

ගම්පහ අධ්‍යාපන කලාපය
Gampaha Education Zone

දෙවන වාර ඇගයීම - 2025
Second Term Evaluation - 2025
இரண்டாம் தவணைப் பரீட்சை - 2025

ශ්‍රේණිය Grade	13	විෂයය Subject	භෞතික විද්‍යාව II Physics II	කාලය Time	Three hours
නම பெயர் Name		අමතර කියවීමේ කාලය - මිනිත්තු 10 යි Additional Reading Time - 10 minutes			

Use additional reading time to go through the question paper, select the questions you will answer and decide which of them you will prioritise.

Important:

- ❖ *This question paper consists of 18 pages..*
- ❖ *This question paper comprises of two parts, Part A and Part B. The time allotted for both parts is three hours.*

Part A – Structured Essay

*Answer **all** the questions on this paper itself. Write your answer in the space provided for each question. Note that the space provided is sufficient for your answer and that extensive answer are not expected.*

Part B – Essay:

- ❖ *.This part contains **six** questions, which **four** are to be answered.*
- ❖ *At the end of the time allotted for this paper, tie the **two parts together** so that **Part A** is on top of **Part B** before handing them over to the Supervisor*
- ❖ *You are permitted to remove only **Part B** of the question paper from the Examination Hall.*

For Examiners' Use Only

For the Second Paper

Part	Question Nos.	Mark Awarded
A	1	
	2	
	3	
	4	
B	5	
	6	
	7	
	8	
	9 (A)	
	9 (B)	
	10	
Total		

In Number	
In Words	

Marking Examiner 1	
Marking Examiner 2	
Marks checked by	
Supervised by	

Second Term Evaluation - 2025

Grade

13

විෂයය
Subject

Physics I

කාලය
Time

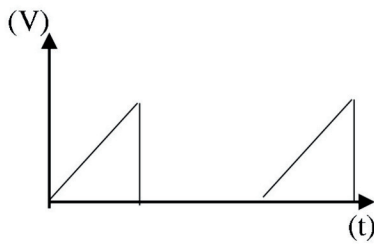
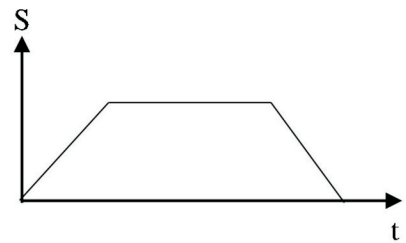
2 Hrs

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Name

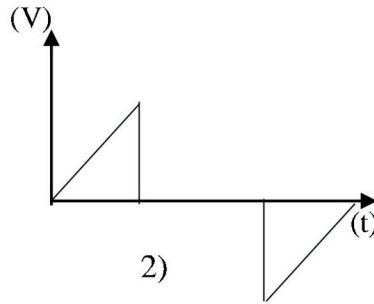
- 1)
2)
3)
4)
5)

07. Displacement (s) - time (t) graph for a particle is given,

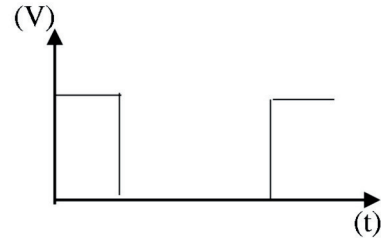
Corresponding velocity(v) - time(t) graph.



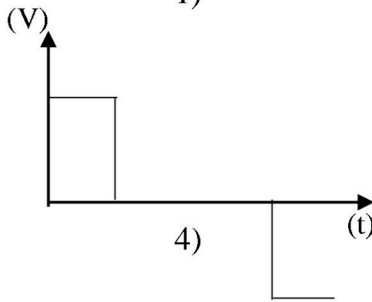
1)



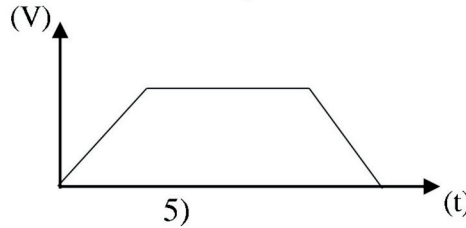
2)



3)



4)



5)

08. When two liquids A and B at 12°C and 19°C are mixed, the final temperature of the mixture is 16°C . The ratio between specific heat capacities of liquids B and A are,

1) $\frac{3}{5}$

2) $\frac{5}{4}$

3) $\frac{4}{3}$

4) $\frac{3}{2}$

5) $\frac{5}{3}$

09. Radius and gravitational field intensity on the surface of the earth are R and g respectively. When a rocket is projected vertically upward at velocity V , The maximum height is h . (Neglect air resistance) The correct statement,

1) $h = \left[\frac{R}{\frac{2gR}{v^2} - 1} \right] - R$

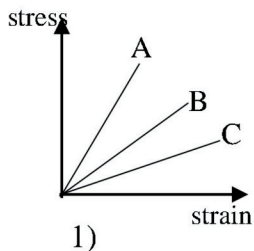
2) $h = \left[\frac{R}{\frac{2gR}{v^2} + 1} \right] - R$

3) $h = \left[\frac{R}{\frac{2gR}{v^2} - 1} \right] + R$

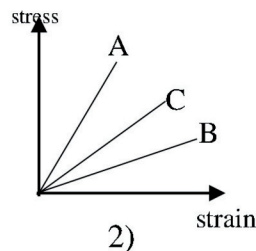
4) $h = R \left[\frac{2gR}{v^2} + 1 \right]$

5) $h = \left[\frac{R}{1 - \frac{v^2}{2gR}} \right] - R$

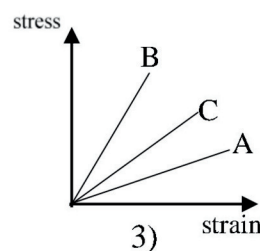
10. Three wires A, B and C having same radius and lengths are, subjected to extension in the limit of elasticity. The relation ship among their young's modulus is $E_A = 2E_B = 3E_C$, the correct variation of stress again strain.



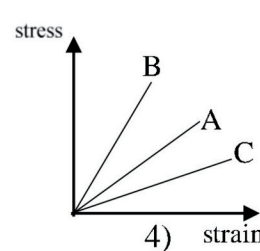
1)



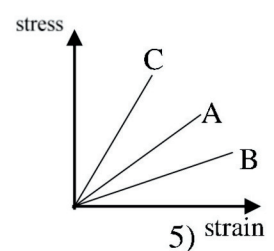
2)



3)



4)



5)

11. Lower fixed temperature and upper fixed temperature of an erroneous thermometer are -0.2°C and 99.6°C . What is the correct temperature, when this thermometer reads 30°C

1) 30.38°C

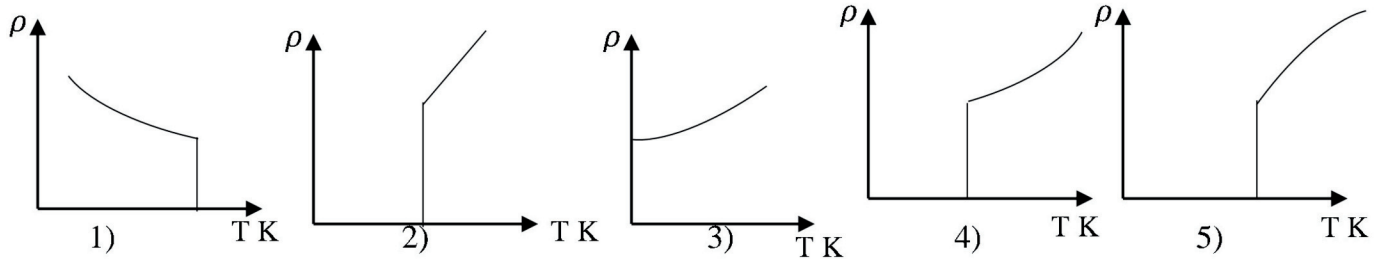
2) 30.06°C

3) 29.94°C

4) 29.74°C

5) 28.26°C

12. What is the correct variation of resistivity ρ with absolute temperature (T) for a super conductor.,



13. Frequency of tuning fork A is 256 Hz when it is sounded simultaneously with tuning fork B, it produces 15 beats in 5 seconds, when the prong of B is loaded by small amount of wax it produces 10 beats in 5 seconds. When B is sounded with a tuning fork of frequency 252 Hz, no of beats per second should be ,

- 1) 12 2) 11 3) 7 4) 6 5) 0

14. There is a circular hole in a steel plate. The fractional change of area when it is heated by 100°C is 2.4×10^{-3} . The linear expansivity of sheet is,

