Provincial Department of Education – Northern Province
Third Term Exam – 2026

பௌதிகவியல்
Physics

Three Hour 10 Min.

Grade - 12 (2027)

01 **E** **I**

Part i

Instructions :

- This paper consists 25 questions in 06 pages
- Write answer for all the questions.
- Write index number in the space provided in the answer sheet.
- In each of the questions 1 to 25 , pick one of the alternatives from (1),(2),(3),(4) and (5) which is correct or most appropriate and mark your response on the answer sheet with a cross (**X**) in accordance with the instructions given on the back of the answer sheet.

Use of calculators is not allowed

$(g = 10\ ms^{-2})$

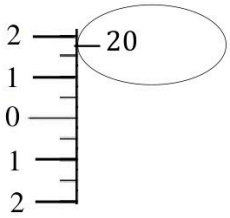
01) The **unit** of sound intensity level is,

(1) Wm^{-2} (2) Hz (3) s^{-1} (4) β (5) dB

02) The **reading** of the spherometer shown in the figure is $(L.C\ 0.01\ mm)$,

(1) $1.20\ mm$ (2) $1.48\ mm$ (3) $1.52\ mm$

(4) $1.70\ mm$ (5) $2.20\ mm$



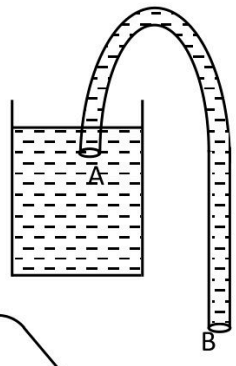
03) Which of the following property is **not** shown by sound wave ?

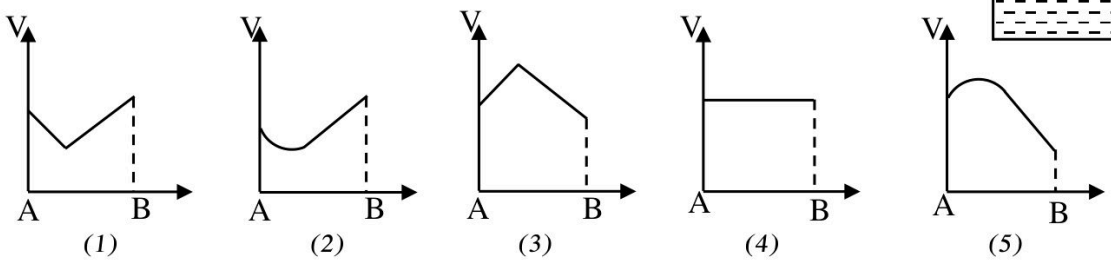
(1) reflection (2) refraction (3) polarization (4) interference (5) Diffraction

04) When a both end open resonance tube resonates with a tuning fork two displacement nodes are formed in the tube for the wave pattern. If the length of the tube is 24 cm then find the wavelength (there **is** an **end correction**)

(1) $12\ cm$ (2) $24\ cm$ (3) $25\ cm$ (4) $48\ cm$ (5) $50\ cm$

05) An incompressible liquid flows steadily through a pipe AB with a uniform cross sectional area from a constant pressure head. The variation in the speed (V) of the liquid as it flows through the pipe from A to B depicted correctly is,



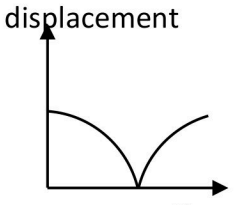


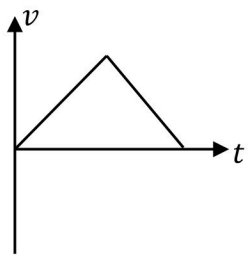
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06) A mass m attached with a spring executes a simple harmonic motion in vertical direction with an amplitude A = 20 cm and period of oscillation 6 s. If the mass starts its motion when its displacement is maximum, the time for the following displacement (x in cm) shown in the table (**ignore** the drag force by air)

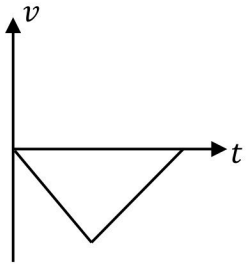
	(1)	(2)	(3)	(4)	(5)
$x(cm)$	Time (s)				
$A/2$	0.5	1	1	1	1
0	1.5	1.5	1.5	3	3
$-A/2$	2	2	2.5	5	2.5

07) Displacement –time graph is given. The corresponding velocity –time graph is ,

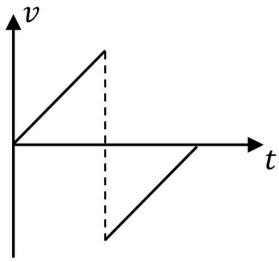




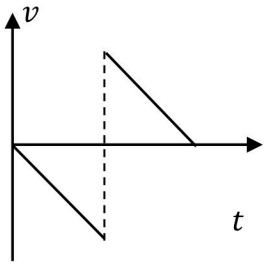
(1)



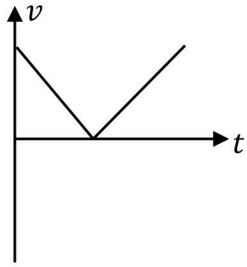
(2)



(3)

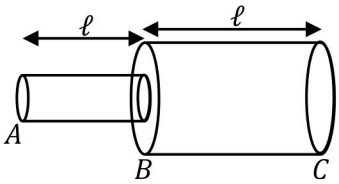


(4)



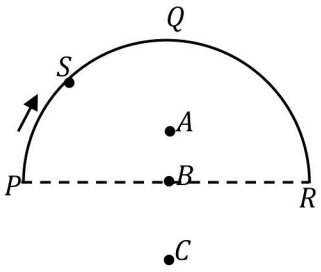
(5)

08) Two solid cylindrical rods of equal length l with radii r and 2r are connected in series with their axes colinear, as shown in the figure. If they are made of the same substance then the centre of gravity of the **composite** body from the end A is,



(1) $\frac{\ell}{2}$ (2) $\frac{3}{4}\ell$ (3) ℓ (4) $\frac{7\ell}{6}$ (5) $\frac{13\ell}{10}$

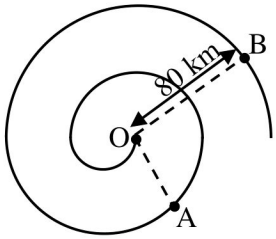
09) The point B is located at the centre of the semi circle and the points A and C are above and below the point B respectively. A source travels along the circular path from P to R with emitting a sound wave of **constant** frequency f. The apparent frequencies heard by the observers at A, B and C are f_A, f_B *and* f_C respectively when the source passes the point **S**, then which of the relationship is correct?



