අධ්‍යාපන, උසස් අධ්‍යාපන සහ වෘත්තීය අධ්‍යාපන අමාත්‍යාංශය
கல்வி, உயர்கல்வி மற்றும் தொழிற்கல்வி அமைச்சு
Ministry of Education, Higher Education and Vocational Education

අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය, 2026 උපකාරක තක්සේරුව
General Certificate of Education (Adv. Level) Exam, 2026 Supportive Assesment

භෞතික විද්‍යාව	I
Physics	**I**

01	E	I

පැය දෙකයි
Two hours

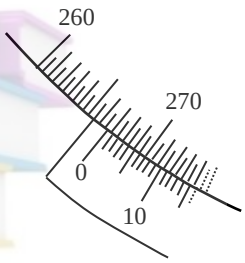
Instructions:-

- This paper consists of 50 questions in 09 pages.
- Answer all the questions.
- 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 (X) in accordance with the instructions given on the back of the answer sheet.
- Use of calculators is not allowed.

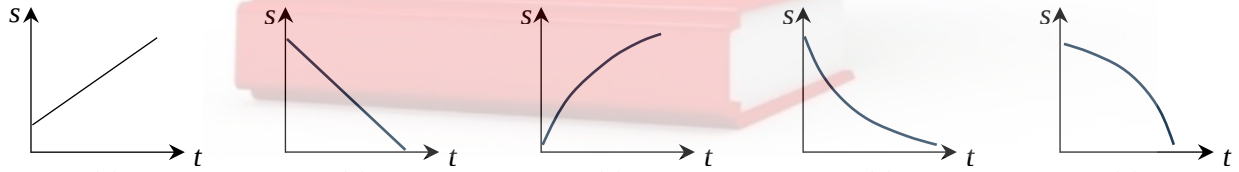
(g = 10 N kg $^{-1}$)

01. The amplitude (A) of a damping oscillation of mass m is given by the following equation. $A = A_0 e^{-\left(\frac{at}{m}\right)}$. Where t is time. The dimension of a is,
(1) $ML^{-1}T$ (2) MLT (3) M^0LT^{-1} (4) MLT^{-1} (5) ML^0T^{-1}

02. A spectrometer has a main scale division of 0.5°. The vernier scale is set up by dividing 29 divisions of the main scale into 30 equal parts. The figure shows how it is set up to obtain a certain reading. What is that reading,
(1) 93° 23′ (2) 265° 07′ (3) 266° 37′
(4) 273°07′ (5) 273° 23′

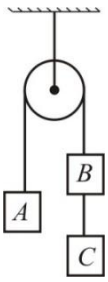


03. The displacement (s) - time (t) graphs of five objects are shown in the figure. Among them, the object that has acceleration is ,



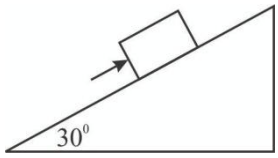
(1) (2) (3) (4) (5)

04. As shown in the figure, three cubes A, B and C, each of mass 2 kg, are suspended by a light inextensible string passing over a smooth pulley. When the system is released in this way, the tension in the string between B and C is approximately,
(1) 0 . (2) 3.3 N . (3) 13.3 N . (4) 19.3 N . (5) 23.3 N .



05. A transverse wave of frequency 60 Hz travels along a string at a speed of 60 m s^{-1}. What is the difference in radians between the amplitudes of vibration of any two points on the string that are 25 cm apart?
(1) 0 (2) $\frac{\pi}{4}$ (3) $\frac{\pi}{2}$ (4) π (5) $\frac{3\pi}{2}$

06. An object of mass 2 kg is placed on a rough inclined plane with an angle of 30° to the horizontal. The coefficient of static friction between the object and the plane is 0.5. What is the minimum force that must be applied along the plane to prevent the object from sliding down ? ($\sqrt{3} = 1.7$)

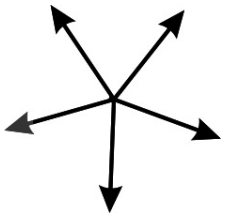


(1) 1.5 N (2) 2.5 N (3) 12.5 N
(4) 18.5 N (5) 22.5 N

07. A ray of light travels from a vacuum into a medium with a refractive index of *n*. If its angle of incidence is twice the angle of refraction, what is the angle of incidence?

