අධ්‍යාපන අමාත්‍යාංශය
නැණ පවුර පෙරහුරු ප්‍රශ්න පත්‍රය

අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය,
கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை,
General Certificate of Education (Adv. Level) Examination, **2024**

භෞතික විද්‍යාව I
பௌதிகவியல் I
Physics I

01 E I

පැය දෙකයි
இரண்டு மணித்தியாலம்
Two hours

Instructions:

- *This question paper consists of* **50** *questions in* **11** *pages.*
- *Answer* ***all*** *the questions.*
- *Write your* ***Index Number*** *in the space provided in the answer sheet.*
- *Read the instructions given on the back of the answer sheet carefully.*
- *In each of the questions* **1** *to* **50**, *pick one of the alternatives from (1), (2), (3), (4), (5) which is correct or most appropriate and mark your response on the answer sheet with a cross (×) in accordance with the instructions given on the back of the answer sheet.*

Use of calculators is not allowed.

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

1. The speed of a liquid flowing through a tube depends on the pressure difference Δp and the density ρ of the liquid. The speed v is given by the equation, $v = k\left(\frac{\Delta p}{\rho}\right)^{n}$ where k is the constant that has no units. What is the value of n,

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

2. Figures (a) and (b) below shows cases where a vernier caliper is checked for zero error and a measurement is taken to find the diameter of a sphere. What is the corrected reading for diameter of the sphere?

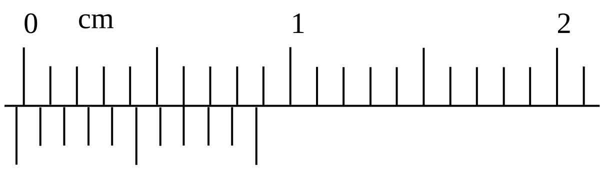


Figure (a)

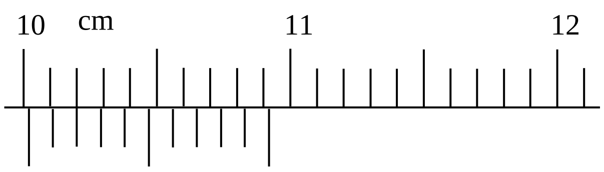


Figure (b)

(1) 9·95 cm (2) 10·05 cm (3) 10·09 cm (4) 10·13 cm (5) 10·27 cm

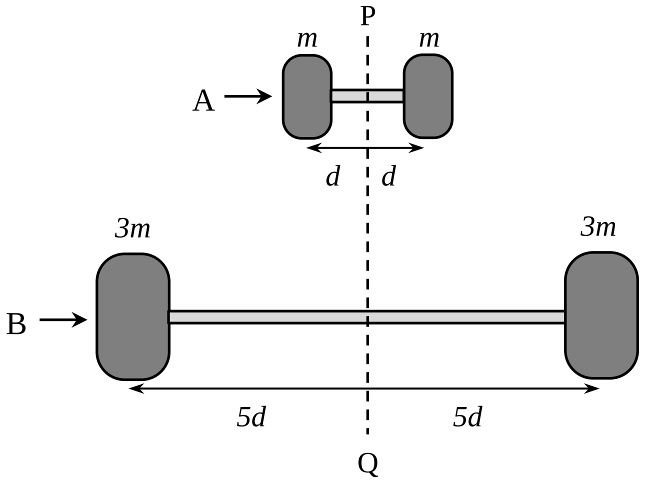
3. The sound intensity due to a point sound source at a distance r from it is I. What is the sound intensity at a distance of $2r$ from the source?

(a) $\frac{I}{16}$ (2) $\frac{I}{8}$ (3) $\frac{I}{4}$ (4) $\frac{I}{2}$ (5) I

4. The tangent drawn to the displacement time graph of an object moving with uniform acceleration at a given instance makes an angle of 45° with the time axis and one second later makes an angle of 60°.What could be the acceleration of the object ?

(1) $\sqrt{3}$ m s^{-2} (2) $(\sqrt{3}+1)$ m s^{-2} (3) $(\sqrt{3}-1)$ m s^{-2} (4) $\frac{\sqrt{3}}{2}$ m s^{-2} (5) $\frac{1}{\sqrt{3}}$ m s^{-2}

5. Two objects shown below are made of connecting two masses to light rods. If the moment of inertia of A and B around the axis PQ are I_1 and I_2 respectively, Find the value of ratio I_2 / I_1?



(1) 9 (2) 15 (3) 25
(4) 45 (5) 75

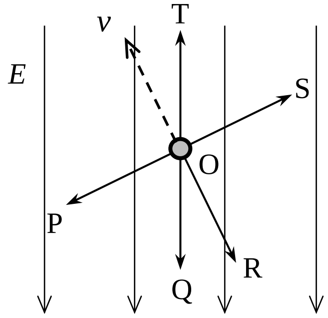
6. Protons and neutrons are composed of elementary particles u-quark and d- quark. When the charges of the u-quark and d- quark particles are expressed in terms of the charge of an electron,

(1) $+\frac{2}{3}e$ and $+\frac{1}{3}e$. (2) $+\frac{2}{3}e$ and $-\frac{1}{3}e$. (3) $-\frac{2}{3}e$ and $+\frac{1}{3}e$.
(4) $-\frac{2}{3}e$ and $-\frac{1}{3}e$. (5) $+1e$ and $-1e$.

7. A wave whose frequency is 500 Hz^{-1} has a speed of 400 m s^{-1}. What is the minimum distance between two points where the phase difference of this wave is $\pi/4$?

(1) 40 cm (2) 20 cm (3) 15 cm (4) 10 cm (5) 5 cm

8. In a vertical uniform electric field E an electron at position O moves with v velocity in the direction shown in the diagram. Which one of the following cases gives The direction of acceleration of the electron?

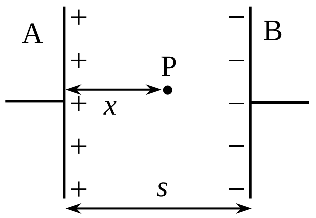


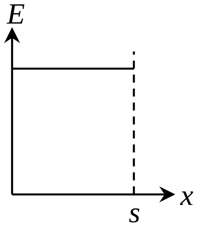
(1) OP (2) OQ
(3) OR (4) OS
(5) OT

9. Consider the following statements about images formed by several optical instruments.
(A) The images formed by plane mirrors are always virtual, upright and equal in height of the object.
(B) The images formed by concave lenses are always virtual, upright and smaller than the object.
(C) Images formed by convex lenses are either real or virtual as well as inverted or upright.
Which of the above statements is / are true,

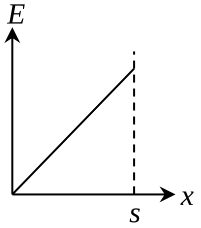
(1). Only (C). (2). Only (A) and (B) . (3). Only (A) and (C).
(4). Only (B) and (C). (5).All of (A), (B) and (C).

10. Two identical conducting plates A and B charged oppositely are shown in the figure. The distance between two plates is *s*. P is a point between the two plates and the distance from plate A to P is *x* . If the electric field intensity at point P is *E*, which graph below represents the variation of *E* vs *x*

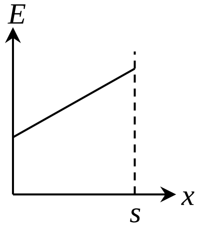




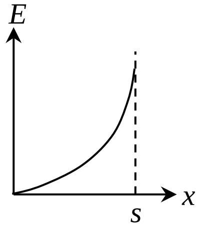
(1)



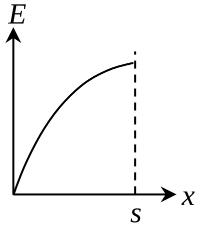
(2)



(3)



(4)



(5)

11. Consider the two satellites A and B an earth orbit. Satellite A has a mass *m* , an orbital radius of *r* and a total orbital energy of E. Satellite B has a mass of 4*m* and an orbital radius *r*/2. What is the orbital energy of satellite B?

(1) *E* (2) 2*E* (3) 4*E* (4) 8*E* (5) 16*E*

12. The sum of magnitudes of two forces is 16 N. If the resultant force is 8 N and its direction is perpendicular to the smaller force then the two forces are,

(1) 2 N and 14 N . (2) 3 N and 13 N . (3) 4 N and 12 N . (4) 6 N and 10 N . (5) 8 N and 8 N .

13. The nuclear fission reaction in $^{235}_{92}A$ is shown below.

$$^{235}_{92}\mathrm{A} + {}^{1}_{0}\mathrm{n} \rightarrow {}^{x}_{57}\mathrm{B} + {}^{87}_{y}\mathrm{C} + 3\,{}^{1}_{0}\mathrm{n} + \text{Energy}$$

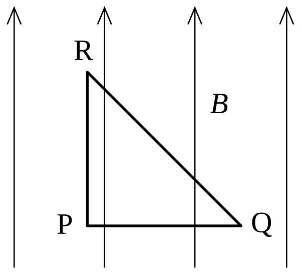
Here x and y are,

(1) 150, 43 . (2) 148, 60 . (3) 146, 35 . (4) 146, 32 . (5) 142, 38 .

14. An electric current carrying closed loop conductor PQR in the form of an isosceles right angled triangle is placed in a uniform magnetic field of flux density *B* directed along the direction PR. If the magnetic force acting on PQ is *F*, then what is the magnetic force acting on QR?

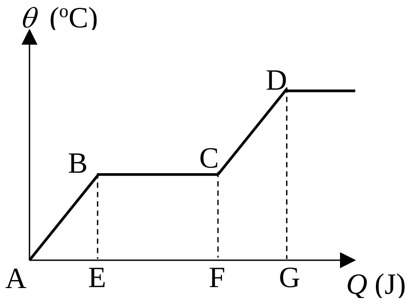
(1) F/2 (2) F/$\sqrt{2}$ (3) F

(4) $\sqrt{2}$ F (5) – F



15. Heat is supplied at a uniform rate to 1kg mass of solid paraffin wax. The graph shows how the temperature (θ) of paraffin wax varies with the amount of heat supplied (Q).Specific heat capacity of the liquid is given by,

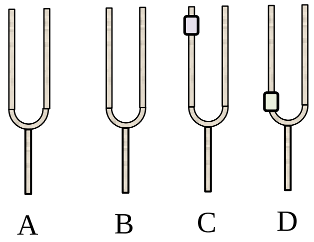
((1) The length of FG.
(2) The gradient of CD.
(3) The reciprocal of gradient AB .
(4) The reciprocal of gradient CD .
(5) The area under the line CD .