(1) $f_A > f, f_B > f, f_C < f$ (2) $f_A < f, f_B = f, f_C > f$ (3) $f_A < f, f_B < f, f_C < f$

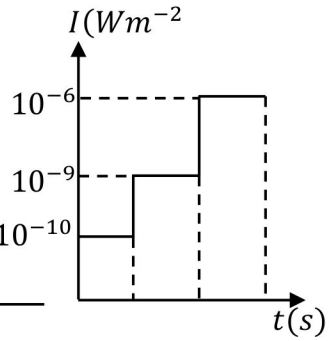
(4) $f_A > f, f_B = f, f_C < f$ (5) $f_A < f, f_B = f, f_C < f$

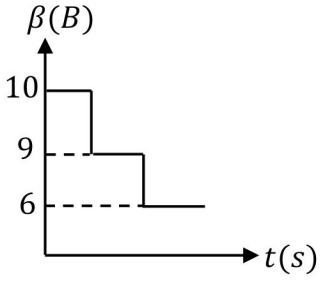
10) An air particle moves along the spiral path around the eye of a cyclone as shown in the figure. The speed of the particle at A and B are $900\ km\,h^{-1}\ and\ 180\ km\,h^{-1}$. If $O\ B = 80\ km$ then **OA** ?



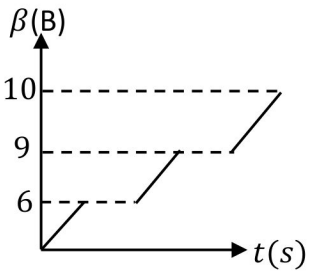
(1) $16\ km$ (2) $20\ km$ (3) $40\ km$
(4) $320\ km$ (5) $400\ km$

11) A graph which shows the variation of sound intensity (I) with time (t) is given. The sound intensity for threshold of hearing is $1 \times 10^{-12}\ Wm^{-2}$. Which of the following graph shows the corresponding variation of the sound intensity level β (unit- **Bel**) with time?

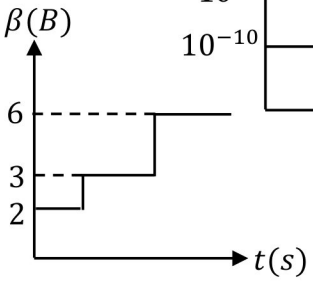




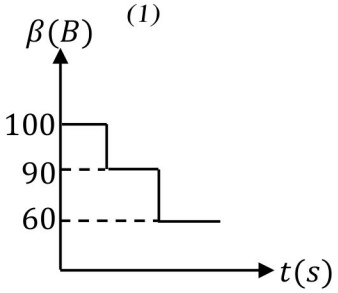
(1)



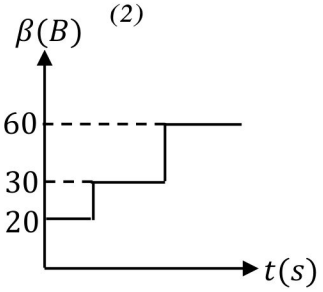
(2)



(3)

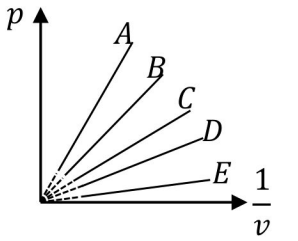


(4)



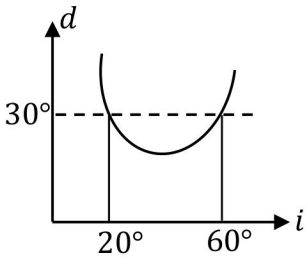
(5)

12) A graph of P versus $\frac{1}{V}$ is shown in the figure. The line **C** indicates the graph for the ideal gas of 4 mol at 27^{0}C. Which of the followings shows the graph for the same ideal gas of 2 mol at 327^{0}C.



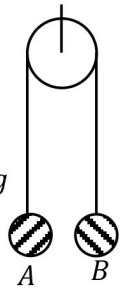
(1) A (2) B (3) C (4) D (5) E

13) A graph shows the variation of deviation (d) against the angle of incidence (i) in a prism. The **prism angle** of the prism is ,



(1) 30° (2) 40° (3) 45°
(4) 48° (5) 50°

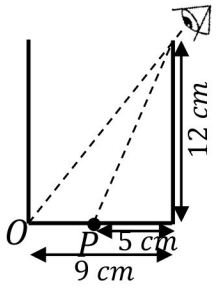
14) Two masses A and B are connected by a light string which goes over a smooth pulley as shown in the figure. When the system is let to move , the mass A goes downward with an acceleration of 4 ms^{-2}. If the total mass of A and B is 10 kg then the **mass of A** is,



(1) $2\ kg$ (2) $4.5\ kg$ (3) $6\ kg$ (4) $6.4\ kg$ (5) $7\ kg$

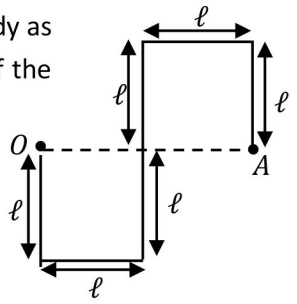
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15) A monochromatic narrow beam of light falls on one side of the bottom of the vessel at O when it is empty. Now it falls on the point P when it is completely filled by a liquid. The **refractive index** of the liquid is,



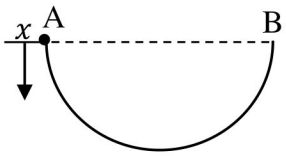
(1) 1.43 (2) 1.56 (3) 1.72
(4) 1.54 (5) 1.47

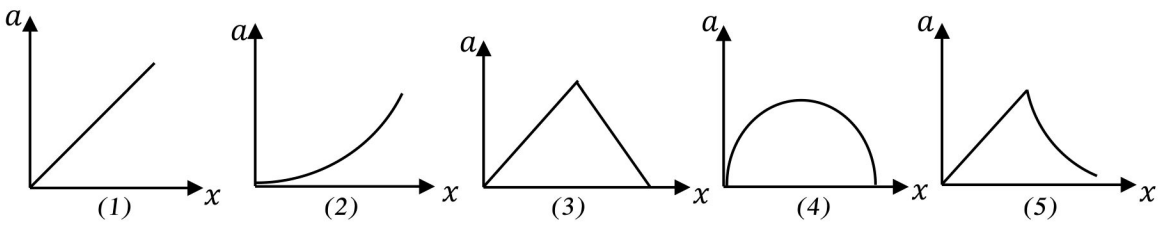
16) Six identical rods of length l and linear expansivity α form a composite body as shown in the figure. The body is fixed at a point O. If the temperature of the system is increased by $\theta\ ^0C$ then the **displacement of the point A** is,