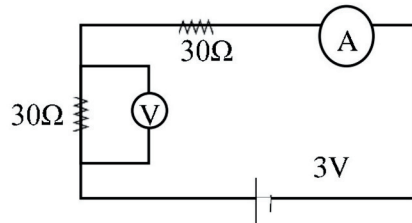
- 1) $12 \times 10^{-5} \text{ }^{\circ}\text{C}^{-1}$ 2) $1.2 \times 10^{-5} \text{ }^{\circ}\text{C}^{-1}$ 3) $1.2 \times 10^{-4} \text{ }^{\circ}\text{C}^{-1}$
4) $12 \times 10^{-4} \text{ }^{\circ}\text{C}^{-1}$ 5) $1.2 \times 10^{-6} \text{ }^{\circ}\text{C}^{-1}$

15. Angular velocity at the second hand of the clock is,

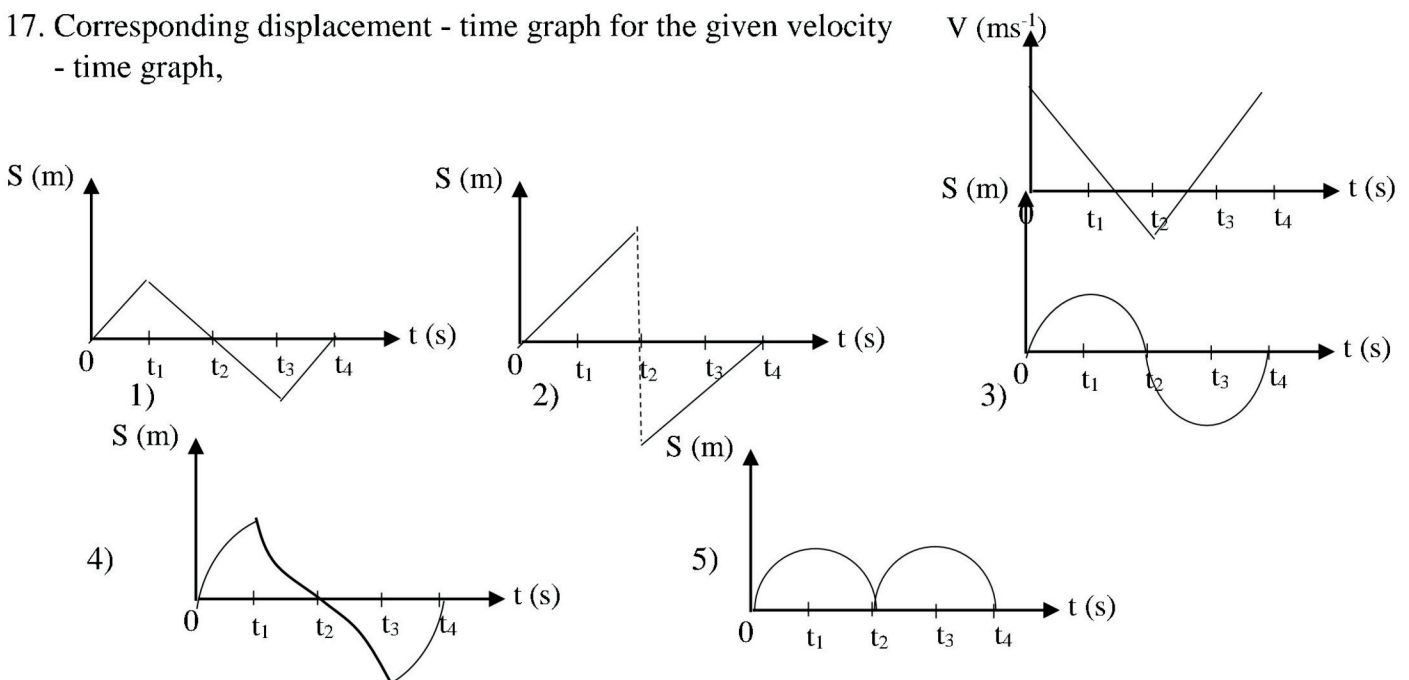
- 1) $\frac{\pi}{180} \text{ rad s}^{-1}$ 2) $\frac{\pi}{60} \text{ rad s}^{-1}$ 3) $\frac{\pi}{30} \text{ rad s}^{-1}$ 4) 60π 5) 180π

16. What are the readings of ammeter and voltmeter. when these are interchanges in the circuit given in figure. ((A) and (V) are ideal)

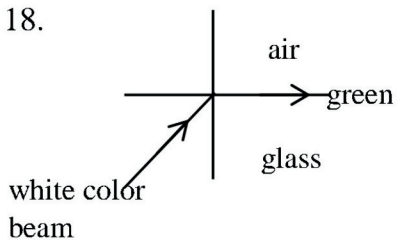
- 1) 0 A, 0 V 2) 0 A, 1.5 V
3) 0.05 A, 1.5 V 4) 0A, 3V
5) 0.05A, 3V



17. Corresponding displacement - time graph for the given velocity - time graph,



18.



When a beam of white colour light falls on the interface of glass and air. green colour light goes along the interface light of colour reflected totally. Speed of blue and red light in glass are $1.96 \times 10^8 \text{ ms}^{-1}$ and $1.99 \times 10^8 \text{ ms}^{-1}$ respectively.

1) Blue, Violet

2) Blue, Green, Yellow

3) All colours

4) Yellow, Orange, Red

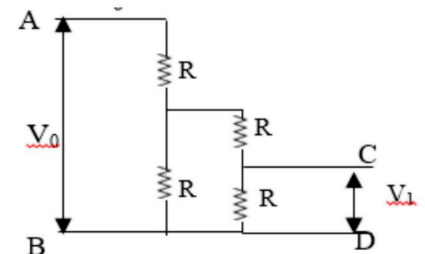
5) All colours except green

19. If potential difference between A and B is V_0 and potential

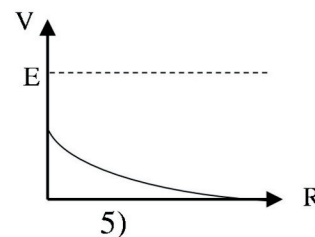
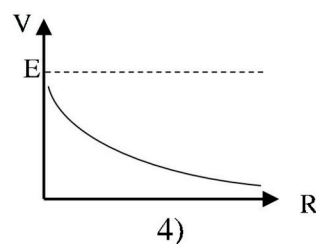
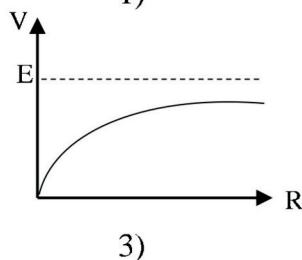
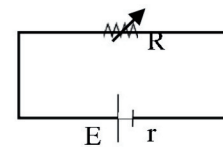
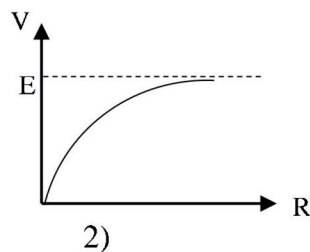
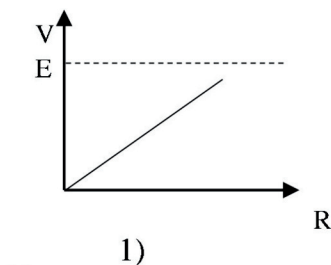
difference between C and D is V_1 then $\frac{V_1}{V_0}$

1) $\frac{2}{5}$ 2) $\frac{1}{5}$ 3) $\frac{5}{2}$ 4) $\frac{2}{3}$

5) 0



20. In the circuit given in figure, the electromotive force and internal resistance of cell are E and r respectively. What is the correct variation of potential difference, across the terminals of a cell, with external resistance R .

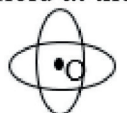


21. Information for three rods A, B and C are given A compound rod is made by connecting three rods in series The young's modules of compound rod is,

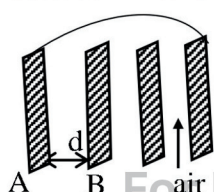
1) $\frac{y}{8}$ 2) $\frac{8y}{7}$ 3) $\frac{8y}{5}$ 4) y 5) $\frac{5y}{4}$

rod	length	young's modules
A	l	$2y$
B	l	y
C	$2l$	$2y$

22. Two concentric circular rings having radius R of each are placed in two perpendicular plane. frequency of rotation of two charges q in two rings is f . Flux density of induces magnetic field at the center is,

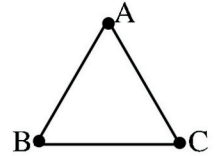
1) $\frac{\mu_0 q f}{2R}$ 2) $\frac{\mu_0 q f}{2\pi R}$ 3) $\sqrt{2} \frac{\mu_0 q f}{2\pi R}$ 4) $\sqrt{2} \frac{\mu_0 q f}{2R}$ 5) $\frac{\mu_0 q f}{\pi R}$ 

23. Four parallel plates each having area A and having same gap d are placed in air the equivalent capacitance between A and B.,

1) $\frac{A\epsilon_0}{3d}$ 2) $\frac{2A\epsilon_0}{3d}$ 3) $\frac{3A\epsilon_0}{2d}$ 4) $\frac{A\epsilon_0}{2d}$ 5) $\frac{3A\epsilon_0}{4d}$

24. Three point charges $20\ \mu\text{C}$, $40\ \mu\text{C}$ and $30\ \mu\text{C}$ are placed on vertices of ABC equilateral triangle of length 10.0 cm. Potential energy of the system ($\frac{1}{4\pi\epsilon_0} = 9 \times 10^9\ \text{Nm}^2\text{C}^{-2}$)

1) 54 J 2) 108 J 3) 234 J 4) 72 J 5) 180 J



25. P-V- curves for four thermodynamic process (1, 2, 3, 4) are given in figure. Consider following statement made regarding the heat absorbed by the system Q and work done by the gas W and change of internal energy u.

