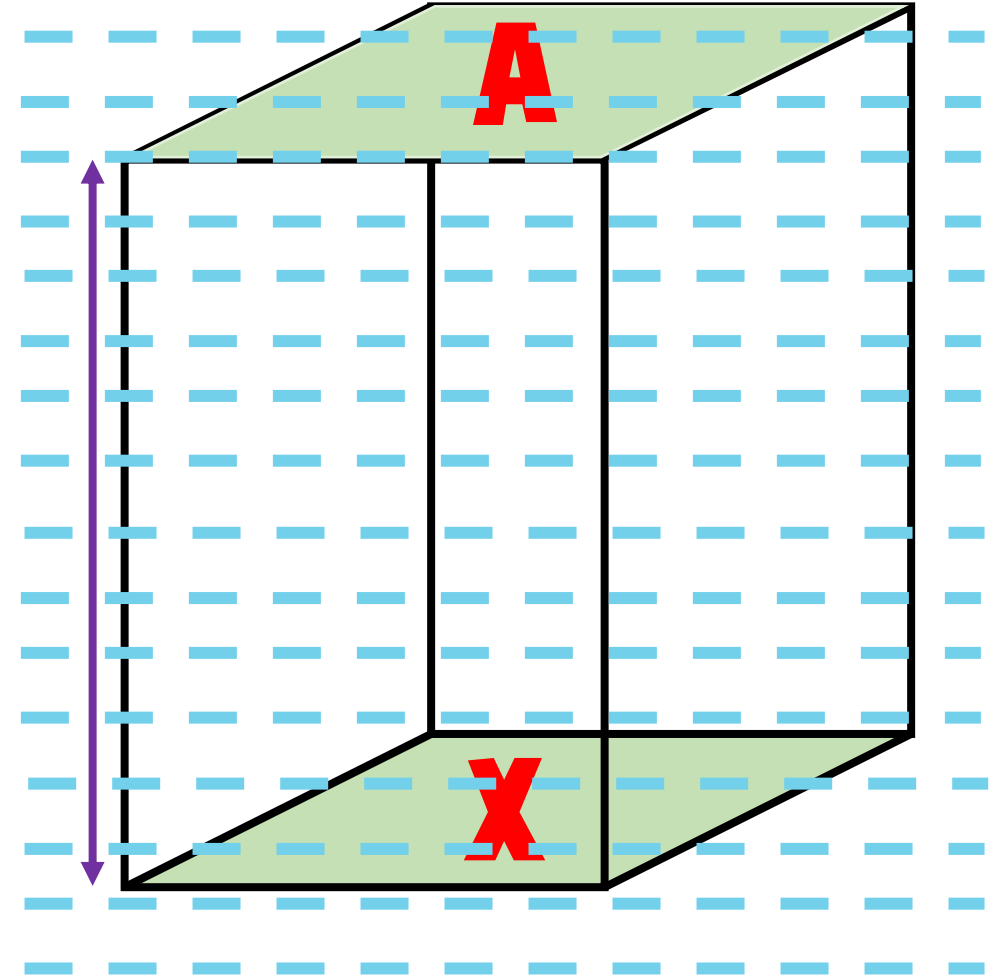
Consider an object is placed at point X at a depth h below the surface area of the liquid.

The pressure P due the liquid exerted on the object at point X can be written as:

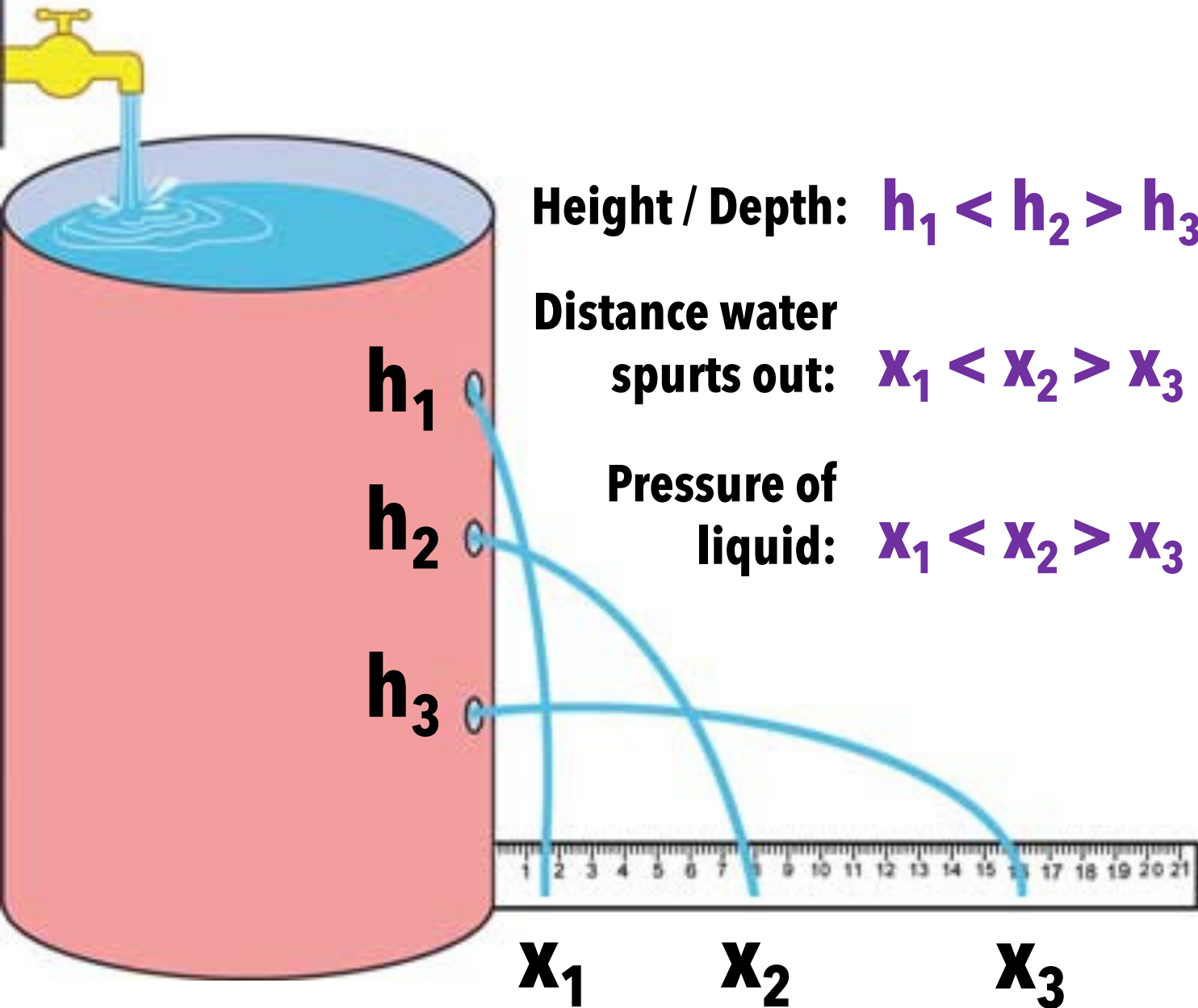
$$\begin{aligned} P &= \frac{F}{A} \\ &= \frac{W}{A} \\ &= \frac{mg}{A} && \text{Because } W = mg \\ &= \frac{\rho Vg}{A} && \text{Because } \rho = \frac{m}{V} \\ &= \frac{\rho Ahg}{A} && \text{Because } V = Ah \end{aligned}$$

$$P = h\rho g$$

P = Liquid pressure ,
 ρ = density of liquid
h = depth of liquid
g = acceleration due to gravity
(9.81 ms^{-2})



LIQUID PRESSURE



Depth **increase**,
Distance water spurts out
increase

Depth **increase**,
Pressure of liquid
increase

Distance water spurts out
increase,
Pressure of liquid
increase

SKILL 1 - UNDERSTANDING



A vessel which has 2 holes, X and Y at difference height as shown on Diagram 1.

When the vessel is filled with water, water spurts out from the two holes due to the water pressure.

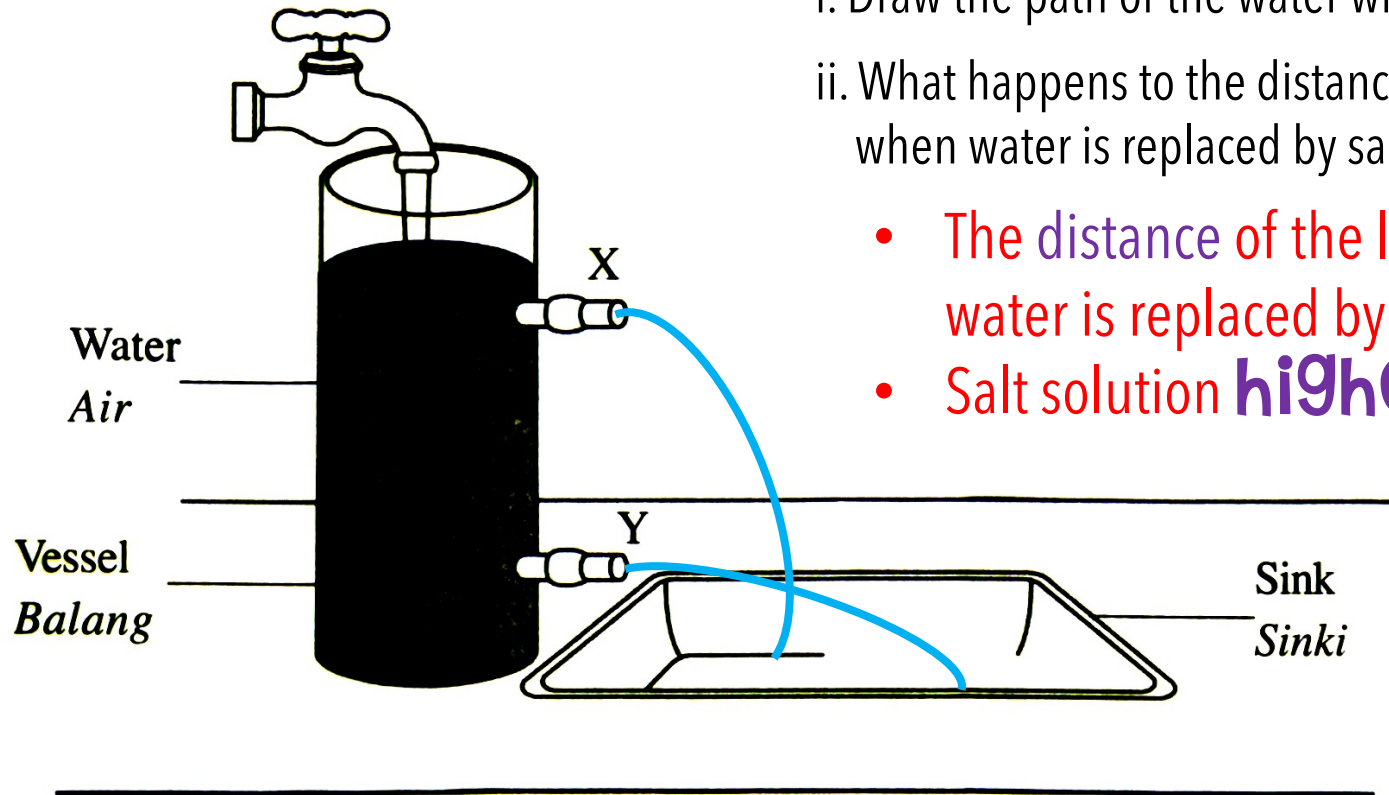


Diagram 1

i. Draw the path of the water which spurts out from the holes X and Y.

ii. What happens to the distance of the liquid spurting out a hole X when water is replaced by salt solution? Explain your answer.

- The distance of the liquid spurting out a hole X when water is replaced by salt solution **increase**.
- Salt solution **higher density** compared to water

- Density **increase**, pressure **increase**

LIQUID PRESSURE

U-tube

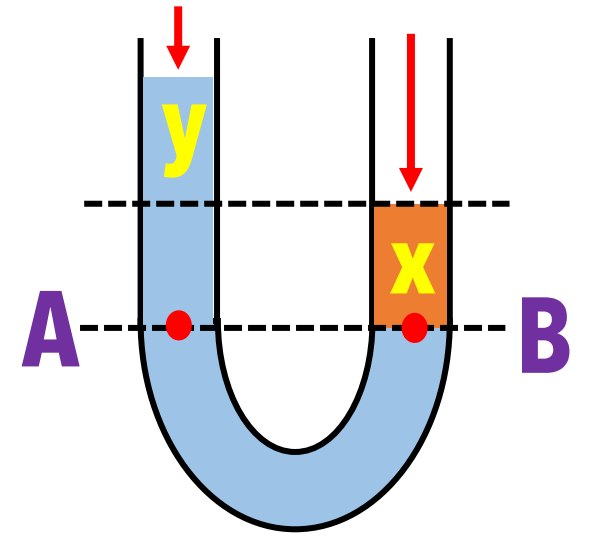
same density

- the pressure at the points A and B must be the same (same level in the liquid)
- $P_A = P_B$

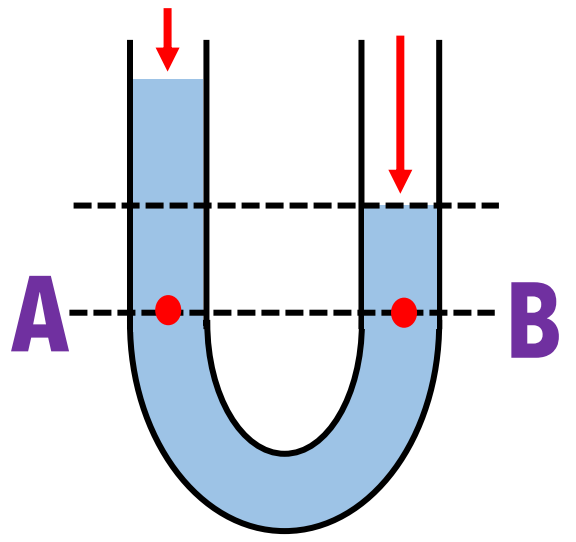
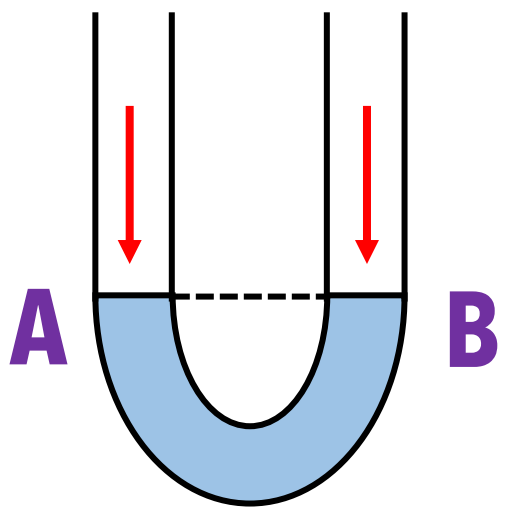
$$P = h\rho g$$

- The pressure at the points A and B must still be the same (same level in the liquid) and so the height of the column of liquid on the right is less than that on the left.
- $P_A = P_B$

difference density

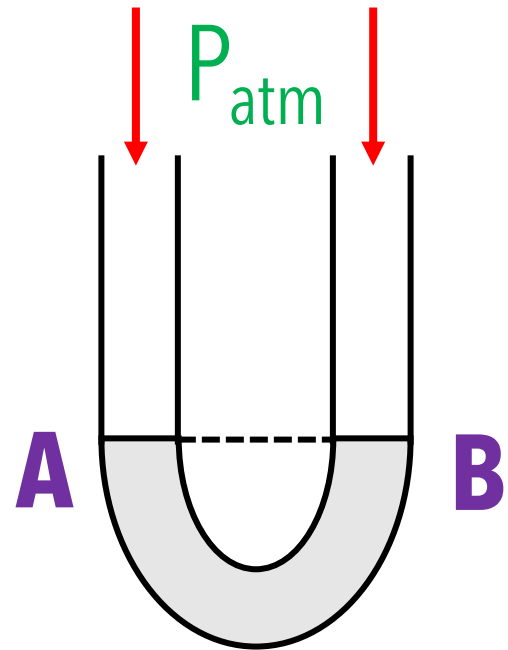


- density $x >$ density y
- height $x <$ height y
- $P_A = P_B$



MANOMETER

to measure
GAS PRESSURE

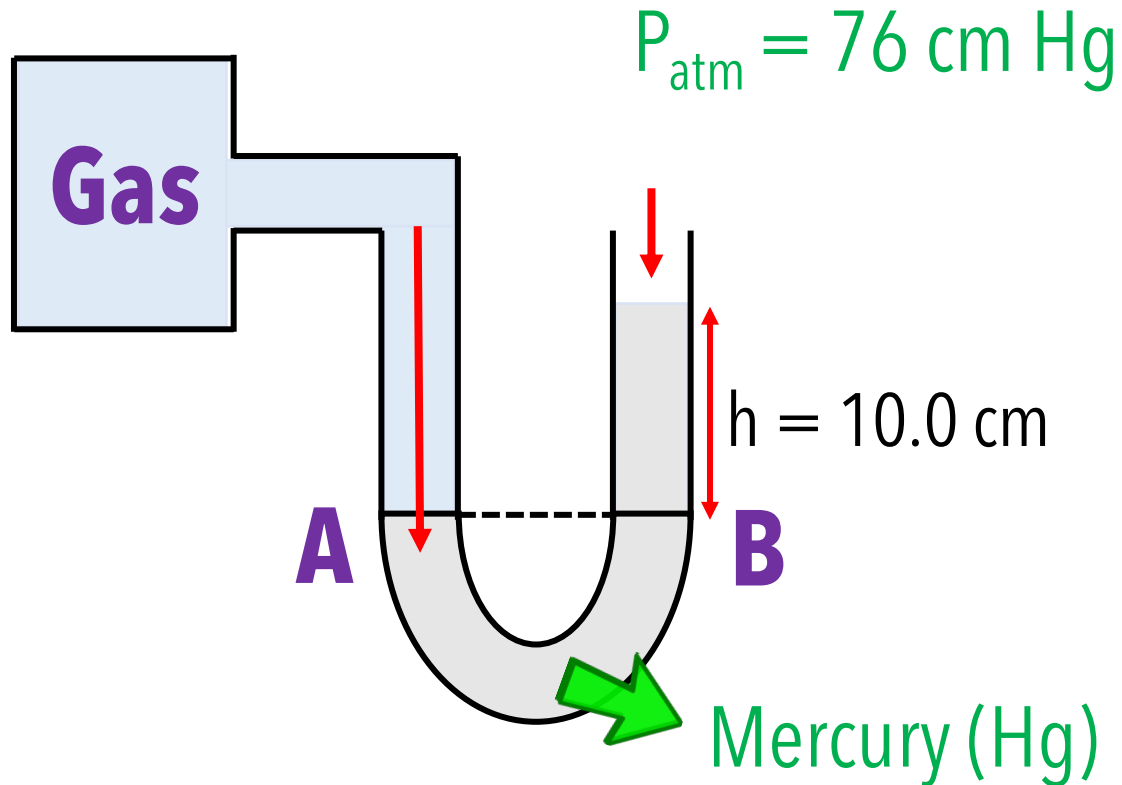


$$P_A = P_B = P_{atm}$$

$$\begin{aligned} P_{atm} &= 1.0 \times 10^5 \text{ Pa} \\ &= 76 \text{ cm Hg} \\ &= 10 \text{ m water} \\ &= 1 \text{ Bar} \\ &= 1 \text{ atm} \end{aligned}$$