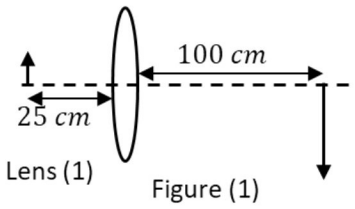
(1) $2\ell \propto \theta$ (2) $4\ell \propto \theta$ (3) $6\ell \propto \theta$
(4) $\sqrt{20}\ell \propto \theta$ (5) $\sqrt{2}\ell \propto \theta$

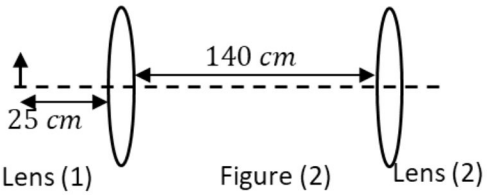
17) A particle is let to move from the edge of a smooth hemispherical bowl from rest as shown in the figure. It travels from A to B along the spherical surface. Which of the following graph shows the variation of the **magnitude** of the centripetal acceleration of the particle with the **vertical distance** moved by the particle





18)

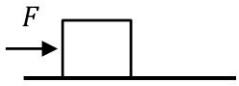




When an object is placed in front of a convex lens at a distance of 25 cm , its inverted image is formed at 100 cm from the lens as shown in the figure(1). When another identical convex lens is placed at 140 cm from the first lens as shown in the figure(2) the image formed is ,

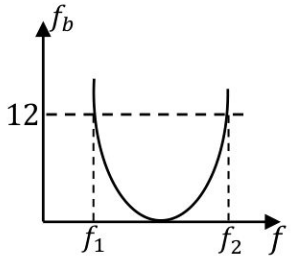
(1) Real and erect image same size as the object.
(2) Real and erect image four times larger than the object size.
(3) Real and inverted image four times larger than the object size.
(4) Virtual and erect image four times larger than the object size
(5) Real and inverted image same size as the object

19) A block of mass m is placed on a horizontal rough surface. A horizontal force F is applied on it for the distance d and released. If the block moves further 3d distance before coming to **rest** then the coefficient of **kinetic friction** is ,



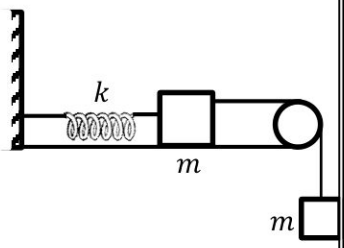
(1) $\frac{F}{4\,mg}$ (2) $\frac{F}{3\,ms}$ (3) $\frac{F}{2\,ms}$ (4) $\frac{F}{ms}$ (5) $\frac{4\,\mu}{3\,ms}$

20) A stretched string resonates with a source of frequency 37 Hz. When the tension along the string changes its own frequency also changes and produces beats with the source. The graph shows the variation of the beat frequency with the variation of the own frequency of the string. The tensions along the string are T_1 and T_2 when the frequency of the string are f_1 and f_2 respectively. The **ratio** of $\frac{T_1}{T_2}$ is



(1) $\frac{5}{7}$ (2) $\frac{25}{49}$ (3) $\frac{49}{25}$ (4) $\left(\frac{25}{49}\right)^2$ (5) $\left(\frac{49}{25}\right)^2$

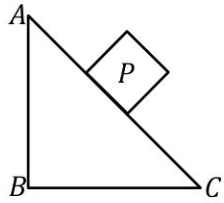
21) One end of a spring is connected to a vertical wall and other end is connected to a block of mass m which is held on a smooth horizontal table. The block is connected to another block of mass m by a light string goes over a smooth pulley. If the system is made to oscillate then the **period of oscillation** is , (k is spring constant)



(1) $T = 2\pi\sqrt{\frac{m}{k}}$ (2) $T = 2\pi\sqrt{\frac{2m}{k}}$ (3) $T = 2\pi\sqrt{\frac{m}{2k}}$

(4) $T_2 = \pi\sqrt{\frac{m}{k}}$ (5) $T_2 = \pi\sqrt{\frac{2m}{k}}$

22) A block is held on a **rough** inclined surface of a wedge as shown in the figure.



A - If the system is in equilibrium ,the friction acts on the block P is in the direction upward along the inclination.

B - If the inclined surface is pulled horizontally with any acceleration also, the friction on the block P acts upward along the inclination.

C - When the wedge is rotated about a vertical axis that passes through AB, such that the block P is always on the inclined surface, the friction on the block P acts downward along the inclination.

The correct statement (s) is or are ,

(1) A only (2) C only (3) A *and* B only (4) A *and* C only (5) B only

23) A person wears a lens with a power of -2.0 D to correct his vision defect. His vision range when **he does not wear the lens** is,

(1) He can see objects clearly that are between 25 cm and 50 cm.

(2) He can see objects clearly that are 50cm to infinity.

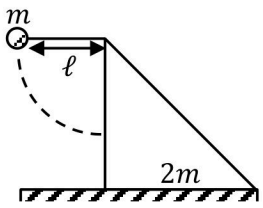
(3) He can see objects clearly that are 25 cm to infinity.

(4) He can see objects clearly that are 200cm to infinity.

(5) He can see objects clearly that are between 25 cm and 200 cm.

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24) A wedge of mass 2 m is held on a smooth horizontal surface, and a mass m is attached to its vertex by a light string. The mass m is initially positioned so that the string is horizontal and is then released. Which of the following statement(s) is or are correct ?



A - If the mass m strikes and sticks to the wedge, then the velocity of the system is $\frac{\sqrt{2g\ell}}{3}$.

B - The wedge remains at rest until the mass m strikes it.

C - If the mass m strikes and sticks to the wedge, the loss of mechanical energy of the system is $mg\ell$.

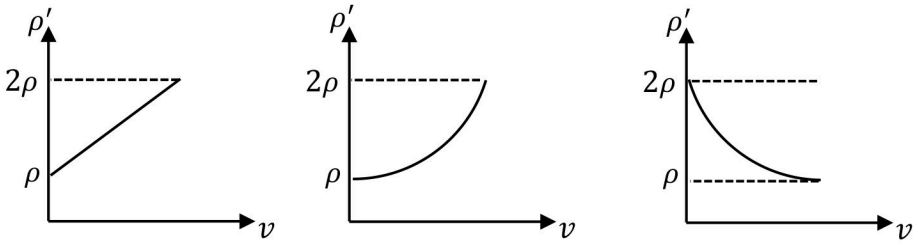
D - If the collision is elastic , the mass reaches the initial height after the collision.