(A) $W_1 > W_2 > W_3 > W_4$

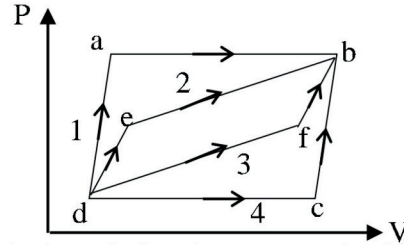
(B) $Q_2 - W_2 > Q_3 - W_3$

(C) $Q_1 - Q_4 = W_1 - W_4$

(D) $Q_1 > Q_2 > Q_3 > Q_4$

true statement / statements,

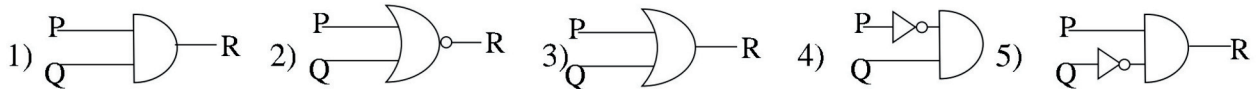
1) Only B 2) Only C 3) B and D only 4) A and C only 5) A, C and D only



26. When one end of lagged rod of length l, radius r and thermal conductivity K is placed in steam bath and other end is placed in ice bath the rate of melting ice is $0.1\ \text{g s}^{-1}$. What should be the rate of melting ice when and another rod having length $l/2$ radius $2r$ and heat conductivity $k/4$ is used

1) $0.1\ \text{g s}^{-1}$ 2) $0.2\ \text{g s}^{-1}$ 3) $0.8\ \text{g s}^{-1}$ 4) $1.6\ \text{g s}^{-1}$ 5) $3.2\ \text{g s}^{-1}$

27. P and Q are two inputs and R is the out put for a logic gate, When $P = 1$, $Q = R$ and when $P = 0$, $R = 0$ that logic gate should be,

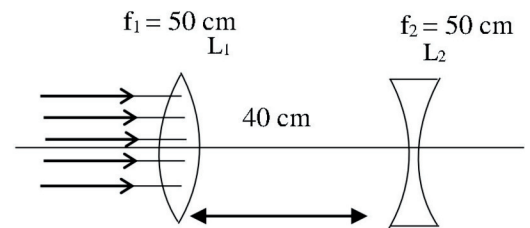


28. A vehicle moving under the steady velocity takes 50 s to travel between two posts located 600 m apart. If the velocity of vehicle when it passes 1st post is $9\ \text{m s}^{-1}$ then velocity of vehicle when it passes the second post is,

1) $12\ \text{m s}^{-1}$ 2) $13\ \text{m s}^{-1}$ 3) $15\ \text{m s}^{-1}$ 4) $18\ \text{m s}^{-1}$ 5) $2\ \text{ms}^{-1}$

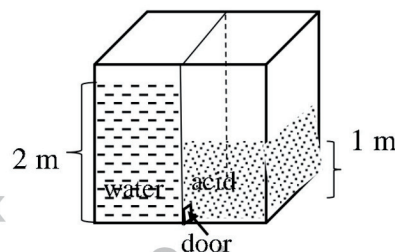
29. A convex lens and concave lens each having focal length 50 cm are placed co-axially 40 cm apart when a parallel beam of light falls on the convex lens, the final image ,

1) Real and 22.2 cm from L_2
 2) Virtual and 22.2 cm from L_1 .
 3) Real and 12.5 cm from L_2
 4) Virtual and 12.5 cm from L_2 .
 5) Virtual and 10 cm from L_2



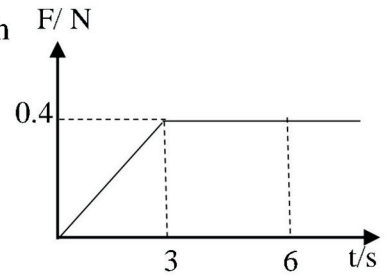
30. A tank having rectangular cross section is separated in to two chambers using a vertical wall. There is a small hole closed by a door of $4\ \text{cm} \times 4\ \text{cm}$. Water is filled up to 2 cm in one chamber and acid of relative density 1.2 is filled 1 m up to in other chamber. Magnitude and direction of the required force to prevent opening the door. (density of water $1000\ \text{kg m}^{-3}$)

1) 6.4 N towards and from water
 2) 12.8 N towards acid from water
 3) 6.4 N towards water from acid
 4) 12.8 N towards water from acid
 5) 16 N towards water from acid



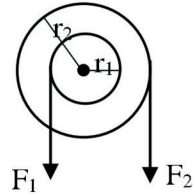
31. Variation of force applied on a block of mass 5 kg placed on smooth horizontal surface with time is given in figure velocity after 6 s is,

- 1) 0.18 m s^{-1} 2) 1.8 m s^{-1} 3) 0.27 m s^{-1}
4) 0.36 m s^{-1} 5) 3.6 m s^{-1}



32. Masses and radii of two co-axial pulleys are m_1 and m_2 and r_1 and r_2 respectively. As shown in figure two tangential forces F_1 and F_2 are applied as shown in figure. The angular acceleration of the system (moment of inertia of the system is $I = \frac{1}{2} m r^2$)

- 1) $\frac{2(F_2 r_2 + F_1 r_1)}{m_1 r_1^2 + m_2 r_2^2}$ 2) $\frac{F_2 r_2 - F_1 r_1}{m_1 r_1^2 + m_2 r_2^2}$ 3) $\frac{(F_2 r_2 - F_1 r_1)^2}{m_1 r_1^2 + m_2 r_2^2}$
4) $\frac{2(F_2 r_2 - F_1 r_1)}{m_1 r_1^2 + m_2 r_2^2}$ 5) $\frac{(F_2 r_2 - F_1 r_1)}{2(m_1 r_1^2 + m_2 r_2^2)}$

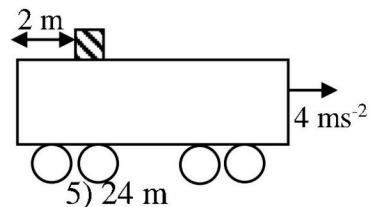


33. Specification of filament bulb is 24 W and 12 V. Amount of charge flown in the period of 5 minutes,

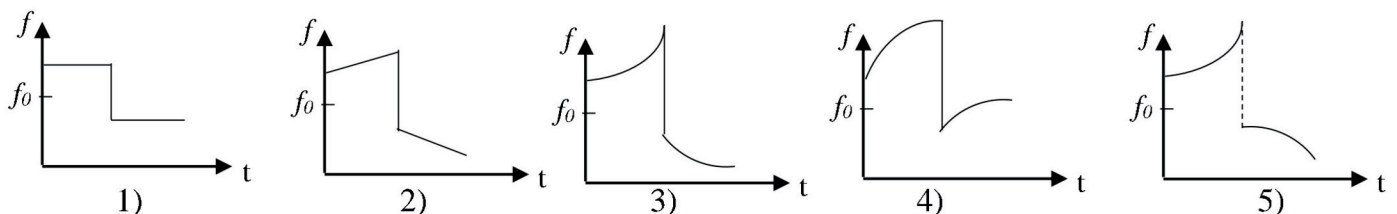
- 1) 2C 2) 600 C 3) 3600 C 4) 120C 5) 1200C

34. A block of mass 5 kg is placed on trolley 2 m before the back end of trolley. coefficient of friction between trolley and the block is 0.3. Trolley is moving horizontally along the path at acceleration 4 ms^{-2} . The displacement of the trolley When block falls down from the trolley.