16. If the De Brogley wave length of H_2 gas molecules at $27\,^{\circ}\mathrm{C}$ and He gas atoms at $127\,^{\circ}\mathrm{C}$ are λ_H and λ_{He} respectively what is the ratio of $\frac{\lambda_H}{\lambda_{He}}$?(The relative atomic mass of H_2 is 2 and relative atomic mass of He is 4)

(1) $\sqrt{\frac{8}{3}}$ (2) $\sqrt{\frac{3}{8}}$ (3) $\sqrt{\frac{4}{3}}$ (4) $\sqrt{\frac{3}{4}}$ (5) $\sqrt{\frac{3}{2}}$

17. In the figure, A shows a tuning fork of 400 Hz. B,C and D are three identical tunning forks, and two equal small loads are attached to C and D as shown in the figure. Tuning forks B, C and D were vibrated separately along with the tuning fork A. Then in one of those cases there was no beats and in two cases the frequencies of beats were 2 Hz and 4 Hz

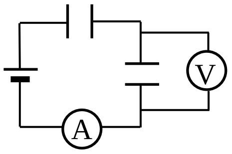


The suggested possible values of the frequencies of B,C and D are given in the table as P,Q, Rand S. Select the case where the correct values displayed. B, C and D,

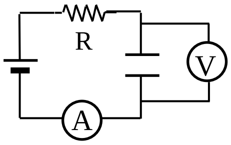
Case	B	C	D
P	404 Hz	400 Hz	402 Hz
Q	402 Hz	396 Hz	400 Hz
R	402 Hz	400 Hz	396 Hz
S	400 Hz	396 Hz	398 Hz

(1) Only P and Q. (2) Only P, Q and S .
(3) Only P, R and S . (4) Only Q, R and S .
(5) All of P, Q, R and S .

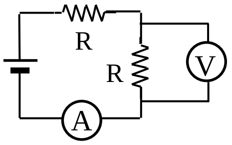
18. The ammeters in the following circuits are ideal. The internal resistance of each voltmeter is 1000 Ω. If the resistance R = 1000 Ω select the circuit in which the ammeter reading is maximum.



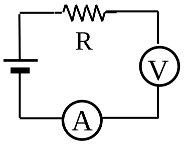
(1)



(2)



(3)



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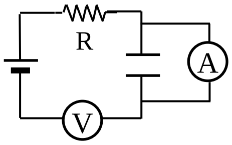
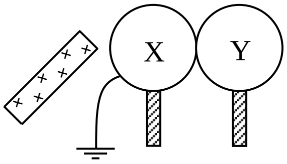


(5)

19. Two uncharged metal spheres X and Y placed on insulators are in contact with each other. The sphere X is grounded as shown and positively charged rod brought near the X. Consider the following statements in this regard.

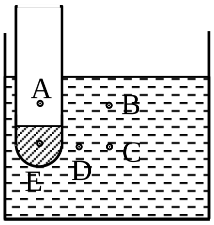


A – The sphere system borrows electrons from the earth.
B – X sphere receives a negative electric potential.
C – Y sphere receives a positive electric potential.

Which of the following statements is / are correct?

(1) Only A. (2) Only A and B. (3) Only A and C.
(4) Only B and C. (5) All of A, B, C.

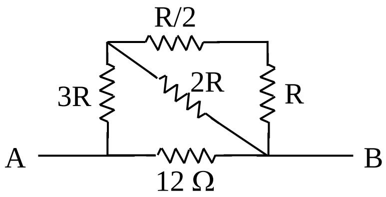
20. A weighted test tube floats in water in a vessel whose mass is negligible as shown in the figure. The point where the center of gravity of the system is the most likely to be.



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

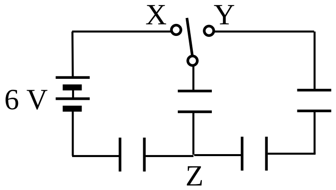
21. In the given circuit , the equivalent resistance between A and B is 6 Ω. If the resistance 12 Ω is replaced by a resistor of 6 Ω, the amount of change in the equivalent resistance between AB will be,

(1) 1 Ω (2) 2 Ω (3) 3 Ω
(4) 4 Ω (5) 6 Ω



22. In this circuit, the battery has an electromotive force of 6 V. All capacitors are equal. Initially the switch is connected to X and then to Y. What is the (final) potential difference between Z and Y (at the end).

(1) 1·0 V (2) 1·5 V (3) 2·0 V
(4) 2·4 V (5) 3·6 V



23. Two small aluminum and brass spheres of equal radii released to a tall (large) cylinder containing a viscous liquid. Consider the following statements..

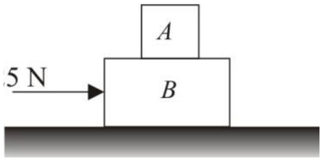
(A) The initial accelerations of both the spheres are same.
(B) Both spheres obtain terminal velocities at the same instant.
(C)Terminal velocities of two spheres are equal.

From the above statements,

(1) Only (A) is true. (2) Only (B) is true.
(3) Only (C) is true (4) All the (A), (B) and (C) are true.
(5) All the (A), (B) and (C) are **false**

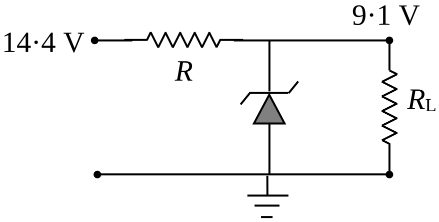
24. The mass of A in the figure is 2 kg and the mass of B is 8 kg. The frictional coefficient between A and B is 0.2 and the coefficient of friction between B and the surface(ground) is 0.5. When a horizontal force of 25 N is applied on B what is the frictional force between A and B?

(1) 50 N (2) 40 N (3) 20 N
(4) 4 N (5) Zero.



25. A rectified voltage of 9.1 V can be obtained from a supply voltage of 14.4 V using the voltage regulator circuit shown in the figure. What is the value of resistance *R* if the output current is 250 mA and the current through the diode is 10 mA?

(1) 10·4 Ω (2) 14·4 Ω (3) 20·4 Ω
(4) 24·4 Ω (5) 30·4 Ω



26. The pressure of water pipe when tap is open and closed are 3×10^5 N m^{-2} and $3{\cdot}5 \times 10^5$ N m^{-2} respectively. With open tap, the velocity of water flowing is, (Note that the density of water is 1000 kg m^{-3})

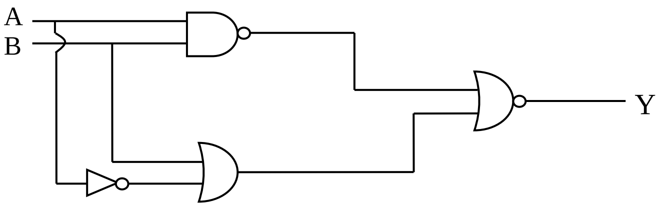
(1) 10 m s^{-1} (2) 12 m s^{-1} (3) 15 m s^{-1} (4) 20 m s^{-1} (5) 25 m s^{-1}

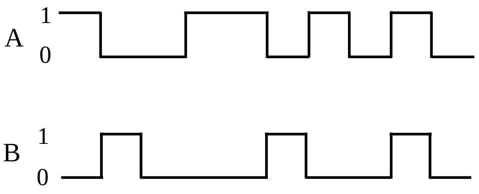
27. Ideal gas under identical initial conditions expands its volume V_o to V in three ways as shown in the table. What is the true statement about the work done in each case?

Type of expansion	Work
Isothermal expansion	W_1
Constant pressure expansion	W_2
Adiabatic expansion	W_3

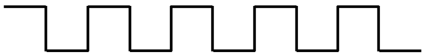
(1). $W_1 > W_2 > W_3$ (2). $W_2 > W_1 > W_3$ (3). $W_2 > W_3 > W_1$

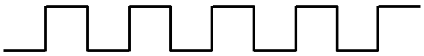
28. Logic inputs A and B in the given circuit are shown below.

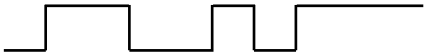


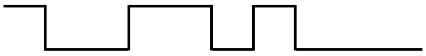


What is the correct shape of Y?

(1) 

(2) 

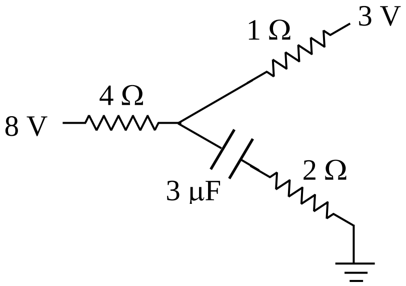
(3) 

(4) 

(5) 

29. How much energy stored in the $3\ \mu\text{F}$ capacitor shown in the circuit ?

(1) 6 J (2) 12 J (3) 18 J
(4) 24 J (5) 36 J



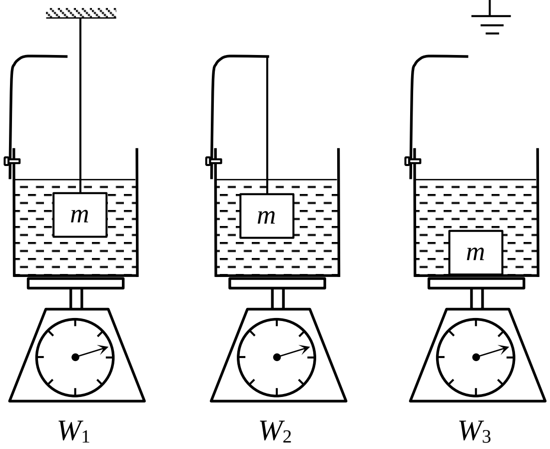
30. Three beakers of equal mass are filled with equal volumes of water. They are placed on three universal scales. A solid cube of mass *m* is placed as shown in the figure. The reading of the three scales are indicated (below)next to them.

Consider the following statements about those readings.