The **correct statement(s) is or are** ,

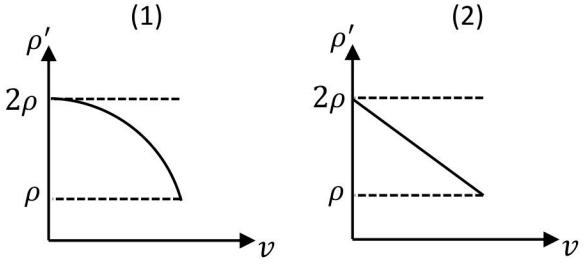
(1) A and B only (2) A, B and D only (3) A, B and C only

(4) C and D only (5) A and D only

25) A volume V of a liquid of density ρ is mixed with a liquid of density 2ρ to form a liquid **mixture of constant total volume**. Which of the following correctly represents the variation of the mixture's density ρ' with the volume V of the liquid of density ρ ? (Both liquids are miscible, and in each instance of mixing, there is no change in the **total volume** of the mixture) .



(1) (2) (3)



(4) (5)

Provincial Department of Education--Northern Province

Third Term Examination - 2026

பௌதிகவியல் Physics	Grade - 12 (2027)	01	E	II (A)

Index Number.....

Use Additional reading time to go through the question paper, select the questions and decide on the questions that you give priority in answering

- This question paper comprises part A and part B. The time allocated for both parts is two hours
- Calculator using is prohibited

Part A – Structured Essay (Pages 7 – 14)

- Answer all four questions in this paper itself.
- Answer each question in the given space. Please note that the space provided is sufficient for answer and that extensive answers are not expected.

Part B – Essay (Pages 15 – 20)

- Answer only two questions out of four questions . Use the papers supplied for this purpose.
- At the end of the time allocated for this paper, tie the answer script to the parts A and B together so that part A is on top and hand over them to the supervisor.
- You are permitted to take with you only parts B of the exam paper from the examination hall.

For examiner use only

Part	Question No	Marks
A	1	
	2	
	3	
	4	
B	5	
	6	
	7	
	8	
Total		

Part i		
Part ii	$\frac{(\quad)}{140} \times 50 =$	
Total (In Number)		
Total (In Words)		

Part – II (A) **Structured Essay**

$g = 10\ m\ s^{-2}$

01) An experimental setup of Hare's apparatus used in a school laboratory is shown in figure(1). As shown, x_w and x_ℓ represent the heights to the mark M of the relevant indicator from the water and liquid surfaces in the beakers respectively

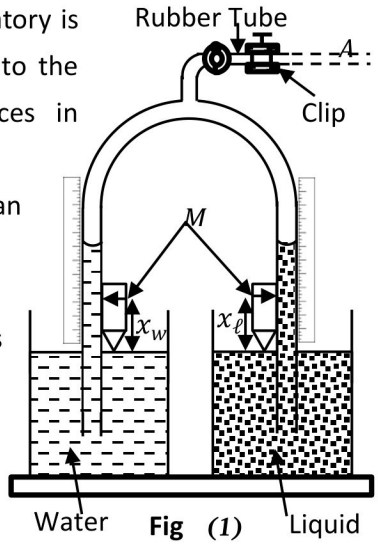


Fig (1)

a) i. For **what type of liquids** is Hare's apparatus suitable than "U" tube ?

.....

ii. How would you establish liquid columns in the Hare's apparatus limbs ?

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iii. The densities of water and the liquid are $d_w\ and\ d_\ell$ respectively. If h_w and h_l represent the heights of the water column and the liquid column in glass tubes as measured from the mark M of the respective indicators, **derive** an expression for h_w in terms of $h_\ell, d_w, x_w, d_\ell\ an\ d\ x_\ell$

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.....

iv. Every time after changing the heights of liquid and water columns in tubes and closing the clip you need to make another adjustment before taking the measurements with regard to new heights. **Write down the experimental** procedure which you should follow to make this adjustment

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.....

b)



Figure (2)

The output port of the syringe shown in the figure(2) is tightly connected to the rubber tube to change the air pressure in the tube of the Hares' apparatus as planned by a student.

i. State the method by which the syringe is connected to the rubber tube.

.....

.....

ii. Is using syringe method is better than the usual method (sucking by mouth) ? give reason.

.....

.....

c) This experiment is done by using the method mentioned in the part(b) to find the relative density of the copper sulphate solution. A set of readings are obtained and a graph is drawn as the height of water level (h_w) is kept as dependent variable. P and Q are the coordinates on the line drawn for the graph and their values are obtained as (15,35) and (5,18) respectively.

i. Find the relative density of the copper sulphate solution by using the values of P and Q.

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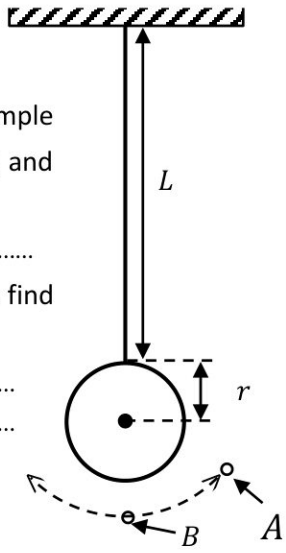
ii. A meter ruler with 1 mm accuracy is used to measure height of the liquid columns. The heights for the copper sulphate solution are obtained as 6 cm, 10 cm, 15 cm , 19 cm, and 21 cm. Give the unsuitable measurement or measurements from these values. **Give the reason for this.**

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.....

02) A student planned to determine acceleration due to gravity (g) and the radius of a sphere (r) by using simple pendulum.



a) i. **Write an expression** for the period of oscillation (T) of the simple pendulum in terms the string length (L) , radius of the sphere (r) and the acceleration due to gravity (g).

.....

ii. **Arrange the above expression** for a graph in a suitable manner to find out the values for g and r.

.....

.....

iii. Identify the independent variable and the dependent variable.

Independent Variable (x) : .....

Dependent Variable (y) : .....

iv. The student place the reference pin at the point B to take reading for T. Why putting the reference pin at B is more accurate than putting it at A for the **time measurement** ?

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b) i. When the student measured the time taken for one oscillation, his reading was $1\frac{2}{3}s$. If the least count of the time measuring instrument is $\frac{1}{3}s$ then calculate the **error percentage** for the period of oscillation.

.....

.....

ii. Calculate the **least** value of the time taken for the total number of oscillations to be the error percentage less than 1 %.

.....