MANOMETER

to measure
GAS PRESSURE



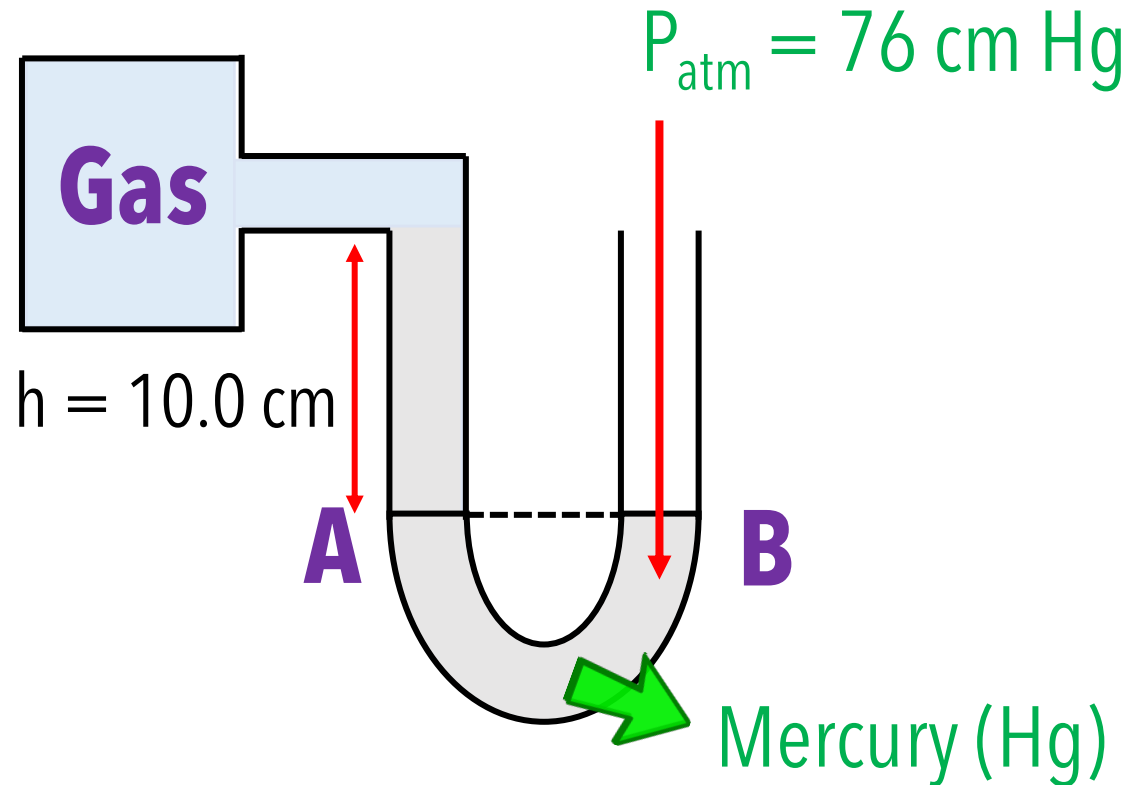
$$P_{\text{gas}} > P_{\text{atm}}$$

$$P_{\text{gas}} = P_{\text{atm}} + h$$

$$P_{\text{gas}} = 76 + 10$$
$$= 86 \text{ cm Hg}$$

MANOMETER

to measure
GAS PRESSURE



$$P_{\text{atm}} > P_{\text{gas}}$$

$$P_{\text{gas}} = P_{\text{atm}} - h$$

$$P_{\text{gas}} = 76 - 10$$
$$= 66 \text{ cm Hg}$$

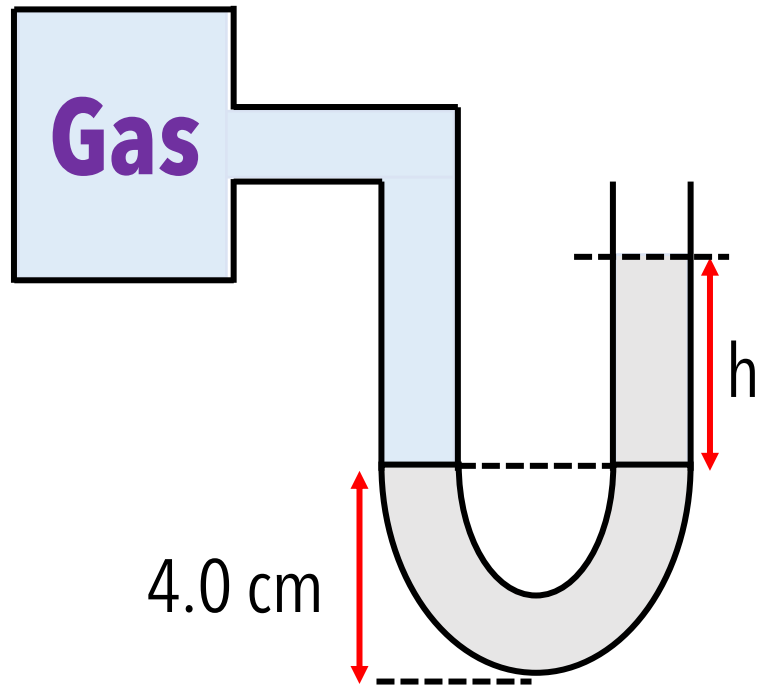
MANOMETER

to measure
GAS PRESSURE

Example:

TRIAL MRSM 2018

What is the value of **h** if the pressure of the gas is 82.0 cm Hg?



$$P_{\text{gas}} > P_{\text{atm}}$$

$$P_{\text{gas}} = P_{\text{atm}} - h$$

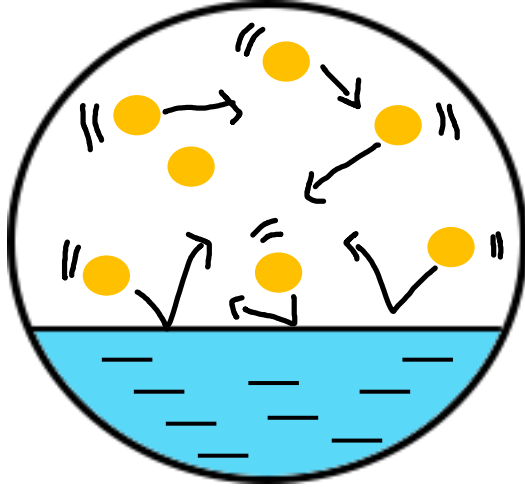
$$82 = 76 - h$$

$$h = 6 \text{ cm}$$

BAROMETER

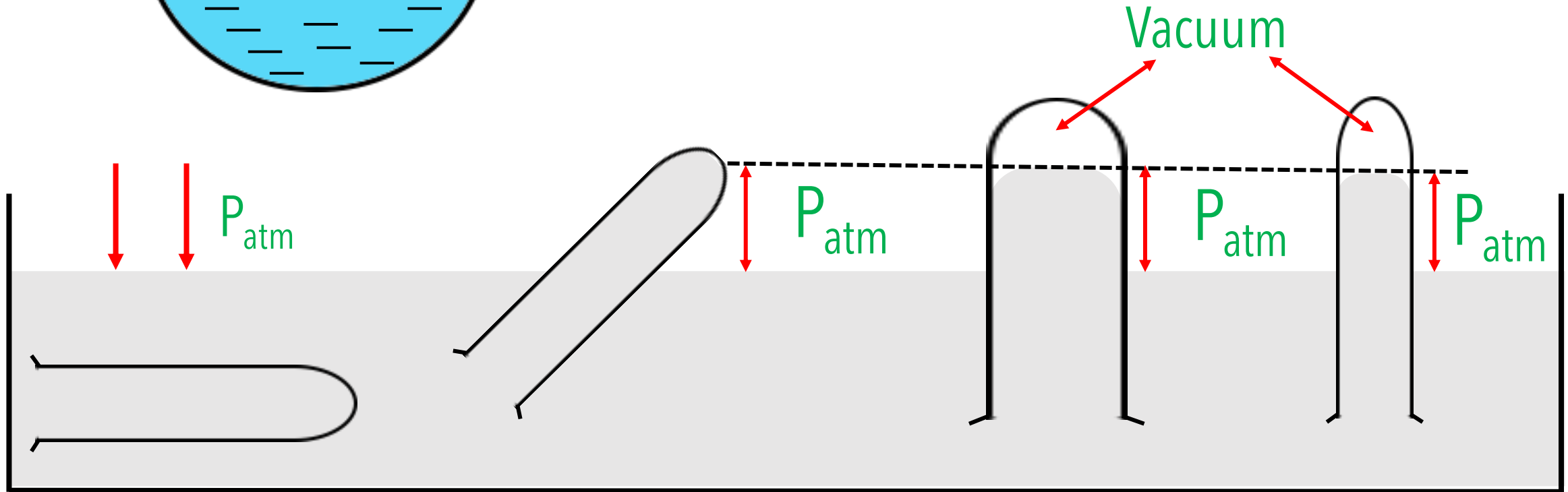
to measure

ATMOSPHERIC PRESSURE



- Air molecules in continuously random motion
- Exerts a pressure on mercury surface etc.

$$P_{\text{atm}} = 76 \text{ cm Hg}$$

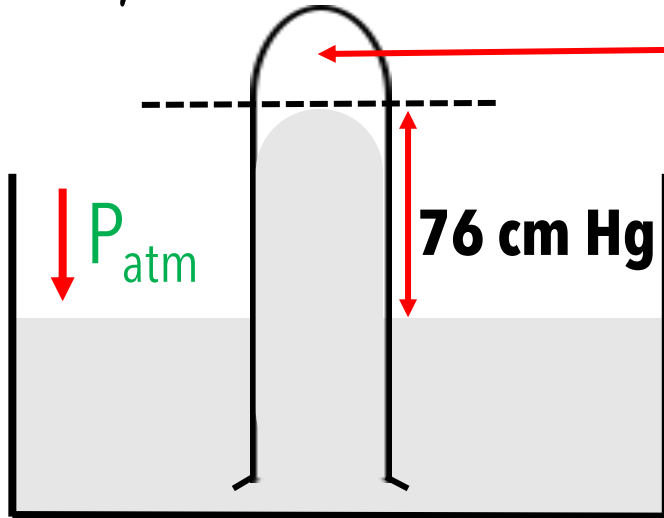


BAROMETER

to measure

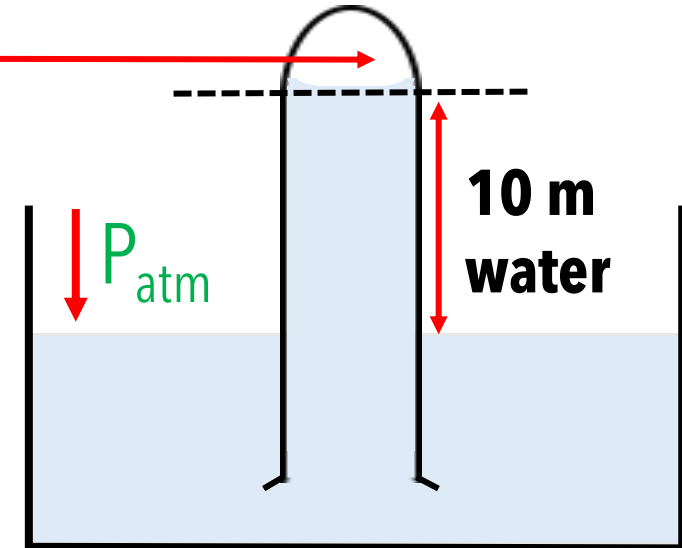
ATMOSPHERIC PRESSURE

MERCURY
Barometer



Vacuum

WATER
Barometer



$$P = \rho g h$$

Density of mercury: $13\,600\text{ kg m}^{-3}$

$$P = (13\,600)(10)(0.76)$$

$$P = 1.03 \times 10^5 \text{ Pa}$$

Density of water: $1\,000\text{ kg m}^{-3}$

$$P = (1\,000)(10)(10)$$

$$P = 1.0 \times 10^5 \text{ Pa}$$

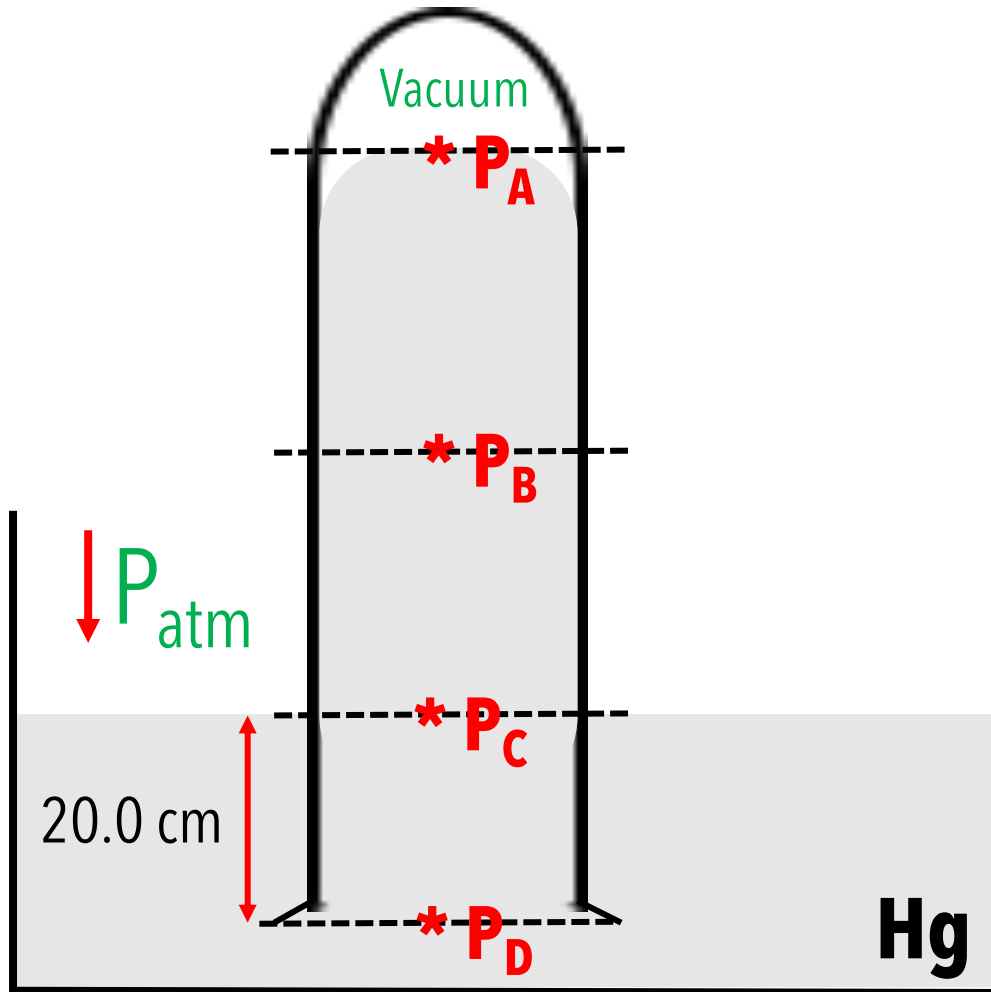
BAROMETER

to measure
ATMOSPHERIC PRESSURE

$$P = \rho gh$$

$$P_{\text{atm}} = 76 \text{ cm Hg}$$

Pressure
At different depth



$$P_A = 0 \text{ cm Hg}$$

$$P_B = \frac{P_{\text{atm}}}{2} = \frac{76}{2} = 38 \text{ cm Hg}$$

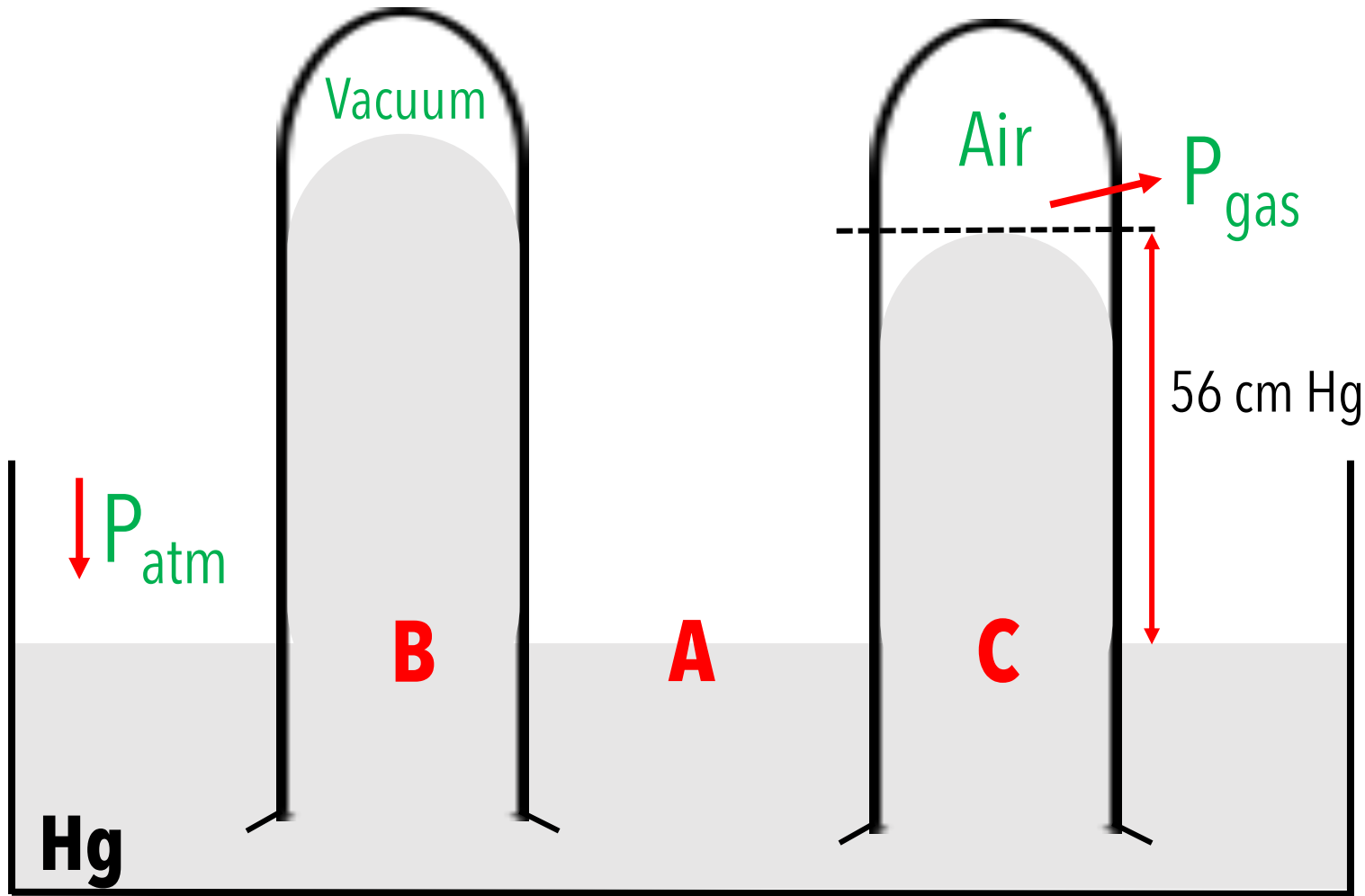
$$P_C = P_{\text{atm}} = 76 \text{ cm Hg}$$