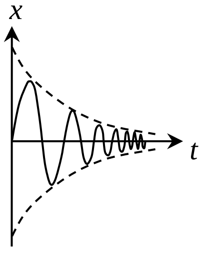
(A) $W_2 = W_3$
(B) $W_1 < W_2 < W_3$
(C) $W_1 < W_2 = W_3$

Which of the following statements is / are correct?

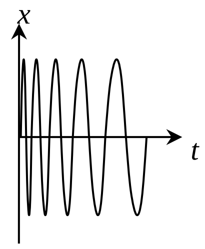
(1) (A) only. (2) (B) only.
(3) (A) and (B) only. (4) (A) and (C) only.
(5) All of (A), (B) and (C).



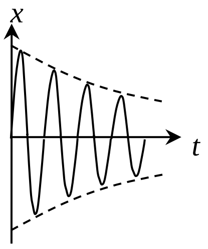
31. Which of the following figures represents the displacement (x) versus time (t) graph of a vibrating object with energy loss?



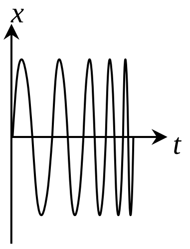
(1)



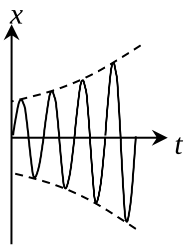
(2)



(3)

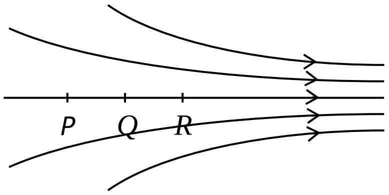


(4)



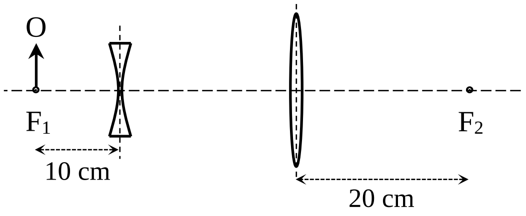
(5)

32. The figure shows a pattern of electric field lines and points P, Q and R such $PQ = QR$ have been marked on one electric line. If potential at P is 0 V which of the following answers gives the possible potential at Q and R?



	Potential at Q	Potential at R
(1)	-200 V	-450 V
(2)	-200 V	-400 V
(3)	-200 V	-350 V
(4)	+200 V	+350 V
(5)	+200 V	+450 V

33. A concave lens of focal length (f_1) 10 cm and a convex lens of focal length (f_2) 20 cm are placed in a common principle axis as shown in the figure. The final image of an object O at the focus of the concave lens forms at the right side of the convex lens after refraction by both lenses. If the height of the image is equal to the height of the object O, what is the distance between the two lenses?

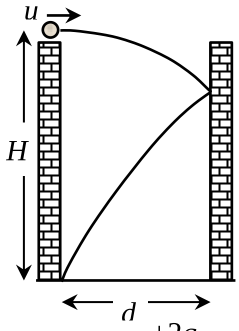


(1) 10 cm (2) 15 cm (3) 20 cm (4) 25 cm (5) 30 cm

34. A substance in liquid state has specific heat capacity , a, specific latent heat of fusion, $100a$ specific latent heat of vaporization $1000a$, melting point 20 ^{o}C and boiling point 100 ^{o}C.
Mass m of the substance at solid state at it's melting point is mixed with mass m of vapor of the substance at boiling point. If there is no heat loss , at the thermal equilibrium, there is a

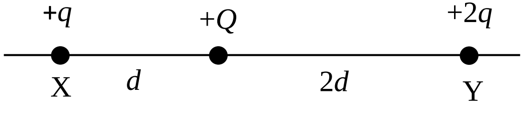
(1) mixer of solid and liquid of the substance in 20 ^{o}C
(2) only liquid of the substance in between 20 ^{o}C and100 ^{o}C
(3) only liquid of the substance in 100 ^{o}C
(4) only vapor of the substance in 100 ^{o}C
(5) mixer of liquid and vapor of the substance in 100 ^{o}C

35. Two smooth vertical walls are spaced apart d. A ball is projected with speed u at the top of one wall. Assume that the ball hits the opposite wall and rebound with same velocity. If the ball lands at the base of the wall as shown in the figure the height of the wall H can be,



(1) $H = \frac{2gd^2}{u^2}$ (2) $H = \frac{gd^2}{u^2}$ (3) $H = \frac{2gd}{u^2}$
(4) $H = \frac{4gd^2}{u^2}$ (5) $H = \frac{gd^2}{2u^2}$

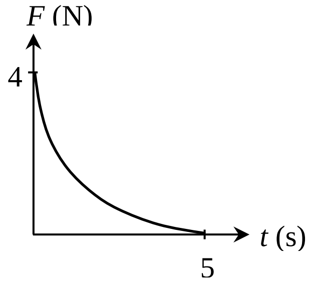
36. Two points X and Yare located at the electric field created by a charge $+Q$ as shown in the figure. Two points charges $+q$ and $+2q$ are brought from infinity to these two points respectively. Consider the following statements.



A : Electric field intensity at X is twice of Y
B : Electric potential at X is greater than Y.
C : The works done to bring $+q$ charge and $+2q$ charge to its positions equal in magnitude
Which statement is/are correct.

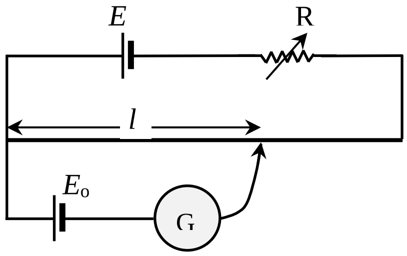
(1) Only A . (2) Only A and C. (3) Only A and B . (4) Only B and C. (5) All the A, B, C.

37. The figure shows how the unbalanced force F acting on an object of mass 1 kg varies with time t. The object is initially at rest and then moves along a straight line. Which of the following statements is **false**?



(1) The object has a decreasing acceleration during the first 5 s.
(2) Object moves with deceleration.
(3) The initial acceleration of the object is 4 m s^{-2} .
(4) The maximum velocity of the object is less than 10 m s^{-1} .
(5) After 5 s the object moves with uniform velocity.

38. The balance length l of the potentiometer circuit can be increased by,



(A) Keeping R unchanged and decreasing the value of E.
(B) Increasing the value of R and keeping fixed E.
(C) Increasing the diameter of the potential meter wire keeping E and R constant.

Which of the above statements is / are correct?

(1) Only A . (2) Only A and B . (3) Only A and C .
(4) Only B and C. (5) All the A, B, C.

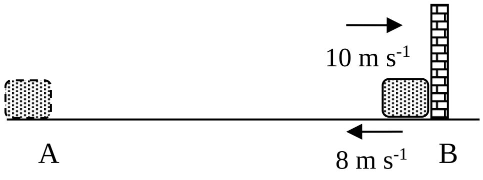
39. Two bodies A and B of similar surface conditions have specific heat capacity C and $2C$, *radii* r and $2r$ and densities 2ρ and ρ. They are cooled in a continuous stream of air in the same room to cool down from 65℃ to 55 ℃. If a takes time period of t , what is the time taken by B?

(1) $\frac{t}{8}$ (2) $\frac{t}{2}$ (3) t (4) $2t$ (5) $8t$

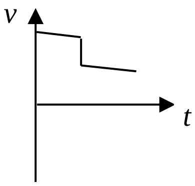
40. A charged simple pendulum in a gravitational field has period T and angular displacement θ. When a uniform magnetic field is applied perpendicular to its plane of oscillation,

(1) T decrease and θ remains constant.
(2) T is constant and θ is decreasing.
(3) T and θ both remain constant.
(4) T and θ both decrease.
(5) T and θ both increase.

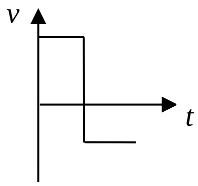
41. AB is a rough surface and there is a solid wall at B. An object projected along the surface from A towards the wall collides with the wall. The collision is inelastic and after the collision object rebound and moves back to A.



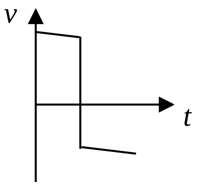
For the motion of the object from A to B and back from B to A what is the relevant velocity – time graph?



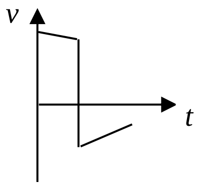
(1)



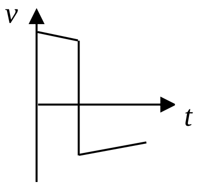
(2)



(3)

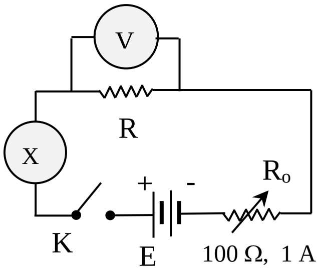


(4)



(5)

42. A circuit set up to study the accuracy of Ohm's law is shown in figure. A standard resistor R has a resistance approximately 10 Ω. What are the most appropriate measuring ranges for the E, X and V instruments shown here?



Number of choice	E – Battery	X – Ammeter	V – Voltmeter
(1)	12 V	0 – 3 A	0 – 15 V
(2)	12 V	0 – 1 A	0 – 15 V
(3)	5 V	0 – 500 mA	0 – 5 V
(4)	5 V	0 – 100 mA	0 – 5 V
(5)	3 V	0 – 100 mA	0 – 5 V

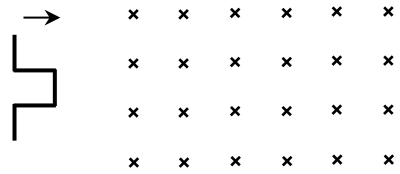
43. A catapult is made of a rubber band 42 cm long and 6 mm in diameter. A stone of mass 20 g was placed , the rubber band was extended up to 62 cm and the stone was released. If The stone is released with velocity 20 m s^{-1} from the band. What is the Young's modulus of rubber?

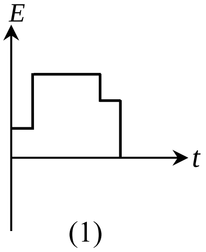
(1) 2.86×10^{8} N m^{-2} (2) 2.97×10^{8} N m^{-2} (3) 3.14×10^{8} N m^{-2} (4) 5×10^{8} N m^{-2} (5) 6.18×10^{8} N m^{-2}

44. Difference between the resonance lengths of two successive overtones of a tube closed at one end was 32 cm. If the end correction of the tube is 0.5 cm, what is the resonance length of the pipe when it vibrates at it's fundamental frequency?