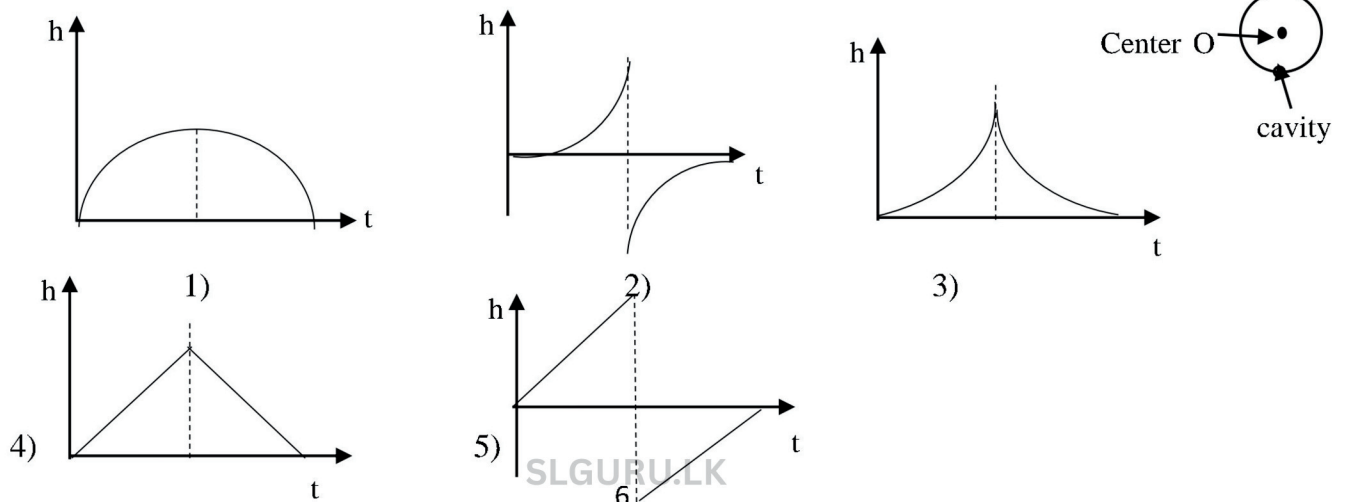
- 1) 4 m 2) 8 m 3) 16 m 4) 20 m



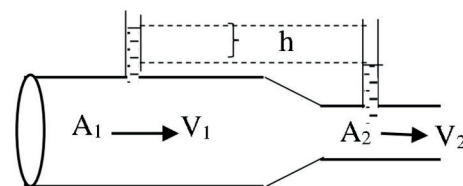
35. Train is moving a straight track of outstand acceleration and moving towards stationary observer standing on platform and passes him. the correct variation of observed frequency with time t ,



36. A spherical shell having cavity n is hung by using a light string and has been completely filled by water. From the small hole, located at the bottom, water is ejected at constant rate. The correct variation of the position of the center of gravity with time with respect to O,



37. Incompressible fluid flows along the, non uniform horizontal tube, having cross sectional area A_1 and A_2 at velocities. V_1 and V_2 receptivity, Height difference between liquid columns in two vertical arms is h . consider following statements.

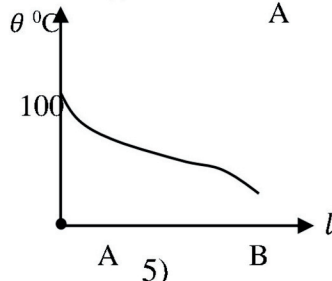
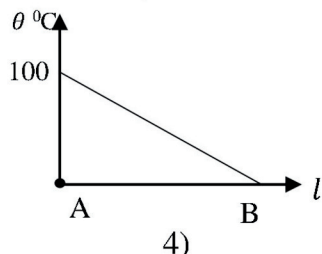
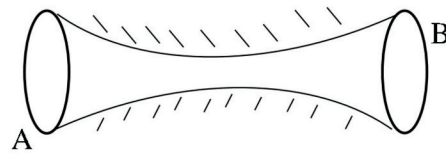
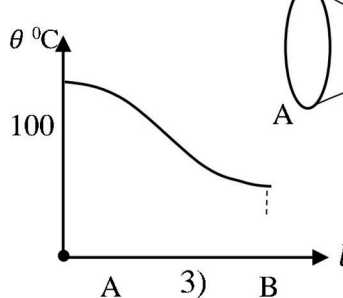
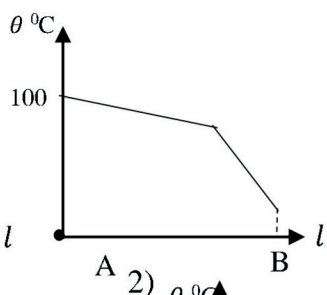
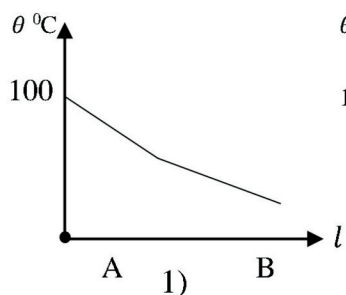


- (A) Rate of volume flow is $A_1 V_1$
 (B) Total energy of unit mass is constant in both tubes
 (C) $V_2 - V_1 = \sqrt{2gh}$
 (D) $V_2^2 - V_1^2 = 2gh$

True statements

- 1) A and B only 2) A and D only 3) A, B and C only
 4) A, B and D only 5) B,C and D only
38. Object of mass m , moving at steady velocity at u on the horizontal plane and hits on an another object of mass nm , which is at rest. The ratio between kinetic energy gain by the object of mass nm after the collision and initial kinetic energy of the system,
- 1) $\frac{n}{(n+1)^2}$ 2) $\frac{4n}{(1+n)^2}$ 3) $\frac{4n}{(n-1)^2}$ 4) $\frac{2n}{(n+1)^2}$ 5) $\frac{6n}{(n+1)^2}$
39. Density of ice at 0°C is $d \text{ kg m}^{-3}$ and density of water is $\rho \text{ kg m}^{-3}$. Change of volume ΔV , when "m" mass of ice is completely converted into water,
- 1) $\frac{m}{\rho-d}$ 2) $\frac{m(\rho-d)}{\rho d}$ 3) $\frac{m(\rho-d)}{\rho+d}$ 4) $\frac{m\rho d}{\rho-d}$ 5) $\frac{m(\rho+d)}{\rho d}$
40. Efficiency of a step up transformer is 100% . In its primary and secondary coil.
- 1) Current same 2) No.of turns same 3) Voltage same
 4) Power same 5) Resistance same
41. Two identical waves having frequency 20 Hz moving in opposite direction at velocity 60 mm s^{-1} produces a stationary wave. The distance between two adjacent nodes.
- 1) 1 mm 2) 1.5 mm 3) 3.0 mm 4) 3.5 mm 5) 4.5 mm
42. Electro - magnetic wave of frequency f and wave length λ moving in air at speed C enters into a medium having refractive index n . frequency wave length and speed of wave in medium.
- 1) $f, \lambda, \frac{C}{n}$ 2) $\frac{f}{n}, \frac{\lambda}{n}, \frac{C}{n}$ 3) $f, \frac{\lambda}{n}, c$ 4) $\frac{f}{n}, \lambda, \frac{C}{n}$ 5) $f, \frac{\lambda}{n}, \frac{C}{n}$
43. Property, which is shown by both waves and particles.
- 1) Interference and refraction 2) Diffraction and interference
 3) Diffraction and refraction 4) refraction and reflection
 5) Diffraction and refraction
44. Radius of the earth is R , Two satellites A and B are located in two orbits of radius $3R$ and $4R$. If the periodic time for both satellite is same the ratio between acceleration of A and acceleration of B,
- 1) $\frac{3}{2}$ 2) $\frac{9}{4}$ 3) $\frac{16}{9}$ 4) $\frac{4}{9}$ 5) $\frac{16}{7}$

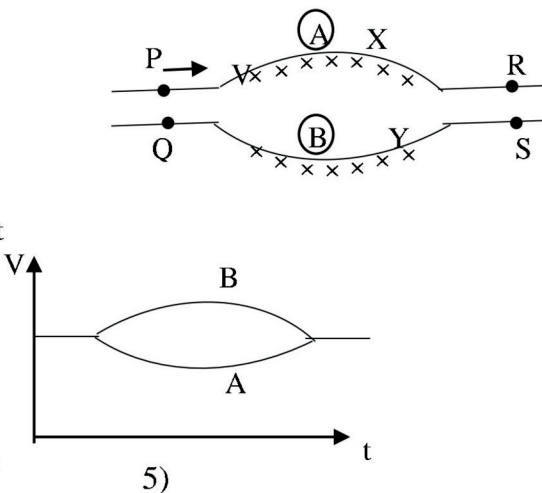
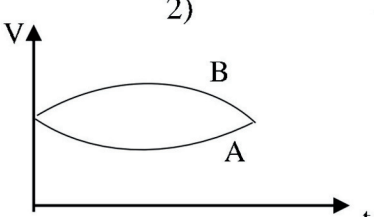
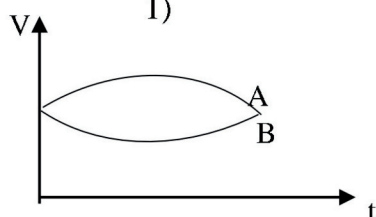
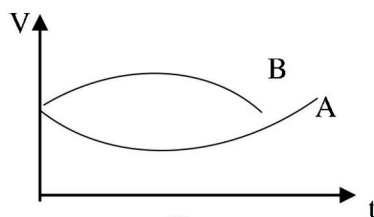
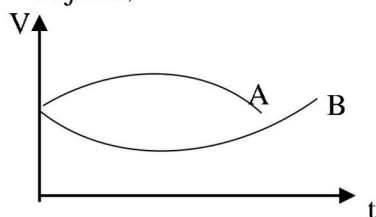
45. AB is a uniform lagged rod. Temperature at A and B are 100°C and 25°C . The correct variation of temperature along the axis at steady state,