$$P_D = P_{\text{atm}} + 20 = 96 \text{ cm Hg}$$

BAROMETER

to measure
ATMOSPHERIC PRESSURE

$$P_{\text{atm}} = 76 \text{ cm Hg}$$



$$P = \rho gh$$

finding pressure of Gas

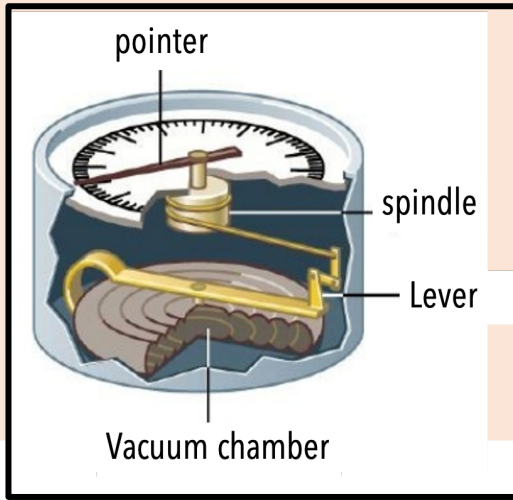
$$P_{\text{atm}} = P_{\text{Hg}} + P_{\text{Gas}}$$

$$76 = 56 + P_{\text{Gas}}$$

$$P_{\text{gas}} = 20 \text{ cm Hg}$$

$$P_A = P_B = P_C = P_{\text{atm}}$$

ANEROID BAROMETER

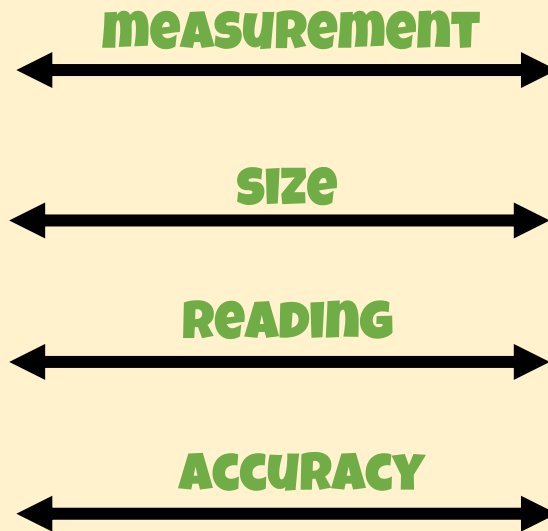


Does NOT contain any **liquid**

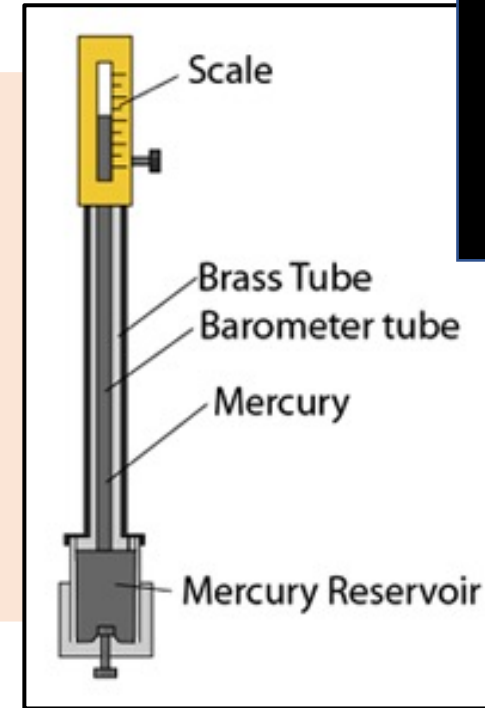
- P_{atm} is determined by the **changes in the volume of the partial-vacuum metal box**
- **Smaller** size and **portable**
- Gives a **direct reading** for atmospheric pressure (NO adjustment required)
- **Lower** accuracy, up to $\pm 1 \text{ mm Hg}$

to measure
Atmospheric pressure

$$\begin{aligned} P_{\text{atm}} &= 1.0 \times 10^5 \text{ Pa} \\ &= 76 \text{ cm Hg} \\ &= 10.3 \text{ m water} \\ &= 1 \text{ Bar} \\ &= 1 \text{ atm} \end{aligned}$$



FORTIN BAROMETER

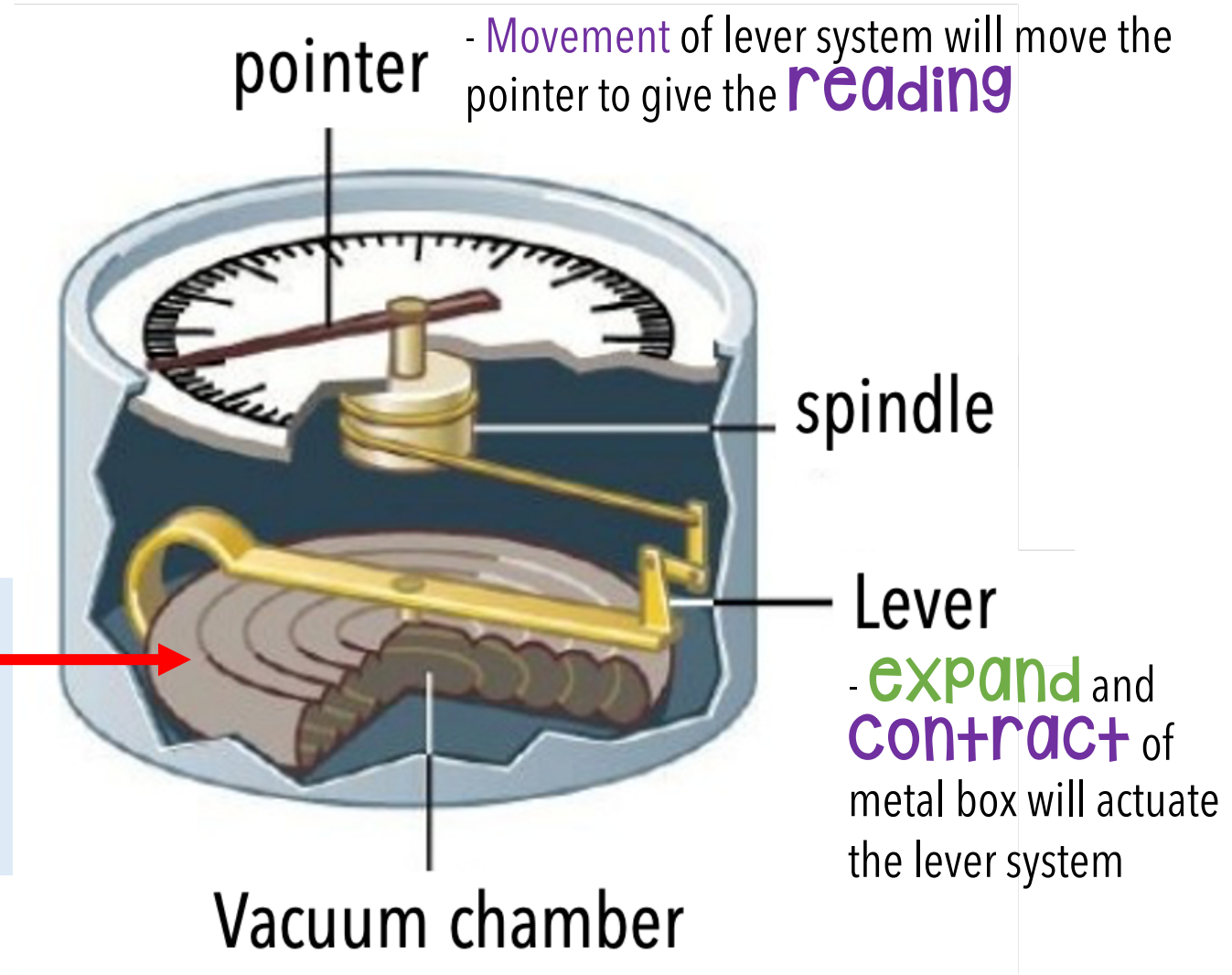


- P_{atm} is determined by the **changes in the height of the mercury column**
- **Larger** size and **not** portable
- Takes a **longer time** to give a **reading** for atmospheric pressure
- **Higher** accuracy, up to $\pm 0.1 \text{ mm Hg}$

ANEROID BAROMETER

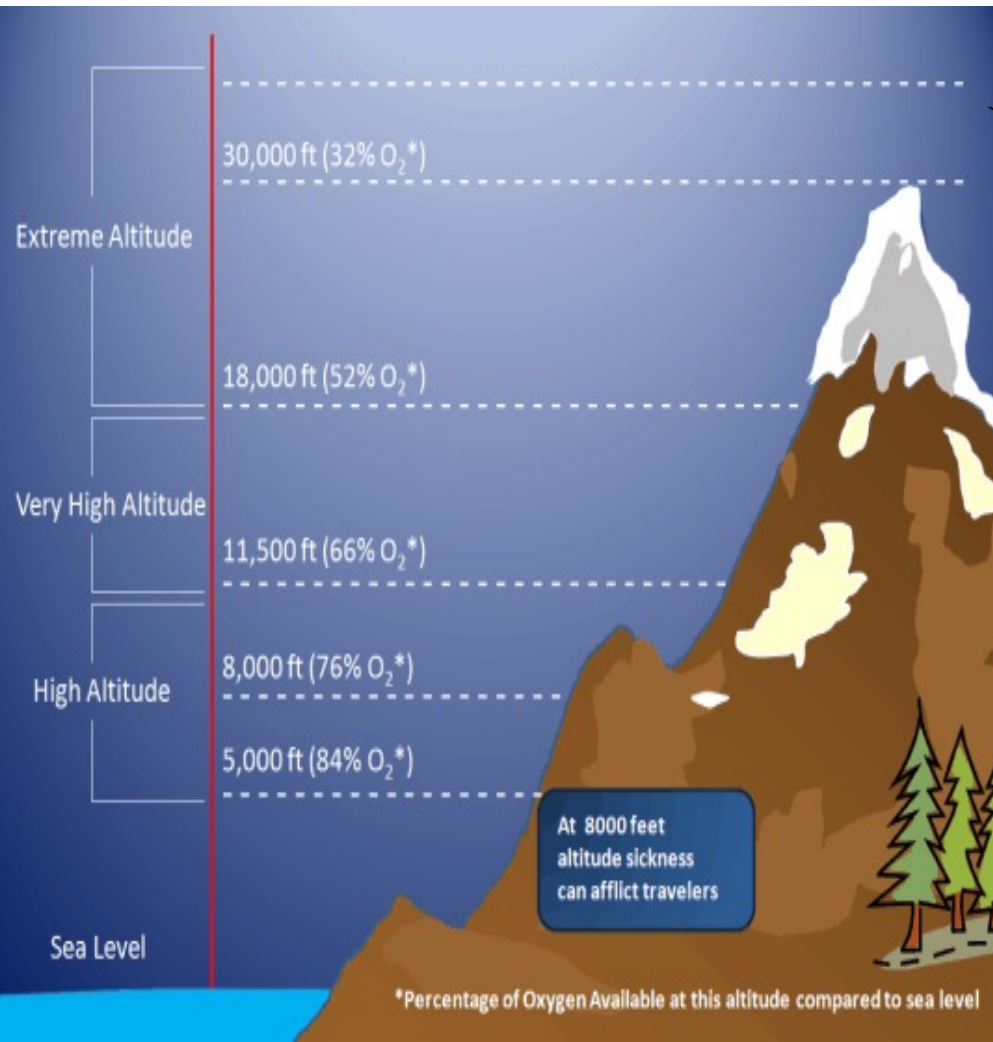
METAL BOX

- **expand** when P_{atm} is **low**
- **contract** when P_{atm} is **high**



HIGHER ALTITUDE

Thin of air causes the atmospheric pressure to become lower



altitude **increase**, P_{atm} **decrease**

EFFECTS OF ATMOSPHERIC PRESSURE

- Increase in the rate of breathing
- Lower absorption of oxygen in the lungs
- Increase in the metabolic rate
- Loss of appetite
- Dehydration
- Inability to think clearly

ACTIONS TO BE TAKEN

- Prepare and train before climbing
- Prepare equipment such as smartwatch that can measure altitude, blood pressure and body temperature
- Climb at a slow rate to allow the body to adjust to the changes in pressure
- Drink water even when not thirsty to prevent dehydration

- Increase the pressure in the aircraft cabin to match the sea level pressure
- Recycle the air in the cabin so that it is fresh and contains adequate oxygen level
- Remind the passengers to drink enough water to prevent dehydration during long distance flights

Depth **increase**, P_{atm} **increase**

EFFECTS OF ATMOSPHERIC PRESSURE

- Body tissues absorb excess nitrogen gas
- Nitrogen gas dissolves into the blood
- Inability to think clearly
- Formation of nitrogen bubbles in the tissues or blood vessels if pressure is reduced too rapidly

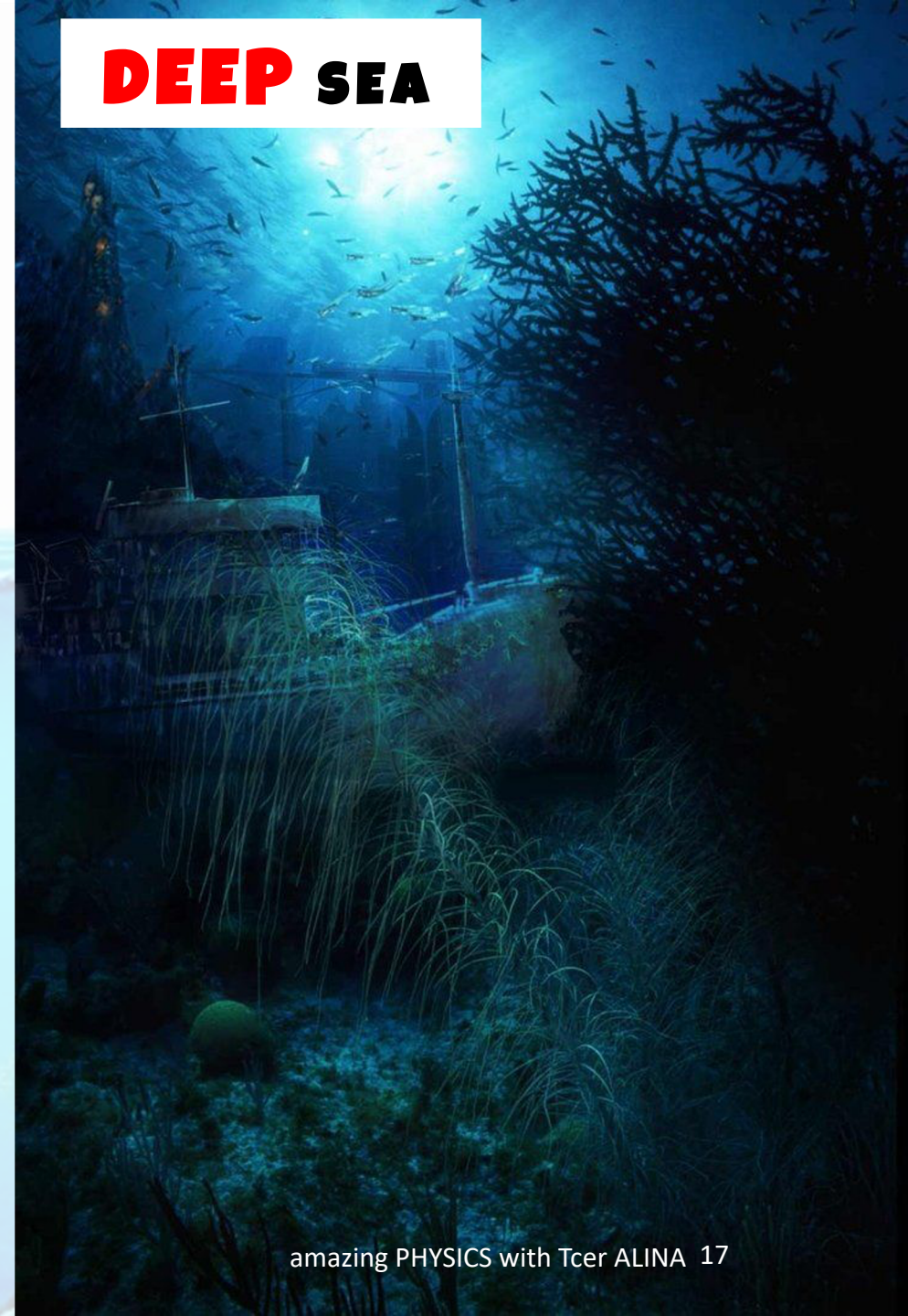
ACTIONS TO BE TAKEN

- Submarine is made of steel or titanium with a circular cross section to withstand the high pressure of surroundings
- Pressure in the cabin of the submarine is controlled to almost the same level as sea level for the comfort of the crew
- Oxygen tanks or electrolytic oxygen generators are provided so that the oxygen supply is adequate



- Do physical exercises to enable the body to adapt to a high pressure environment before diving
- Wear a diving suit to slow down heat loss from the body
- Slowly ascend to sea level so that nitrogen bubbles do not form in the tissues and blood vessels

DEEP SEA



SKILL 1 - UNDERSTANDING



Diagram 5 shows a dropper in a bottle.