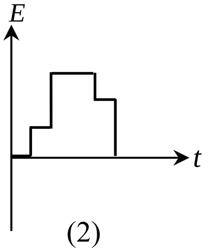
(1) 15.5 cm (2) 16 cm (3) 16.5 cm (4) 31.5 cm (5) 32 cm

45. A conductor as shown in figure enters into a magnetic field with uniform velocity. Which of the following graphs best represents how the electromotive force generated between its two end changes with time during the movement from the position shown here to the point it leaves the magnetic field?

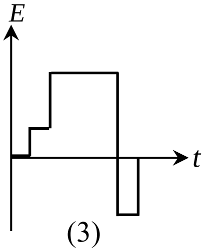




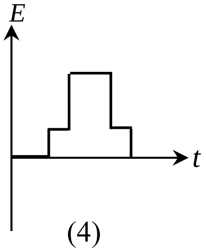
(1)



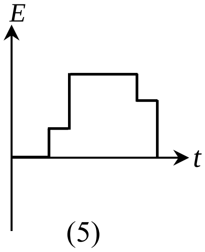
(2)



(3)



(4)

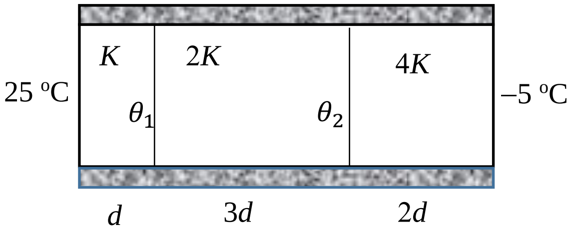


(5)

46. For a capillary tube immersed in a liquid the capillary rise on Earth is h. When the liquid and the capillary tube are taken to a planet where the gravitational acceleration is 2/3 that of the Earth and the atmospheric pressure is ½ that of the earth, the capillary rise will be,

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

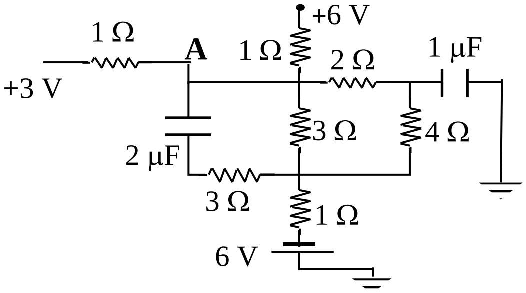
47. A wall with a uniform cross section consisting of three layers of thickness d, $3d$ and $2d$ and made of material with thermal conductivity K, $2K$ and $4K$ respectively is used to retain heat in a house in a cold climate. The top and bottom of the wall are well insulated as shown in the figure. On a day when the external environmental temperature is –5 °C and the internal temperature of the house is maintained at 25 °C. Respective temperatures θ_1 and θ_2 at interfaces of walls shown are,



(1) 15 °C, 0 °C. (2) 15 °C, 5 °C. (3) 20 °C, 0 °C. (4) 20 °C, 5 °C . (5) 23 °C, –1 °C.

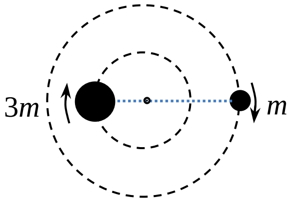
48. What is the potential at A in the circuit shown in the figure?

(1) 1 V (2) 2 V (3) 3 V
(4) 3.6 V (5) 4.2 V



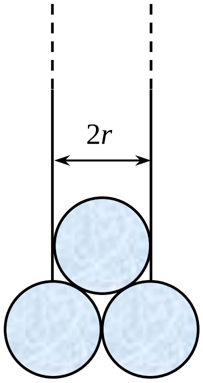
49. Two stars orbit around their common center of mass as shown in the diagram below. The masses of the two stars are $3m$ and m. The distance between the stars is d. what is the periodic time of planet of mass $3m$.

(1) $\frac{\pi}{4}\sqrt{\frac{d^3}{Gm}}$ (2) $\pi\sqrt{\frac{d^3}{3Gm}}$ (3) $\frac{3\pi}{4}\sqrt{\frac{d^3}{Gm}}$ (4) $\pi\sqrt{\frac{d^3}{Gm}}$ (5) $2\pi\sqrt{\frac{d^3}{Gm}}$



50. Two identical rigid spheres each of radius r and mass m are hung by long inelastic strings as shown in the figure. Then a third identical sphere is carefully placed between two spheres such that the system remains at equilibrium. Assume that two strings remain vertical. The minimum value of coefficient of friction between spheres for this equilibrium to be possible is,

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



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නැණ පවුර - පෙරහුරු ප්‍රශ්න පත්‍රය

අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය, 2022(2023)
கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை, 2022(2023)
General Certificate of Education (Adv. Level) Examination, 2022(2023)

භෞතික විද්‍යාව II
பௌதிகவியல் II
Physics II

01 E II

පැය තුනයි
மூன்று மணித்தியாலம்
Three hours

අමතර කියවීම් කාලය - මිනිත්තු 10 යි
மேலதிக வாசிப்பு நேரம் - 10 நிமிடங்கள்
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.

Index No. . ...

Important:

- *This question paper consists of* **16** *pages.*
- *This question paper comprises of two parts,* **Part A** *and* **Part B.** *The time allotted for* ***both parts*** *is* ***three hours.***
- *Use of calculators is* ***not*** *allowed.*

PART A — Structured Essay:
(pages 2 - 8)

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

PART B — Essay:
(pages 9 - 16)

This part contains ***six*** *questions, of which,* ***four*** *are to be answered. Use the papers supplied for this purpose.*

- *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.*

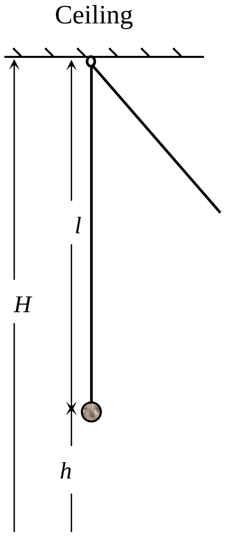
For Examiners' Use Only

For the second paper		
Part	**Question Nos.**	**Marks Awarded**
A	**1**	
	2	
	3	
	4	
B	**5**	
	6	
	7	
	8	
	9 (A)	
	9 (B)	
	10 (A)	
	10 (B)	
Total	In numbers	
	In words	

Code Numbers

Marking Examiner 1	
Marking Examiner 2	
Marks checked by	
Supervised by	

1. A student wishes to design an experiment to determine the value of acceleration due to gravity (g) and height (H) to the ceiling of the laboratory using the simple pendulum.



(a). (i). Write an equation for the period of oscillation of the pendulum in terms of the variables you selected and quantities H and g, and rearrange the expression in the most suitable manner to find H and g using the graphical method.

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(ii). What are the variables you choose in this experiment?

(a) Independent variable : …………………………………...
(b) Dependent variable : …………………………………...

(b). (i). In this experiment, what technique would you use to most **accurately** determine the exact point of an oscillation is completed in this experiment? Explain with reasons.

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(ii). Here is an image of the stopwatch provided to measure time in this experiment , for a certain number of oscillations selected what is the reading of this stop watch ?

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(iii). If the time taken for one oscillation is approximately 2 s, by calculation verify the number of oscillations (n) you select to minimize the error in measuring the period of oscillation?

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(c). (i). What technique do you use to measure the time taken for a selected number of oscillations more accurately?

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(ii). What is the reason for using the above mentioned technique?

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(d). If the gradient and the intercept of the graph drawn by a student T^2 against h are 4.02 $s^2\ m^{-1}$ and 14.07 s^2 respectively, Calculate,

(i) the gravitational acceleration (g).(Take $\pi^2 = 9.87$)

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(ii). the height to the ceiling (*H*).

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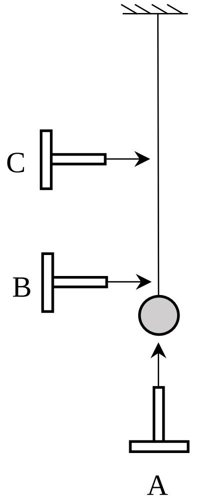

(e). The figure shows three ways which three students placed their locating pin. Note that the pendulum is oscillating along a plane perpendicular to the plane of the paper.

(i). Which student has used the locating pin correctly?

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(ii) Explain reasons for your choice and rejection of other ways.

A : …………………………………………………………………………
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B : …………………………………………………………………………
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C : …………………………………………………………………………
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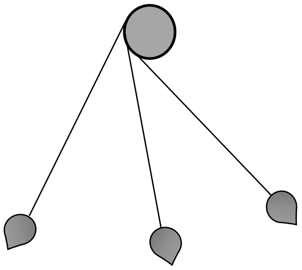

(f). Figure shows the simple pendulum attached to the lab stand by a student in a simple pendulum experiment.

(i). State what is the error of this setup?

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(ii). State what should be done to avoid that error.

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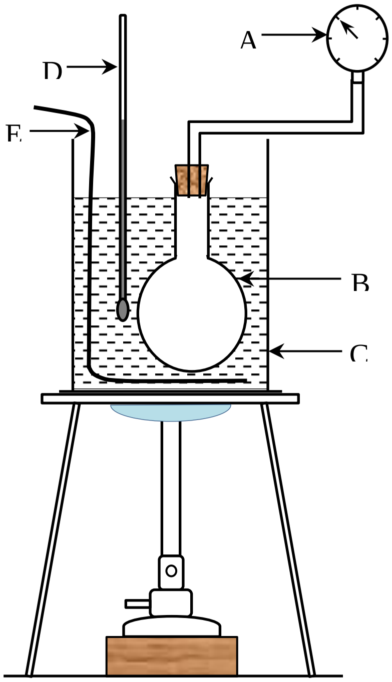
02. The figure shows an apparatus setup used to study the relationship between pressure and temperature of a gas at constant volume.

(a) Name the items labeled here.