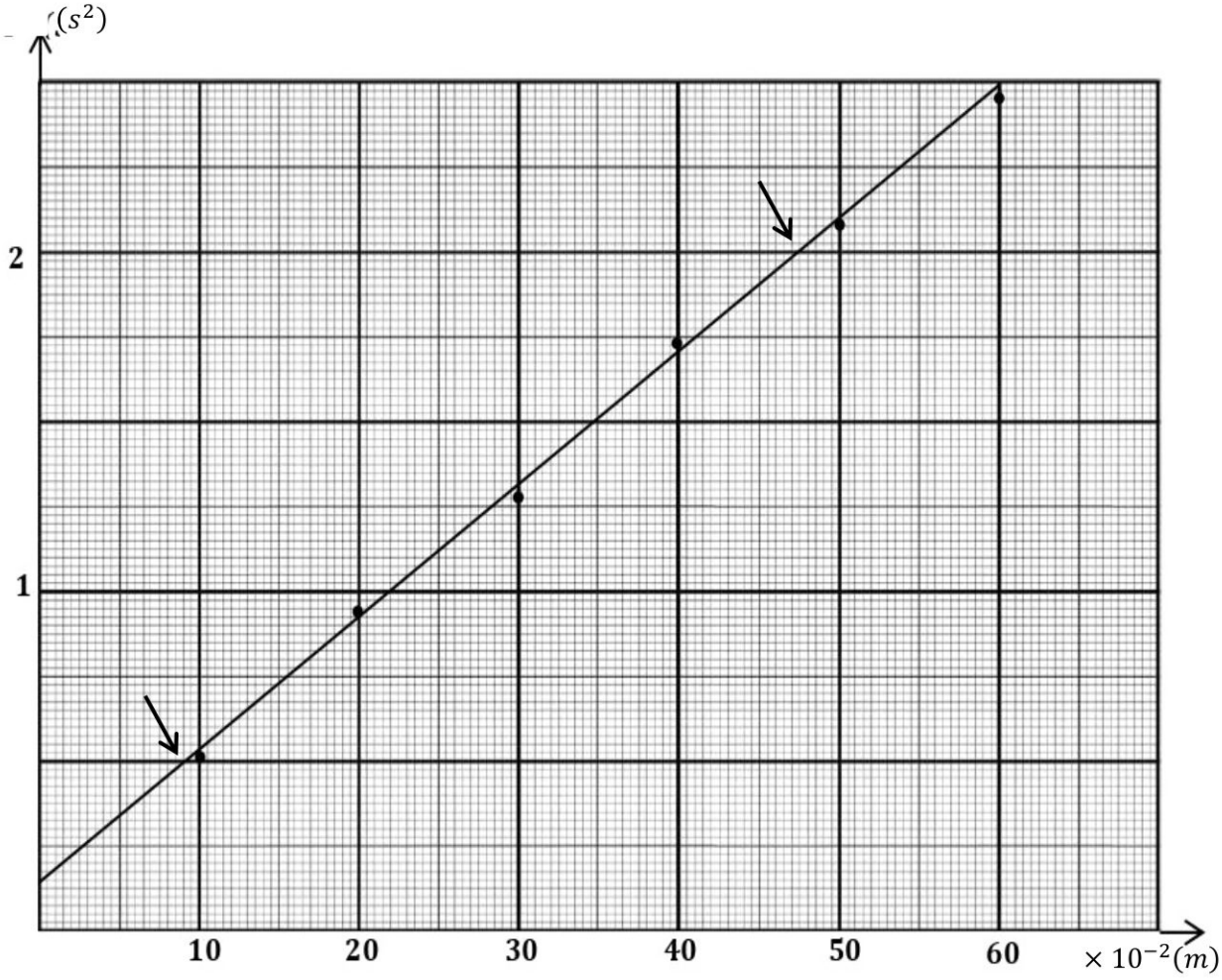
.....

iii. What is the least number of oscillations to be the error percentage less than 1 %?

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c) The graph obtained by the student by using a uniform metal solid sphere of radius r as the pendulum bob is given below.



i. Calculate the **gradient** of the graph ?

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.....

ii. Determine the gravitational acceleration (g) $(\pi = 3.1)$

.....

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iii. Determine the **intercept** of the graph.

.....

iv. Determine the radius of the sphere (r).

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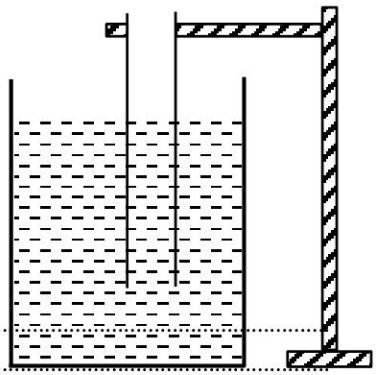
d) The student observed that the amplitude of the oscillations decreases gradually with time due to the viscous air drag and finally the bob comes to rest. He did the experiment again by using a wooden solid sphere of same radius. Which sphere takes **less time** to come to rest? Give reason for your answer.

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.....

03) (a) An experimental arrangement is shown in the figure to find out speed of sound in air (V) and the end correction (e) of the tube. A set of tuning forks of known frequencies (f) is given and initially the tube is totally immersed into the water.



i. Which tuning fork is used initially to check **correctness** of the setup ? Give reason.

.....

.....

ii. Draw the wave pattern with end correction (e) in the given figure for the fundamental mode of vibration (length of the tube is l) and show the correct method of placing the tuning fork above the tube.

iii. Give the **experimental steps** required to obtain fundamental mode of vibration by using the given tuning fork.

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(b) i. If the speed of sound in air is V , the frequency of the tuning fork is f and the end correction is e then **obtain an expression** for V in terms of $f, \ell \ and \ e$.

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ii. **Arrange** the expression obtained in part b(i) for a straight line graph.

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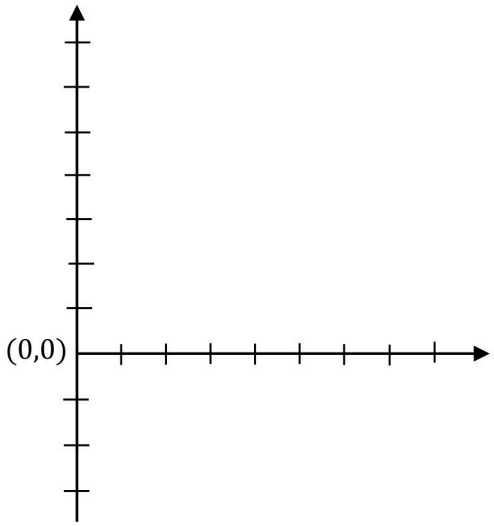
iii. **Identify** the independent variable and dependent variable from the arranged expression in the part b(ii)

Independent Variable : .....

Dependent Variable : .....

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iv. Sketch the graph on the given axes below and **label** them.



v. The gradient of the graph is obtained as $85.5 \times 10^2\ cm\ s^{-1}$ and the intercept is obtained as 0.2 cm.

1. Find the **speed** of sound in air .

.....

2. Find the **end correction**.

.....

(c) The tube mentioned in the part (a) is taken out from the water and mounted horizontally in a stand. Some tubes are inserted into the main tube to create a both open ended tube of varying length, as shown in the figure (2).

