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MELAKA
29 DIS 2022

SPM PHYSICS 2022

'It's not about being the BEST.
'It's about being BETTER than you were yesterday.'

#amazing Physics
amazing Physics with Tcer Alina

Maklumat berikut mungkin berfaedah. Simbol-simbol mempunyai makna yang biasa.
The following information may be useful. The symbols have their usual meaning.

1. FORCE AND MOTION I

$a = \dfrac{v-u}{t}$

$s = \frac{1}{2}(u + v)t$

$s = ut + \dfrac{1}{2}at^2$

$v^2 = u^2 + 2as$

$Momentum = mv$

$F = ma$

$F = \dfrac{mv-mu}{t}$

$Ek = \frac{1}{2}mv^2$

$Ep = mgh$

2. GRAVITATION

$F = \dfrac{Gm_1m_2}{r^2}$

$g = \dfrac{GM}{r^2}$

$F = \dfrac{mv^2}{r}$

$a = \dfrac{v^2}{r}$

$v = \sqrt{\dfrac{GM}{r}}$

$v = \dfrac{2\pi r}{T}$

$U = -\dfrac{Gm_1m_2}{r}$

$v = \sqrt{\dfrac{2GM}{r}}$

$T^2 = \dfrac{4\pi^2r^3}{GM}$

$\dfrac{T_1^2}{T_2^2} = \dfrac{r_1^3}{r_2^3}$

$g = 9.81\ ms^{-2}$ @ N kg^{-1}

$G = 6.67 \times 10^{-11}\ N\ m^2\ kg^{-2}$

3. HEAT

$Q = mc\theta$

$Q = ml$

$Q = Pt$

$P_1V_1 = P_2V_2$

$\dfrac{V_1}{T_1} = \dfrac{V_2}{T_2}$

$\dfrac{P_1}{T_1} = \dfrac{P_2}{T_2}$

4. WAVES

$f = \dfrac{1}{T}$

$v = f\lambda$

$\lambda = \dfrac{ax}{D}$

5. LIGHT & OPTICS

$n = \dfrac{c}{v}$

$n = \dfrac{\sin i}{\sin r}$

$n = \dfrac{1}{\sin C}$

$n = \dfrac{H}{h}$

$n_1\sin\theta_1 = n_2\sin\theta_2$

$\dfrac{1}{f} = \dfrac{1}{u} + \dfrac{1}{v}$

Linear magnification, $m = \dfrac{v}{u}$

The **KEY** to **SUCCESS** is to start **BEFORE** you are **READY**

6. FORCE AND MOTION II

$F = kx$

$E = \frac{1}{2} Fx$

$E = \frac{1}{2} kx^2$

7. PRESSURE

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

$P = h\rho g$

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

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

$A_1h_1 = A_2h_2$

$F_b = \rho V g$

8. ELECTRICITY

$E = \frac{F}{Q}$

$I = \frac{Q}{t}$

$V = \frac{E}{Q}$

$V = IR$

$R = \frac{\rho l}{A}$

$E = V + Ir$

$P = IV$

$P = \frac{V^2}{R}$

$P = I^2R$

$P = \frac{E}{t}$

$E = \frac{F}{d}$

9. ELECTROMAGNETISME

$\frac{V_S}{V_P} = \frac{N_S}{N_P}$

$n = \frac{\text{Output power}}{\text{Input power}} \times 100\%$

10. ELECTRONIC

$E = eV$

$E = \frac{1}{2} mv^2$

$\beta = \frac{I_C}{I_B}$

$e = 1.66 \times 10^{-19}$ C

11. PHYSICS NUCLEAR

$N = \left(\frac{1}{2}\right)^n N_o$

$E = mc^2$

$c = 3.00 \times 10^8$ m s^{-1}

1 a.m.u. $= 1.66 \times 10^{-27}$ kg

12. QUANTUM PHYSICS

$E = hf$

$f = \frac{c}{h}$

$\lambda = \frac{h}{p}$

$\lambda = \frac{h}{mv}$

$E = \frac{hc}{\lambda}$

$P = nhf$

$hf = W + \frac{1}{2} mv^2_{\text{maks}}$

$W = hf_o$

$h = 6.63 \times 10^{-34}$ J s

$e = 1.66 \times 10^{-19}$ C

Section A
[60 marks]
Answer **all** questions in this section.

1 Diagram 1 shows a circuit which is used to determine the internal resistance, r of a dry cell.

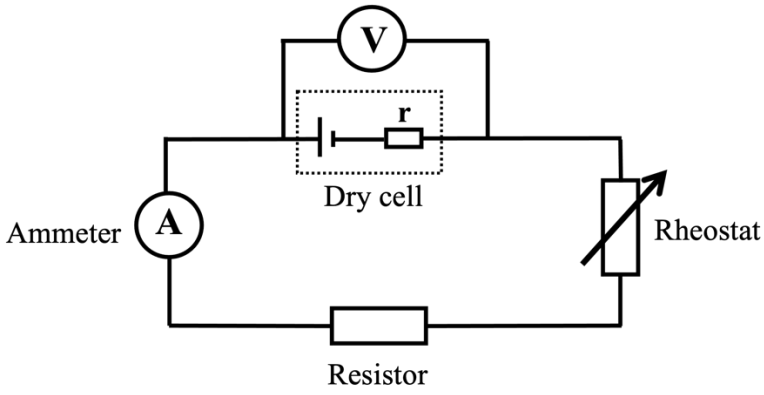


Diagram 1

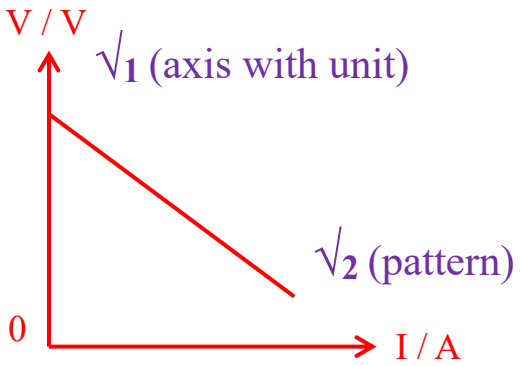
(a) Name the physical quantity that measured by the voltmeter.

Electromotive force

.....

[1 mark]

(b) Based on the Diagram 1, sketch the expected voltage against current graph.



[2 marks]

(c) What happened to the internal resistance, r if the dry cell is used for a long time?

Increase

.....

[1 mark]

TOTAL 4 marks

2 Diagram 2.1 and Diagram 2.2 show two rectangular glass blocks with different optical density and refractive index. Ray of light is directed toward the glass blocks with the same angle of incidence 30°.

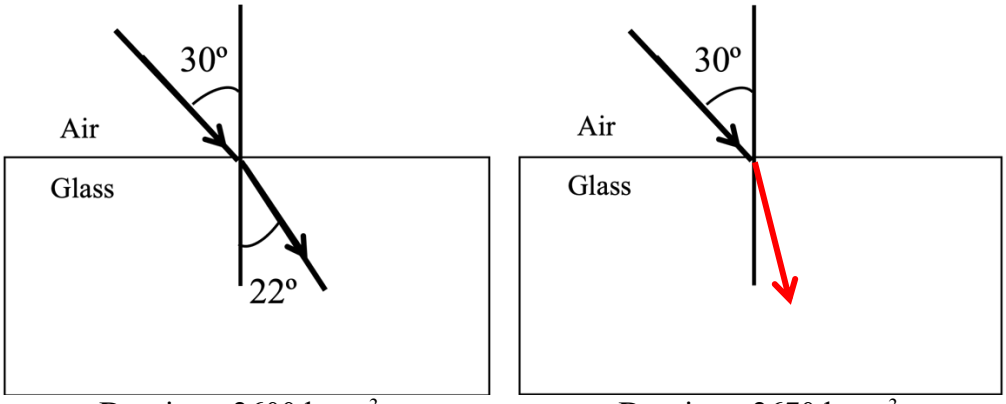


Diagram 2.1 **Diagram 2.2**

(a) What is meant by refraction?