(1) $\cos^{-1}\frac{n}{2}$ (2) $\sin^{-1}\frac{n}{2}$ (3) $2\cos^{-1}\frac{n}{2}$ (4) $2\sin^{-1}\frac{n}{2}$ (5) $\tan^{-1}\frac{n}{2}$

08. Five forces of magnitude 10 N each acting in five directions from a single point on the same plane. The same inclination exists between any two adjacent forces. What is the magnitude of the resultant of this system of forces?



(1) 0 N (2) 3.3 N (3) 13.3 N
(4) 19.3 N (5) 23.3 N

09. A fluid of density 1.2×10^3 kg m^{-3} flows through a horizontal pipe of cross-sectional area 2.5×10^{-3} m^2. Its static pressure and total pressure are 6 kPa and 8 kPa respectively. If the fluid is a non-viscous incompressible fluid, what is the flow rate of the fluid?

(1) 3.0×10^{-3} m^3 s^{-1} (2) 5.0×10^{-3} m^3 s^{-1} (3) 8.0×10^{-3} m^3 s^{-1} (4) 1.0×10^{-2} m^3 s^{-1} (5) 2.0×10^{-2} m^3 s^{-1}

10. A rod of Young's modulus 2×10^{10} N m^{-2} is subjected to a tensile strain of 0.06%. What is the elastic potential energy stored in its unit volume?

(1) 3.6 kJ m^{-3} (2) 7.2 kJ m^{-3} (3) 10.8 kJ m^{-3} (4) 14.4 kJ m^{-3} (5) 17.6 kJ m^{-3}

11. A container of depth *d* is half filled with a liquid of refractive index μ_1 and the other half with a liquid of refractive index μ_2. When looking at the bottom of the container from above, the apparent depth is,

(1) $d(\mu_1 + \mu_2)$ (2) $\frac{d}{2}(2 - \frac{1}{\mu_1} - \frac{1}{\mu_2})$ (3) $\frac{d}{2}(\mu_1 + \mu_2)$ (4) $\frac{d}{2}(\frac{1}{\mu_1} + \frac{1}{\mu_2})$ (5) $\frac{2}{d}(\mu_1 + \mu_2)$

12. A uniform circular rim of radius *r* and mass *m*, as shown in the figure, is rolling without slipping on a horizontal plane with a velocity *v*. What is the maximum height it can travel up the rough inclined plane?

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

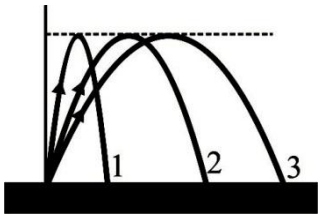
13. What is the time taken for light to travel through a transparent medium of thickness 4 mm made of a material with a refractive index of 3? (The speed of light in a vacuum 3×10^8 m s^{-1})

(1) 2×10^{-11} s (2) 4×10^{-11} s (3) 16×10^{-11} s (4) 4×10^{-10} s (5) 8×10^{-10} s

14. Two capillary tubes *A* and *B* of equal length with radii r and $\frac{r}{2}$ respectively are connected in parallel, and a viscous liquid is allowed to flow through them under the same pressure difference. If the flow rate through *A* is 8.0×10^{-3} cm^3 s^{-1}, what is the flow rate through the combination of tubes,

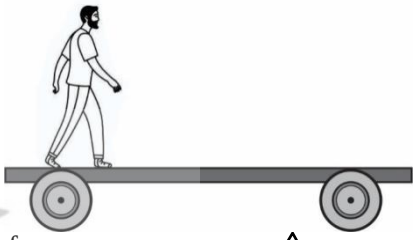
(1) 8.0 cm^3 s^{-1} (2) 8.5 cm^3 s^{-1} (3) 12.0 cm^3 s^{-1} (4) 16.5 cm^3 s^{-1} (5) 24.0 cm^3 s^{-1}

15. The figure below shows three possible paths for a football that is thrown upwards from ground level. In the answers below, V, U and t represent the vertical velocity, horizontal velocity and flying time respectively. The letters in the brackets indicate the base characters respective paths. If air resistance is ignored, which of the following statements is correct?