A: ……………………………………………
B: ……………………………………………
C: ……………………………………………
D: ……………………………………………



(b) Write down the law expected to be verified in this experiment.

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(c) (i) Mention one error in this arrangement.

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(ii) What is the reason of it to be considered as an error?

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(d) (i) write down a quality that the flask chosen here should have. Explain the reason .

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(ii) Mention the techniques used to minimize the error in measuring the temperature of the air inside the flask.

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(e) (i) If the first part of the graph drawn from the experimentally obtained readings was a curve and the rest was a straight line then what could be the reason for that?

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(ii) What type of pressure gauge should be chosen to minimize errors in the measured pressure values?

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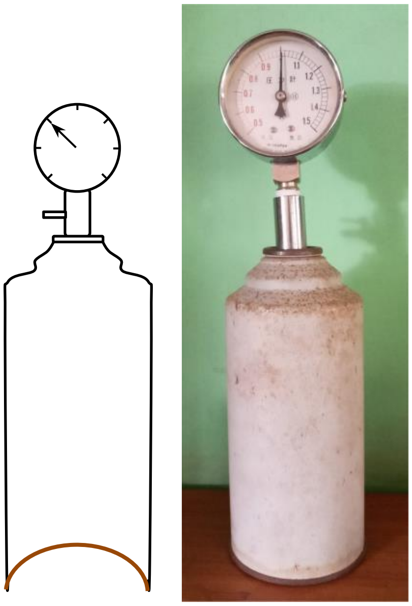
(f) The figure shows another type of Charles's law demonstration apparatus in the laboratory that can be used for the above experiment. This is made by attaching the pressure gauge to a cylindrical metal can.



(i) Although the metal can expands when it heated, How does the internal volume maintain at constant in this device?

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………………………………………………

(iii) State another advantage of using this?

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03. (a). Figure shows a set up designed by a student to find the refractive index of the material of a glass prism , using the critical angle method.

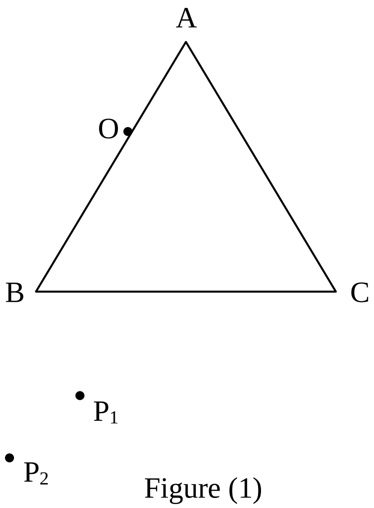

Figure (1)

(i) Write down the steps of the experiment you will perform until you get the emergent ray to find the critical angle.

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(ii) Two pins P_1 and P_2 fixed by a student in this experiment are shown in Figure (1). On the above diagram Draw the construction of the ray diagram required to find the critical angle.

(iii) Calculate the refractive index of the glass if the value obtained for the critical angle (${}_a n_g$) is 42^o. Consider $\sin 42^0 = 0.6691$.

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(b). (i) Why the pin O should be fixed vertically in contact with surface AB of the prism in this experiment?

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(ii) Give two errors related to the positions of pins P_1 and P_2.

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(iii) Explain the effect of the errors you mentioned above.

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(c). In order to determine the refractive index of water by obtaining the critical angle for the glass-water interface using the above experiment a thin layer of water was trapped on the AC surface using a glass slide as shown in the Figure (2).

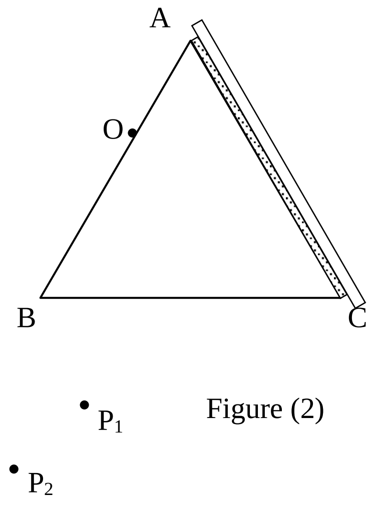

Figure (2)

(i) To find the critical angle for the glass-water interface, mark the places where two pins P_3 and P_4 should fix on this Figure (2) and construct both the relevant ray diagrams here to find the critical angle for glass – air and the glass-water interfaces.

(ii) Calculate the refractive index of water if the critical angle for the glass – water interface is 63^{o}' Consider sin $63^{0} = 0.8910$.

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(d). (i) In the experiment to find the critical angle for the glass-water interface, a certain student got a value of 45^{0} for the critical angle. Explain the reason for this by drawing a ray diagram in Figure (3).

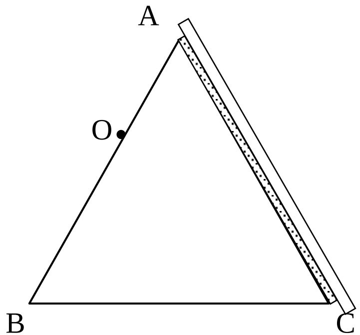

Figure (2)

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(ii) Avoiding the error mentioned in (d) (i) above, another student did the experiment but he could not get the corresponding emergent ray. Explain why. 1

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(iii) By placing pin O too close to vertex A, would it cause an error? , or not ? Explain.

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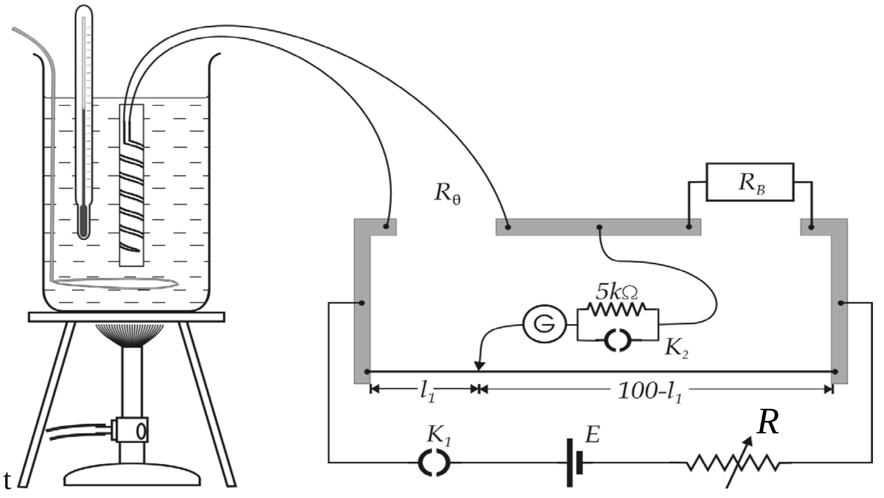
04. The figure below shows an arrangement of apparatus used in laboratory experiments to find the temperature coefficient of resistance (α) of a metal.



(a). (i). Name the devices indicated by E, K_1, K_2 R, R_B and G in this figure.

K_1 : ……………………………………………… $K_{2:}$…………………………………………..
R : ……………………………………………… R_B…………………………………………..
G : ………………………………………………

(b). What are the measurements you get in this experiment?

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(c). (i) To find the temperature coefficient of resistance (α) of the metal, write down the required two equations using your measurements and other parameters. Name those parameters

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(ii) To find temperature coefficient of resistance of metal (α) using graphical method, rearrange the above equation.

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(d). (i). Draw a rough sketch of the graph expected on the given axes.

(ii). How do you calculate the temperature coefficient of resistance α from the graph?

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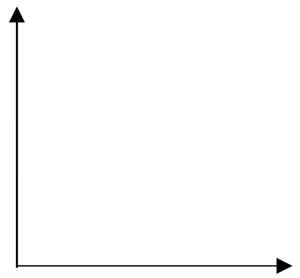

(e). (i). Which liquid would be more suitable to replace water in the liquid heater used to heat the coil in this experiment?

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(ii). Explain the reasons for your selection.

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(f). The following table shows the readings obtained by a student using a metal wire with a resistance of 50Ω.

θ (^{0}C)	30	40	50	60	70
l (cm)	45.7	47.4	48.0	48.7	49.4

(i). Another student mentions that he is not satisfied with the readings obtained. Give your opinion about it.

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(ii). What procedures do you follow to overcome those shortcomings?

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(g) (i) . Suggest a suitable value for R_B in this experiment?

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(ii) Briefly explain the reason for your suggestion in g(i).

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கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை, 2022(2023)
General Certificate of Education (Adv. Level) Examination, 2022(2023)

භෞතික විද්‍යාව II
பௌதிகவியல் II
Physics II

PART B Essay

01 E II

Answer four questions only.
($g = 10\ \text{m s}^{-2}$)

- **Note**: For an example the number 65210 can be written as $6{\cdot}52\times10^4$ in scientific notation after rounding off to two decimal places.

05. Figure 1 shows a simplified model of a hydro-electric power station. Water from a reservoir is directed to drive a turbine which is at 12 m below the water level of the reservoir. The turbine rotates at a uniform angular velocity of 9.0 rad s^{-1} and drives an electric generator through a system shown in Figure 2.

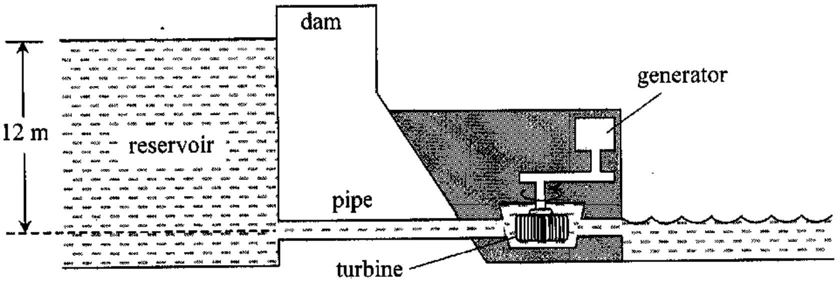


Figure 1

(a) (i) If the driving force on an object is F, its velocity is v and its power is P, the relationship between those quantities is given by the following equation. $P = Fv$
Show that this equation is dimensionally correct.

(ii) A rotating object has torque τ and angular velocity ω about its axis of rotation. Using the equation in (a) (i) above, obtain that; $P = \tau\omega$

(b) (i) The flow rate of water in the uniform pipe is 15 kgs^{-1}. Determine the power input to the turbine if 90% of the change in gravitational potential energy of water is achieved by the turbine.