46. Terminal velocity V_0 for a solid sphere moving in viscous fluid having very small density. If there is an internal cavity, terminal velocity of object is same medium is $\frac{V_0}{3}$, The ratio between volume of cavity and total volume of sphere is,

- 1) $\frac{1}{9}$ 2) $\frac{1}{3}$ 3) $\frac{1}{2}$ 4) $\frac{3}{1}$ 5) $\frac{2}{3}$

47. A and B two identical balls are entering into two smooth paths X and Y at points P and Q. Initial velocities of A and B are same, and both objects pass points R and S. Velocity - time graph for both objects,

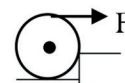


48. At 27°C speed of sound in air 300 m s^{-1} , speed of sound in air when the absolute temperature is increased by 21%,

- 1) 311 ms^{-1} 2) 321 ms^{-1} 3) 330 ms^{-1} 4) 345 ms^{-1} 5) 363 ms^{-1}

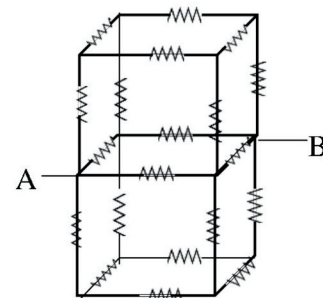
49. The minimum force F should be applied horizontally, to lift a cylinder of mass M and radius R from the edge of height $R/2$,

- 1) $\frac{Mg}{3}$ 2) $\frac{2}{3} Mg$ 3) $2 Mg$ 4) $\frac{\sqrt{3}}{2} Mg$ 5) $\frac{Mg}{\sqrt{3}}$

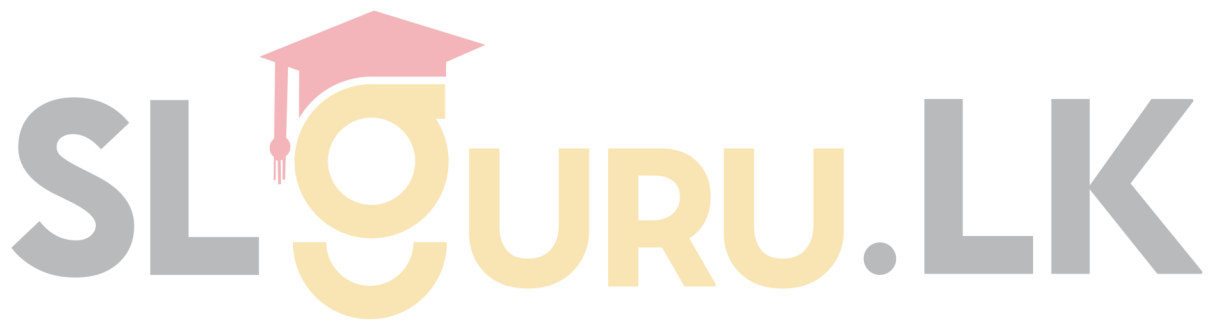


50. In the network given in figure there are 20 resistors each having resistance R . The equivalent resistance between A and B,

- 1) $R/2$ 2) $3R/5$ 3) $3R/4$ 4) R 5) $3R/2$



“Knowledge is power.” – Francis Bacon



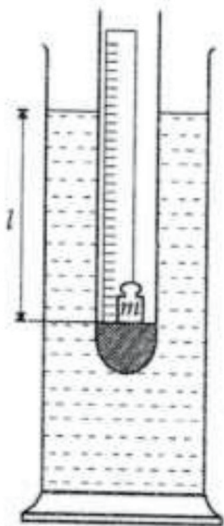
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($g = 10 \text{ N kg}^{-1}$)

- a)



-
-
-
-
-

- ii. The physical quantities used in this system can be named as follows.

L – length of the cylindrical portion immersed in the liquid when the tube floats in a liquid

A —

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iv. Write down an expression for the upthrust force acting on this boiling tube.

.....

.....

.....

v. Construct a suitable equation to find the density of liquid using a graphical method.

.....

.....

.....

vi. Name the independent and dependant variables of the graph you wish to create.

.....

.....

b) To find the density of the liquid, the value of the gradient calculated from the graph is not enough. For that, you need to calculate A.

Below are some readings obtained from the instrument you used in (a)(ii) above to calculate the value of A.

i. 3.01 cm, 3.00 cm, 3.00 cm, 2.99 cm. What is the least count of the instrument that obtained these readings ?

.....

.....

ii. If the gradient of the graph created above is 1.48, what is the density of the liquid?

.....

.....

.....

.....

c) A hydrometer can be defined as an instrument that can be used to find the density of a liquid. It can measure the density of a liquid at once.

i. A hydrometer is floated vertically in a liquid in such a way that it remains in equilibrium under two forces. Name those two forces.

.....

.....

ii. Name the points where these forces act.

.....

.....

iii. Explain the positions of the 2 forces you presented in (c)(ii) above when the hydrometer is raised vertically in the liquid.

.....
.....

iv. When a hydrometer is immersed vertically in a liquid, there is an inverse relationship between the height of the hydrometer immersed in the liquid and the density of the liquid. Draw a rough graph of the height of immersion against the density of the liquid.



2) You are provided with the following materials for an experiment to find the specific heat capacity of iron balls using the method of mixtures.

A calorimeter, a boiling tube, a quantity of iron balls, a tripod with a wire gauze, a beaker with water, a stirrer , A piece of asbestos

a)

i. Name the measuring instruments that are not provided for the experiment but are essential for it, and name the physical quantity they measure.

.....
.....

ii. Draw the experimental setup you arranged and name it.



The piece of asbestos

iii. What is expect by using a wire gauze here?

.....

iv. The calorimeter should also be prepared for the experiment by applying heat to the iron balls. Write down the list of measurements that you would take before adding the iron balls to the calorimeter.

m

m_0

θ_1

v. When heat is applied to the iron balls, the iron balls will reach a maximum temperature. How would you verify this?

.....

b) After adding iron balls to the calorimeter , you should take the measurements of mass and temperature.

i. State in few steps how to do it.(your measurements are θ_2 and m_2)

.....

ii. Before adding the iron balls, you should pay more attention to the amount of water filled to the calorimeter. What does this mean?

.....

iii. The iron balls should be added to water very quickly and very carefully. What does that mean?

.....

iv. Write down an expression for the specific heat capacity of iron balls (C_{Fe}) by taking the specific heat capacity of water is C_w and the specific heat capacity of copper is C_{cu} .

.....

c)

- i. During the experiment period, the calorimeter will lose heat to the environment. Suggest a method to minimize this heat loss.

.....

.....

.....

.....

- ii. What is the main assumption you made in the calculation in (b) (iv) above?

.....

- 3) The speed of sound in air and the end error can be calculated by using a closed tube and a set of tuning forks. Some of the instruments used for this purpose are given below.

A tube of diameter about 2.5 cm and length about 50 cm, a tall jar, water, a stand, cotton wool, a set of tuning forks

a)

- i. If there are any measuring instruments and devices required for this experiment but not mentioned here, name them.

.....

.....

- ii. Draw a diagram of the setup prepared for this experiment in the space provided below. Name it.

- iii. You must select atleast 5 tuning forks from the set of tuning forks given for the experiment. How do you select tuning forks by frequency? What is the reason for that?

.....

.....

.....

.....

iv. According to the tuning forks you have chosen, what is the most important test you have to do before starting the experiment?

.....
.....

v. What do you expect by using a tube open at both ends?

.....
.....

b)

i. In setting up the experimental setup the tube open at both ends is completely immersed in water and then gradually raised up. What do you expect by completely submerging the tube?

.....
.....

ii. A vibrating tuning fork is placed along the top of the tuning fork and the sound emitted through the tube is heard. Draw how you would place the tuning fork in the arrangement (a)(ii).

iii. You should use the small amount of cotton wool provided. How do you use it and what is the expected result from that?

.....
.....

iv. Name the wave pattern that produced in the resonance tube in this experiment. Draw the wave pattern and the end correction (e) in that.