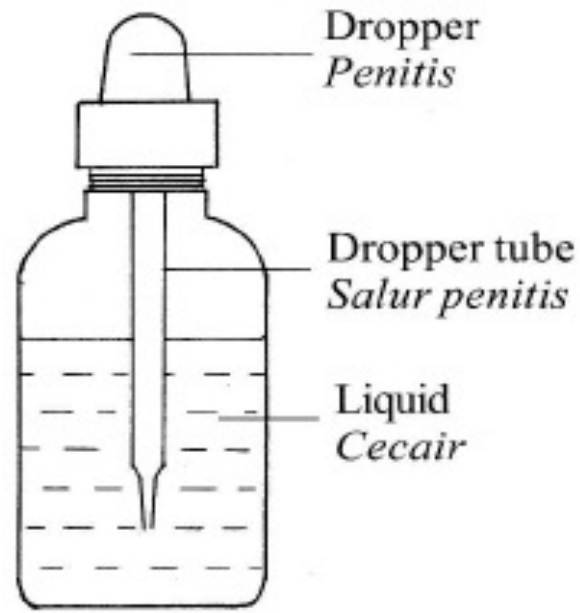
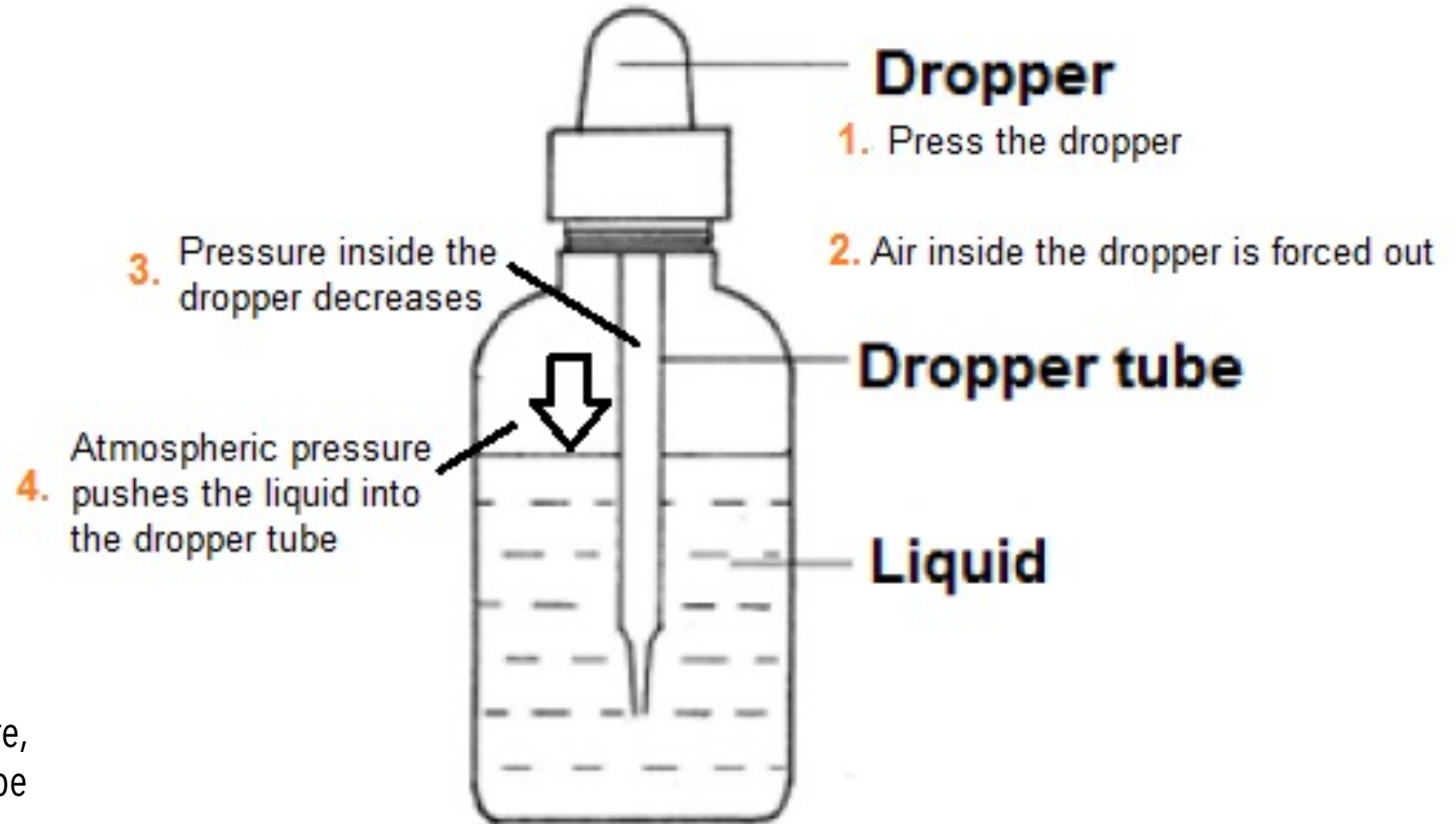


Diagram 5

Using the knowledge of atmospheric pressure, explain how the liquid in the bottle can be sucked into the dropper tube.



SKILL 2 - CALCULATION

Diagram 2 shows a U-tube connected to a cylinder of gas.

- (i) Calculate the value of **d** in unit of cm Hg if height of Y is 6 cm and height of X is 14 cm.

$$d = 14 - 6 = 8 \text{ cm}$$

- (ii) Calculate the total gas pressure in the unit of cm Hg
[Atmospheric pressure = 76 cm Hg]

$$P_g > P_{\text{atm}}$$

$$P_g = P_{\text{atm}} + h$$

$$P_g = 76 + 8$$

$$P_g = 84 \text{ cm Hg}$$

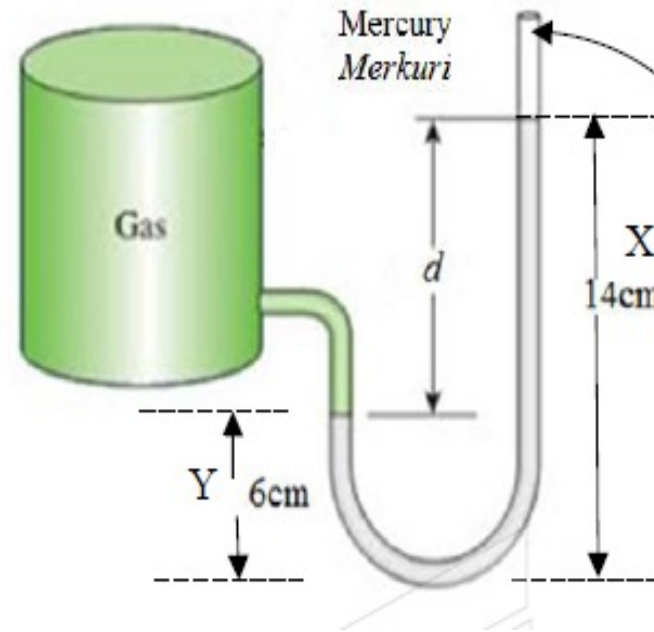


Diagram 2

- (iii) Calculate the total gas pressure in the unit of Pascal
[Density of mercury = $13.6 \times 10^3 \text{ kg m}^{-3}$]

$$P_g = 84 \text{ cm Hg}$$

$$P_g = (13.6 \times 10^3)(10)(0.84)$$

$$P_g = 1.14 \times 10^5 \text{ Pa}$$

$$P = \rho gh$$

Gas pressure instrument Z
Alat pengukur tekanan gas Z

IDEA!



SKILL 3 - COMPARISON

CHAPTER 3: FORCES & PRESSURE

Diagram 1.1 shows the positions P and Q at different altitude. Two identical simple barometers are placed at both positions. The height of the mercury column in the barometers are shown in Diagram 1.2.

Diagram 1.1

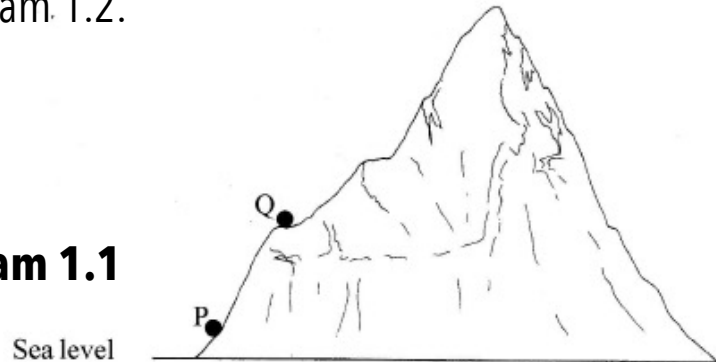
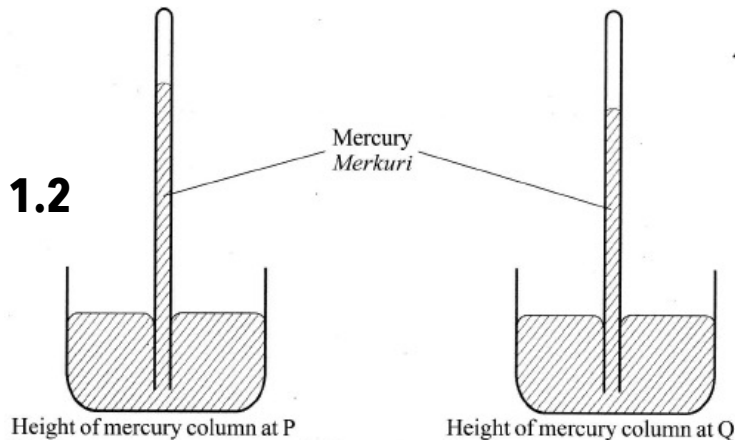


Diagram 1.2



The density of air at P is 1.2 kg m^{-3} and the density of air at Q is 1.0 kg m^{-3} .

Using Diagram 1.1 and Diagram 1.2, compare the altitudes of P and Q, the density of surrounding air and the height of mercury column in the simple barometer at positions P and Q.

Characteristics	P region	Q region
altitudes	low	high
density of surrounding air	high	low
height of mercury column	high	low

State the relationship between the altitude and

(i) the density of the air

Altitude **increase**, density of air **decrease**

(ii) the atmospheric pressure

Altitude **increase**
Atmospheric pressure **decrease**



SKILL 4 - MODIFICATION

CHAPTER 3: FORCES & PRESSURE



Diagram 2 shows a submarine.

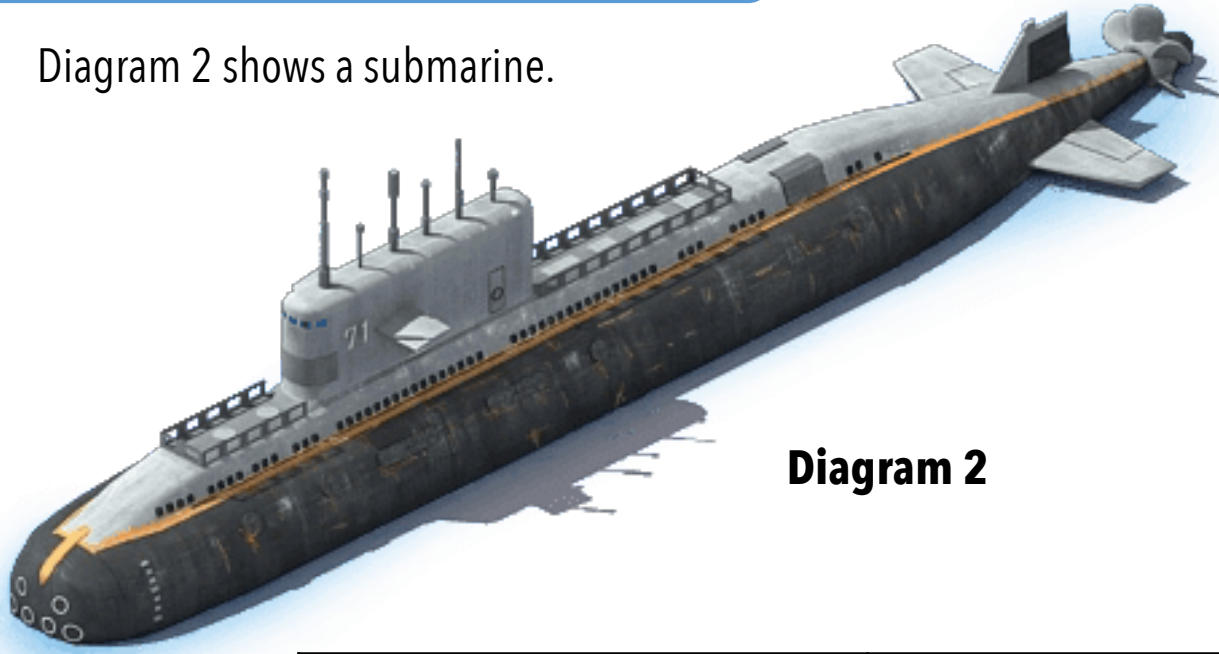


Diagram 2

Using the knowledge on light, pressures and forces, you are required to modify the submarine to enable it to reach a greater depth in the sea and to be able to observe the situation above the surface of water clearly.

In your explanation, include the following aspects:

- (i) The material of the submarine.
- (ii) The size/volume of the ballast tank.
- (iii) The power of the water pump in the ballast tank.
- (iv) The surface area of the submarine.
- (v) The type of periscope.

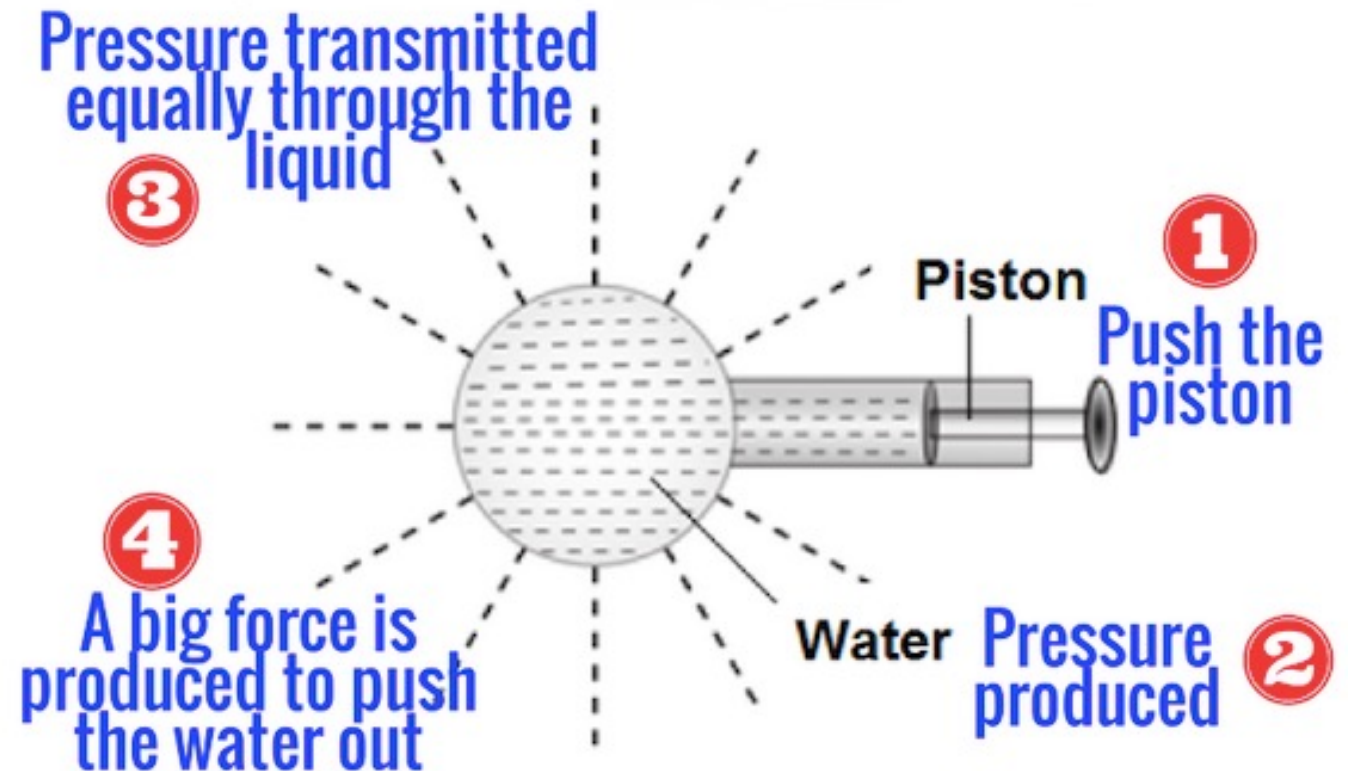
Characteristics	Reason
Thick and strong material	Withstand high pressure in deep sea
Large volume ballast tank	Can increase the weight and hence able to submerge deeper in the sea
High power water pump	Can pump in and out water in shorter time and so can sink and float quickly
Big surface area of submarine	To reduce the pressure acting toward the submarine
Use prism periscope	Produce clearer and brighter image

PASCAL'S PRINCIPLE

the **pressure** applied on an **enclosed** fluid is **transmitted uniformly** in all directions in the fluid

TRIAL PAHANG 2017

Explain how the spurts of water come out uniformly.

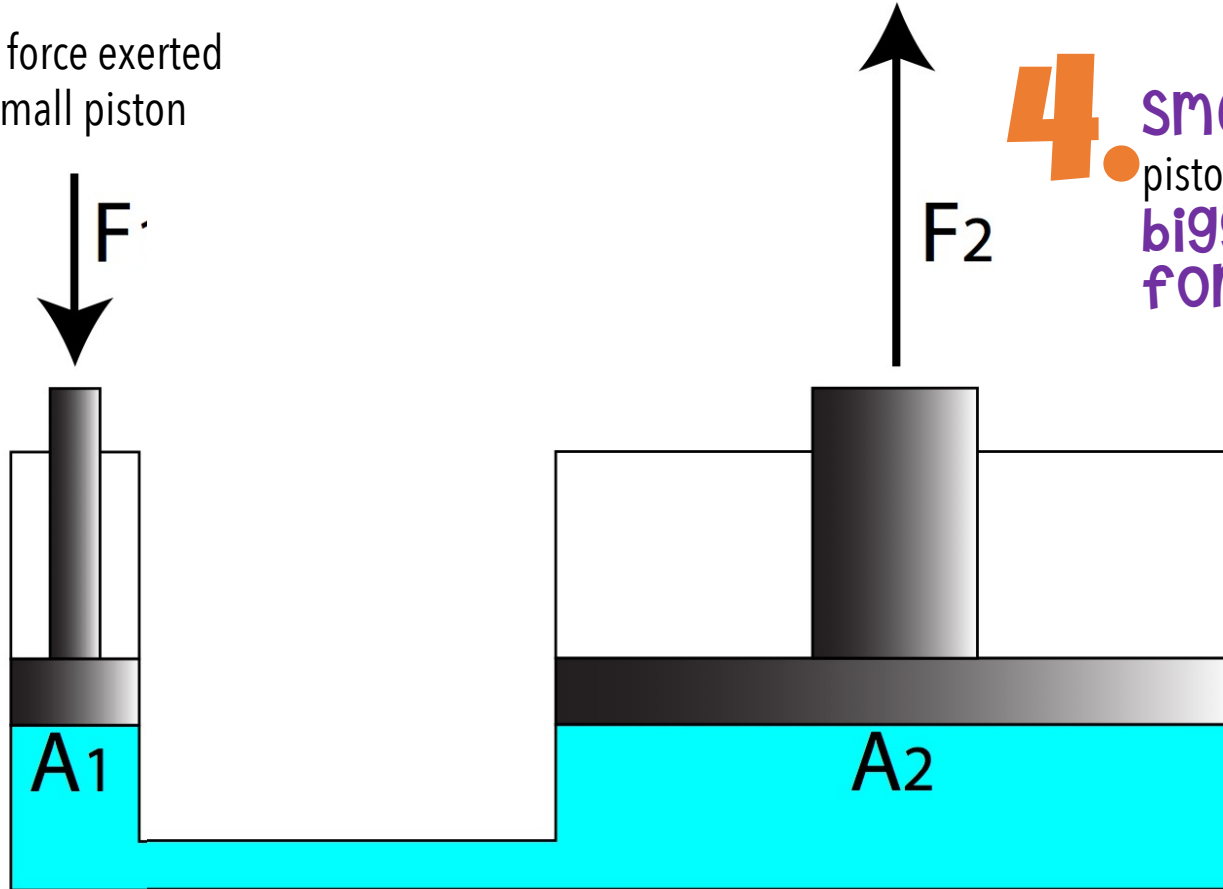


PASCAL'S PRINCIPLE

1. **small** force exerted on the small piston

2. **pressure** is produced

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



4. **small** force in small piston will produced a **bigger output force** at bigger piston