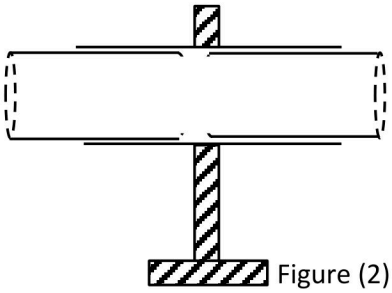


Figure (2)

i. Draw the wave pattern of the fundamental mode of vibration in this tube by considering end correction e.

ii. This setup in the figure(2) also is to be used to find out speed of sound in air (V) and the end correction of the tube(e). Obtain an expression for the fundamental mode of vibration and arrange it for a straight line graph. Identify the dependent and independent variables. State how would you find out V and e.

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.....

iii. Sketch the graph for part c (ii) on the same axes given in part b(iv) and **label it as x**.

(d) What is the additional measurement required to mention the speed of sound in air ?

.....

04) A standard spectrometer , a glass prism , and a monochromatic light source (Sodium Lamp) are used to determine the refractive index (n) of the glass by using glass prism.

a) Fill in the **blanks** by using proper word (term)

i. A standard spectrometer is a measuring instrument based on .....principle.

b) i. What is the least count of the standard spectrometer?

.....

ii. What are the **two** important parts of the spectrometer which can be rotated independently about a vertical axis?

.....

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c) Write down important steps of the adjustments for the following items before starting to take measurements.

i. Eye piece

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ii. Telescope

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iii. Collimator

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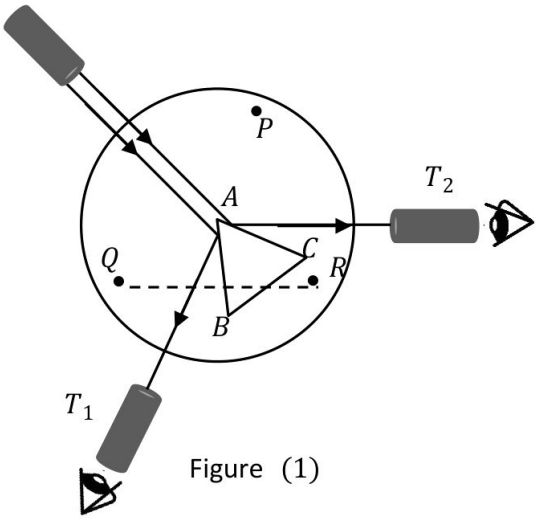


Figure (1)

d) The prism is placed on the prism table as shown in the figure(1) and the screws P, Q and R are adjusted for the leveling of the prism table.

i. When the telescope is at positions T_1 and T_2 ,the readings of the spectrometer are $260^\circ 16'$ and $20^\circ 16'$, respectively . Note that the telescope **passes the zero** of the main scale when it is moved from T_1 to T_2. Calculate the prism angle.

.....

.....

e) To determine the minimum angle of deviation of the given glass prism, two readings are required.

i. The prism is placed on the prism table and the spectrometer is adjusted to the minimum deviation position of the prism when the slit is illuminated by a sodium lamp. Draw the ray diagram to show the minimum deviation of the ray in the figure (2). Show the positions of the telescope and the prism clearly.

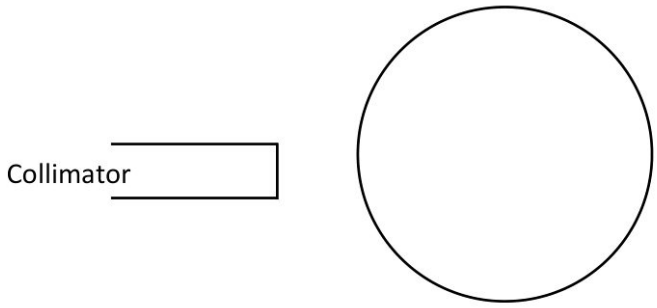


Figure (2)

ii. The two spectrometer readings for the required adjustments are $18^\circ 40' \ and \ 55^\circ 50'$ (Note that the telescope does **not passes the 360 ^{0}** of the main scale when it is moved across the two positions). Find the angle of minimum deviation (D).

.....

.....

f) If the A is the prism angle and D is the angle of minimum deviation of the prism then

i. **Write down an expression** for the refractive index (n) of the prism in terms of **A and D** .

.....

.....

ii. Determine the refractive index (n) of the glass. $(Sin\ 48°35' = 0.75)(\ Sin\ 43°35' = 0.7)$

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Provincial Department of Education- Northern Province
Third Term Examination - 2026

பௌதிகவியல்
Physics

Grade - 12 (2027)

01 | E | II (B)

Part – II (B) Structured Essay

$g = 10\ m\ s^{-2}$

Answer any two questions only

05) Figure (1) shows a metal pipe with a heavy base plate being driven into the ground by lifting a solid metal cylinder and letting it fall under gravity. This process is repeated until the pipe is pushed to the desired depth into the ground.

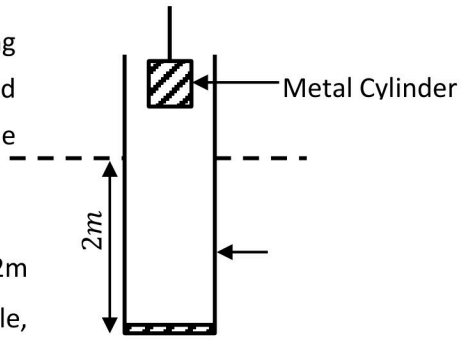


Figure (1)

Initially, the metal heavy base plate is located at a depth of 2m from the ground level. For very tall buildings to remain stable, the pillars supporting the buildings are installed vertically inside this pipe.

a) i. Give the law of **conservation of mechanical** energy.

ii. How would the metal pipe gain the **initial energy**?

iii. what is the change in **energy** in the metal cylinder just before the collision with the base of the pipe?

b) The mass of metal pipe and the mass of the metal cylinder are equal, each being 1500kg. The metal cylinder strikes the base of the metal pipe at a speed of 10 ms^{-1}

i. From what height above the base of the metal pipe is the cylinder released?

ii. A metal cylinder **loses 50%** of its kinetic energy during a collision with a metal pipe. The cylinder then sticks to the pipe, and the composite body **penetrates** 30 cm into the soil without **recoiling**.

1. What **type of collision** is this? Give reason.
2. Find the **velocity of the composite** body after the collision.
3. Find the average **resistive force** acting on the pipe as it moves downward.

iii. For the next collision of the cylinder, the composite body penetrates into the soil by the same distance, and the average **resistive force increases** to 210,000 N.

1. What is the **velocity** at which the metal cylinder strikes the metal pipe base ?
2. From what **height** above the ground level is the cylinder released?

(C) The metal cylinder is raised by an inextensible wire that passes over a smooth pulley with the help of an electric motor as shown in the figure (2). The electric motor pulls the wire with a constant force 18.05 kN. The radius of the pulley is 0.1 m and its moment of inertia is $2.5 \times 10^{-1} kg\ m^2$.