.....

c)

i. Write down an expression for the wavelength of the wave produced in the tube. (the vibration length is l and end error is e)

.....
.....

ii. Take speed of sound in air as v and frequency of a tuning fork as f . Write down an expression to find the speed of sound in air (v) and end error (e) by using a graphical method.

.....
.....

iii. Draw a rough sketch of the graph that you would expect in this experiment.



iv. If the gradient of the graph is m and the intercept is c , obtain values for the speed of sound and end error.

.....

.....

.....

v. In this experiment, the sound of intensity of the initial vibration length seemed to decrease for later tuning forks. What is the reason for this?

.....

.....

vi. Can a liquid such as kerosene or alcohol be used instead of water. Explain your answer.

.....

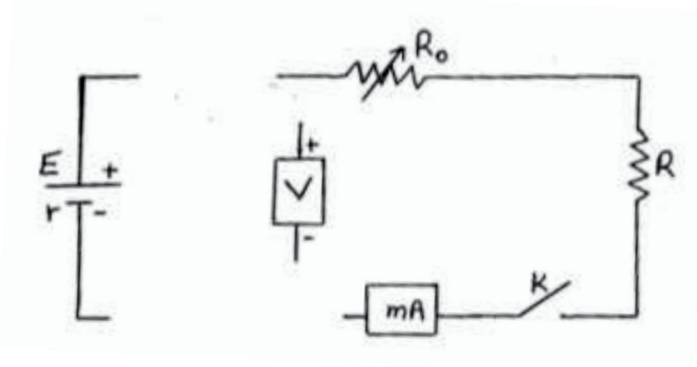
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4)

a) An incomplete circuit diagram designed to determine the electromotive force (E) and the internal resistance (r) of a given cell is shown below.

i. Complete the circuit diagram correctly.



ii. Define the electromotive force of a cell.

.....

.....

iii. Name the type of the key K used in the circuit.

.....

iv. Give the reason for selecting the key.

.....

.....

v. Name R_0 and R here.

.....

.....

vi. What is expected from using this resistor R.

.....

.....

.....

b)

i. Mark the polarity in the ammeter used.

ii. By varying the value of R_0 , the miliammeter reading (T) and the voltmeter reading (V) are obtained at that time. Obtain a suitable equation to find the E and r using a graphical method.

.....

.....

.....

iii. Draw a rough sketch of the graph expected.



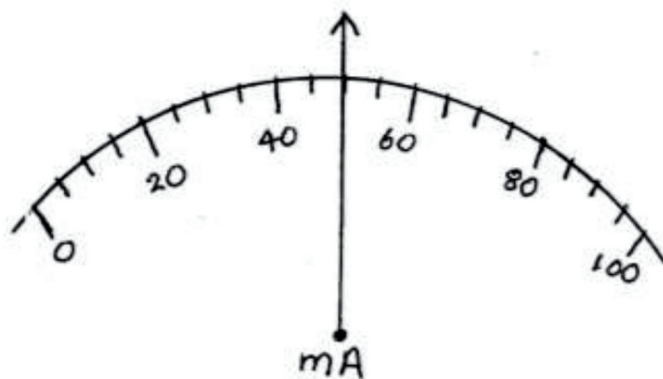
iv. Present the electromotive force and internal resistance using the gradient and the intercept of the graph you created.

.....

.....

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c) Readings for the current in the above experiment were as shown in the figure below.



i. Write down the mA reading shown here.

.....

ii. Write down the fractional error of this reading.

.....

.....

Part B – Essay
Answer four questions only.
($g = 10 \text{ N kg}^{-1}$)

5. a) A space station has been established in space at an altitude of 400 km above the Earth and it rotates around the Earth.

A rocket carrying astronauts travels towards this space station. This rocket consists of a section with two primary combustion engines, a center section with four secondary combustion engines and a pre-shuttle with lateral balancing engines.

This rocket will launch from a platform created on earth. The rocket, with only the primary combustion engine firing, is carried up to a distance of 90 km to the thermosphere, which is considered the edge of the Earth's atmosphere. The time taken for that is 120 s. At the same time the primary combustion engine is turned off and the rocket travels at a constant speed for 5 s.

Here, a planned explosion in the thermosphere causes the booster to separate from the rocket and travel upward at a velocity of 800 ms^{-1} relative to the ground. The primary combustion engine has a mass of 4000 kg, and this primary and secondary engine will provide the necessary thrust force for the rocket. The rocket then moves at a constant speed for another 2 s and operate all four secondary combustion engines simultaneously. This secondary engine takes the rocket to a distance of 350 km above the Earth's surface. The center section also then separates from the rocket with an explosion and becomes stationary relative to the ground. This engine also has a mass of 4000 kg. After traveling at a uniform velocity for another 2 s, the lateral balancing engines are activated and the shuttle reaches orbit. Mass of the shuttle is 24 000 kg. This engine operates to reach the required orbital velocity of 8500 ms^{-1} . The lateral balancing engines then move along the orbit, maintaining a speed of 8500 ms^{-1} , with control as needed, until they reach the space station.

A velocity-time graph can be created for the entire motion of the shuttle, ignoring the change in velocity caused by mass loss due to fuel combustion as the rocket accelerates. It is given below.



- i. If the velocity is V_1 when it reaches the thermosphere, what is its value?
- ii. What is the acceleration given to the rocket by the two primary combustion engines?
- iii. If the velocity of the shuttle after support is removed is V_2 , what is the value of it?
- iv. What is the acceleration given to the rocket by secondary combustion engines?
- v. Calculate the velocity (V_4) of the shuttle after the secondary combustion engine is released.
- vi. Calculate the acceleration given to the rocket by pre-shuttle with lateral balancing engines.
- vii. Calculate the time taken for the rocket to reach the orbit.

b) The rocket builds thrust by releasing gas produced by a reaction between liquid O_2 and liquid H_2 at high speed through a nozzle. When a rocket of mass m is moving upwards with a velocity u , a mass of air Δm is thrown downwards with a velocity V relative to the rocket in a very small time Δt . Thus the rocket obtains a velocity V_0 relative to earth. (Ignore the effect of gravity during the time Δt)

- i. What is the velocity at which the air moves downward relative to the ground? ($V > V_0$)
- ii. Obtain an equation for the velocity change of rocket using the conservation of linear momentum.
- iii. If $m \gg \Delta m$, Write an expression for the thrust force exerted on the rocket using Newton's second law of motion.

6.

a) Angular magnification and linear magnification are important in optics. But angular magnification is most commonly used when considering the images of objects formed by optical instruments. Therefore, when compared to linear magnification, angular magnification is considered as a better measurement of the magnification provided by an optical instrument.

- i. What is "linear magnification"?
- ii. As mentioned above, explain why the angular magnification is considered as a better measurement than linear magnification.
- iii. When considering the image formed by an optical instrument, the most suitable position to place the eye to observe a sharp and clear image is eye ring. Define the eye ring.

b) A compound microscope is an optical instrument used to magnify and observe a very small object.

- i. Write down an expression for the magnifying power (M) of a compound microscope as an optical instrument.
- ii. Take the focal length of eyepiece lens as f_e and focal length of objective lens as f_o . Derive an expression for the magnifying power or angular magnification for a compound microscope at normal adjustment by taking the least distance of distinct vision as D ($D=25\text{cm}$).

- iii. A compound microscope uses two convex lenses of focal lengths 2.0 cm and 2.0 mm. Here, an object placed 2.5 mm from the objective lens is expected to be observed during normal adjustment.
- 1) What is the image distance (v_0) for the image formed by objective lens?
 - 2) Find the object distance (u_e) for objective lens.
 - 3) Calculate the linear magnification of the objective and the linear magnification of the eyepiece for this situation.
 - 4) What is the angular magnification for the compound microscope?
 - 5) What is the length of the microscope tube?
 - 6) Find the location of the eye ring.

7.

When a solid spherical particle moves downward in a viscous fluid, the fluid will oppose its motion by a force called fluid friction. This force is described by Stokes' law.