The bending of light ray at the boundary as it travels from one medium to another of different optical densities due to the change in direction and velocity [1 mark]

(b) Calculate the refractive index of the glass block in Diagram 2.1.

$n = \frac{\sin i}{\sin r}$ $\surd_1$

$n = \frac{\sin 30^0}{\sin 22^0} = 1.33$ $\surd_2$ (NO UNIT)

[2 marks]

(c) (i) On Diagram 2.2, draw the light path when the light passes through a glass block.

[1 mark]

(ii) Give a reason.

Higher optical density // speed of light decrease // distance between particle in the glass block more closer // light ray travel from lower optical density to higher optical density [1 mark]

TOTAL **5 marks**

3 Diagram 3.1 shows two n-type semiconductor materials and n-type semiconductors are combined and then connected to a cell and a bulb. When the current is turned on, the bulb light up.

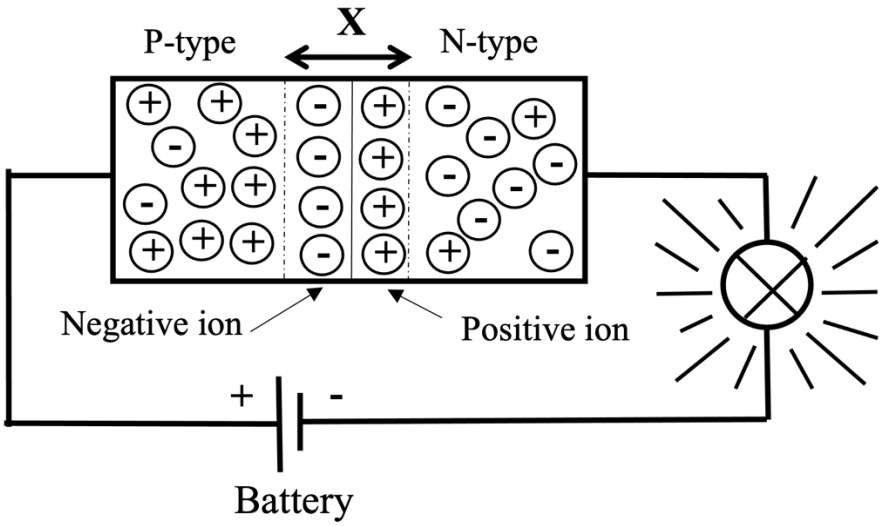


Diagram 3.1

(a) Name the part label X?

Depletion layer

.....

[1 mark]

(b) The cell terminal in Diagram 3.1 is then reversed.

(i) What happens to the distance of X.

Increase // wider

.....

[1 mark]

(ii) State the condition of the bulb.
Explain.

Bulb not light up

.....

Current not flow // reverse bias

.....

[2 marks]

(c) Diagram 3.2 shows a boron (B) atom embedded among silicon (Si) atoms in a semiconductor.
In Diagram 3.3 the embedded atom is phosphorus (P).

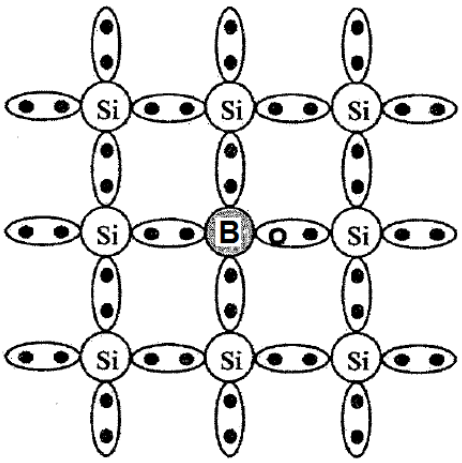


Diagram 3.2

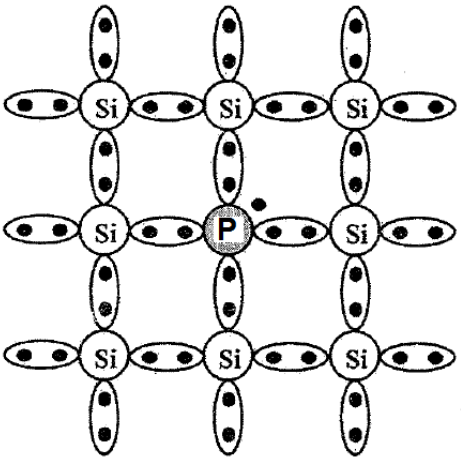


Diagram 3.3

(i) What is the purpose of doping a semiconductor?

To increase the conductivity

.....

[1 mark]

(ii) Name the type of semiconductor as shown on Diagram 3.2.

P-type semiconductor

.....

[1 mark]

TOTAL 6 marks

4 Diagram 4.1 show the image form of convex lenses, from a ray box with triangle hole as an object.

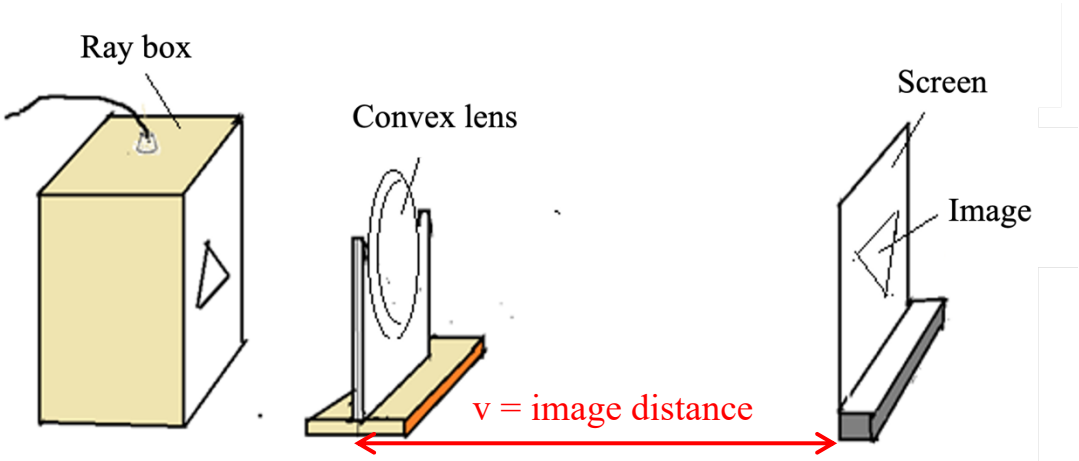


Diagram 4.1

Distance from center of the lens and in front of the screen

(a) **Underline** the **correct** answer.