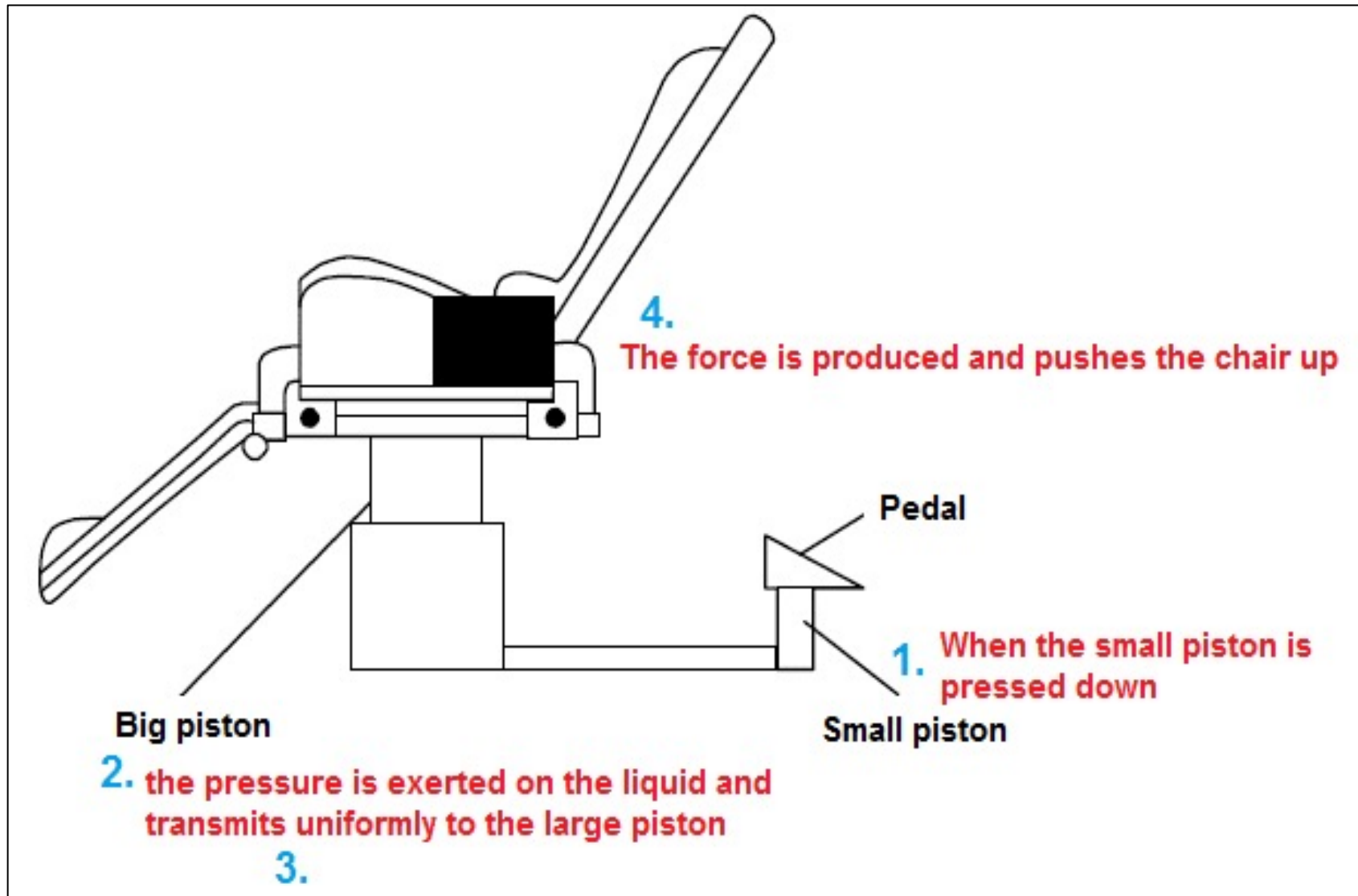
$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$

$$F_2 = \frac{F_1 A_2}{A_1}$$

3. **pressure** is transmitted in all direction equally

SKILL 1 - UNDERSTANDING

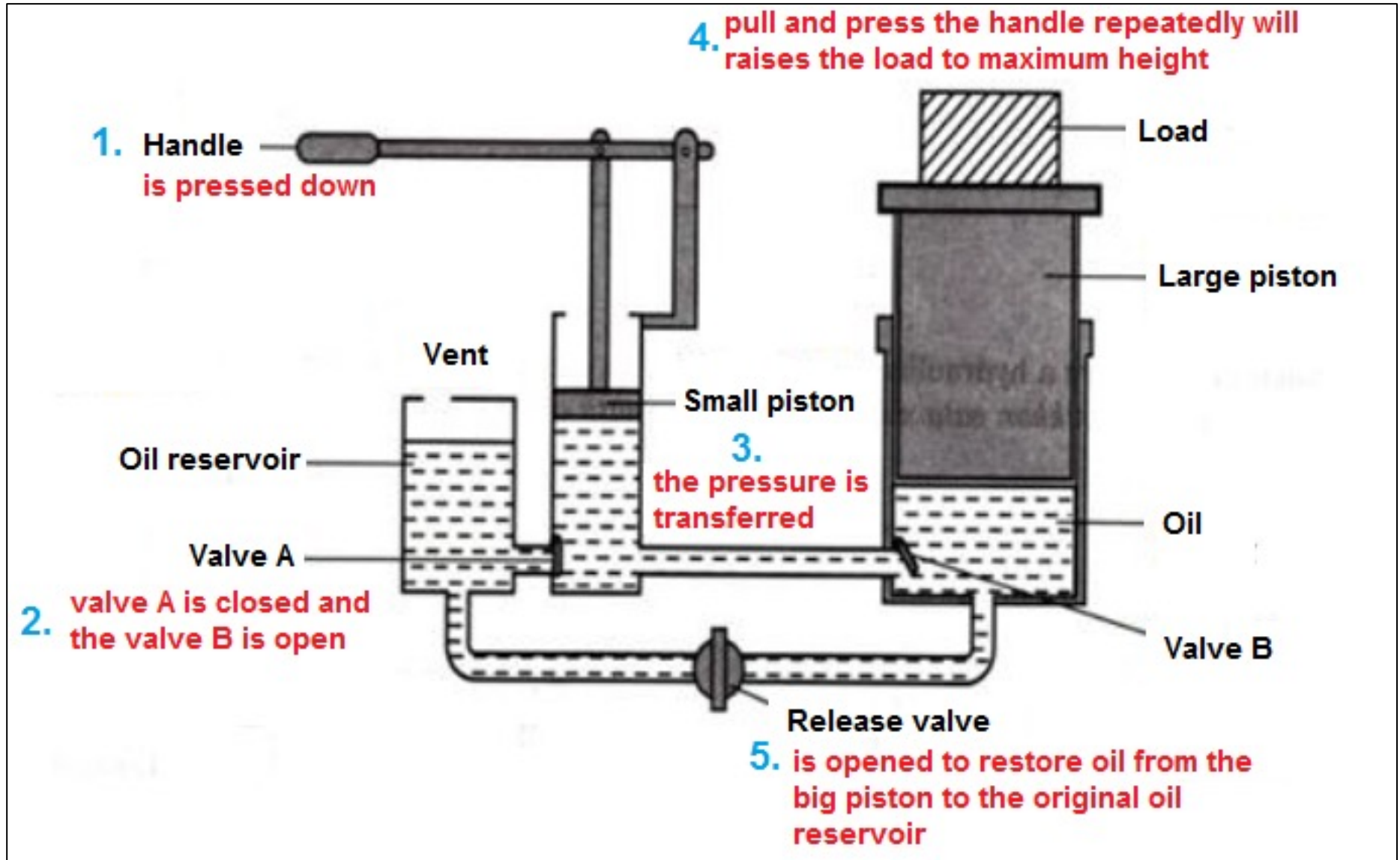
Explain how the chair can be lift up?



SKILL 1 - UNDERSTANDING



Explain how the handle is used to lift the load to its maximum height and state how the load is lowered without using the handle.



SKILL 2 - CALCULATION

In a hydraulic brake system, the cross-section area of the pistons in the master cylinder and the front wheel are 2 cm^2 and 6 cm^2 respectively. A force of 50 N is applied to the piston in the master cylinder. Calculate:

(i) the pressure transmitted throughout the brake fluid.

$$A_1 = 2 \text{ cm}^2 \quad F_1 = 50 \text{ N}$$
$$A_2 = 6 \text{ cm}^2$$

$$P = \frac{F_1}{A_1} = \frac{F_2}{A_2}$$

$$P = \frac{F_1}{A_1} = \frac{50}{2}$$

$$P = 25 \text{ N cm}^{-2}$$

PASCAL'S
PRINCIPLE

(ii) the force exerted on the piston of the front wheel.

$$25 = \frac{F_2}{6}$$

$$F_2 = 150 \text{ N}$$

IDEA!



SKILL 4 - MODIFICATION

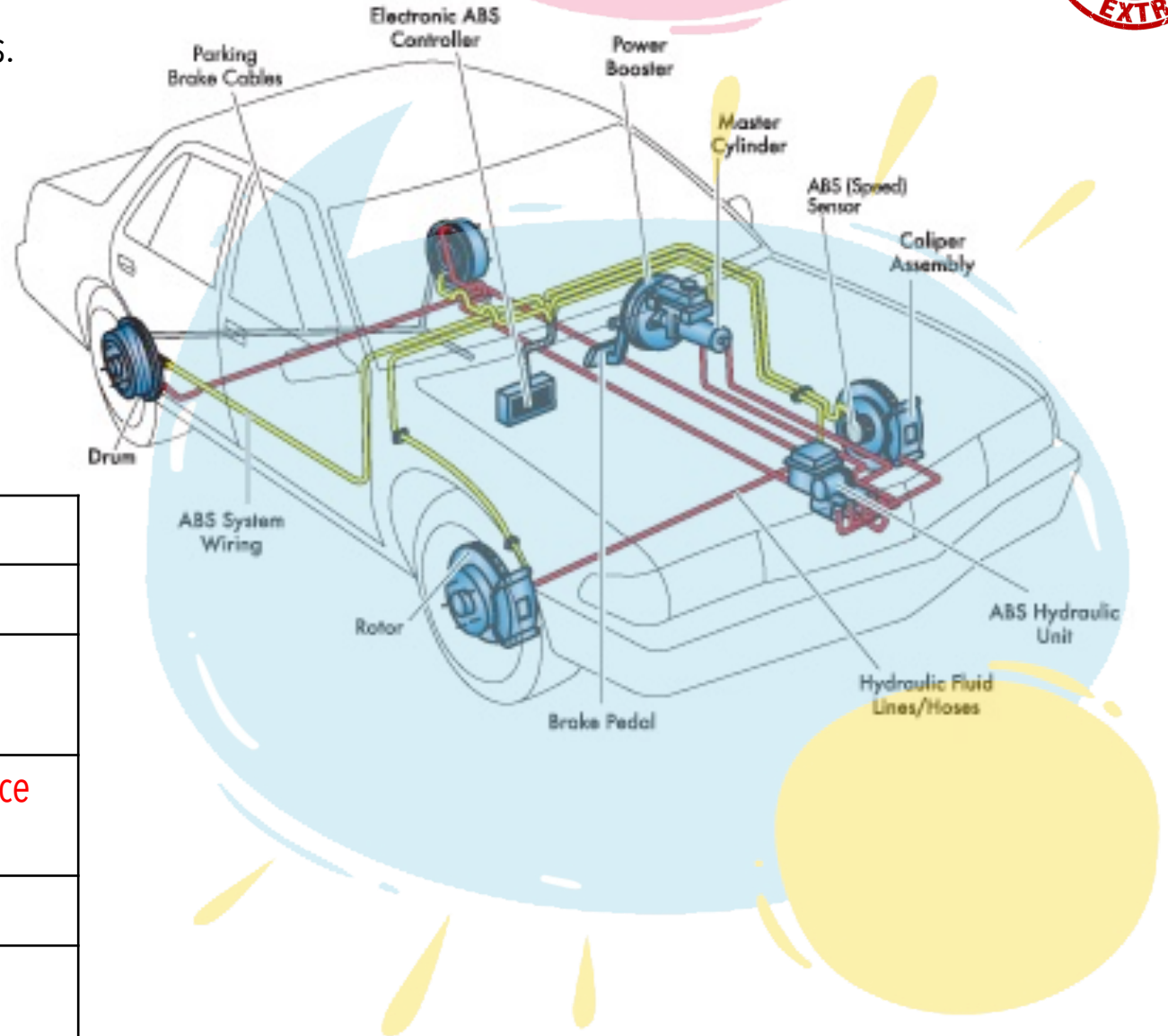
CHAPTER 3: FORCES & PRESSURE



A car needs an efficient hydraulic brake system for safety purposes.

Suggest and explain how to build a hydraulic brake system which can function effectively, based on the following aspect:

- (i) The type and characteristics of the brake fluid.
- (ii) The size of the master piston and slave piston.
- (iii) The material used for the fluid transmission pipe.



Characteristics	Reason
Type of brake fluid: oil	Incompressible
Characteristic of brake fluid : high boiling point	Not easily vaporized
Size of master piston: small	Small force is needed to produce high pressure
Size of slave piston: big	Produce bigger force
Material of transmission pipe: Strong // stainless steel	Not corrode // Not rust // last longer // not easily break

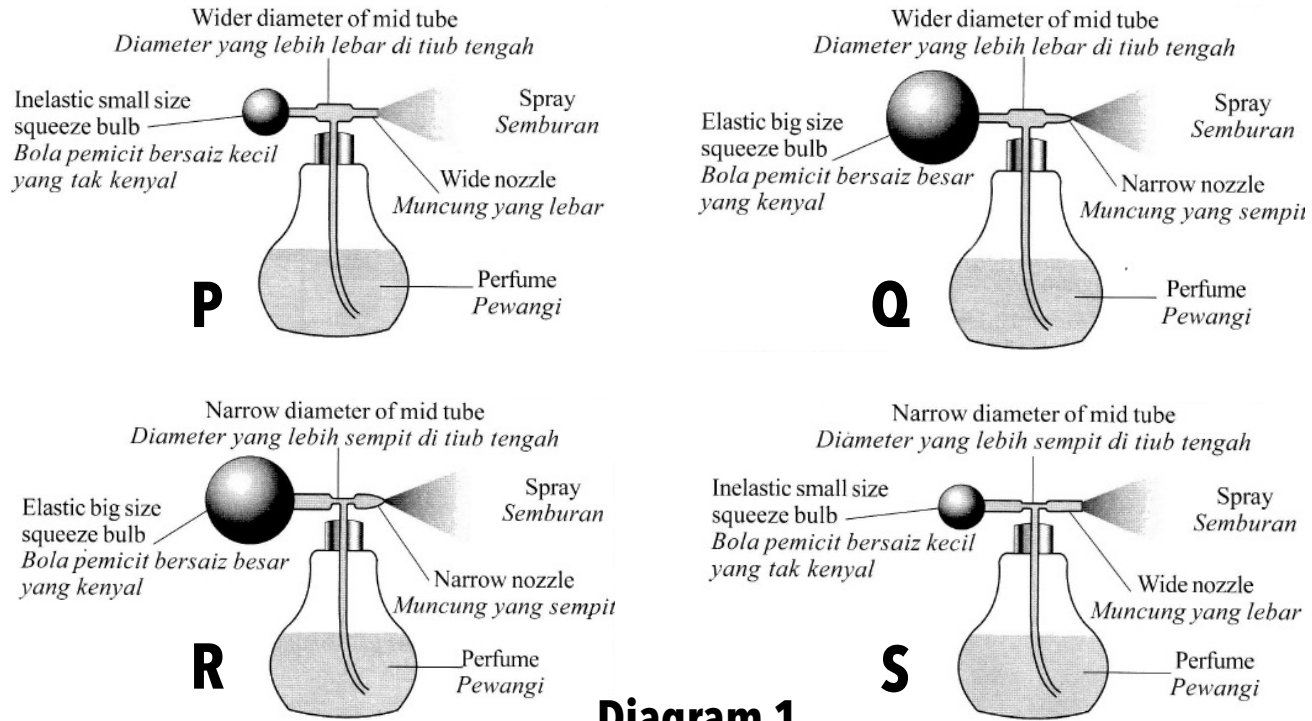


Diagram 1 shows four design of perfume sprays, P, Q, R and S with different specifications. You are required to determine the most suitable design of a perfume spray to produce a fine spray.

Study the specifications of the four perfume sprays based on the following aspects:

- (i) Size of the squeeze bulb.
- (ii) Elasticity of the squeeze bulb.
- (iii) Shape of the mid tube.
- (iv) Size of the nozzle.

Characteristics	Reason
Size of the squeeze bulb: big	To produce more air flow in the tube
Elastic	To allow the squeezed bulb return to its original shape after squeezing
Narrow shape (mid tube)	Produce low pressure, Air travel higher speed to create lower pressure
Size nozzle: narrow	Liquid carried out from the nozzle in a tiny droplets // large area
R	Big size of bulb Elastic Narrow shape Narrow nozzle



Diagram 2 shows a hydraulic brake system in a car.

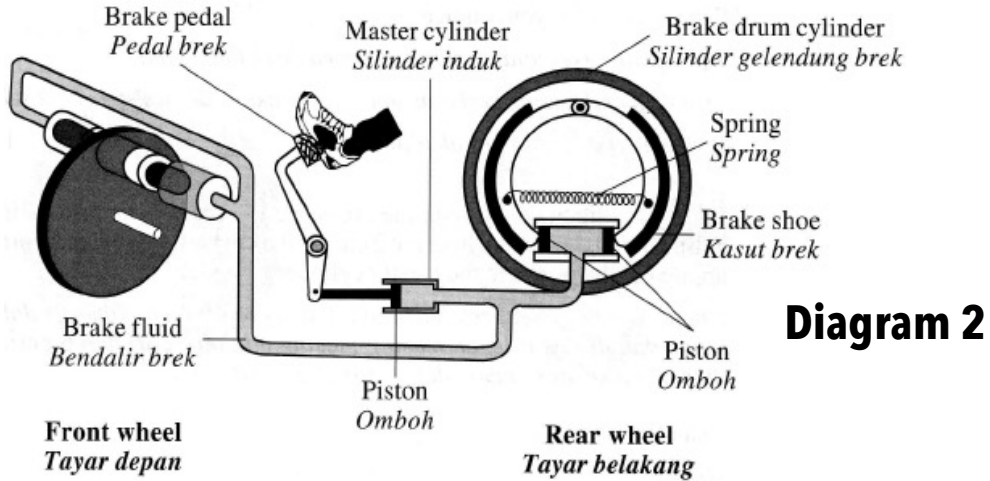


Diagram 2

You are required to investigate the characteristics of a hydraulic brake system as shown in Table 2.