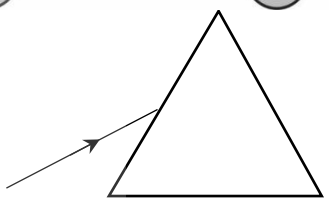
(1) $V_3 > V_2 > V_1$ $U_3 > U_2 > U_1$ $t_3 > t_2 > t_1$
(2) $V_3 = V_2 = V_1$ $U_3 > U_2 > U_1$ $t_1 > t_2 > t_3$
(3) $V_3 = V_2 = V_1$ $U_3 > U_2 > U_1$ $t_1 = t_2 = t_3$
(4) $V_1 > V_2 > V_3$ $U_3 = U_2 = U_1$ $t_1 > t_2 > t_3$
(5) $V_3 = V_2 = V_1$ $U_3 = U_2 = U_1$ $t_1 = t_2 = t_3$

16. A trolley of mass 200 kg and length 5 m is at rest on smooth horizontal rails, and a man of mass 50 kg is at one of its ends. He walks along the trolley to the other end. Then, the distance walked by the man relative to the ground is,



(1) 2.5 m . (2) 4 m . (3) 5 m.
(4) 7.5 m . (5) zero.

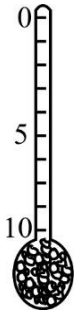
17. A light ray incident on an equilateral prism is shown in the figure. If its angle of incidence is ¾ of the prism angle, and the angle of incidence is equal to the angle of emergence, what is the refractive index of the material of the prism?



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

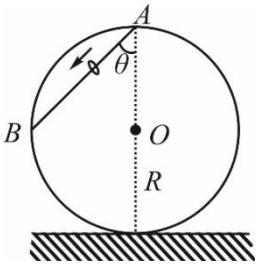
18. Consider the following statements about inertia:
(A) Inertia is the reluctance of an object to change its state of motion.
(B) The force required to push an object on a smooth horizontal surface depends on the gravitational mass of the object.
(C) Inertial mass is measured by a spring balance.
From the above statements
(1) Only (A) is true. (2) Only (B) is true. (3) Only (C) is true.
(4) (A) and (C) is true. (5) All of (A), (B) and (C) are true.

19. A uniform body of a hydrometer is uniformly calibrated from top to bottom, 0, 1, 2, 3, etc., up to 10. When it floats in water, it sinks to level 0, and when immersed in a liquid of relative density 1.5, it sinks to level 10. The relative density of a liquid that sinks to level 5 is,



(1) 1.10 (2) 1.15 (3) 1.20
(4) 1.25 (5) 1.30

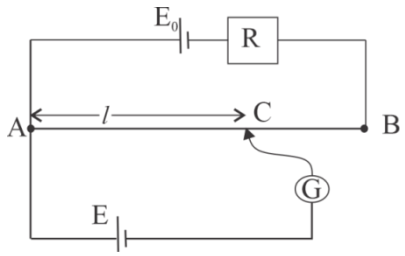
20. A smooth wire connects two points A and B on a fixed, vertical wheel of radius R. When a smooth beat attached to it is placed at B and released from rest, the time taken by it to reach B is



(1) $2\sqrt{\frac{R}{g}}$ (2) $2\sqrt{\frac{R}{g\cos\theta}}$ (3) $\frac{2\sqrt{gR}}{g\cos\theta}$
(4) $\frac{gR}{\sqrt{g\cos\theta}}$ (5) $\frac{2\sqrt{gR\cos\theta}}{g}$