- a) i. Write an equation for the viscous force acting on a solid spherical particle in a viscous fluid. Identify it's all terms.
 - ii. There are several assumptions used in deriving the equation you presented above. Write two of them.
 - iii. A spherical particle of density d and radius r is submerged in a liquid of density ρ and then released. $\rho > d$. The coefficient of viscosity of the liquid is η . The terminal velocity acquired by this particle as it rises through the liquid is V_0 . Derive an equation for the terminal velocity. (Ignore the change in pressure as the particle rises)
- b) After reaching the free liquid surface, this particle will move vertically under gravity. Consider that the viscous force exerted by the atmosphere is negligible.
- i. The particle moves under gravity after released from liquid surface. Derive an expression for the maximum height it travels.
 - ii. Calculate the time taken for this particle to return to the liquid surface.
 - iii. Show the variation of velocity with time for a particle rising up through the liquid using a graph.
 - iv. If the spherical particle, which falls back to the liquid surface as mentioned in (b)(ii) above, repeatedly undergoes several such motions in the liquid and floats on the liquid surface, plot the displacement-time graph related to its motion.
- c) If the average radius of an air bubble coming up through the above liquid is $r = 0.1$ mm, density of the liquid $\rho = 900 \text{ kg m}^{-3}$, density of air inside the bubble $= 1.25 \text{ kg m}^{-3}$ and coefficient of viscosity of the liquid is $\eta = 7.5 \times 10^{-2} \text{ N s m}^{-2}$, obtain a value for the terminal velocity. ($g = 10 \text{ ms}^{-1}$)

8. A capacitor is a device that can store electric charges. Here, the electric field is the mechanism by which the capacitor stores energy. Capacitors are widely used in electric circuits. Because the electrical energy stored in capacitors can release very quickly.

Conductors are used to store electric charges, and also this device is designed to store a large amounts of electric charges in a very small space.

The flash lamp in a camera is activated by the rapid discharge of electrical energy stored in a capacitor.

Applications of capacitors are providing a backup power to the computers during power outages, used in tuning circuits in radio, used in motor vehicles for managing voltage spikes.

A capacitor made of two conducting plates placed parallel to each other is called a parallel plate capacitor. Such a capacitor can be charged using a battery.

When the capacitance of the capacitor is C , the distance between the plates is d , and the area of a plate A , the capacitance of the capacitor is expressed as $C = \frac{\epsilon A}{d}$. Here ϵ is the permittivity of the medium between plates. When the medium between the plates is air or a vacuum, the permittivity of the medium is denoted by ϵ_0 . The charge (q) on one plate of such a capacitor is inversely proportional to the potential difference between the plates.

a)

- i. What is the reason for using capacitors in electric circuits?
- ii. State two situations where capacitors used in practice.
- iii. Draw a circuit you have designed to charge a capacitor.
- iv. Name the items you used there.
- v. Plot a graph to show the amount of charge stored in a capacitor when charging with time.

b)

- i. Write down the gauss law.
- ii. Write down an expression for the capacitance of a capacitor using potential difference and charge.
- iii. Derive an expression for the electric field intensity (E) in the space between the plates of a capacitor using the gauss law.
- iv. Thus, Show that the capacitance of a parallel plate capacitor is given by the expression $C = \frac{\epsilon A}{d}$.
- v. Derive an expression for the potential energy stored in a capacitor .

- c) A parallel plate capacitor is created by placing two circular metal plates of radius 9 cm and 9 mm apart. This is charged by a potential difference of 100 V. The space between the plates is filled with air. (permittivity of air, $\epsilon_0 = 8.85 \times 10^{-12} \text{ Fm}^{-1}$)

- i. Find the capacitance of capacitor. ($\pi = 3$)
- ii. What is the charge of a capacitor?
- iii. Find the electrical potential energy of a capacitor.

9. Answer only Part A or Part B.

A.

a)

- Write down the kirchhoff's law of electricity.
- This law express the conservation of charges and conservation of energy . Explain.
- A compound cell is formed by connecting two cells of electromotive force E_1 and E_2 with internal resistance r_1 and r_2 respectively, in parallel. If the equivalent internal resistance of this compound cell is r , write an expression for r in terms of r_1 and r_2 . From that, write an equation for the equivalent electromotive force (E).
- When using cells for electrical circuits, it is preferable to use a large number of similar cells connected in parallel to each other instead of using a single cell. Explain this.

b) Here R is a temperature sensitive resistor. The ammeter is perfect. The internal resistance of the cells is zero.

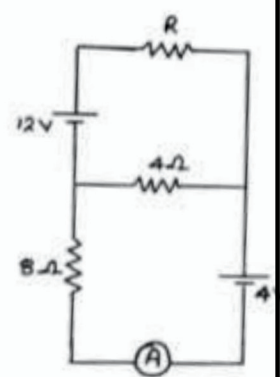
i. If the room temperature is 27°C , the ammeter reading is zero. Calculate the value of R here.

ii. A student wants to find the temperature of an oven using this setup. For this the variation of value of R with current (I) is important. Show that,

$$R = \frac{8(I+1)}{(1-3I)} \text{ by using kirchhoff's law.}$$

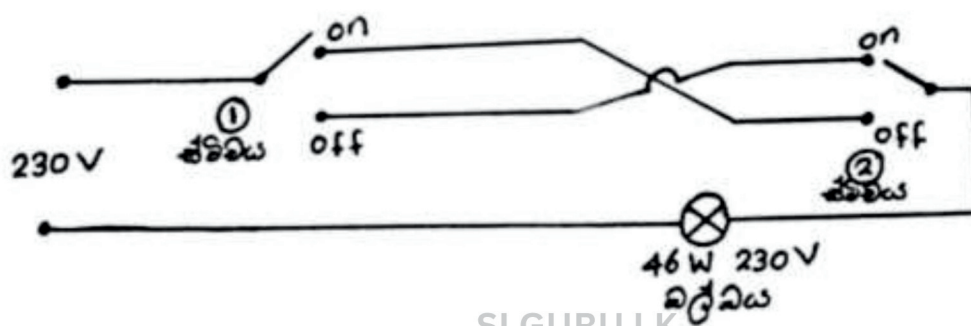
iii. Find the value of R when the reading of the ammeter is 0.25 A .

iv. If the ammeter reading is 0.25 A when the temperature of the oven measured by R is 535°C , find the temperature coefficient of resistance of the material of which R is made.



c) Electricity is used in the home to make everyday tasks easier. Both simple and complex electrical circuits are used in the home. The use of substandard fuses, wires, and switches in these electrical circuits can even cause fires and extensive property damage.

The circuit shown below is a two-way switch bulb circuit used to illuminate a staircase in a house. This circuit uses one switch above the staircase and another switch below the staircase. Both of these switches are two-way switches.

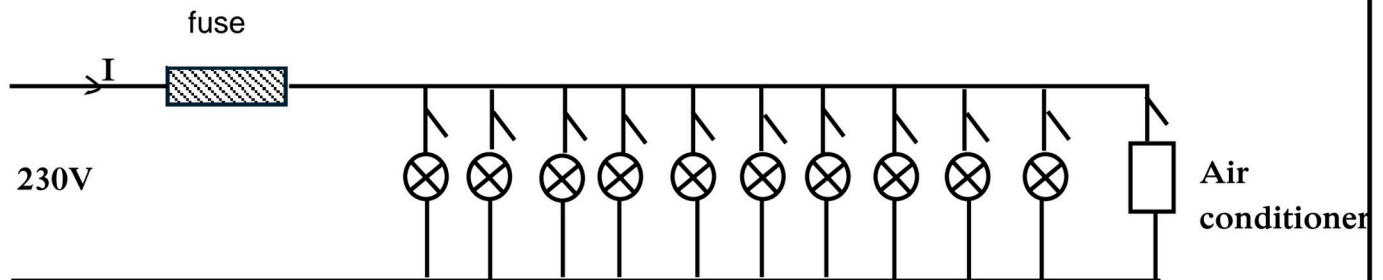


OFF - open

ON - closed

situation	Switch 1	Switch 2	Bulb lights up / does not light up
1	OFF	OFF	
2	OFF	ON	
3	ON	OFF	
4	ON	ON	

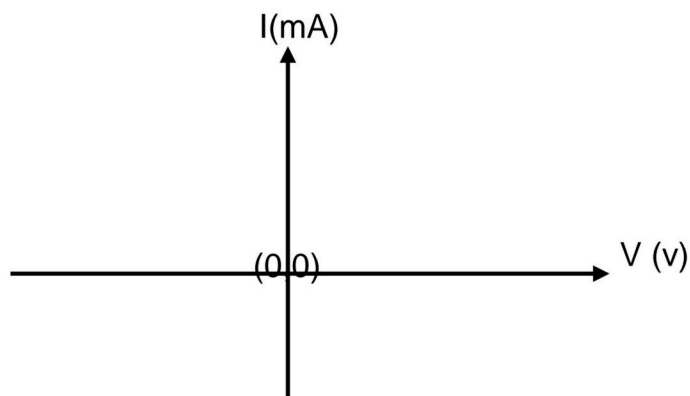
- Copy the table above and indicate whether the bulb will light up/not light up depending on the conditions of the two switches.
 - Write the dimensions of [potential difference X charge] .
 - Find the resistance using the values of 46W, 230V shown on the bulb.
 - Find the current flowing through the bulb when it is light up.
- d) A room in a house lights up by 10 bulbs of 46W, 230V and cooled by a 2300W, 230V air conditioner. All these electrical devices are connected in parallel as shown in the figure below.