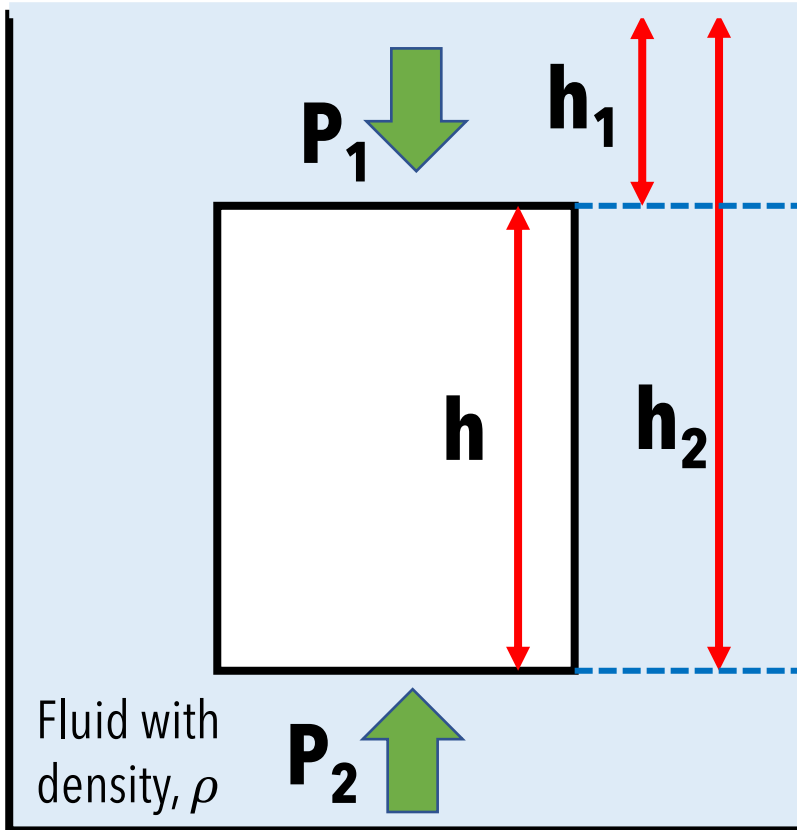
Hydraulic brake	Type of brake fluid	Boiling point of brake fluid	Spring constant of the spring	Ratio of cross-section area of piston in the master cylinder to the brake drum cylinder
J	Incompressible	Low	Low	1:1
K	Compressible	Low	High	5:1
L	Incompressible	High	High	1:5
M	Compressible	High	Low	3:2

Table 2

Characteristics	Reason
Incompressible	Pressure transmitted equally in all direction
High boiling point	Not easy to evaporate
High spring constant	Withstand greater force
Big ratio master to drum cylinder	Larger force exerted on the piston
L	Incompressible High boiling point High spring constant Big ratio master to drum cylinder

ARCHIMEDES' PRINCIPLE

Surface of fluid



Consider the density of the fluid is ρ .
The upper surface of the object is at a depth of h_1
The bottom surface of the object at a depth h_2 .

$$\begin{aligned} F &= PA \\ F_B &= (P_2 - P_1) A \\ &= (h_2 \rho g - h_1 \rho g) A \\ &= [(h_2 - h_1)(A)] \rho g \\ &= hA \rho g \Rightarrow \mathbf{V = hA} \\ &= V \rho g \end{aligned}$$

$$\mathbf{F_B = \rho V g}$$

Where :

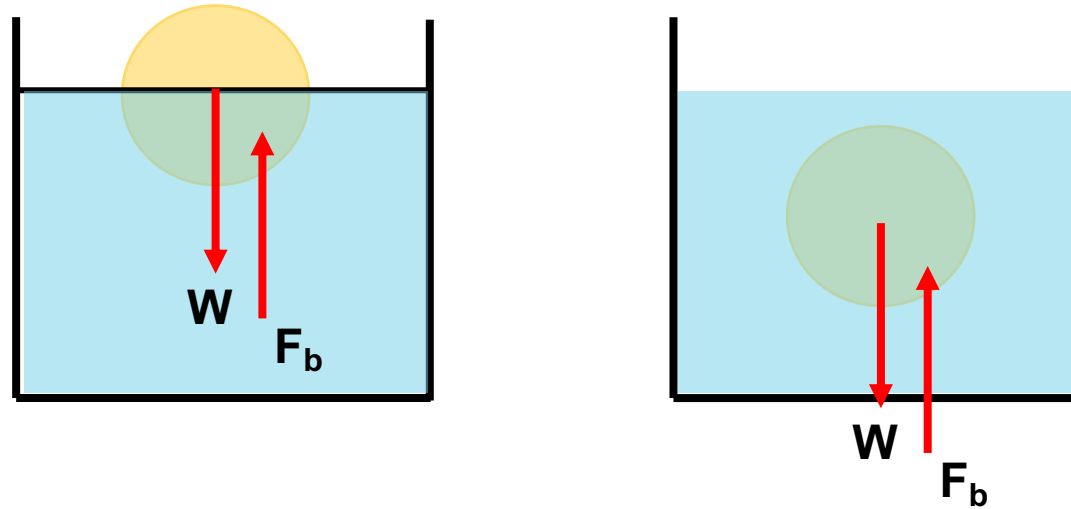
ρ = density of fluid

V = volume of fluid displaced (the volume of object in the submerged part only)

g = gravitational acceleration

ARCHIMEDES' PRINCIPLE

For a body **Wholly** or **Partially** immersed in a fluid, the buoyant force is equal to the weight of the fluid it displaces

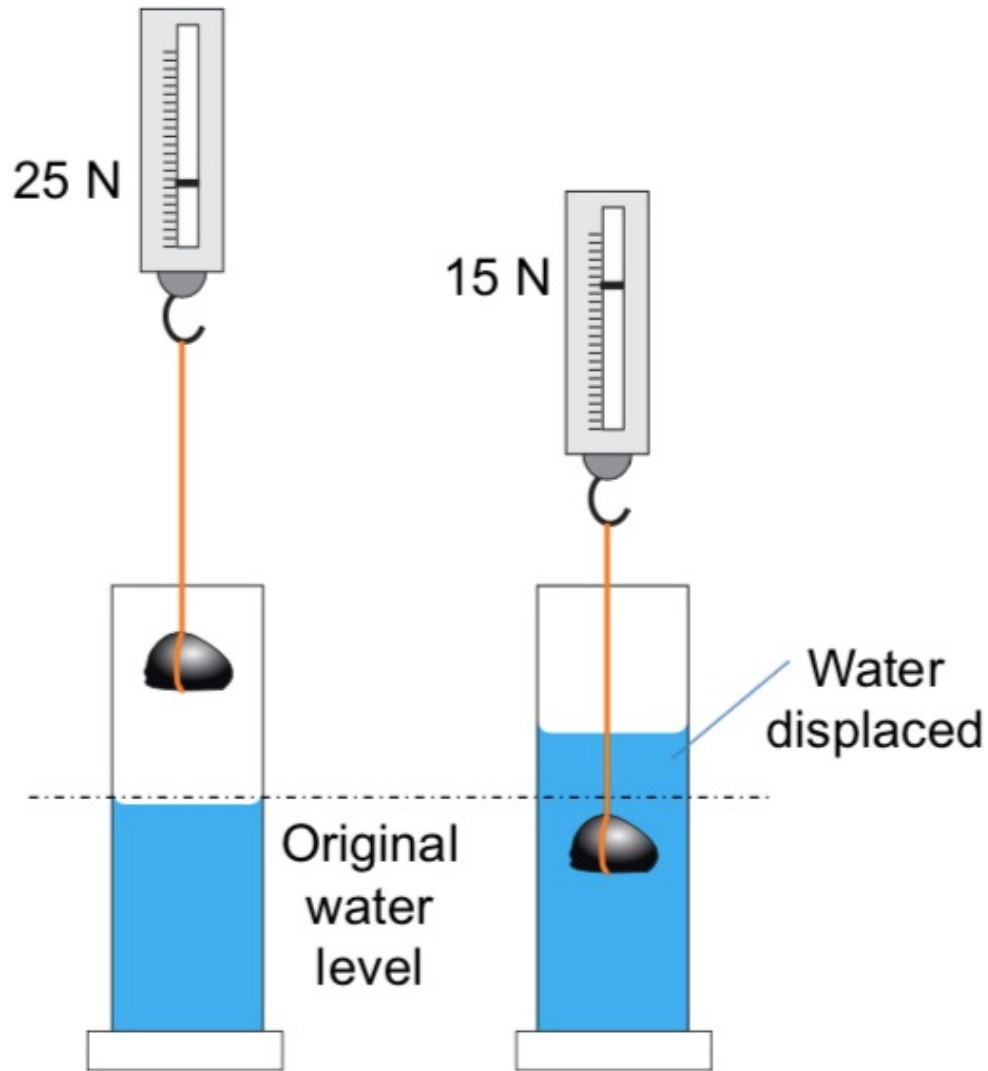


$$W = F_b$$

$$F_b = \rho V g = mg = W \text{ (weight of water displaced)}$$

ARCHIMEDES' PRINCIPLE

EXAMPLE:



Actual weight, $W_1 = 25 \text{ N}$

Apparent weight, $W_2 = 15 \text{ N}$

$$F_b = W_2 - W_1 = 10 \text{ N}$$

$$W = F_b$$

$$mg = F_b$$

Mass of object = 1 kg

SKILL 1 - UNDERSTANDING



Diagram 4 shows what happens when a wooden block is held above the water surface and then released into the water. When the wooden block is released, it falls into the water and goes completely under the water surface. Then it moves upwards and floats on the water surface.

Using the concept of buoyant force, explain why the **wooden block moves upwards** and then **floats** on the water surface.

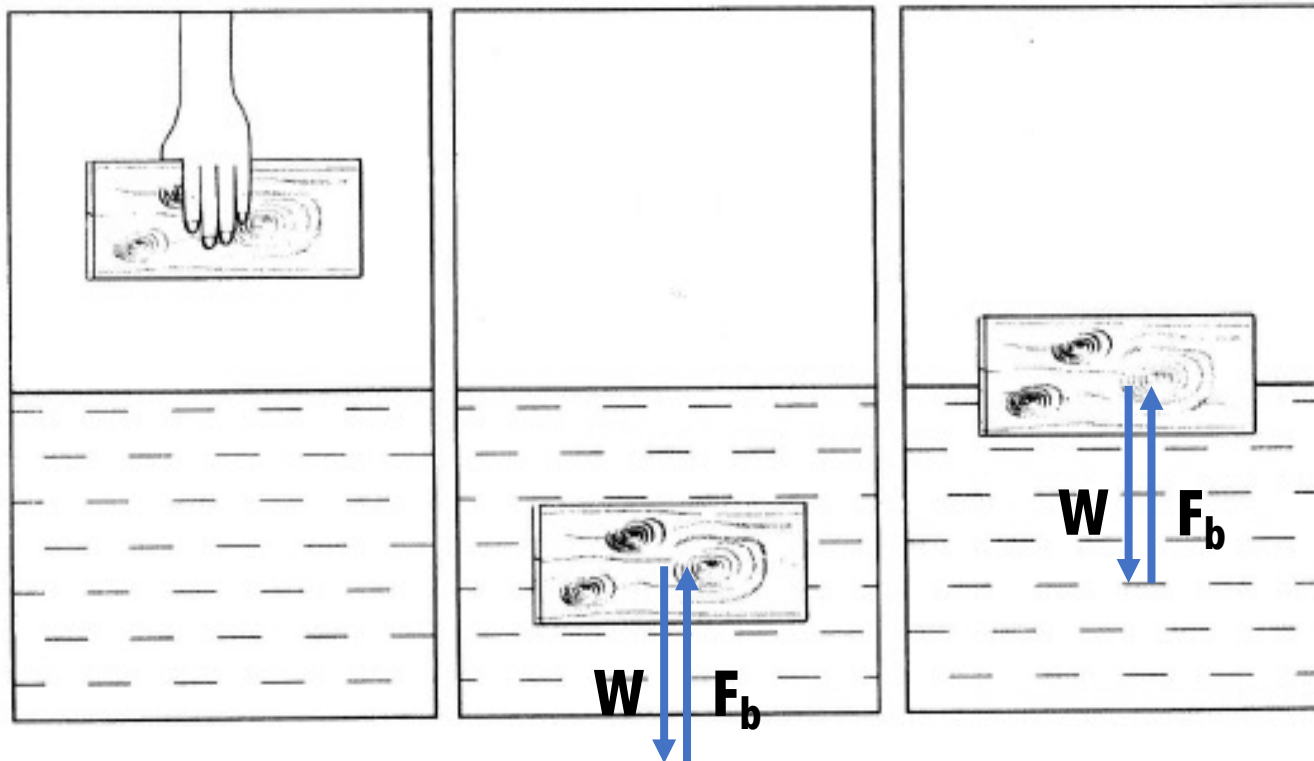


Diagram 4

Wooden block moves upwards because:

- Buoyant force $>$ weight of wooden block
- Net force acting upward

Wooden block floats because:
buoyant force = weight of block

SKILL 2 - CALCULATION

Diagram 1 shows a boy on a rubber raft which is placed on water surface.

The mass of the rubber raft is 30 kg.

The volume of water displaced is 0.05 m³.

[Density of water = 1000 kgm⁻³]

[Density of rubber raft = 600 kgm⁻³]

Calculate:

(i) buoyant force acted on rubber raft

$$F_b = \rho V g$$

$$F_b = (1000)(0.05)(10)$$

$$F_b = 500 \text{ N}$$



ARCHIMEDES'
PRINCIPLE

Diagram 1

(ii) the mass of the boy.

$$F_b = W_{\text{Raft}} + W_{\text{Boy}}$$

$$500 = 30 + W_{\text{Boy}}$$

$$W_{\text{boy}} = 500 - 30 = 470 \text{ N}$$

$$\text{Mass}_{\text{boy}} = 47 \text{ kg}$$

IDEA!



SKILL 3 - COMPARISON

CHAPTER 3: FORCES & PRESSURE

ARCHIMEDES' PRINCIPLE

Diagram 3 shows a boy and his father sitting on two identical beach balls, A and B, respectively. Their weights are balanced by the buoyant force.

- (a) Using Diagram 3, compare the **weight of the boy and his father**, the **volume of the water displaced** and the **buoyant force** acted on both of them.

Characteristics	Boy	Father
Weight	low	high
volume of the water displaced	low	high
buoyant force	low	high

- (b) State the relationship between the buoyant force and:

- (i) The volume of water displaced

Buoyant force **increase**
Volume of water displaced **increase**

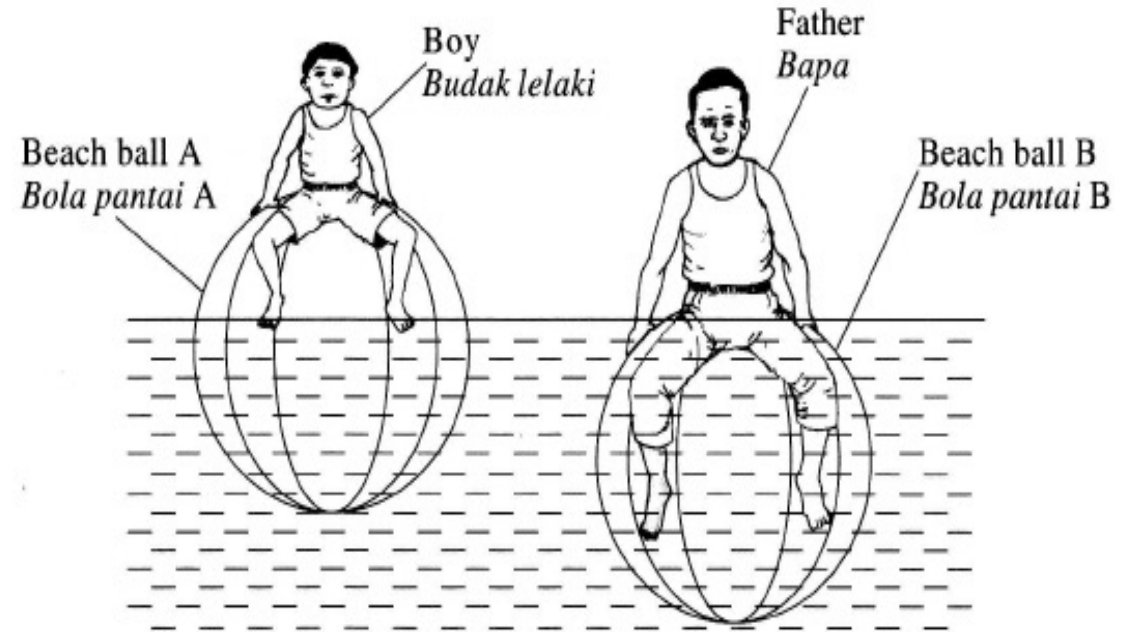


Diagram 3

- (ii) The weight of water displaced

Buoyant force **increase**
Weight of water displaced **increase**





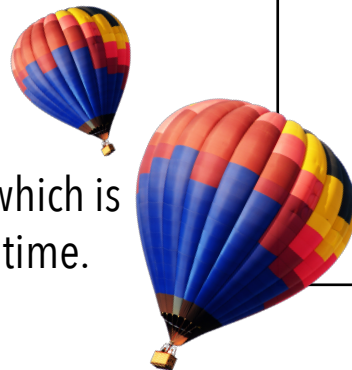
Table 3 shows four hot air balloons P, Q, R and S with different features.