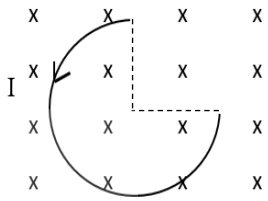
21. A person wearing a pair of glasses with a power of +2D must hold a book at least 40 cm away from his eyes to read clearly. The power of the lens he must wear to see clearly an object 25 cm away from his eyes is,
(1) +4.5 D (2) +4.0 D (3) +3.5 D (4) -3.0 D (5) -3.5 D

22. Consider the following statements about the potential meter circuit shown in the figure.



(A)Even if $E > E_0$ is an equilibrium length can be obtained.
(B)The internal resistance of E has no effect on the equilibrium length l.
(C) If the value of R is increased, the equilibrium length l also increases.
Which of the above statements is/are true?
(1) Only A. (2) Only . (3) Only A and B.
(4) Only B and C. (5) All of A, B, C.

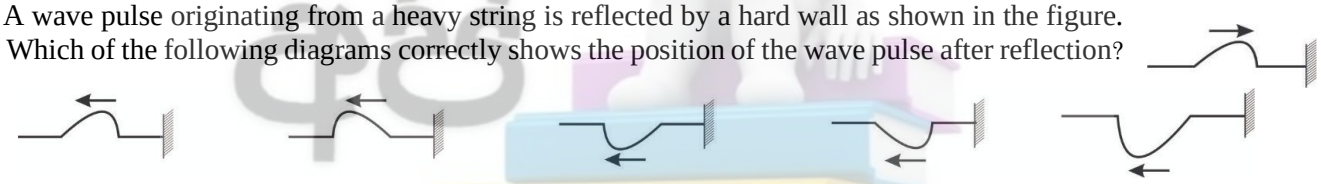
23. A conducting wire bent into a circular arc of radius r as shown in the figure is placed in a magnetic field of flux density B parallel to its axis. Find the magnetic force acting on the wire when a current of I flows through the wire.



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

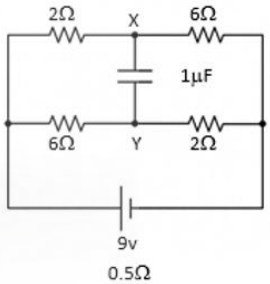
24. A wire of uniform cross-sectional area is stretched until its length is four times its original length. Consider the following statements.
(A)The resistance of the new wire is four times the resistance of the original wire.
(B)The resistance of the new wire is sixteen times the resistance of the original wire.
(C)If the same potential difference was applied to the two ends of the wire before and after stretching, then the rate of heat generation from the wire increases sixteen times after stretching.
Which of the following statements is true?
(1) Only A. (2) Only B. (3) Only C. (4) Only A and C. (5) Only B and C

25. A wave pulse originating from a heavy string is reflected by a hard wall as shown in the figure. Which of the following diagrams correctly shows the position of the wave pulse after reflection?



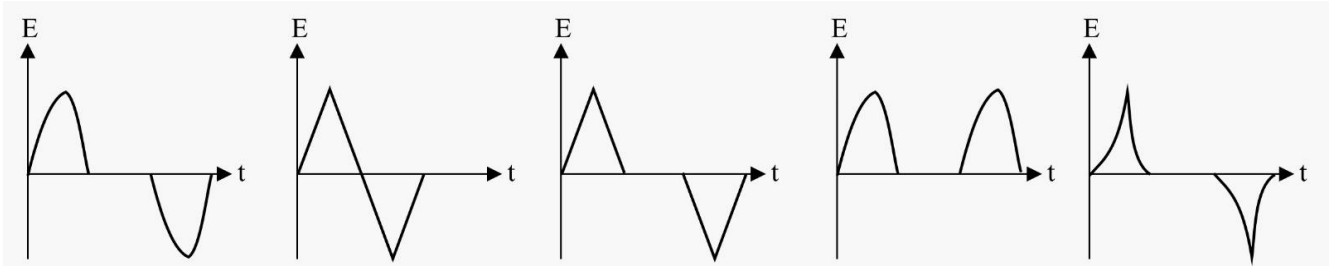
(1) (2) (3) (4) (5)

26. The electromotive force of the cell shown in the figure is 9 N and the internal resistance is 0.5 Ω. The capacitance of the capacitor is 1 Ω. What is the total energy stored in the capacitor after it is fully charged?