Image form of the convex lens is (**real**, virtual)

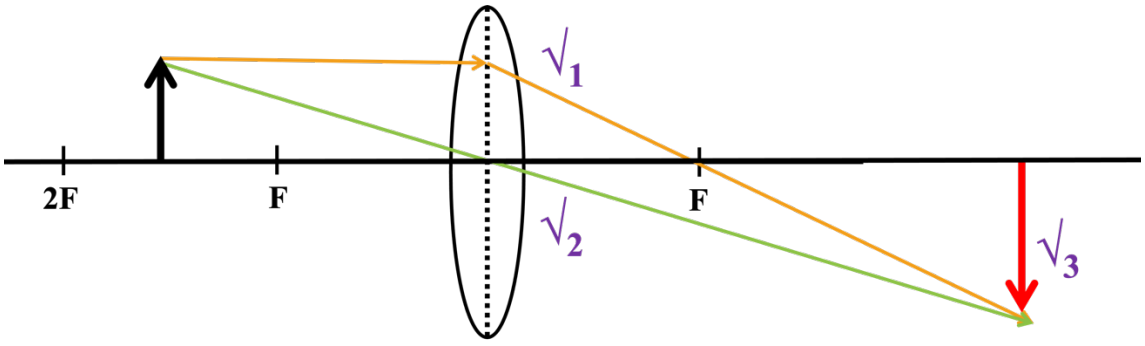
[1 mark]

(b) On Diagram 4.1, label the image distance.

[1 mark]

(c) Based on Diagram 4.1, draw a ray diagram to show the image form on the screen in the space below.

F < u < 2F



[3 marks]

(d) Diagram 4.2 shows the student used a slide projector to display a large sharp image on the screen.

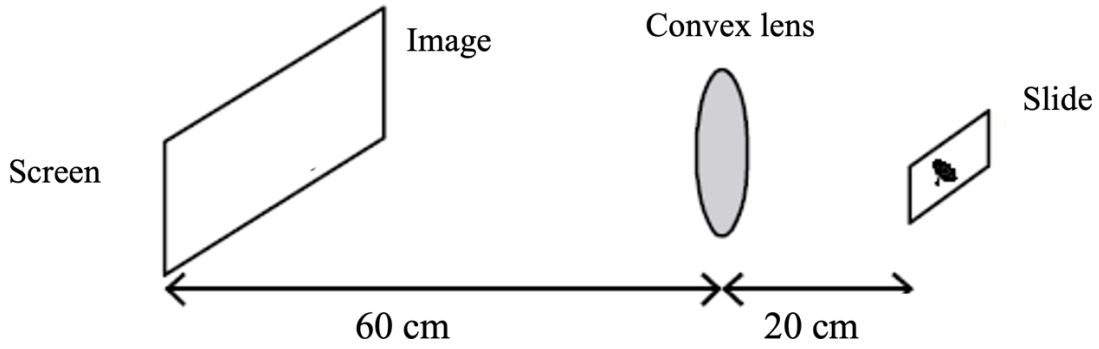


Diagram 4.2

(i) Based on Diagram 4.2, calculate the focal length of lens, f.

$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

$\frac{1}{f} = \frac{1}{20} + \frac{1}{60}$ $\surd_1$

$f = 15$ cm $\surd_2$ **UNIT!** [2 marks]

(ii) Draw the image formed on the screen in Diagram 4.2.

[1 mark]

(iii) State **one** characteristics of the image formed.

Real, Inverted, Magnified

[1 mark]

TOTAL 9 marks

5 Diagram 5.1 and Diagram 5.2 show trapped gas being heated in an enclosed space.

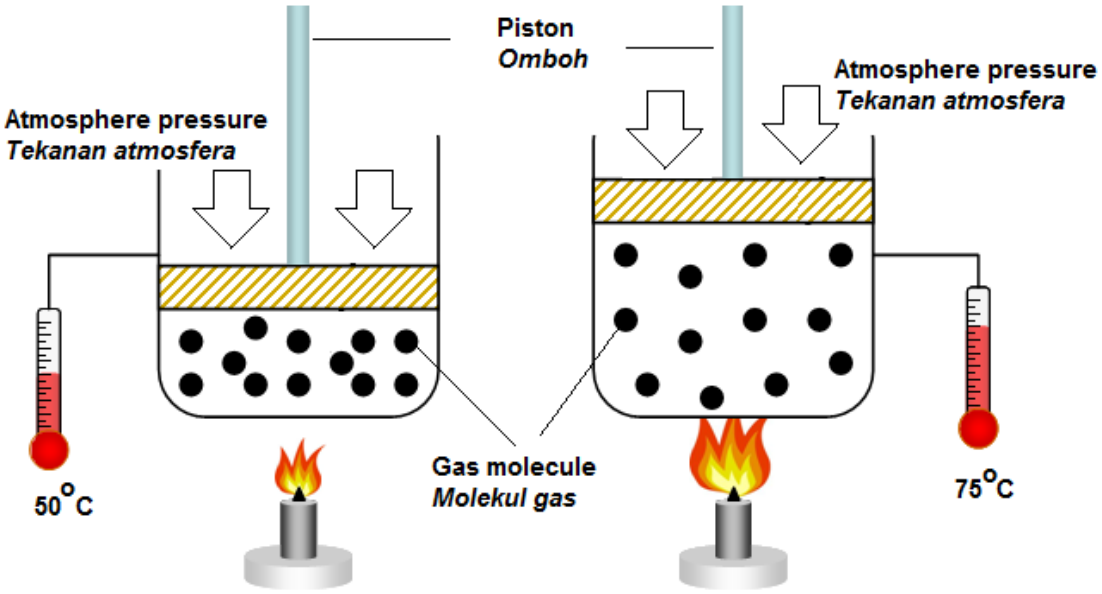


Diagram 5.1 **Diagram 5.2**

(a) What is the meaning of absolute temperature?

The lowest temperature in theory in which the pressure and the kinetic energy of gas molecules are zero

[1 mark]

(b) Observe Diagram 5.1 and Diagram 5.2. Compare

(i) heat given.

Heat: Diagram 5.2 > Diagram 5.1

[1 mark]

(ii) temperature of gas.

Temperature of gas: Diagram 5.2 > Diagram 5.1

[1 mark]

(iii) volume of gas.

Volume of gas: Diagram 5.2 > Diagram 5.1

[1 mark]

(c) Based on answer in 5(b), state the relationship between the temperature and

(i) heat

Heat increase, temperature increase

[1 mark]

(ii) volume of gas.

Temperature increase, volume of gas increase

[1 mark]

(d) Name the law involved when the pressure is kept constant.

Charles' law

[1 mark]

REJECT:
Wrong spelling

(e) Air with temperature of 27 °C and volume of 0.24 m^3 is in a cylinder with constant pressure. What is the volume of the air at temperature of 80 °C?

$T_1 = 27\ ºC + 273\ K = 300\ K$
$V_1 = 0.24\ m^3$

$T_2 = 80\ ºC + 273\ K = 353\ K$

Temperature in KELVIN

[2 marks]

$\frac{V_1}{T_1} = \frac{V_2}{T_2}$

$V_2 = \frac{V_1\ x\ T_2}{T_1} = \frac{0.24\ x\ 353}{300}$ √1

$V_2 = 0.2824\ m^3$ √2 UNIT!
Min: 2 dp
Max: 4 dp

TOTAL 9 marks

6 Diagram 6.1(a), Diagram 6.1(b) and Diagram 6.1(c) show a beaker filled with water.
The level of water in the beaker changes when the number of fingers immersed into water increases.