Balloon	Volume of balloon	Number of burners	Type of fabric	Temperature of flame
P	Small with 800 m ³	1	Synthetic nylon	100°C
Q	Large with 2500 m ³	2	Synthetic nylon	120°C
R	Large with 2500 m ³	1	Canvas	60°C
S	Small with 800 m ³	2	Canvas	80°C

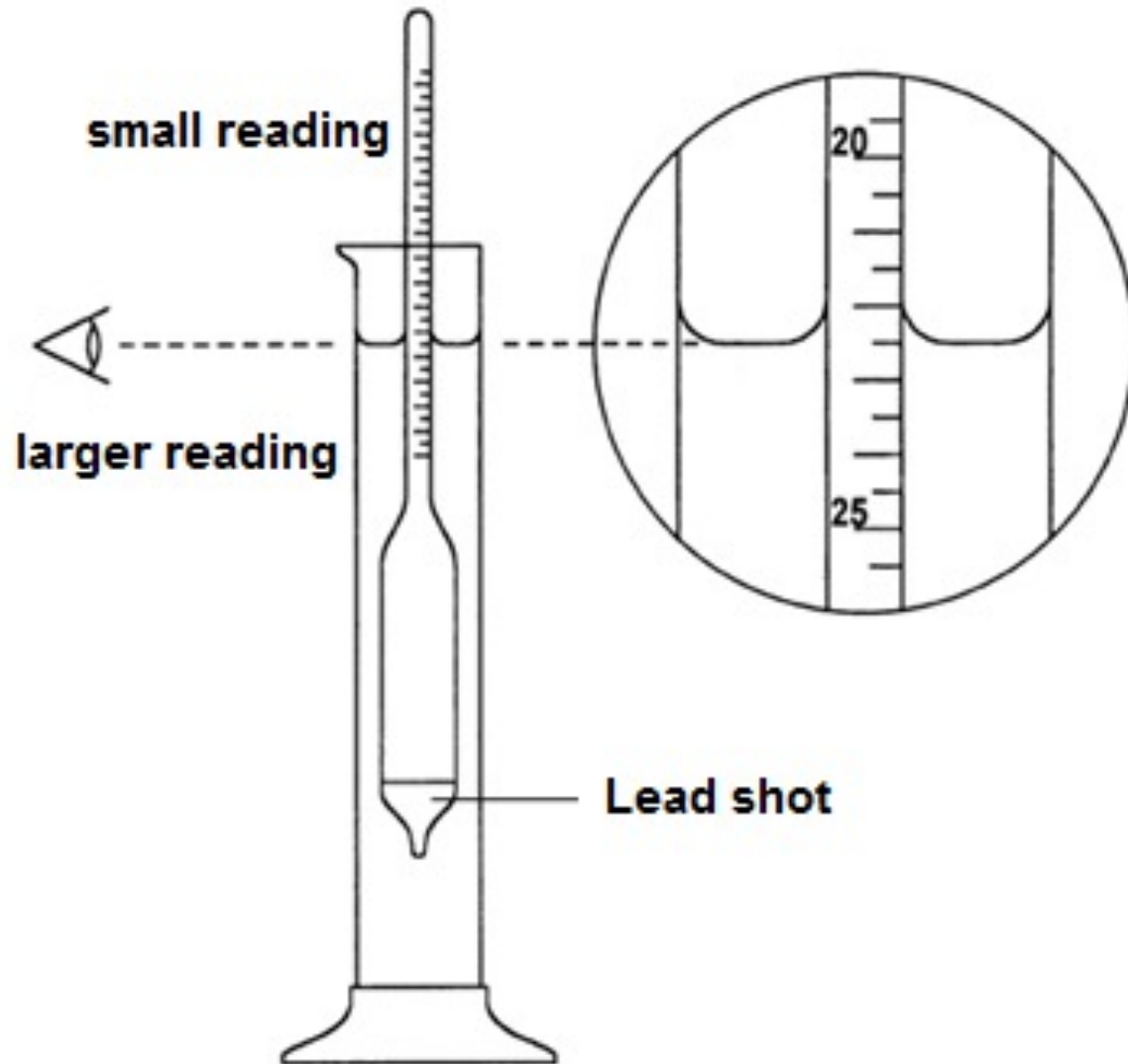
Table 3

You are required to determine the most suitable hot air balloon which is able to carry three or four people to a higher altitude in a shorter time.

Characteristics	Reason
Large volume	To produce bigger buoyant (up thrust) // Increase the volume of the air displaced
More number of Bunsen burner	To produce bigger flame // heat up the gas in the balloon faster
Synthetic nylon	Light-weight // strong // air-proof material
High temperature of the air in the balloon	Reduce the density // weight of the air in the balloon
Q	Large volume More number of Bunsen burner Synthetic nylon High temperature of the air in the balloon



HYDROMETER



- Used to measure relative density of liquids
- Lead shots = to weight it down // enable the hydrometer floats vertically in the liquid
- **lesser density** = larger volume of liquid displaced (hydrometer is **Submerged**)
- **higher density** = lower volume of liquid displaced (hydrometer **floats**)

HYDROMETER

Material of stem : **GLASS**
Will not corrode

Length of stem : **LONG**

Wide range of scale

Diameter of stem : **SMALL**

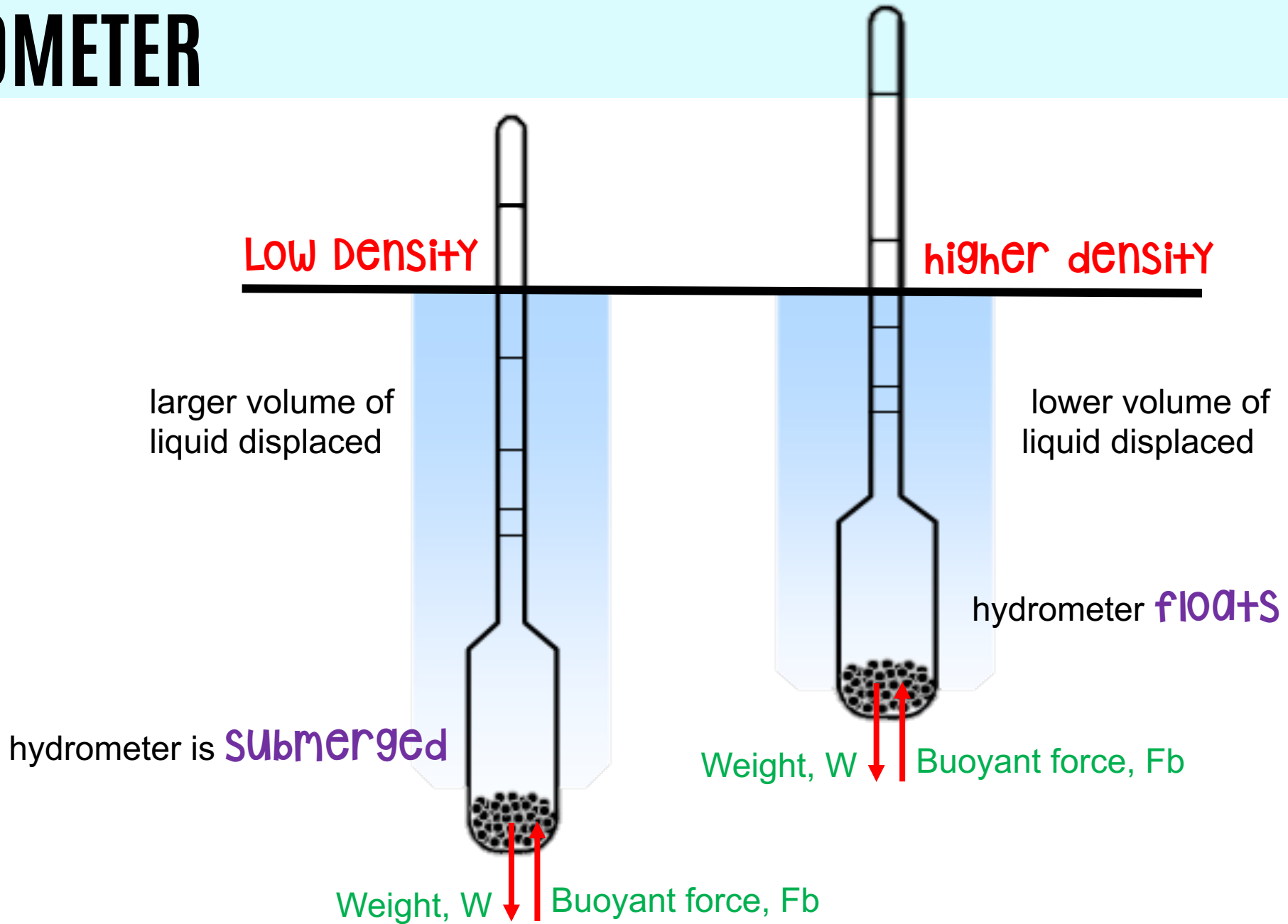
More sensitive / can measure @
detect small changed in density

Size of air bulb : **BIG**
easy to floats /
high buoyant force

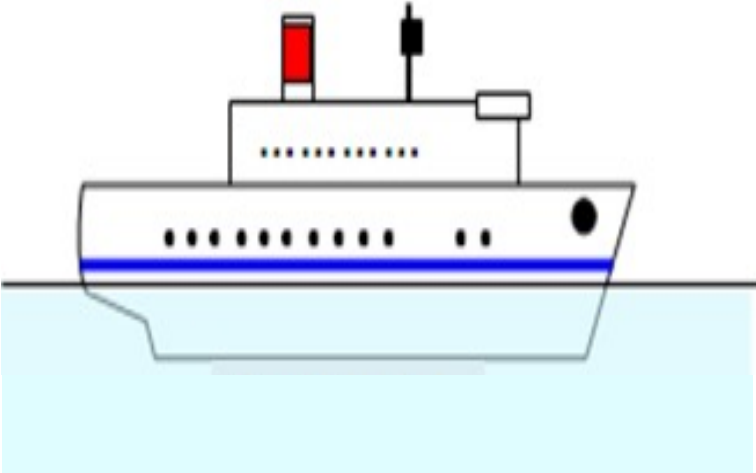
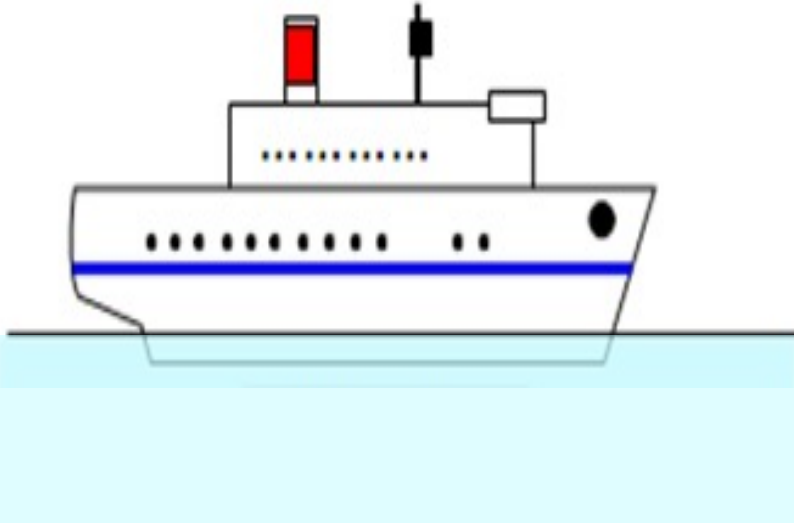
No. of lead shot : **MANY**
Stay upright /
easy to floats



HYDROMETER



SITUATION : COMPARISON

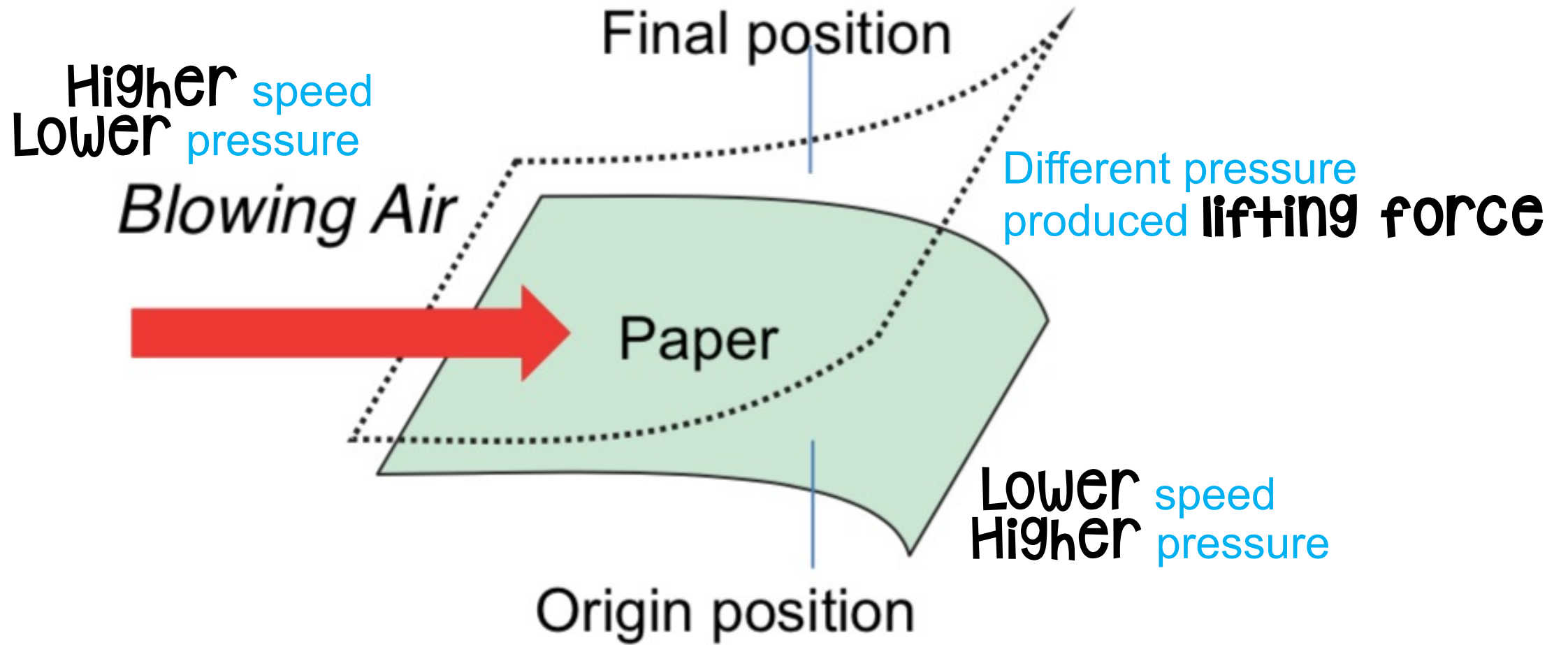
	RIVER WATER	SEA WATER
Density	LOW	HIGH
Volume of liquid displaced	HIGH	LOW
Depth of sinking	HIGH	LOW
		

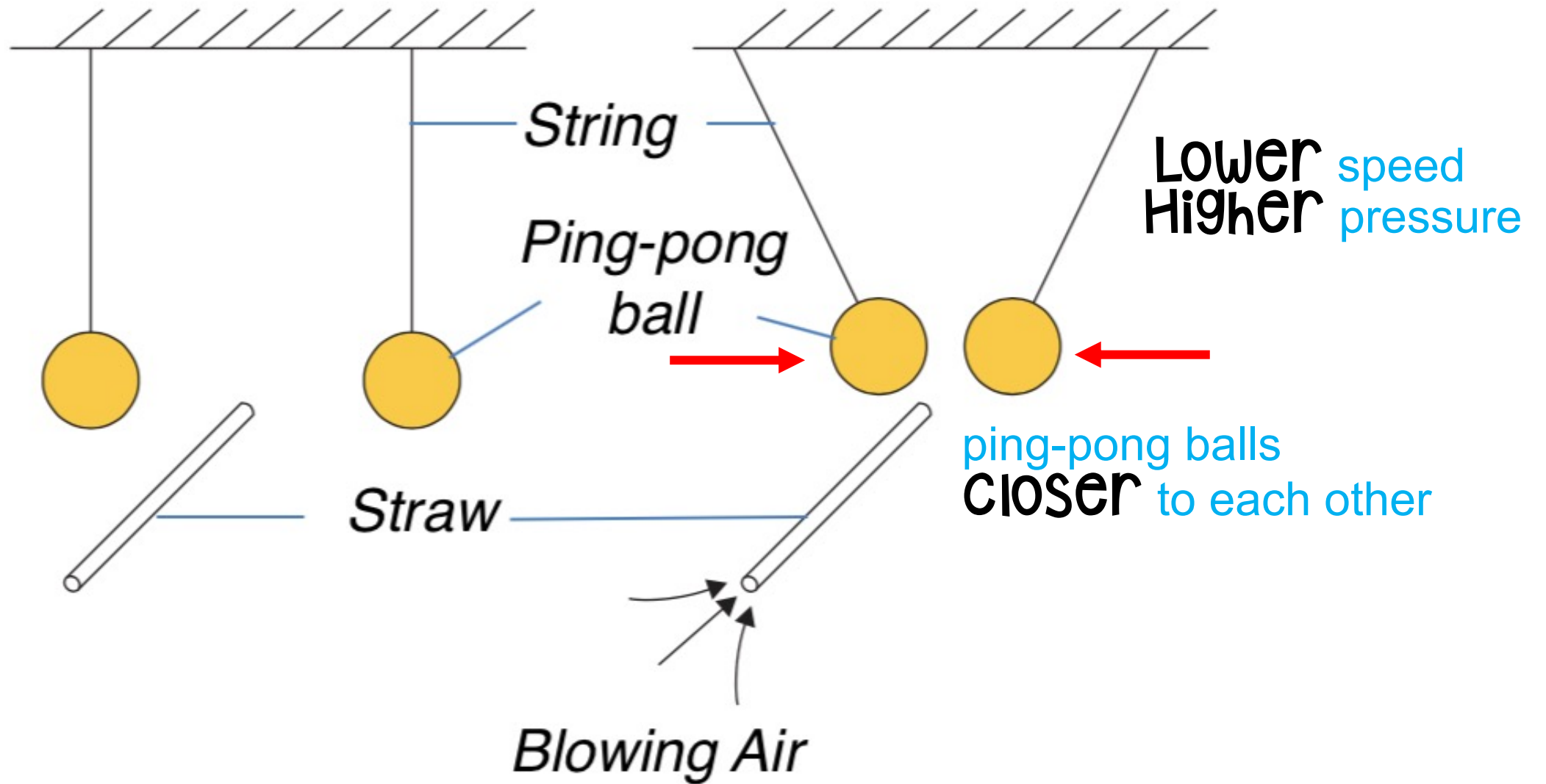
$$\text{Weight, } W = \text{Buoyant force, } F_b$$

BERNOULLI'S PRINCIPLE

In a moving fluid, where the speed is low, the pressure is high and where the speed is high, the pressure is low