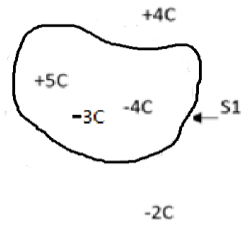
(1) 0 (2) 4×10^{-6} J
(3) 8×10^{-6} J (4) 16×10^{-6} J
(5) 10.125×10^{-6} J

27. What is the graph showing how the induced electromotive force in the loop of wire shown in the figure below varies with time when it moves at a constant speed through the magnetic field in the plane of the paper as shown in the figure?



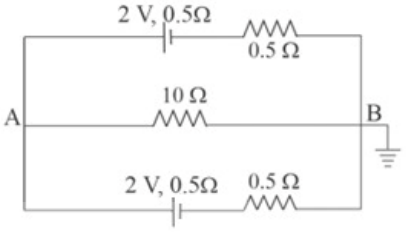
(1) (2) (3) (4) (5)

28. In the figure, a closed Gauss surface is indicated by S_1. There are charges + 5 C, - 4 C, - 3 C inside the Gauss surface, and charges + 4 C, - 2 C outside it. The effective electric flux into or out of the Gauss surface can be completely reversed by:



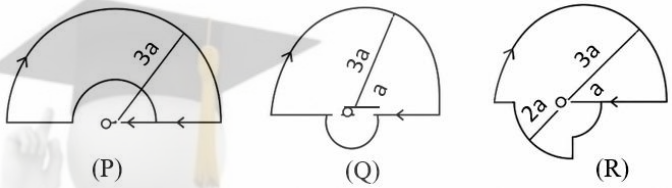
(1) placing a charge of + 2 C inside the Gauss surface.
(2) placing a charge of + 4 C inside the Gauss surface.
(3) placing a charge of + 4 C inside the Gauss surface.
(4) placing a charge of + 5 C outside the Gauss surface.
(5) placing a charge of - 6 C outside the Gauss surface

29. The electromotive force of the cells in the circuit shown is 2 V each and the internal resistance is 0.5 Ω each. What is the potential at point A when point B is grounded?



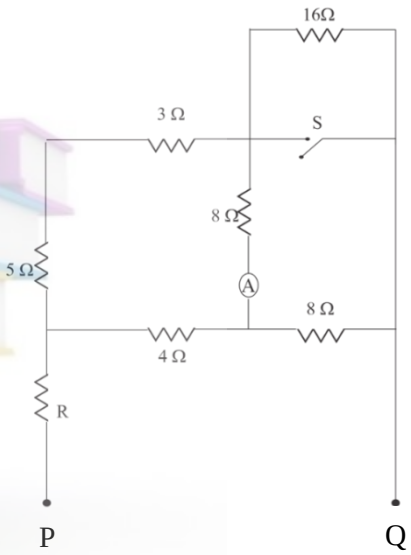
(1) - 1.6 V (2) + 1.6 V
(3) - 0.8 V (4) + 0.8 V
(5) 0

30. Three concentric circular arcs *P*, *Q*, *R* (semicircles or quarter-circles of radius *a*, 2*a*, 3*a*) are shown in the figure. The loops carry the same *I* current. If the magnetic flux densities at O in each loop are B_P, B_Q, and B_R, respectively,



(1) $B_P = B_Q = B_R$ (2) $B_Q > B_R > B_P$ (3) $B_R > B_Q > B_P$ (4) $B_P = B_Q > B_R$ (5) $B_R > B_P = B_Q$

31. In the circuit shown in the figure, A is a perfect ammeter. A potential difference of 12 V is given between P and Q. When the *S* switch is closed, the ammeter shows a reading of 0.3 A.