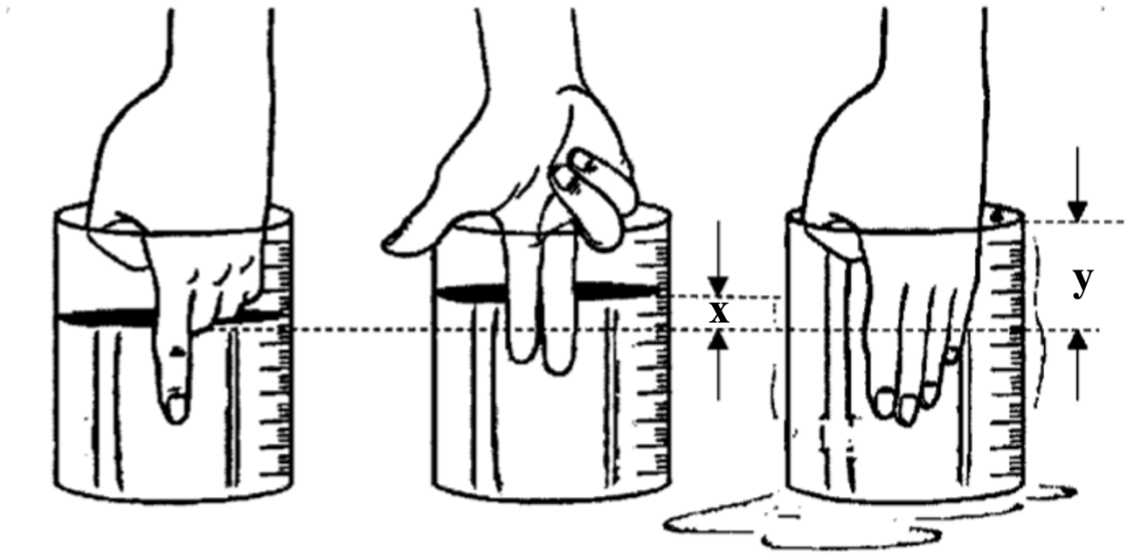


Diagram 6.1(a) **Diagram 6.1(b)** **Diagram 6.1(c)**

(a) Name one force acted on the fingers.

Buoyant force // Upthrust

[1 mark]

(b) Observe Diagram 6.1(b) and Diagram 6.1(c).

(i) Compare the number of fingers immersed into the water.

Number of fingers immersed into the water:
Diagram 6.1(c) > Diagram 6.1(b) [1 mark]

(ii) Compare the water level difference x and y.

Water level difference: y > x

[1 mark]

(iii) Compare the volume of water displaced.

Volume water displaced: Diagram 6.1(c) > Diagram 6.1(b)

[1 mark]

(c) Based on answer in 6(b), state the relationship between the force acted on the fingers and

(i) the number of fingers immersed into the water

Number of fingers immersed into the water increase,
Force acted on the fingers increase [1 mark]

(ii) the volume of water displaced.

Force acted on the fingers increase, volume of water displaced increase

[1 mark]

(d) The water in the beaker is replaced with liquid P of a higher density.

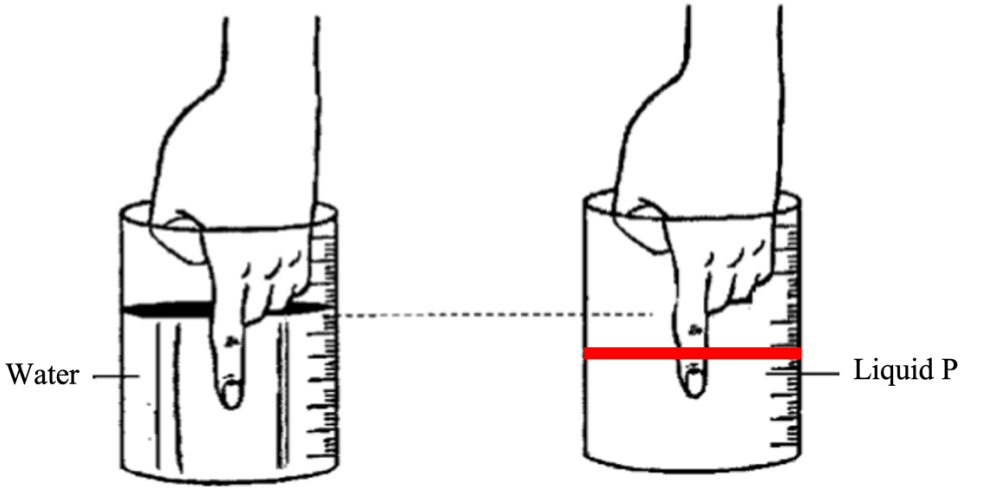


Diagram 6.2(a) **Diagram 6.2(b)**

(i) On Diagram 6.2(b), mark the level of liquid P in the beaker compared to the water level in Diagram 6.2(a).

[1 mark]

(ii) The density of liquid P is 1 300 kgm^{-3} and the volume of liquid P displaced is 0.15 m^3.
Calculate force acted on the fingers.

$F_b = pVg$

$F_b = (1300)(0.15)(9.81)$ √1

$F_b = 1912.95$ N √2 UNIT!

Min: 2 dp
Max: 4 dp

[2 marks]

TOTAL 9 marks

7 Diagram 7 shows an athlete spinning an hammer in an hammer throw sport event.

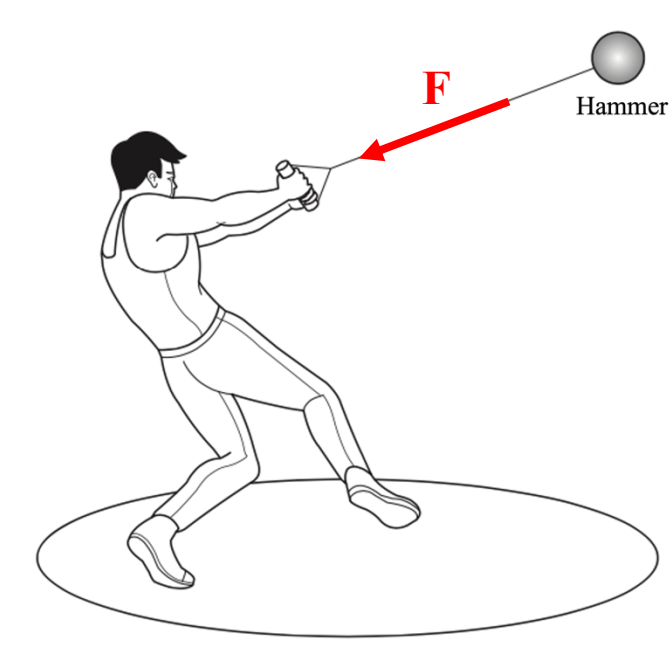


Diagram 7

The centripetal force acting on the hammer when rotated is the tension of string.

(a) What is centripetal force?

Force that acts to an object in circular motion

.....

[1 mark]

(b) On Diagram 7, mark the direction of the centripetal force, F, acting on the hammer.

[1 mark]

(c) The hammer of mass 5 kg is rotated in a horizontal circle of radius 1.6 m with a linear speed of 25 m s^{-1}.
Calculate the centripetal force acted on the hammer.

$$F = \frac{mv^2}{r}$$

$$F = \frac{(5)(25)^2}{1.6} \quad \surd_1$$

$F = 1953.125$ N $\surd_2$ UNIT!

Min: 2 dp
Max: 4 dp

[2 marks]

(d) Table 7 shows the characteristics of the hammer A, B and C throws involved in a hammer throw sport event.

Hammer throw	Length of steel string (m)	Linear speed of the hammer, when it is rotated ($m\ s^{-1}$)
A	1.85	24
B	1.55	20
C	1.15	29

Table 7

Based on the specifications in Table 7, state the suitable characteristics of the hammer throw that has the highest rope tension when it is rotated.
Give reason for the suitability for each of the characteristic.