(ii) If the cross-sectional diameter of the uniform pipe is 4.0 cm, find the velocity of water flowing along the pipe. Take density of water as 1000 kg m^{-3} and π=3.

(iii) Note that the water is flowing at the velocity calculated in (b)(ii) on to the blades of the turbine. The velocity of the water flowing out after it hitting the blade is 2.5 m s^{-1}. What is the rate of change of momentum of the water stream?

(iv) If the average distance from the turbine axis to the center of the blades is 1.0 m, calculate the torque it produces about its axis.

(v) What is the power output of the blade?

(vi) Hence, calculate the efficiency of the turbine in transferring mechanical power.

(c) The motion of the turbine is transmitted to the generator through the system shown in Figure 2. A large wheel *X* with a radius of 0.80 m is connected to a small wheel *Y* with a radius of 0.02 m through a driving belt. The wheel *X* and the turbine have a common axle while the wheel *Y* and the generator also have a common axle. Assume that there is no slipping between the wheels and the belt.

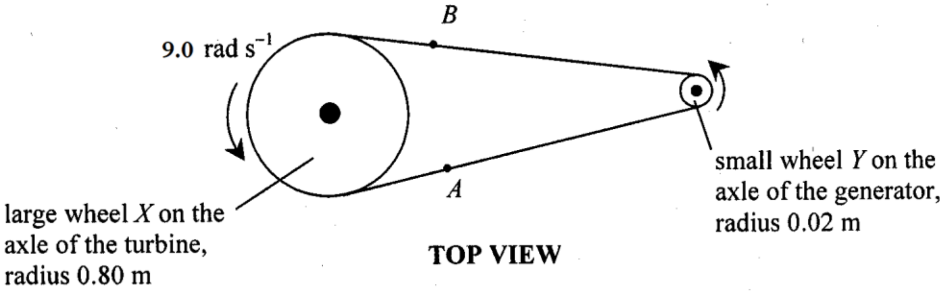


Figure 2

(i) Find the angular velocity of the axle of the generator.
(ii) The tension in the belt at *A* is 50 N. Use the information provided in (a)(iii) to find the tension at *B*.

06. Sound waves transmit energy. At Occasions like sonic boom, that energy could be cause to damage buildings and windows. Sound waves of loud sound carry more energy than that of sound wave of mild sound. Loudness can be measured by the rate of energy flow through a microphone or detector.

(a) Sound waves can vibrate the ear drum. Hearing ability of the loudness or mildness of a sound depends on the vibration of ear drum by the sound wave. When the ear drum is vibrating with high amplitude, the signal to the brain is strong and it is identified as a loud sound.

(i) What is the range of frequency that the human ear is sensitive?
(ii) What is the magnitude of threshold of audibility of the human ear?
(iii) Give an example of an occasion where a destruction caused by the sound.
(iv) Why loud sounds carry more energy than a mild sound?

(b) A fire cracker at an exhibition exploded up in the sky. Assume that the sound energy is spread equally in every direction and the reflection of the sound from the ground is negligible. The power of the sound of fire cracker is *P* and the intensity of sound when the sound reaches an observer *A* at 640 m (*R*) from the explosion is $I_A = 0.01$ W m^{-2}.

(i) Write down an expression for the intensity of sound I_A at *A* in terms of *P*.
(ii) What is the intensity I_B of sound heard by an observer *B* at a 160 m distance from the explosion.
(iii) Determine the intensity levels of sound at *A* and *B*.

(c) An observer at a point *C* observes a sound intensity three times that of an observer at a point *D* observes. Further, the intensity level observed by *C* is also three times that of *D*. determine the intensity level observed by *C*.

(d) A rocket starting from rest, accelerate at 60 m s^{-2} vertically upwards. When it is at 600 m above, its sound intensity observed by the control room on the ground is *I* and it became *I*/3 after some time. The speed of sound in air is 340 m s^{-1}.
(i) Find the distance travelled by the rocket when the intensity become *I*/3.
(ii) Determine the time interval between above two occasions where the control room measures the intensity.

07. (a) Consider a glass rod submerged vertically in a liquid. Draw the liquid surface around the glass rod and show how the surface tensional forces are acting on the rod from liquid when the angle of contact is 0, 90°and 180°.

(b) (i) a bubble of radius R and made of a liquid B of density σ is floating half submerged on a liquid A of density ρ. If the surface tension of liquid A is γ , show that the diameter D of the liquid bubble is given by $D = \sqrt{\dfrac{12\gamma}{g(2\sigma - \rho)}}$. Assume that the sphere is perfectly spherical and the contact angle is 180°.

(ii) If the density of A and B liquids are 2000 kg m^{-3} and 3000 kg m^{-3} respectively and the surface tension of A is 9 x 10^{-2} N m^{-1}, determine the radius of the bubble.

(iii) If an liquid droplet with same radius as the above liquid bubble is broken in to 64 identical drops, Show that the change of temperature in this process $\Delta\theta$ is given by, $\Delta\theta = \dfrac{9\gamma}{\sigma RC}$. Here C is the specific heat capacity of the liquid.

(iv) Consider an air bubble of radius R in the water of surface tension γ . If the internal pressure of the bubble is P_0 and the pressure outside the bubble is P, write down the relationship between P_0 and P.

(iv) Can above expression used for a soap bubble? Explain.

(c) The internal pressure of a soap bubble of radius R in air is P_1. Its density and temperature are ρ_1 and T_1 respectively. The pressure, density and temperature of the surrounding air are P_2, ρ_2 and T_2 respectively. Assume that the density and surface tension does not change with the temperature.

(i) Write down an expression for relationship between the internal pressure P_1 and external pressure P_2 of the soap bubble.

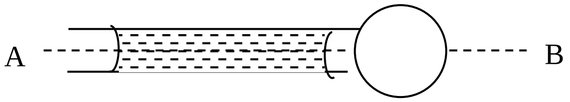
(ii) Two soap bubbles of radius 2 cm and 3 cm stick together, determine the radius of the common surface between these bubbles. Assume that the internal pressure of two bubbles remain unchanged.

(iii) Assuming that the air inside and outside of the bubble behave as an ideal gas, get an expression for $\dfrac{\rho_1 T_1}{\rho_2 T_2}$.

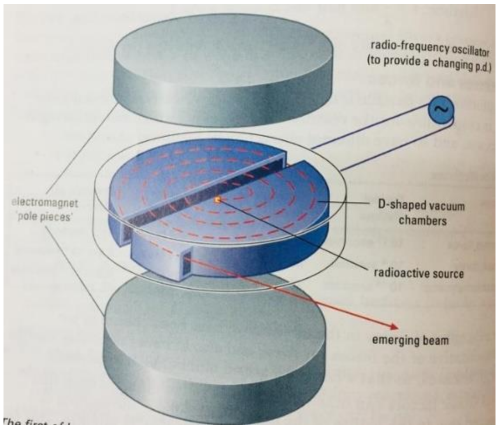
(iv) If the surface tension of soap is 2.5 x 10^{-2} N m^{-1} , radius is 15 mm, density of air is 1.2 kg m^{-3} and density of air inside the bubble is 1.3 kg m^{-3} determine the temperature inside the bubble. Assume that the temperature and pressure of the atmosphere are 27 °C and 1 x 10^5 N m^{-2} respectively.

(v) assuming that the thickness of the soap film is very small, determine the tension of the soap film.

(vi) The soap bubble mentioned above is then caught in the wind and attached to the end of a tube with a water column as shown in the figure. Draw a rough sketch to show how the pressure varies from A to B.



08. Cyclotrons are used to accelerate charged particles using electric and magnetic fields and to produce high-speed particle beams.



It consists of two semi-circular hollow metal blocks arranged in the shape of the English letter D inside a vacuum chamber as shown in the figure. The ion source is placed between the two hollow D blocks. A high frequency alternating voltage is connected to create an electric field between the two blocks and a uniform magnetic field is maintained perpendicular to the plane of the blocks. The ions emitted from the ion source travel along a spiral path as shown in the figure, undergo repeated acceleration and gain high speed and are finally ejected through the cavity.

(a). Heavy hydrogen (deuterium) nuclei are used as charged particles. What is its polarity?

(b).

- (i). What is the direction of the initial electric field if the particles emitted from the sample first enter chamber D on the right?
- (ii). If the charged particles move counterclockwise in a semicircular path as shown in the figure, what is the direction of the magnetic field applied?

(c). Explain why D-shaped hollow metal blocks are placed in a vacuum chamber.

(d). Through which area do the particles emitted by the ion source gain energy?

(e). A particle of mass *m* and charge *q* emitted from the sample enters a chamber with speed *v* and travels in a semicircular path of radius *r*. The flux density is *B* in the supplied magnetic field.

- (i). Name the centripetal force provided to move in the semicircular path.
- (ii). Write an expression for the magnitude of the centripetal force named in (e) (i) above.
- (iii). Obtain an expression for the speed at which the particle is moving in terms of *B*, *q*, *r* and *m*.
- (iv). Derive an expression for the time taken to travel a semicircular path and thereby show that if the alternating voltage must have a frequency *f*, then;

$$f = \frac{Bq}{2\pi m}$$

- (v). Derive an expression for the kinetic energy of a particle as it moves along a semicircular path.

(f). Note that the maximum energy delivered by this cyclotron to a particle is 15 MeV. Find the minimum radius of the segment composed with two D-shaped segments if the $\frac{q}{m}$ ratio of the particle is 4.8×10^{6} C kg^{-1}, the charge of the particle is 1.6×10^{-19} C and the flux density of the magnetic field is 5.0 T.

(g). Suggest a change here to accelerate the particle along a circular path instead of a spiral path.