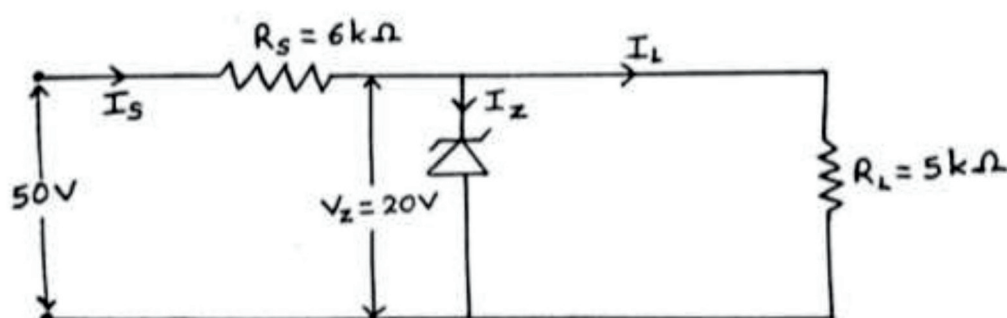
- Find the current passing through the fuse used here while protecting it.
- The fuse is available in 5A, 10A, 15A . Write down the maximum current of the fuse suitable for this circuit.
- If the 10 bulbs and the air conditioner in this room were operated for five hours, find the total energy consumed in kWh.
- If the charge for 1 kWh is Rs.30 , find the total cost.

B.

a) Copy the graph below and create the forward and reverse bias characteristic curve of a diode.



b)

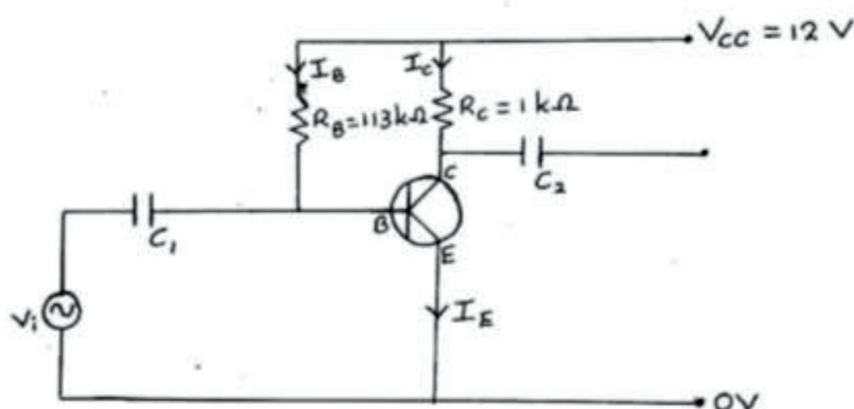


The figure shows a voltage regulator circuit that uses a Zener diode to obtain a constant voltage of 20 V across a load from a 50 V voltage supply.

- Find the current I_S flowing through R_S .
- Find the current I_L flowing through R_L .
- Find the current I_Z flowing through zener diode.
- Find the power dissipation of the zener diode.

c)

- State the two main functions performed using a transistor in a circuit.
- The circuit shown in the figure contains an npn silicon transistor in a common emitter configuration. Current gain $\beta = 100$ ($V_{BE} = 0.7$ V)

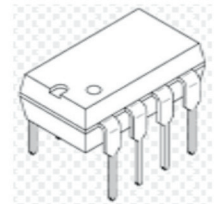
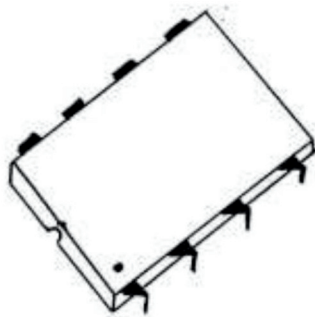


- 1) Find the current I_B flowing through R_B .
- 2) Find the current I_C flowing through R_C .
- 3) Find the current I_E .
- 4) Find the potential difference V_{CE} .

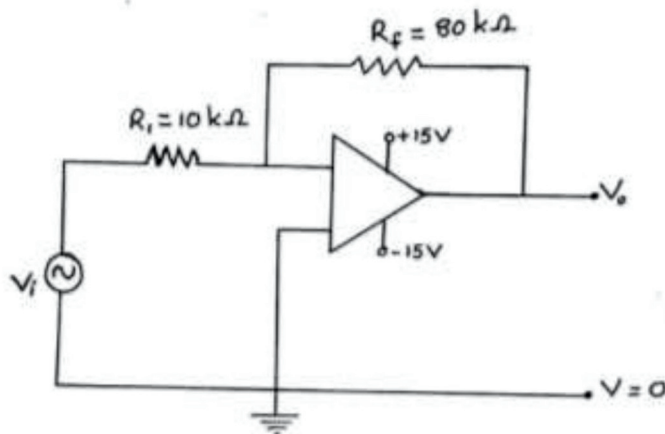
d)

i. The creation of a large circuit on a small piece of Si is done by the integrated circuit (IC). Nowadays, these integrated circuits are widely used in electrical appliances. Mention three advantages of these integrated circuits.

ii. The figure shows how an integrated circuit looks when viewed from above. Copy this figure and number the pins of the integrated circuit.



iii.



Consider the operational amplifier given above. In that $R_f = 80 \text{ k}\Omega$ and $R_i = 10 \text{ k}\Omega$. A sinusoidal voltage signal with a maximum value of 20 mV is applied to V_i .

- 1) What type of operational amplifier is shown above?
- 2) Find the voltage gain of this circuit.
- 3) Find the maximum value of output voltage V_o .
- 4) What is the phase difference between V_i and V_o .

Considering the expansion of liquids with heat, the density of the liquid decreases as the temperature increases. But when heat is supplied to water, its density also increases as its temperature increases within the range of 0°C to 4°C . This is known as the anomalous expansion of water. Hence maximum density of water exists at 4°C .

a)

- i. When heat is supplied to a liquid of volume V_1 , its volume changes to V_2 . Consider the temperature change as $(\Delta\theta)$, and taking the volume expansion as γ , write down an equation for the expansion in volume.
- ii. When the temperature of a liquid was increased by $\Delta\theta$, its density changed from d_1 to d_2 . Derive an equation for the new density of the liquid.
- iii. Define the real expansion and the apparent expansion of a liquid.
- iv. Derive an equation for the relationship between the real expansion and the apparent expansion by considering the expansion of the vessel that contains the liquid.
- v. A glass block at room temperature is placed inside a brass vessel. The remaining space in the pot was completely filled with oil and the pot was gradually heated. The volume of the vessel in room temperature is 100 cm^3 . If the volume of oil is sufficient to fill the remaining space of the container without spilling the liquid at each temperature, calculate the volume of the glass block at room temperature.

$$\text{Volume expansivity of brass} = 60 \times 10^{-6} \text{ }^{\circ}\text{C}^{-1}$$

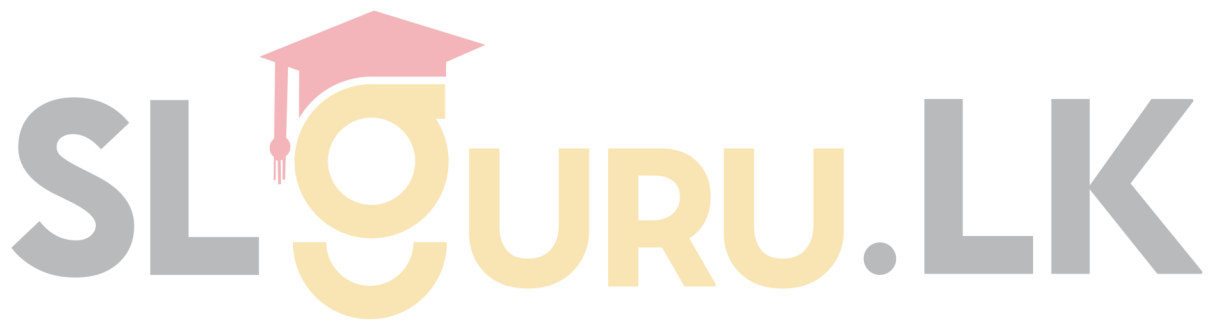
$$\text{Volume expansivity of oil} = 100 \times 10^{-6} \text{ }^{\circ}\text{C}^{-1}$$

$$\text{Volume expansivity of glass} = 25 \times 10^{-6} \text{ }^{\circ}\text{C}^{-1}$$

b)

- i. As mentioned above, draw a suitable graph for the variation of density with temperature of water, considering the anomalous expansion that occurs within the range of $(0 - 4)^{\circ}\text{C}$. (Must have the temperature below 0°C)
- i. Draw a graph for the variation of volume within the temperature range mentioned in (b) (i).
- ii. Even though European countries experience snowfall for an extended period of the year, aquatic life survives safely throughout that period. Explain that using anomalous expansion of water.

“Knowledge is power.” – Francis Bacon



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