(i) Length of steel string

Shorter
.....
[1 mark]

Reason

High centripetal force
.....
[1 mark]

(ii) Linear speed of the hammer, when it is rotated

Higher
.....
[1 mark]

Reason

Centripetal force increase // hammer can go further
.....
increase the distance after throwing the hammer [1 mark]

(e) Based on the answer in 7 (d), which hammer throw has the highest rope tension when it is rotated?

C
.....
[1 mark]

TOTAL 9 marks

8 Diagram 8.1 shows a hydrogen line spectrum.

Diagram 8.1

Coloured lines formed have specific wavelength, frequency and quantum energy.

(a) What is meant by quantum energy?

Discrete energy packet and not a continuous energy

[1 mark]

(b) (i) A coloured line from line spectrum of hydrogen atom has a wavelength of 486 nm. Determine the photon's energy of the coloured line.
[Planck's constant, h = 6.63 x 10^{-34} J s]
[Speed of light in vacuum, c = 3.00 x 10^{8} m s^{-1}]

$E = hf = \frac{hc}{\lambda}$

$E = \frac{(6.63 \times 10^{-34})(3 \times 10^{8})}{(486 \times 10^{-9})}$ $\surd_1$

$E = 4.0926 \times 10^{-19}$ J $\surd_2$ UNIT!
Min: 2 dp
Max: 4 dp

[2 marks]

(ii) Based on your answer in 8(b)(i), if the number of photons emitted is 3.37 x 10^{18} s^{-1}, calculate the output power of the coloured line.

$P = nE = nhf = \frac{nhc}{\lambda}$

$P = (3.37 \times 10^{18})\ (4.0926 \times 10^{-19})$ $\surd_1$

$P = 1.3792$ W // Js^{-1} $\surd_2$ UNIT!
Min: 2 dp
Max: 4 dp

[2 marks]

(c) Diagram 8.2 shows a simple solar panel.

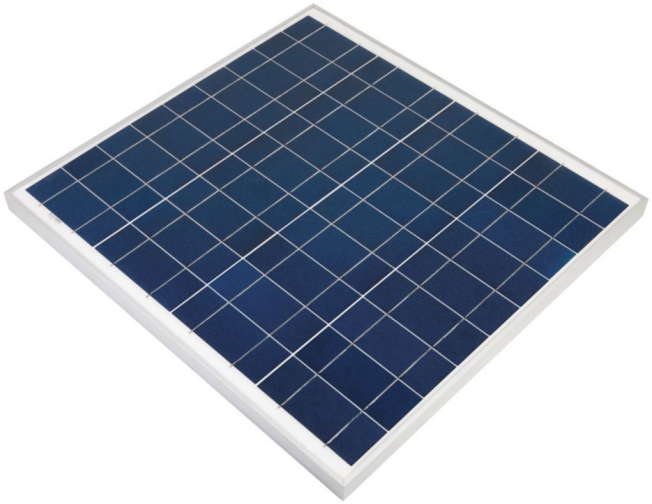


Diagram 8.2

Suggest modification that can be made so that the solar panel can be used to absorb more light and convert to larger electrical energy based on the following aspect:

(i) Work function of material used

Small

.....

[1 mark]

Reason

Less energy required for photoelectron to emitted from the metal surface //

.....

Photoelectric effect occurs // easily to release photoelectron [1 mark]

(ii) Surface area

Bigger // more // higher // increase

.....

[1 mark]

Reason

Receive more light // expose to more light //

.....

more sunlight can be illuminated [1 mark]

TOTAL 9 marks

Section B
[20 marks]
Answer any **one** question in this section.

9 Diagram 9.1 shows a bat using ultrasonic waves to detect obstacle in front of it.

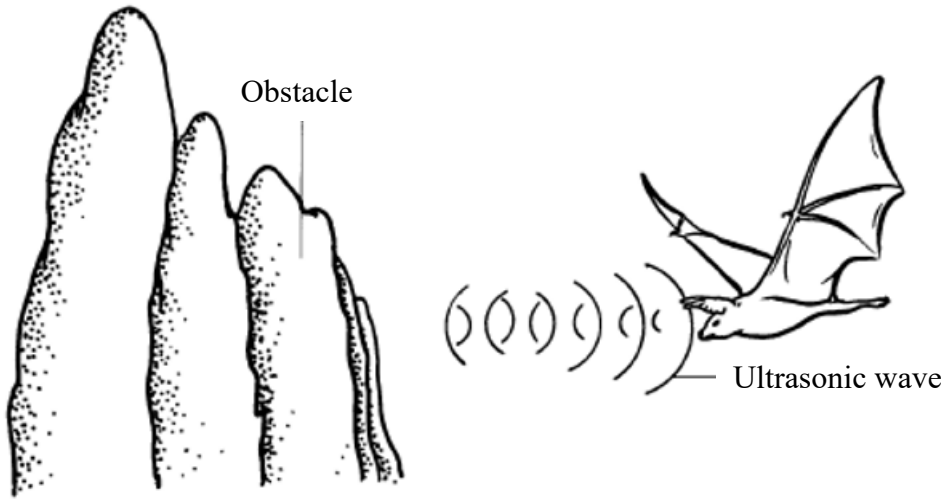


Diagram 9.1

(a) (i) What is the meaning of ultrasonic wave?

Sound wave with frequency exceeding 20000 Hz.

[1 mark]

(ii) Explain how the ultrasonic waves are used by the bat to detect the distance of the obstacle.

- Bat emits ultrasonic sound to detect the distance of obstacle.
- It detects the distance by listening to the echoes that reaches it.
- The period of time between the sending and receiving of the ultrasonic wave is noted
- The distance can be estimated.
- Bat can detect ultrasonic sound with high frequency.

[4 marks]

(b) A beam of sonar with speed 1450 m s^{-1} sent to a shoal of fish underneath a fishing boat.

(i) The depth of the shoal of fish when the echo returns after 100 milliseconds.

$t = 100 \text{ ms} = 100 \times 10^{-3} \text{ s} = 0.1 \text{ s}$ $\surd_1$

$d = \frac{vt}{2}$

$d = \frac{(1450)(0.1)}{2}$ $\surd_2$

$d = 72.5 \text{ m}$ $\surd_3$ UNIT!

[3 marks]

(ii) The wavelength of the sonar waves when its frequency is 40 kHz.

$v = f\lambda$

$\lambda = \frac{v}{f} = \frac{1450}{40\,000}$ $\surd_1$

$\lambda = 0.0363 \text{ m}$ $\surd_2$ UNIT!

Min: 2 dp
Max: 4 dp

[2 marks]

(c) Three classrooms in your school are combined to become a lecture hall.
Table 1 shows four types of sound system to be used in the hall.

Sound system	Location of the loud speakers	Distance between two loud speakers	Material used to cover the wall	The position of the microphone
W	High	Small	Softboard	Behind the speaker
X	Low	Large	Hardwood	In front of the speaker
Y	High	Large	Softboard	Behind the speaker
Z	Low	Small	Hardwood	In front of the speaker

Table 1

You are asked to investigate the design of the sound system to produce better quality of sound.
Explain the suitability of each characteristic of the sound system.
Determine the most suitable sound system.
Give reasons for your choice.