(9A)

(a) i. Figure 1 shows a cell of electro motive force E and internal resistance r.
Show that when a current I flows through the circuit, the potential difference (V) between the two terminals of the cell is given by,

$$V = E - Ir$$

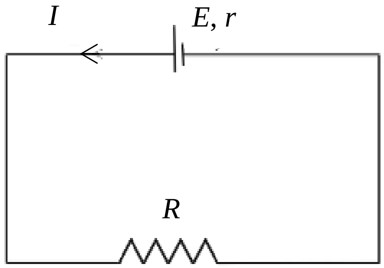


Figure 1

ii. If the equivalent cell that can be replaced the two cells of emf E_1 and E_2 in the circuit of figure 2, has the emf E and the internal resistance r then Show that

$$\frac{E}{r} = \frac{E_1}{r_1} + \frac{E_2}{r_2}$$

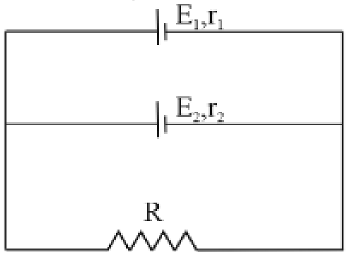


Figure 2

(b) Due to the power cut caused by the economic crisis in Sri Lanka last year, the studies at night of many students were interrupted. As a solution, an A-level student created the following setup. He named it as the **solar jar** and when small solar panels on the lid of the jar placed under the sunlight, it stores energy in the rechargeable cell. The student placed the solar jar on the roof during the day and took it inside the house at night.

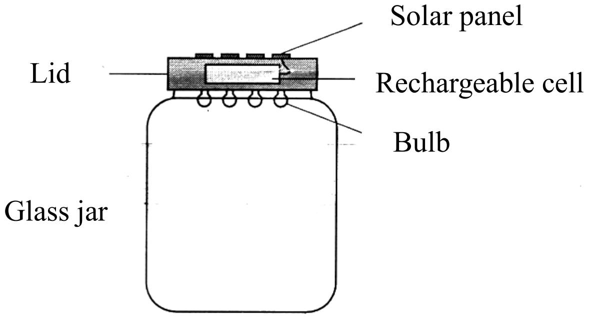


Figure 3 – Solar Jar

A portion of this circuit is shown in figure 4. Note that the resistance of the connecting wires can be neglected for all calculations given below.

Under the direct sunlight the student measured the potential difference between the two terminals of the solar panel system as $12\ V$.

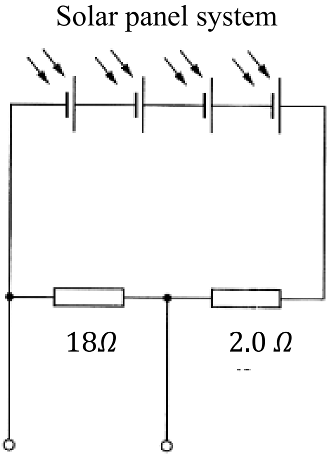


Figure 4

i. If all the solar panels are identical , assuming that they have no internal resistance, find the voltage between the terminals of one solar panel .

ii. Practically, the above assumption in part b (i) is flawed not accurate. Therefore, through another test, the student found that the internal resistance of one solar panel is $1\ \Omega$. Find the effective voltage can be obtained through the solar panel system?

iii. In the cases b(i) and b(ii) above, calculate the potential difference across the 18Ω resistor.

(c) Figure 5 shows the completed final circuit diagram prepared by the student. A is the rechargeable cell.

i. There is a fault in this circuit. What is it?
ii. Draw the corrected circuit in your answer sheet.
iii. Find the value of R if the current and voltage required for a bulb to work properly are $25\ mA$ and $5\ V$. (Note that the terminal voltage of the rechargeable cell A is $10\ V$.)
iv. Doing some modification to the above circuit will he be able to recharge his phone? (The phone battery charger requires $1\ V$ and $1\ A$). Give reasons for your answer.

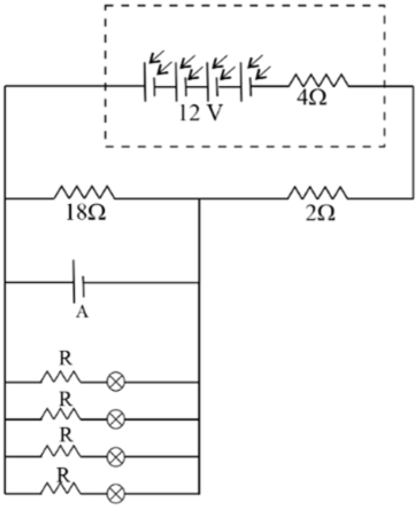


Figure 4

(d) The student decides to use several solar jars to illuminate the whole house. Figure 5 shows the plan of the house illuminating system.

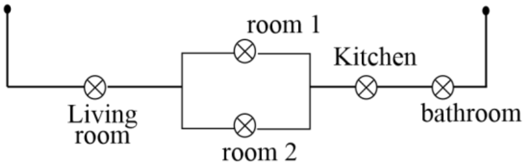


Figure 5

And the student designed a single circuit diagram for the whole house as figure 6.

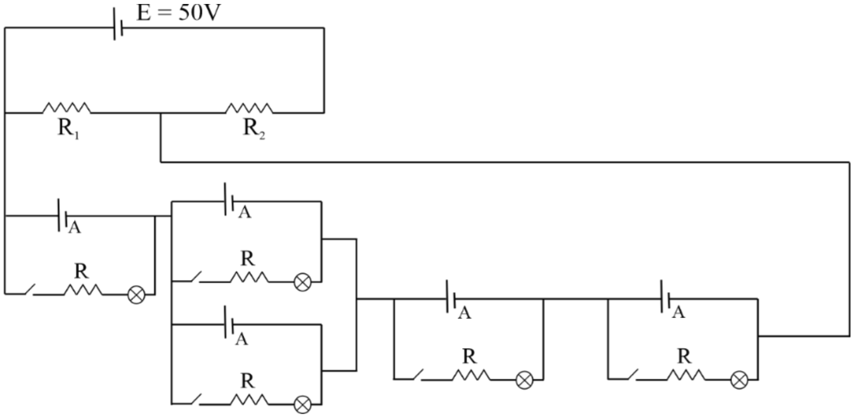


Figure 6

E is the solar panel system of the solar jar .This new solar jar is similar to the previous one , but there is a large collection of solar panels to obtain a voltage of $50\ V$. Note that all the bulbs used here also identical to the bulbs mentioned in part (d) and they light up under same rated conditions.

(i) Find the value of $\frac{R_1}{R_2}$
(ii) If $R_2 = 50\Omega$ then find R_1
(iii) Calculate the current flowing through the entire circuit when the cells (A) are charging.

(iv) The student says that a $30\ V$ solar panel system can be used instead of $50\ V$. Explain the validity of the above statement.

(v) If this $50\ V$ solar panel system takes six hours to make the cells (A) to fully charge, how much electrical energy is produced in the solar panel system during that charging period?

(vi) Using this circuit, the student tries to operate the ceiling fan of his room. Whether his effort is successful or not. Explain

(9B) Figure 1 shows a common-emitter transistor circuit and also its input/output voltage characteristics.

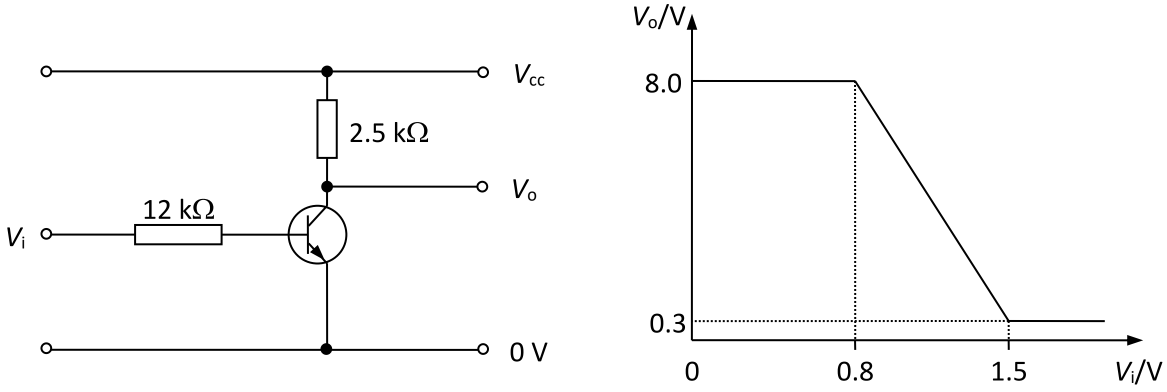


Figure 1

(a) (i) Find the voltage V_{cc}.

(ii) What is the voltage between base and emitter when $V_i = 1.5$ V?

(iii) Find the voltage gain and the current gain of this transistor circuit.

(b) In order to amplify the rectified signal of alternating current (a.c.) shown in Figure 2, two resistors and two capacitors are added to the circuit as shown in Figure 3.

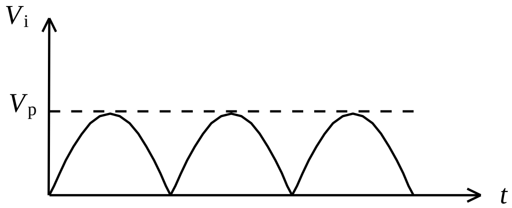


Figure 2

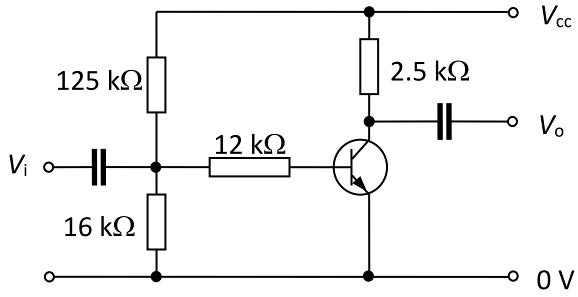


Figure 3

(i) State the function of the capacitors in the circuit.

(ii) What is the maximum value of V_p such that the signal can be amplified without chopping off the peaks?

(iii) Draw a rough diagram of the corresponding output signal if $V_p = 0.2$ V.

(c) Figure 4 shows an operational amplifier circuit.