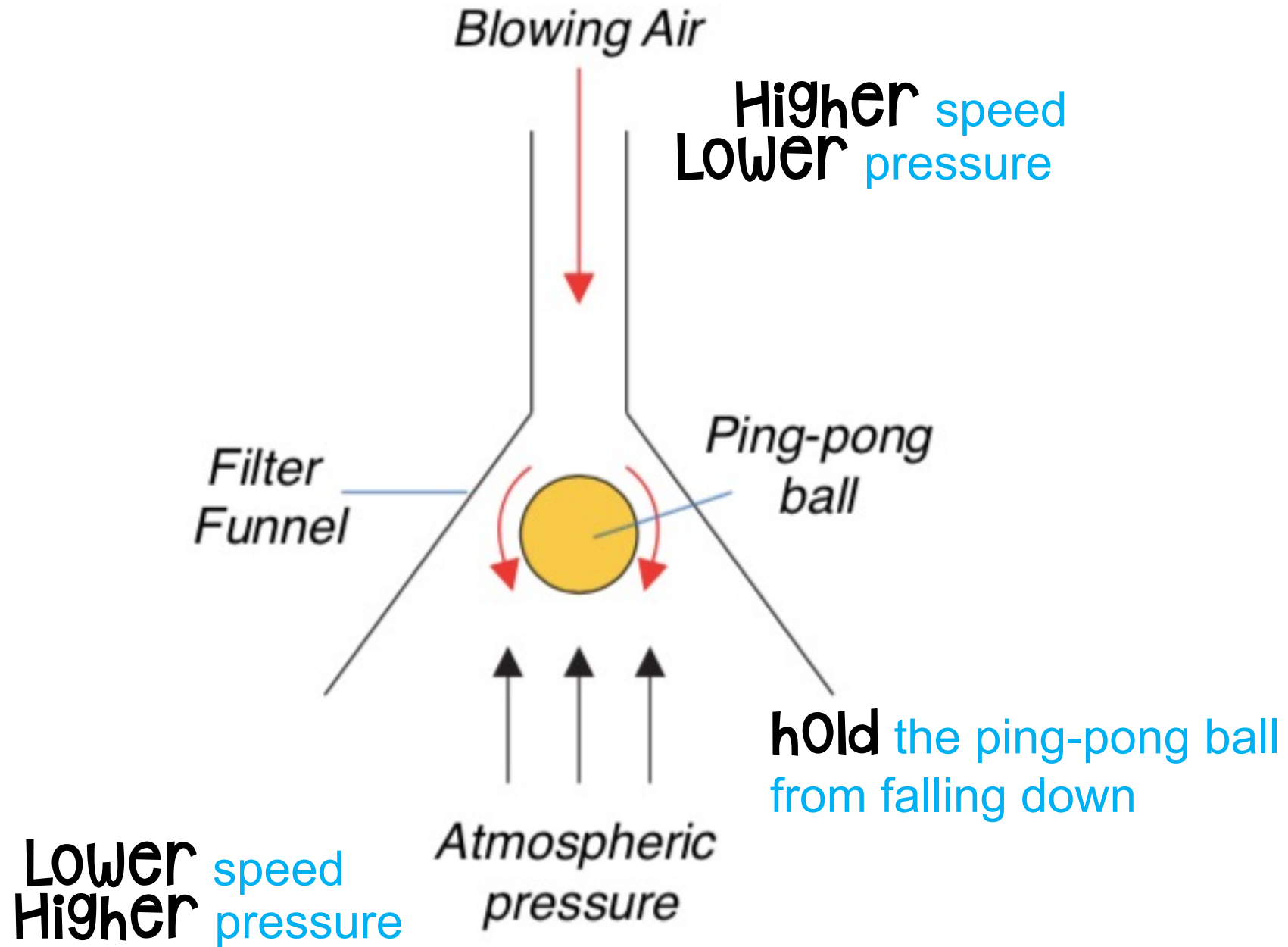




Higher speed
Lower pressure

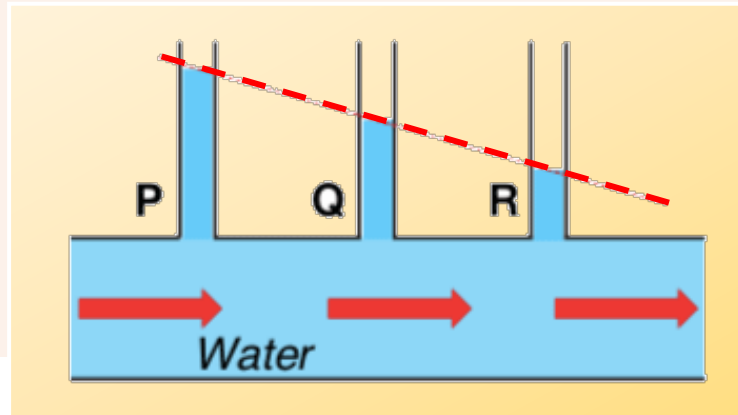
Lower speed
Higher pressure

ping-pong balls
CLOSER to each other

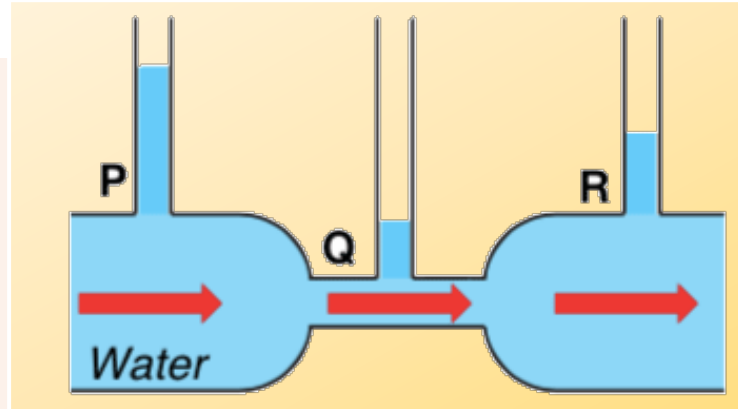


Water level in the vertical tubes P, Q and R

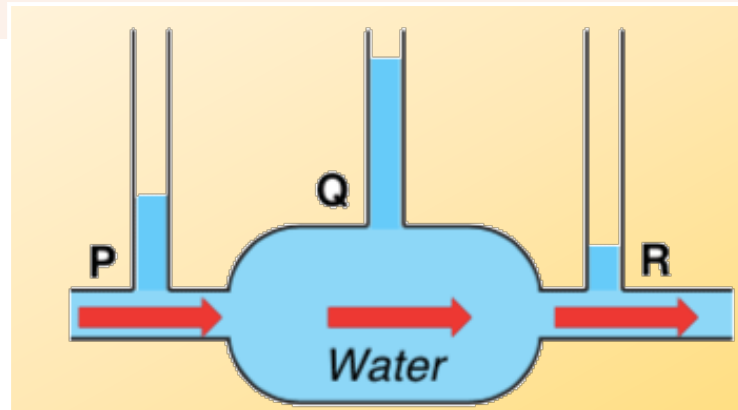
1



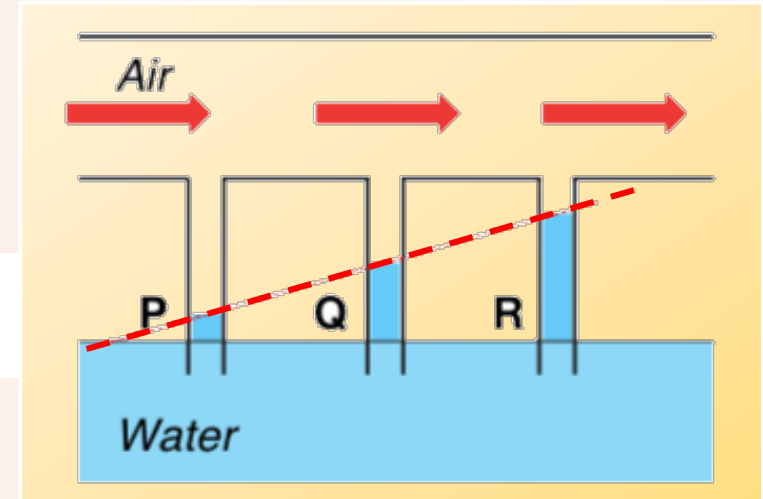
2



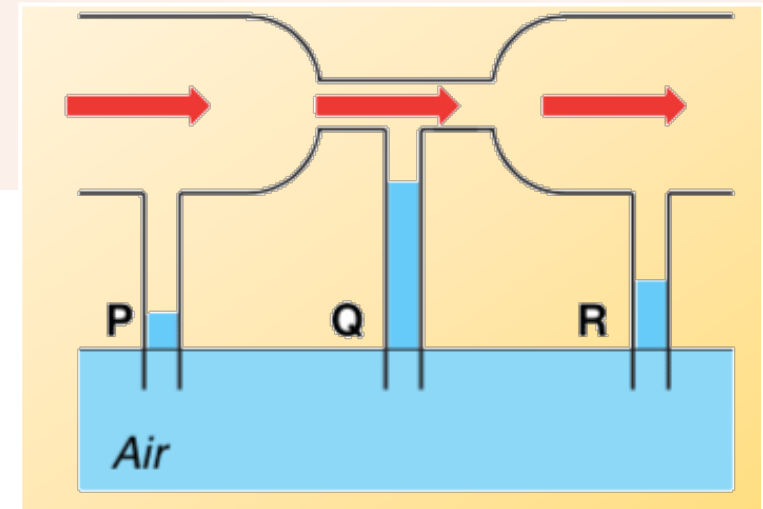
3



4



5



NOTES:

Pressure of moving fluid at point **R** (end) always less than pressure at point **P** (initial)

SKILL 1 - UNDERSTANDING



Diagram 3 shows the cross-section of a wing of a moving aeroplane. A lifting force is exerted on to the wing.

Name the shape of the cross section shown in Diagram 3.

Explain how the lifting force is produced.

Aerofoil.

1. The velocity of air is high and the air pressure is low at the top of the aerofoil.

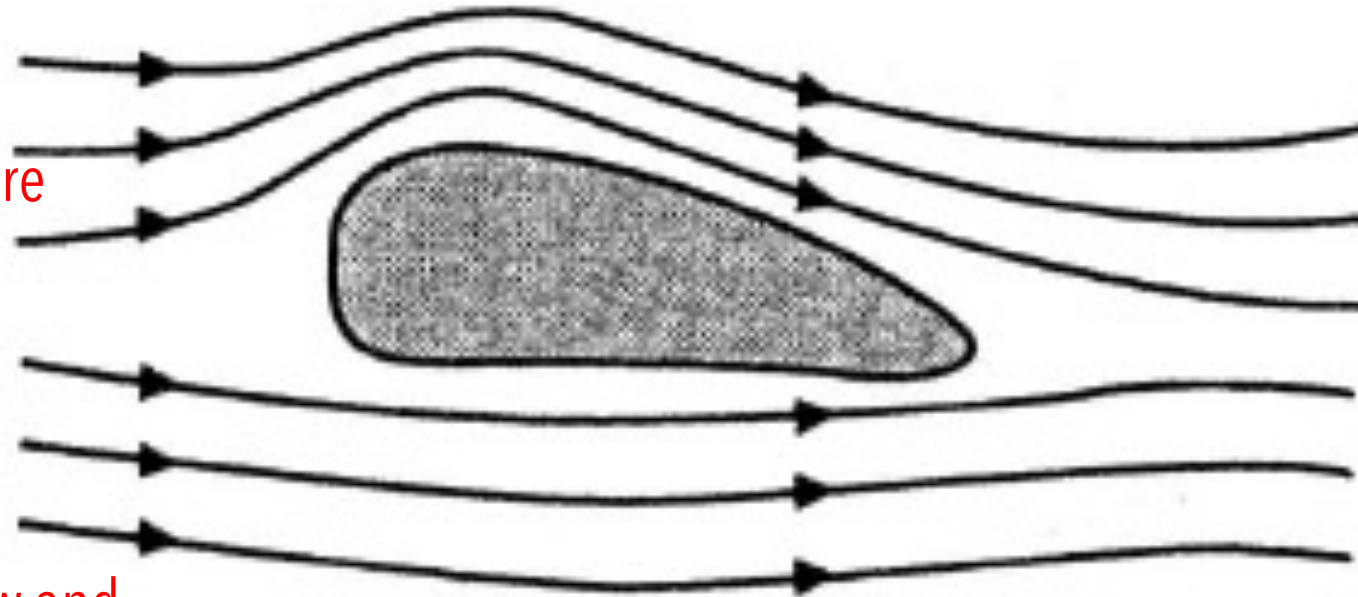


Diagram 3

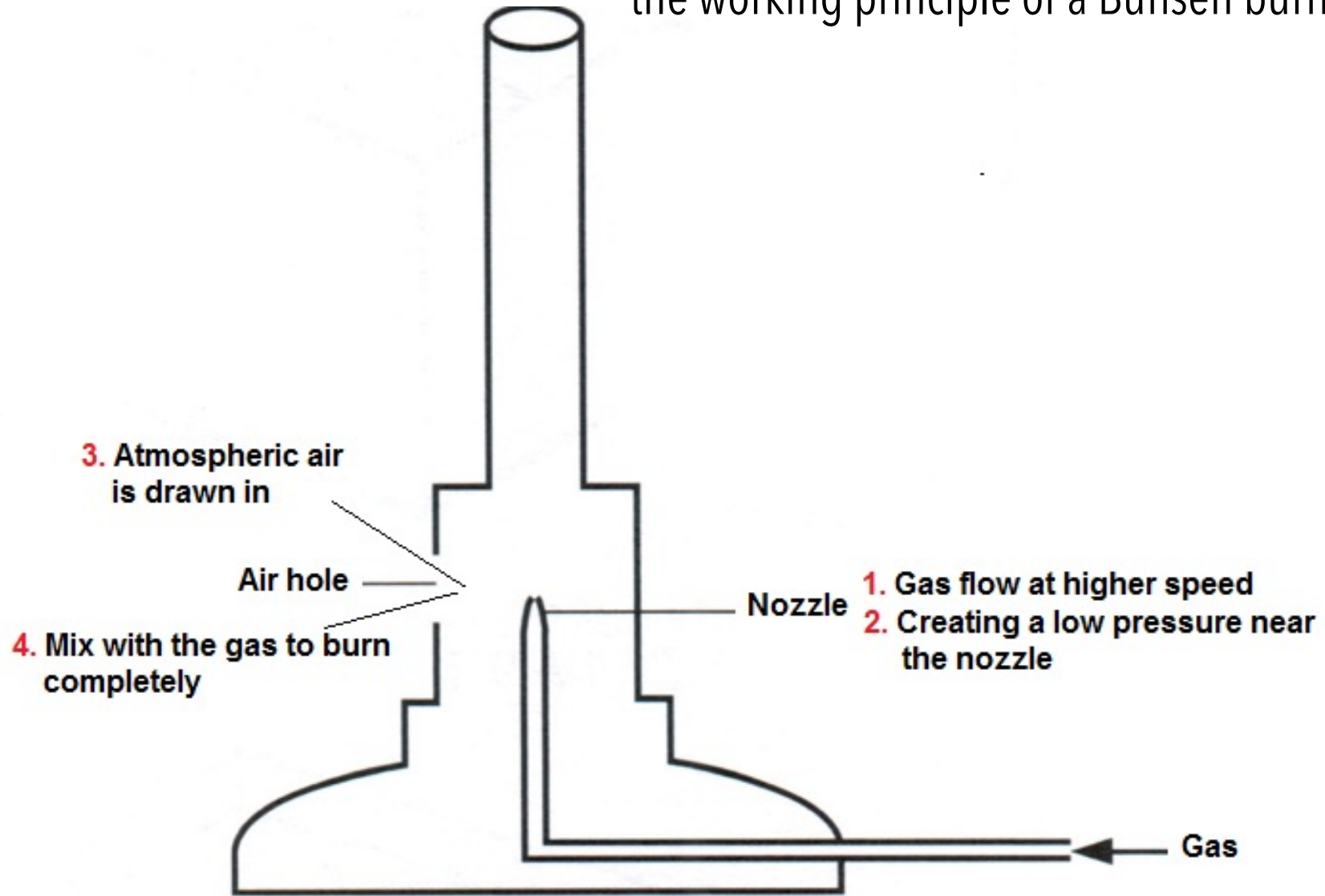
2. The velocity of air is low and the air pressure is high at the bottom of the aerofoil.

3. The difference in pressure produces a lifting force.

SKILL 1 - UNDERSTANDING



With the aid of suitable diagram, describe the working principle of a Bunsen burner.



SKILL 2 - CALCULATION

CHAPTER 3: FORCES & PRESSURE

An aeroplane with mass of 3.6×10^5 kg and total surface area of 460 m^2 is at a constant height. The resultant force acting on the aeroplane at that moment is zero.

(i) Calculate the weight of the aeroplane.

$$W = mg = (3.6 \times 10^5)(10)$$

$$W = 3.6 \times 10^6 \text{ N}$$

(ii) Determine the lifting force acting on the aeroplane.

Constant height

Lifting force = Weight of aeroplane

$$\text{Lifting force} = 3.6 \times 10^6 \text{ N}$$



(iii) calculate the pressure difference between the upper and lower surfaces of the wings of the aeroplane.

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

$$P = \frac{3.6 \times 10^6}{460}$$

$$P = 7826 \text{ Pa}$$

IDEA!



SKILL 3 - COMPARISON

CHAPTER 3: FORCES & PRESSURE



Diagram 2.1 and Diagram 2.2 show the effect of atmospheric pressure on a sheet of paper before and while the air is blown across the upper surface of the paper.

Using Diagram 2.1 and Diagram 2.2, compare the air speed on the upper and the lower sides of the paper. Relate the speed of air with its pressure to explain how the paper is lifted up when air is blown towards the top of the paper as shown in Diagram 2.2.

Diagram 2.1

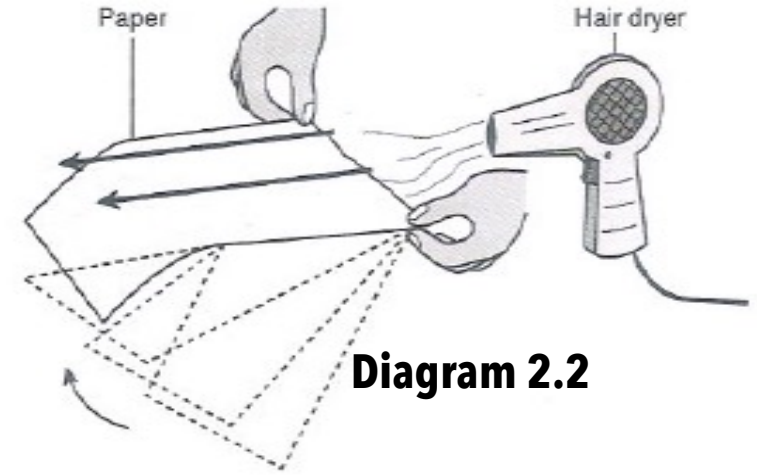
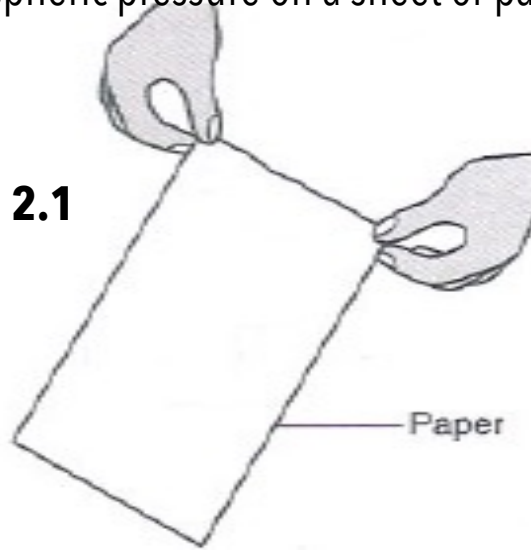


Diagram 2.2

The speed of air at top and bottom in Diagram 2.1 the **same**.

In Diagram 2.2, the speed of air at the **upper** is greater than **lower** side.

Speed of air **increase**, the pressure **decrease**.

The **difference in pressure** at the upper and the lower of the paper produce **lift force**

Name the physics principle involved in the above explanation.

BERNOULLI'S PRINCIPLE