Characteristics	Reason
Location of speaker: **high**	Decreases reflection of sound wave by the obstacles.
Distance between both speakers: **Big**	More loud sound produced between the audiences / Less interference produced.
Material used to cover the wall: **Softboard**	More sound is absorbed. / Less echoes produced.
Position of the microphone: **Behind speaker**	To avoid more humming / disturbance of sound.
Y	Location of speaker: **High** Distance between both speakers: **Big** Material used to cover the wall: **Softboard** Position of the microphone: **Behind speaker**

[10 marks]

TOTAL 20 marks

10 Diagram 10.1 shows a hydraulic jack which used to lift the side of a car.
The working principle of the hydraulic jack is based on the Pascal's principle.

Diagram 10.1

(a) (i) State the Pascal's Principle.

The pressure applied on an **enclosed fluid** is **transmitted uniformly (equally) in all directions** in the fluid.

[1 mark]

(ii) Explain how the hydraulic jack can be used to lift the side of the car.

- A **force** is applied to the **smaller piston** of the jack
- A **pressure is produced** inside the jack.
- A **pressure is transmitted equally** inside the jack to the bigger piston
- A **larger output force** is produced to the larger piston of the jack

[4 marks]

(b) Diagram 10.2 shows a hydraulic brake system in a car.

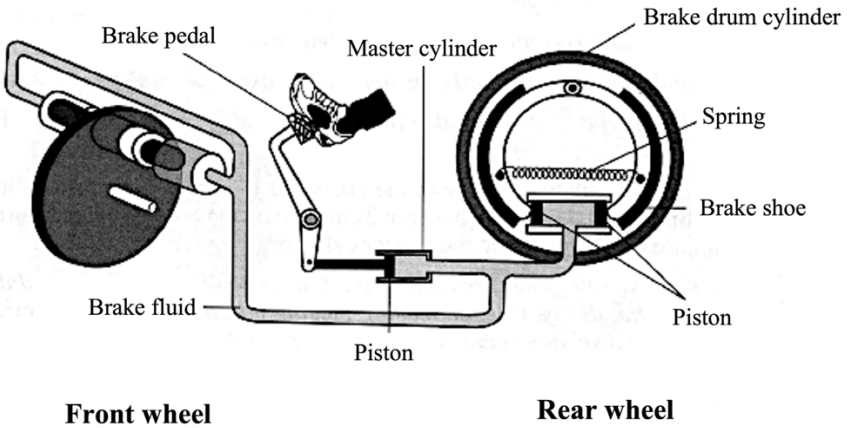


Diagram 10.2

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

Hydraulic brake	Type of fluid	Boiling point of brake fluid	Spring constant	Ratio of cross-section area of pistons in the master cylinder to the brake drum cylinder
P	Water	Low	Low	1:1
Q	Oil	High	High	1:5
R	Water	High	High	1:1
S	Oil	Low	Low	3:2

Table 2

Determine the most effective hydraulic brake to be used in a car brake system.
Give reasons for your choice.

CHARACTERISTIC	REASON
Type of brake fluid: Oil	Pressure transmitted equally // incompressible
Boiling point: High	Not easy to evaporate // not easily change its state
Spring constant: High	Withstand greater force // can return to its original position after force is removed // stiffer
Ratio of cross-section area of pistons in the master cylinder to the brake drum cylinder: Big	Larger force exerted on the piston // Produce large output force
Q	**Type of brake fluid:** Oil **Boiling point:** High **Spring constant:** High **Ratio of cross-section area of pistons in the master cylinder to the brake drum cylinder:** Big

[10 marks]

(c) 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.

$P = \frac{F}{A} = \frac{50}{2}$ $\surd_1$

P = 25 N cm^{-2} // 250 000 Nm^{-2} $\surd_2$ UNIT!

[2 marks]

(ii) the force exerted on the piston of the front wheel in S.I. base unit.

Force = 25 N cm^{-2} x 6 cm^2 $\surd_1$
= 150 N $\surd_2$
= 150 kg m s^{-2} $\surd_3$ UNIT! (S.I. base unit)

[3 marks]

TOTAL 20 marks

Section C
[20 marks]
Answer **all** questions in this section.

11. Diagram 11.1 and Diagram 11.2 show an experiment to study a current-carrying conductor in a magnetic field.

When the switch is closed, the combination of the magnetic field and the current produced a resultant force. The copper rod pushed out at distance, d_1. When the current is changed, the distance of copper rod change to d_2.

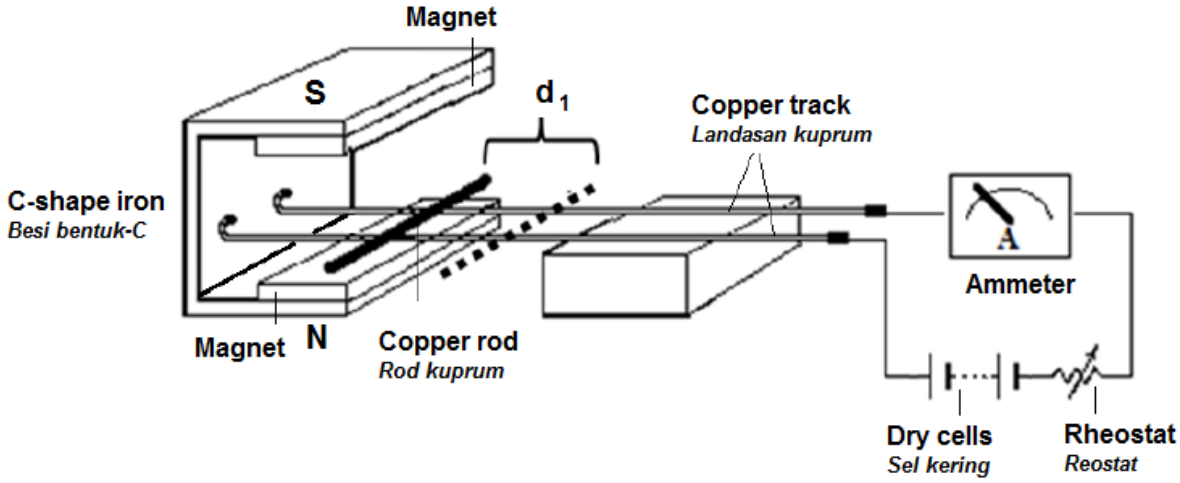


Diagram 11.1

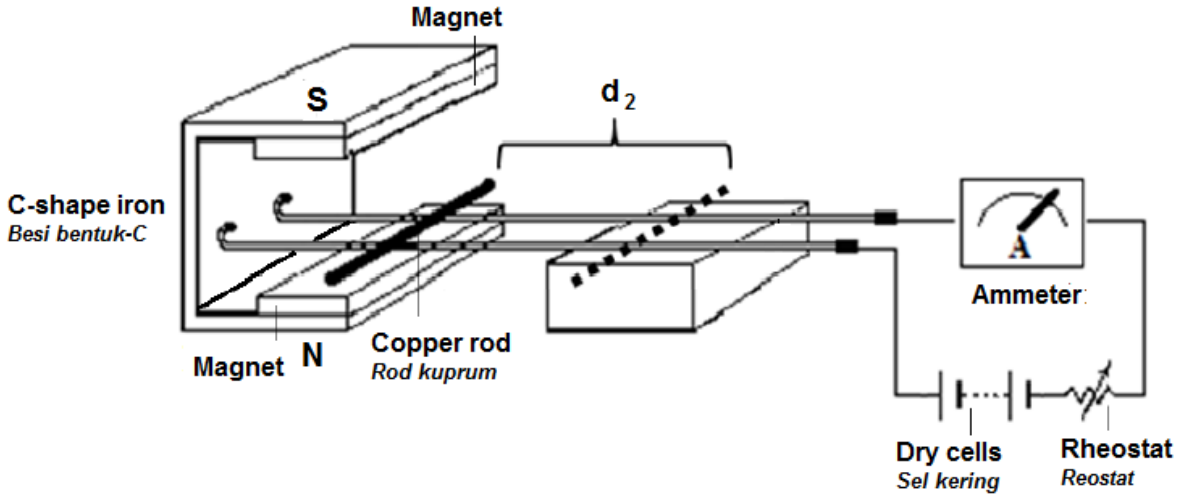


Diagram 11.2

(a) Name the rule used to determine the direction of the force.