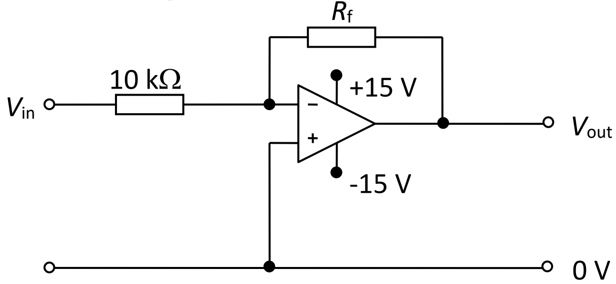
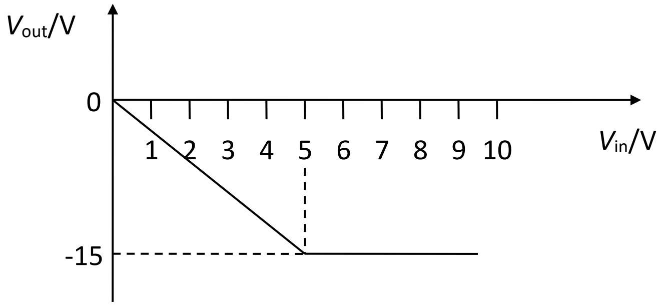


Figure 4

A graph of output voltage V_{out} plotted against input voltage V_{in} is shown below.



(i) What is the resistance of the resistor R_f?

(ii) With reference to the graph, explain the function of the above circuit.

(d)

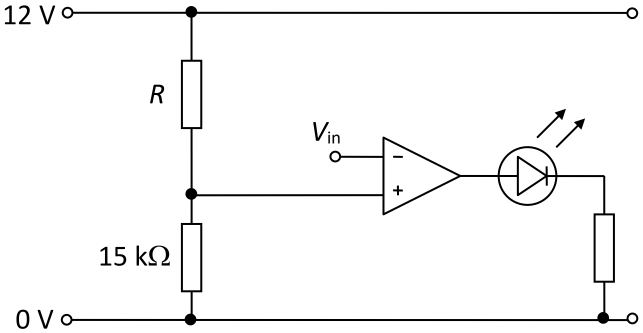


Figure 5

Figure 5 shows the circuit of a comparator. The LED lights up when the input voltage V_{in} is less than 4.5 V. Find the minimum resistance value of R.

(e) A stable power supply is essential for the operation of computer parts, which usually work at 5 V d.c. A fluctuation in the supply voltage V_{in} of more than 10% is certainly not tolerable, so it is therefore important to keep a regular check on it. Figure 6 shows a warning device designed for such a purpose.

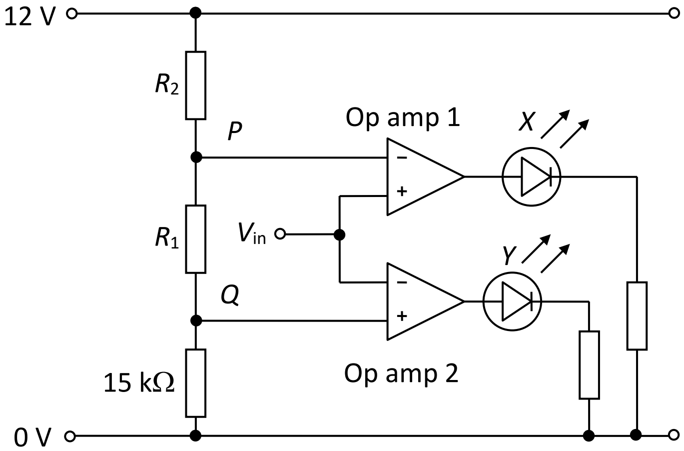


Figure 6

(i) State the potentials at P and at Q.

(ii) Briefly explain the requirement to be satisfied for lighting the LEDs indicated as X and Y.

(iii) Calculate the values of resistors R_1 and R_2.

(10A)

(a) Introduce the apparent expansion and absolute expansion of a liquid.

(b) (i) What is meant by the sensitivity of a thermometer?

(ii) When the volume of mercury in the bulb remain unchanged, should the cross section of the capillary be increased or decreased?

(c) Volume of the bulb of a mercury in glass thermometer is 0.2 cm^3 at 0 °C. This thermometer is calibrated to measure temperature in the range of 0 – 150 °C. The coefficient of linear expansion of the glass of this thermometer is 3×10^{-6} $°\text{C}^{-1}$ and the coefficient of absolute expiation of mercury is $2 \times 10^{-4}$$°\text{C}^{-1}$. Assume that the bulb is filled with mercury at 0 °C and the expansion of the tube is negligible.

(i) Determine the volume of the bulb and mercury at 150 °C. Assume that the mercury in the capillary is also reached to 150 °C.

(ii) Calculate the minimum length of the capillary if its cross sectional area is 2.292×10^{-4} cm^2.

(iii) Find the sensitivity of this thermometer in mm $°\text{C}^{-1}$.

(d) .In this temperature range, it can be assumed that the volume expansion of mercury as a metal is almost linear, but glass is not. Therefore the reading of a this type of thermometer is not so accurate. A student suggests to insert a piece of metal into the bulb so that the mercury volume is always a constant.

(i) If a metal of linear expansivity 1.2×10^{-4} $°\text{C}^{-1}$ is given, determine the volume of the piece of metal to be inserted at 0 °C such that the mercury volume in the bulb is always a constant .

(ii) When a metal is selected for this purpose, what are the other important properties to be concerned other than the expansivity?

(iii) If the capillary tube used in c(ii) is to be used in this thermometer too, find the required length, so that the same range of temperature is to be maintained.

(iv) Find the sensitivity of new thermometer in mm $°\text{C}^{-1}$.

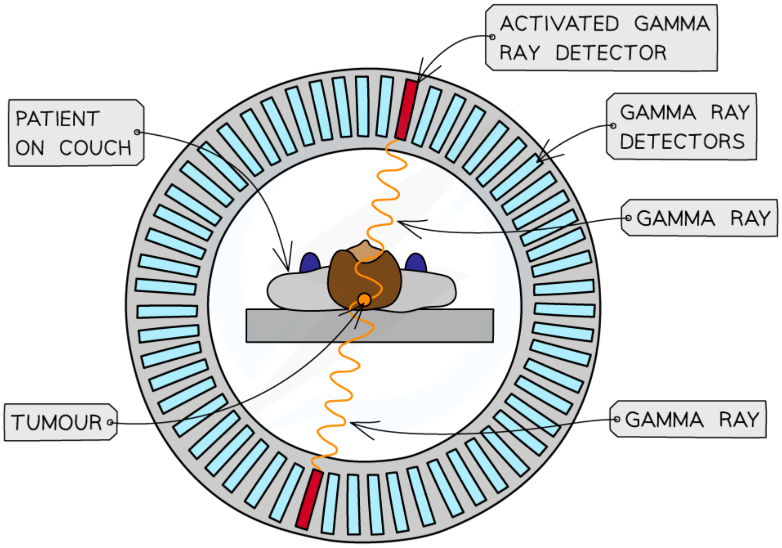
(v) There is a spherical bulb at the upper end of the capillary of the new thermometer to prevent possible damage due to over expansion of mercury if thermometer is placed in a liquid where temperature is higher than 150°C. Calculate the minimum radius of the bulb in mm to protect the thermometer up to 300 °C. (assume $\pi = 3$ and $\sqrt[3]{1462.5} = 11.35$)

(10B)

Positron emission tomography (PET) is a modern technique used in medicine for imaging soft tissues. Before scanning, the patient is injected with a sugar-like substance called Fluorodeoxyglucose (FDG). The FDG molecules are absorbed into various tissues within the body. These FDG molecules have been added with radioactive isotope ^{18}F as a tracer. This ^{18}F tracer has a short half-life and begins emitting positrons immediately. Therefore, the exposure time to radiation is short. A positron is identical to an electron except that it carries an equal but opposite charge.

When the positron travels about 1 mm through the soft tissue of the patient, it interacts with an electron in the tissue. When a positron meets an electron, their mass (m) turns into energy (E) according to the equation $E=mc^2$ (where c is the speed of light in vacuum). This energy is released in the form of two identical gamma ray photons which travel in opposite directions. This is called **annihilation**. The frequency (f) of gamma rays, is given by the equation, $E = hf$ (where h is the Planck's constant). The relevant part of the body being checked is surrounded by a detection ring that a diameter of about 1 m. The delay time between the two gamma ray photons reaching the detection ring is used to determine the location of the **annihilation** occurred due to the tracer ^{18}F. The line that connects the two points at which the two gamma ray photons were detected by the detection ring is known as the **line of response** (LOR). The **source of emission** must lie somewhere along the LOR.

The computer connected to the detection ring produces images of this soft tissues. PET scans are useful for identifying tumors because tumors use more glucose than a normal tissue. The FDG tracer, which is a form of glucose, is found in higher quantities at the tumor site and this shows up as a bright area on the PET image. When having a PET scan the patient is injected with a radioactive substance. Nevertheless, the effective dose of radiation involved in a PET scan is within the tolerance and is nearly equal to the dose that a person would naturally expose to in two years.



As shown by the above figure, a patient having a tumor undergoes a PET scanning. In the scanner, ^{18}F decays by positron emission. A particular positron meets with an electron at a point in the tumor and **annihilates** producing two gamma-rays.

Mass of an electron = mass of a positron $m_e = 9.11 \times 10^{-31}$ kg
Speed of light, $c = 3.0 \times 10^{8}$ m s^{-1}

(a) With reference to the electric charge of the positron and the electron,
  (i) What is the difference between them?
  (ii) What is the similarity between them?
(b) Mention an advantage that can be expected from using a radioactive tracer having a short-half life.
(c) According to the passage,
  (i) What is the phenomenon which the PET scanning is based on?
  (ii) Explain briefly, how brain tumors are detected through PET scans.
(d) (i) Write the relevant equation in order to calculate the energy released in joules, when a positron and an electron annihilate. Do the correct substitution for quantities in that equation.
  (ii) If the answer to the part d (i) above is E_i, how much is the energy of a single gamma ray photon in joules ?

(e) When the annihilation is considered,

(i) Why do the two gamma ray photons travel in opposite directions?

(ii) The two gamma rays emitted, have the photons of same energy. What is the equation you use to justify that the two rays have the same frequency?

(f) Calculate, how far the **source of emission** be, from the center of the line of response (LOR) if the two gamma ray photons emitted from that source arrive at the detection ring 500 picoseconds apart? Assume that the LOR lies on a diameter of the detection ring. (Take that the speed of gamma rays is same as the speed of light)

(g) (i) How can gamma rays cause health hazards?

(ii) Considering the information given in the passage, estimate the effective dose of radiation used in a PET scan if the natural dose of radiation in the environment is 3.1 mSv per year.