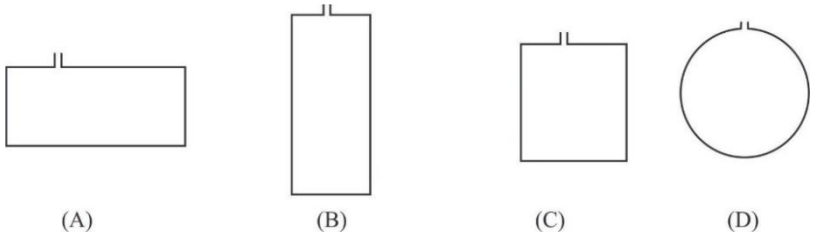
	Value of *R* (Ω)	Current through *R* when *S* switch is open (A)	Current through *R* when *S* switch is closed (A)
(1)	1	0.6	$^3/_4$
(2)	4	0.3	$^3/_4$
(3)	6	1.2	$^6/_7$
(4)	2	0.8	$^5/_3$
(5)	6	1.2	$^7/_6$

32. When an iron block floats in mercury at 0°C, k_1 fraction of its volume is submerged, and at 60°C, k_2 fraction is submerged. If the volumetric expansion of iron is γ_{Fe} and the volumetric expansion of mercury is γ_{Hg}, then the ratio of $\frac{k_1}{k_2}$ is equal to,

(1) $\frac{1+60\gamma_{Fe}}{1+60\gamma_{Hg}}$ (2) $\frac{1-60\gamma_{Fe}}{1+60\gamma_{Hg}}$ (3) $\frac{1-60\gamma_{Fe}}{1-60\gamma_{Hg}}$ (4) $\frac{1+60\gamma_{Hg}}{1+60\gamma_{Fe}}$ (5) $\frac{1-60\gamma_{Hg}}{1+60\gamma_{Fe}}$

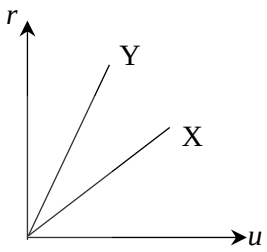
33. As the frequency of photons incident on a metal surface increases, while keeping the rate of incident photons constant;
(1) The number of electrons emitted increases.
(2) The photoelectric current increases.
(3) The maximum kinetic energy of the emitted electrons increases.
(4) The stopping voltage of the metal decreases.
(5) The work function of the metal increases

34. Four wires of length $2a$ are suspended parallel to a magnetic field and are made to carry equal currents as shown in the figure. In shape, *A* and *B* are rectangular, *C* is square, and *D* is a circular. The short sides of the two wire frames $\frac{a}{4}$ each. On which wire frame/frames will the maximum torque be produced?



(1) A (2) B (3) C (4) D (5) A සහ B

35. Two charges *A* and *B* enter a magnetic field perpendicularly. The graph shows how the radius of the path changes with the speed of the charges. Consider the following statements in this regard.



(A) If the two charges are equal in magnitude, then *Y* has a greater mass.
(B) If the two particles are equal in mass, then *X* has a greater charge.
(C) The ratio of mass to charge of *X* is greater than that of *Y*.

Which of the following is/ are true
(1) Only A (2) Only B (3) Only A and B
(4) Only A and C (5) Only B and C

36. A thin conducting shell of radius *R* carrying a charge + *q* has another charge +*Q* placed at its center. The electric potential at a point called *P* located at a distance *R*/2 from the center of the shell is,

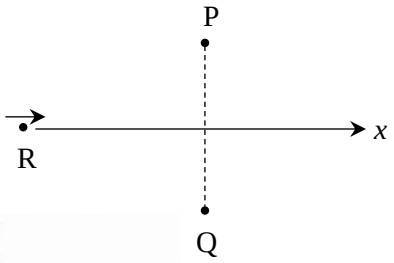
1) $\frac{Q}{2\pi\varepsilon_0 R}$ (2) $\frac{1}{2\pi\varepsilon_0 R}(Q-q)$ (3) $\frac{1}{4\pi\varepsilon_0 R}(2Q+q)$ (4) $\frac{1}{2\pi\varepsilon_0 R}(2Q+q)$ (5) $\frac{1}{4\pi\varepsilon_0 R}(Q-q)$