[1 mark]

Fleming's Left-hand rule

REJECT:
Wrong spelling

(b) Based on Diagram 11.1 and Diagram 11.2, compare ammeter reading, distance of copper rod and the magnitude of force produced.

State the relationship between electric current with distance of copper rod and the magnitude of force produced.

Comparison:

- Ammeter reading: Diagram 11.2 > Diagram 11.1
- Distance of rod movement: Diagram 11.2 > Diagram 11.1
- Magnitude of force: Diagram 11.2 > Diagram 11.1

Relationship:

Current increase, distance of copper rod increase

Current increase, magnitude of force produced increase

[5 marks]

(c) Diagram 11.3 shows a wire is connected to a galvanometer which placed between two magnets of opposite poles.

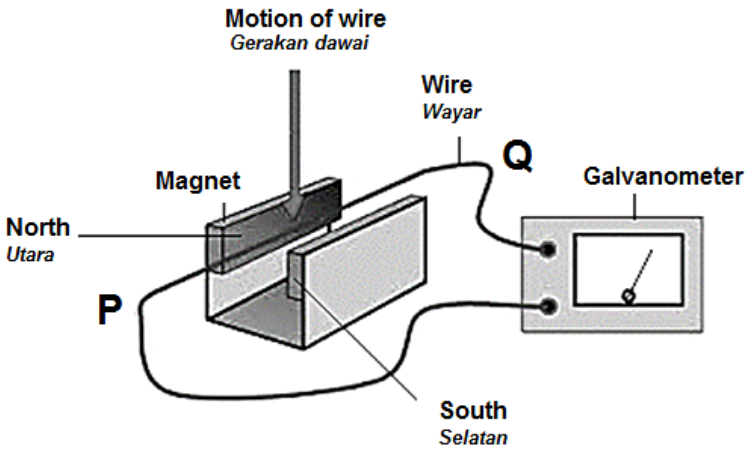


Diagram 11.3

Explain:

(i) why the galvanometer shows a reading when the wire is moved downwards.

- Induced current produced // current flows in the wire
- Because there is a change in magnetic field

[2 marks]

(ii) how to determine the direction of the current produced in the wire.

REJECT:
Wrong spelling

- Using Fleming's Right Hand Rule
- The deflection of the pointer of galvanometer shows the current flows in the wire.

[2 marks]

(d) Diagram 11.4 shows an ac generator.

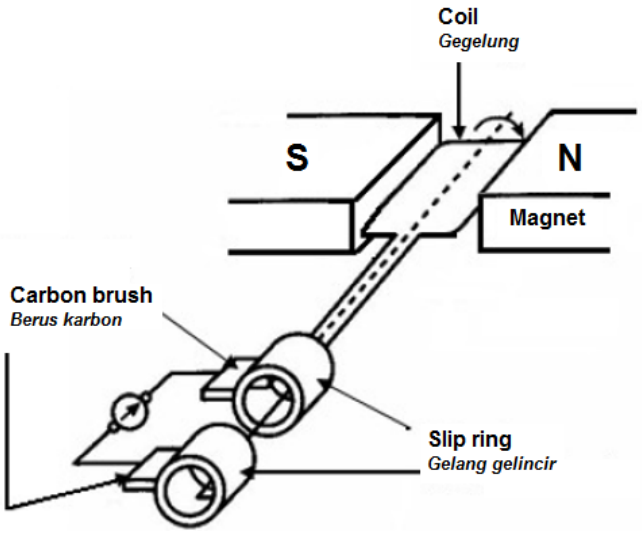


Diagram 11.4

Suggest modifications that can be made to increase the output current to the generator in Diagram 10.4.
State and explain the modifications based on the following aspects:

(i) Strength of the magnet
(ii) Shape of the magnet
(iii) Number of turns of the coil
(iv) Diameter of the wire of the coil
(v) The speed of rotation.

Characteristic	Reason
Strength of the magnet **Increase**	To increase the strength of magnetic field
Shape of the magnet **Concave**	To produced radial magnetic field // To increase the concentrated of magnetic field
Number of turns of the coil **Increase**	More current can flow
Diameter of the wire of the coil **Increase**	Low resistance so more current can flow
The speed of rotation. **Increase**	More change in magnetic flux // more induced current produced

[10 marks]

TOTAL 20 marks

EXTRA!

11 Diagram 11.1 a test tube filled with lead shots floating upright in water of density 1 g cm^{-3}. Diagram 11.2 the same test tube filled with lead shots floating upright in oil of density 0.9 g cm^{-3} .

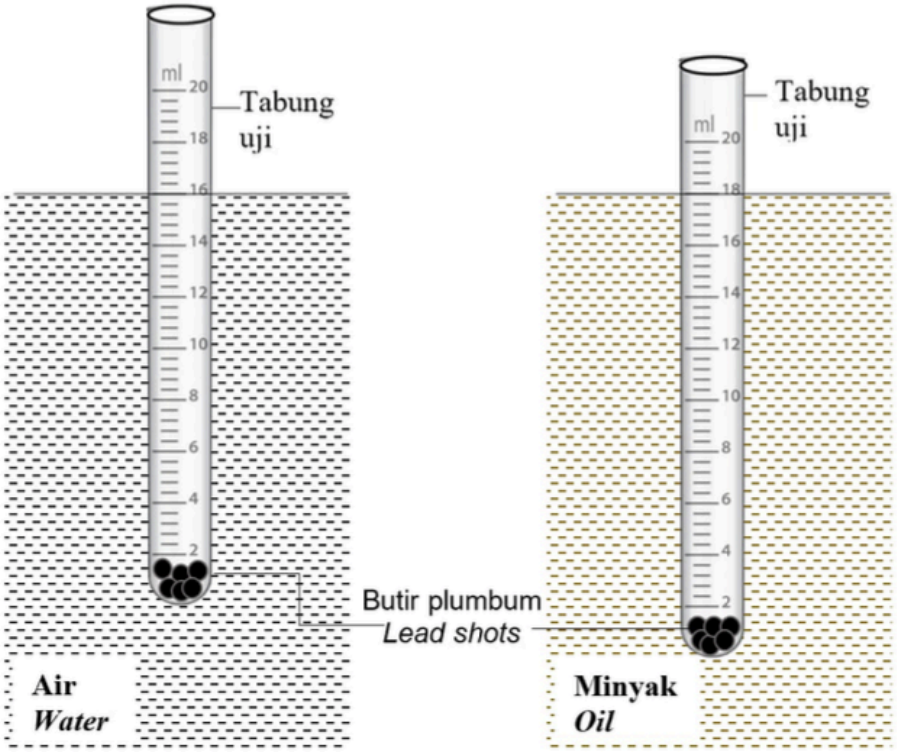


Diagram 11.1 **Diagram 11.2**

(a) Name the physics principle involved in Diagram 11.1?