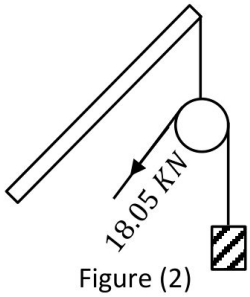


Figure (2)

i. Calculate the **linear acceleration** of the metal cylinder.

ii. If the system starts from rest find the **work done** by the electric motor in 2 seconds.

06) (a) **Draw the shapes** of the wave fronts produced by a sound source for the following instances. The speed of sound in air is V.

i. When the sound source moves to the **right** at a speed **less** than the speed of sound $(U < V)$

ii. When the sound source moves to the **left** at the **speed of sound** $(\boldsymbol{U = V})$

iii. When the sound source moves to the right at a speed **greater** than the speed of sound $(U > V)$

(b) Following the attack by Israel and America on Iran's military and nuclear-related targets on February 28, 2026, Iran retaliated with missiles and drones, after which the conflict has expanded and continues.

When there is a danger to Israel from **missiles** or **drones**, the main system used to warn the general public is the **Air Raid siren**. As soon as a missile attack is detected, the siren is sounded on a city or regional basis, and a warning system called Red Alert is also used. Additionally, the **Home front command APP**, which sends alerts to mobile phones, is also utilized.

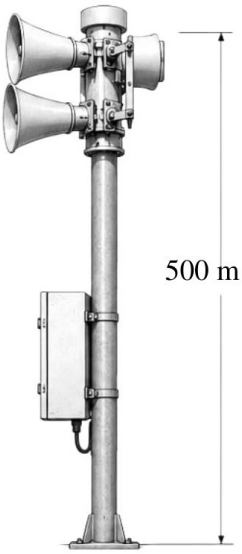


Figure (1)

This **'Red Alert'** is Israel's primary national early warning system. As soon as radar and surveillance systems detect that a missile has been launched, its trajectory and the area where it could fall are calculated within a few seconds, and warnings are issued only to the areas in danger.

In a city area of Israel, this warning siren is installed as a point sound source at a height of **500 m** from the ground. This device continuously emits sound at a constant power of **3000 W** as long as danger is present.

i. What are the **technologies** used to alert about the threat of missile or drone attacks in Israel?

ii. If a man is at a point (A) on the ground **directly below** this warning device, find the sound intensity perceived by that man. (Take $\pi = 3$)

iii. What is the **sound intensity** level perceived by the man at A? (Threshold of hearing sound intensity $I_0 = 1 \times 10^{-12} Wm^{-2}$)

iv. Another man B is on the ground at a horizontal distance of 1500 m from the man A. Find the **sound intensity** level of this sound perceived by this man B.

(c) The speed of sound in air depends on factors such as temperature and the nature of the gas. Normally, the speed of sound (V) in dry air is given by the following equation $\boldsymbol{V = 332 + 0.6\,\theta}$. Here, θ is the temperature in ^{0} C. Assume the temperature in Israel is 30 ^{0}C.

i. What is the **speed of sound** in air of Israel?

ii. What is the **time** taken for the warning sound to reach A?

iii. If the wavelength of the wave traveling in air from this sound source is **7 m**, what is the **frequency** of this warning device?

iv. A loud sound is heard from a chimney located at ground level in the area where this warning device is present.

1. What is the reason for the **loud sound** coming out of the chimney?
2. Considering the chimney as a pipe closed at one end, what is the **minimum length** of the pipe to hear this loud sound? (Neglect end correction)

(d) An aero plane sent by Iran to carry out a bombing attack in Israel is being steered by the pilot towards the warning siren in a straight path parallel to the ground at a constant horizontal speed of 125 ms^{-1}, at a vertical height of 3500 m above ground level in the area where this warning siren is located. At t = 0 s , the horizontal distance from the warning siren to the airplane is 4000 m. Find the **apparent frequency** of the warning device heard by the pilot in the aero plane at times t = 0 s, t = 32 s, and t = 64 s.

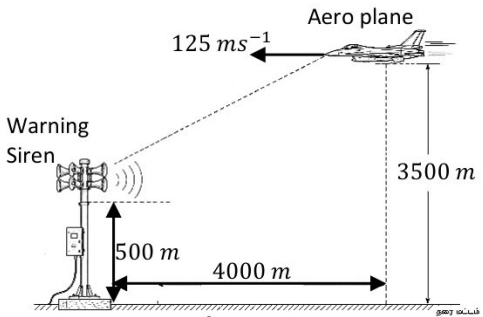


figure (2)

(e) A supersonic aero plane is traveling along a straight path parallel to the ground at a constant speed u, at a vertical height of 3500 m from the ground. The speed of sound in air in this region is v. The **Mach number M** and **Mach angle** α (half of the apex angle of the Mach cone) are defined by $M = \frac{u}{v}, \sin \propto = \frac{v}{u}$ respectively. If the Mach number of the aero plane is $\frac{2}{\sqrt{3}}$, **how much time after the aero plane passes directly above an observer on the ground will they hear the sonic boom**? (The speed of sound in the region where the aero plane flies is equal to the speed of sound on the ground)

07) (a) i. Write down the laws of **refraction of light**.

ii. Write an expression for the absolute refractive index of that medium in terms of the speed of light **propagating in a vacuum(u)**, and the speed of light propagating through the **corresponding medium (V)**.

iii. Give the critical angle C for common interface between the medium mentioned in part a(ii) and air, in terms of u and v.

iv. If the speed of a yellow laser beam in a vacuum is $3 \times 10^8\ ms^{-1}$ and the speed of yellow laser light in water is $2.4 \times 10^8\ ms^{-1}$, what is the critical angle for the yellow laser light at the air-water interface?
$(\mathbf{cos(0.8) = 36°54', sin(0.8) = 53°6'})$

v. If a yellow light laser beam has a speed of $1.8 \times 10^8 ms^{-1}$ in glass, what is the **refractive index** of glass for yellow light?