Archimedes' principle

REJECT:
Wrong spelling

[1 mark]

(b) Observe Diagram 11.1 and Diagram 11.2,

(i) compare the density of liquid, depth of test tube immersed in liquid and volume of liquid displaced.

- Density of liquid: Diagram 11.1 > Diagram 11.2
- Depth of test tube immersed: Diagram 11.2 > Diagram 11.1
- Volume of liquid displaced: Diagram 11.2 > Diagram 11.1

or

- Density of liquid: Water > Oil
- Depth of test tube immersed: Oil > Water
- Volume of liquid displaced: Oil > Water

[3 marks]

(ii) state the relationship between the density of liquid and depth of test tube immersed in liquid. Make a deduction regarding the relationship between the density of liquid and volume of liquid displaced to study the physics principle in 11(a).

Density of liquid increase, depth of test tube immersed decrease
Density of liquid increase, volume of liquid displaced decrease

[2 marks]

(c) Diagram 11.3 shows a dropper made into a Cartesian diver and is floating in a plastic bottle filled with water.

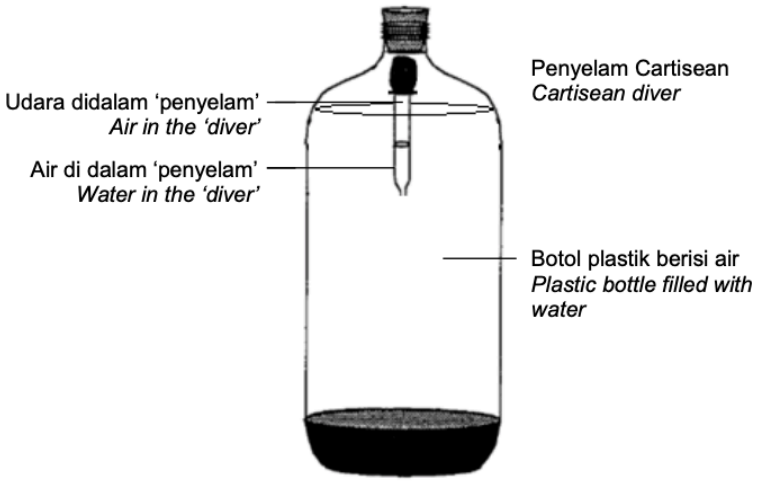
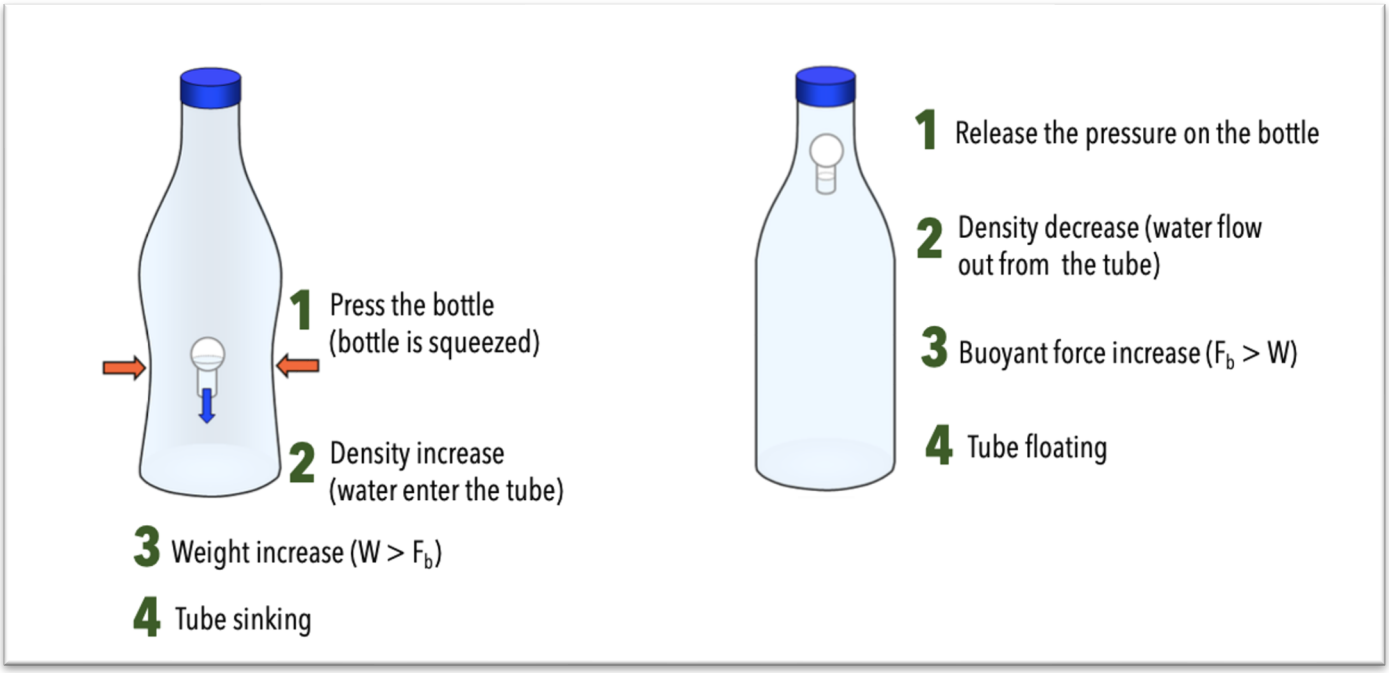


Diagram 11.3

Describe what happens to the Cartesian diver when the plastic bottle is squeezed.



[4 marks]

(d) Cartesian diver in Diagram 11.3 can be used to understand the working principle of an old submarine as shown in Diagram 11.4.

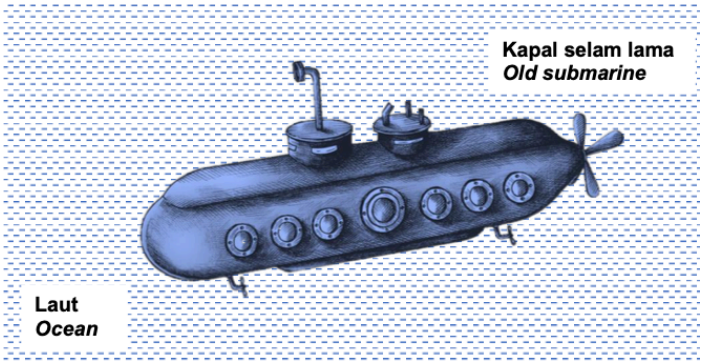


Diagram 11.4

Using appropriate physics concept, suggest modifications that need to be done to the old submarine in Diagram 11.4 so that it can dive to thousands of metres below the surface of the ocean, able to rise and sink easily, can navigate under the water safely and remain underwater for several months.

Characteristic	Reason
Shape: Streamline shape // hydrodynamic	Reduce water resistance
Special compartments: Ballast tanks	Water will be pumped in and out to vary the weight of the submarine
Number of ballast tanks: More	Can increase weight and buoyant force
Material of body: Steel // Titanium Strong material	Strong material // will not rust Will not break // Can withstand high pressure
Navigation system: Equip with sonar system Prism periscope	To estimate distance or to detect objects Observe surroundings clearly while floating
Fuel: Radioactive substance	Can be used for longer time // renewable

[10 marks]

TOTAL 20 marks

The best and most beautiful things in the world cannot be seen or even touched: they must be felt with the heart.
-Helen Keller-