(b)

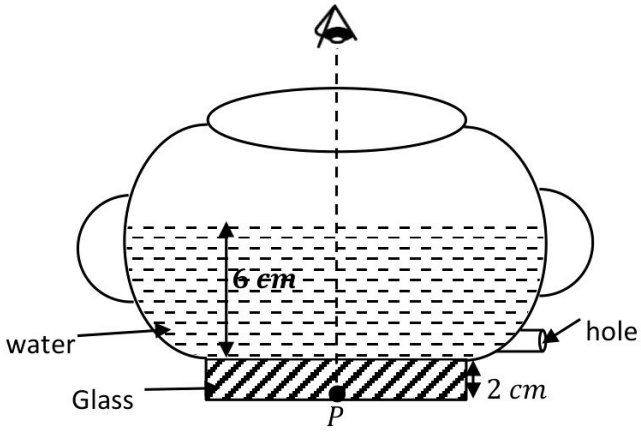


Figure *(1)*

Figure (1) shows a jar discovered among antique items from a ship that traveled from England to Sri Lanka in the past. Its bottom base is made of glass with a thickness of **2 cm**. A photograph of the Queen of England, embedded in the glass on the outer side of the base, is engraved at point P. The image of the Queen's beautiful photograph can be viewed from above the jar symmetrically along the vertical axis.

i. Show in a **ray diagram** how the image is formed, using t**wo light rays** symmetrically with respect to the vertical axis of the Queen's photograph shown in the figure.

ii. When water is filled in the jar to a height of **6 cm**, at what **depth from** the water surface will the image of the Queen appear to be to an observer **viewing** from above the jar? (The refractive indices of water and glass are $\frac{5}{4}$ and $\frac{5}{3}$ respectively)

iii. Now, the jar is filled with water up to its brim. To an observer looking from above, the beautiful photograph of the Queen **appeared to be at a depth** of **12 cm** from the water-air interface. If so, what is the **height of the jar** ?

iv. When the jar is completely filled with water, and instead of the photograph, a point luminous object emitting yellow light is placed at the bottom of the jar, a circular patch of light is seen on the water-air interface. If so, what is the **radius of this patch** of light?

(c)

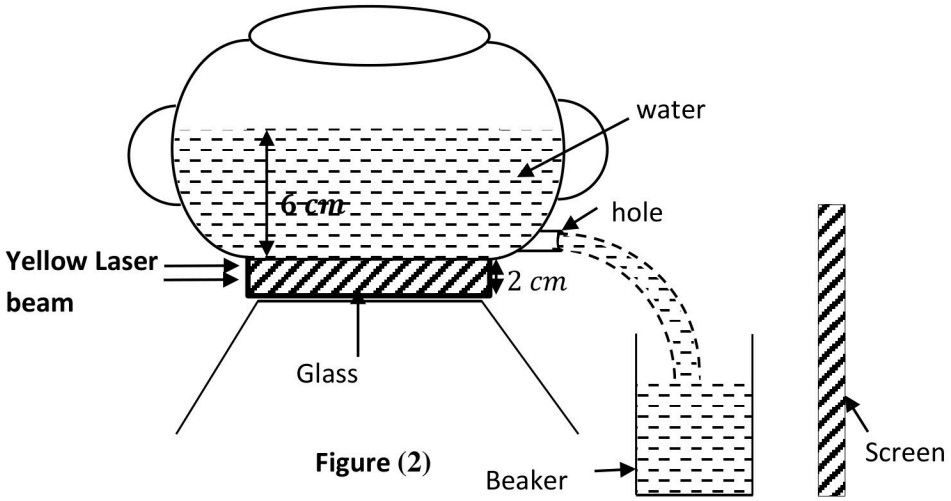


Figure (2)

As shown in Figure (2), the hole at its bottom is opened to drain water from the water-filled jar. Furthermore, water is added at the same rate at which water is being drained out. As shown in Figure (2), a yellow laser beam is directed perpendicularly into the glass section of the jar; the colour of water coming out of that hole turns yellow. The colour of water in the beaker also turns yellow. A student states that the reason for this is **total internal reflection**.

i. What is **total internal reflection**? **Explain.**

ii. Show the event that occurred above by **drawing a diagram**.

iii. When a red laser beam is used instead of the yellow light mentioned above, the aforementioned phenomenon **does not occur**. **Explain why**.

iv. What are the **fields** in which total internal reflection is used ?

08) a) i. What are the **assumptions** regarding ideal gases?

ii. Give two complications in using the ideal gas equation for real gases at **high pressure** and **low temperature** .

b) The pressure, volume, and absolute temperature of an ideal gas having a fixed mass (m) are P, V, and T respectively.

i. Draw the graph of P **against** V when the temperature remains constant.

ii. Draw the graph of V **against** T when the pressure remains constant.

(c) i. Write Boyle's law and Charles's law, and **write** the relationship between **P, V and T**.

ii. The volume of 1 mole of an ideal gas at 0 ^{0}C and a pressure of $1 \times 10^{5} Nm^{-2}$ is $22.4\ \ell$. Calculate the universal gas constant R.

(d) A horizontally placed cylindrical tube of total length **8 *l*** having a uniform cross-sectional area is divided into three sections by two thin, frictionless, thermally conducting partitions named A and B. From left to right, H_2, He , and CO_2 gases are initially trapped in each section with lengths of $2\,l, 2\,l\ and\ 4\,l$ respectively, as shown in Figure (1), at an initial atmospheric pressure of $1 \times 10^5 Nm^{-2}$ for all three gases. These gases consist of $1\ mol, 2\ mol\ and\ 3\ mol$ amounts respectively, and are initially trapped at temperatures of $600\ K, 300\ K\ and\ 400\ K$ respectively.

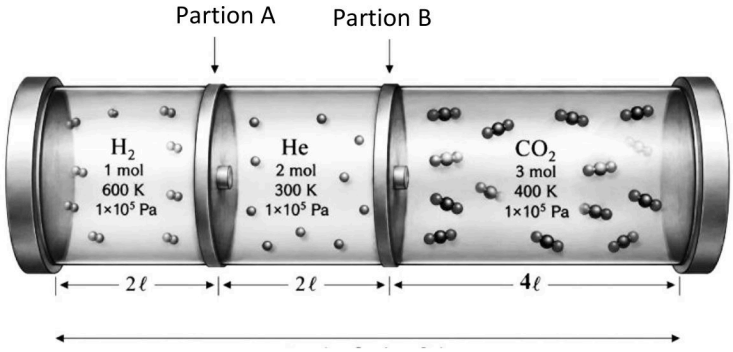


Figure *(1)*

The system is **well-insulated** to prevent any **heat exchange** with the surroundings. Since the thin partitions are good thermal conductors, the system finally reaches thermal equilibrium when these two thermal plates (A and B) move freely and **come to rest**. When these thin thermal plates move in this manner, the total **work done** by the gas system is also found to be **zero**. And also the molar heat capacity at constant volume are given as $C_v(H_2) = \frac{5}{2}R, C_v(He) = \frac{3}{2}R\ and\ C_v(CO_2) = 3R$. The expression for the internal energy is $u = nC_vT$ where T is **absolute temperature** of the gas and n is the **number of moles**.

i. Even though the pressure of the gases is initially equal, what is the **reason** for plates **A and B** to move?

ii. Give the initial **internal energy** of each gas in terms of the universal gas constant R.

iii. What is the final **equilibrium temperature** of the gas system?

iv. Find the **lengths** of each gas section after the thin plates have moved and reached equilibrium.

v. What is the pressure in the gas after reaching **thermal equilibrium**?

vi. When the thin plates move in this system, the total work done by the system is **zero**. State the reason why it is so?

vii. What is the reason for there being no change in the **internal energy** of this system**?**

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