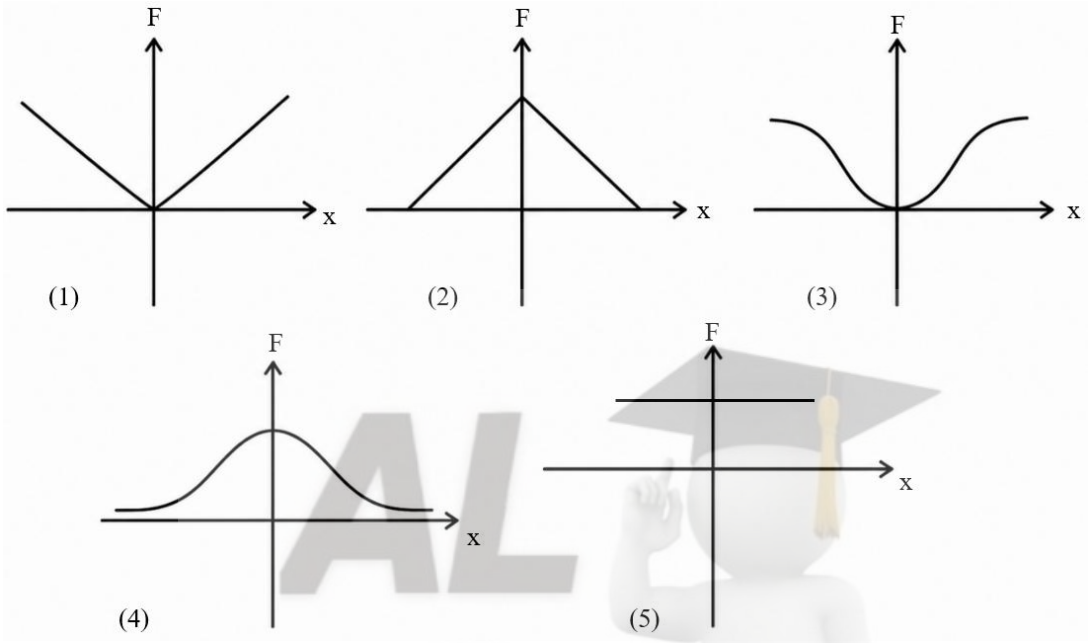
37. A satellite moves in a circular orbit very close to the surface of a planetary body of density ρ . What is its orbital period? (Here, *G* is the universal gravitational constant.)

(1) $\sqrt{\frac{\rho G}{3\pi}}$ (2) $\sqrt[3]{\frac{3\pi}{2\rho G}}$ (3) $\sqrt{\frac{3\pi}{\rho G}}$ (4) $\sqrt{\frac{3\pi}{2\rho G}}$ (5) $\sqrt[3]{\frac{3\pi}{\rho G}}$

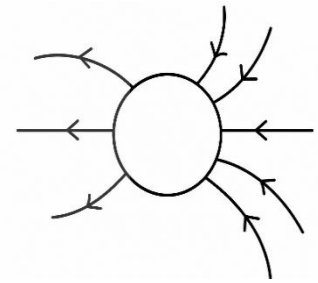
38. The boiling point of mercury is 357 °C. However, a mercury thermometer is constructed such that it can measure temperatures up to 500°C. This is achieved by doing which of the following in the stem of the thermometer?
(1) Maintaining a vacuum above the mercury column.
(2) Filling the space above the mercury column with nitrogen gas under pressure.
(3) Completely filling the space above the mercury column with an alcohol column at room temperature.
(4) Filling the space above the mercury column with oxygen gas under pressure.
(5) Enlarging the mercury bulb.

39. A positive point charge *R* moving along the perpendicular bisector of the line joining two fixed, equal negative point charges *P* and *Q* is shown in the figure. Which of the following best represents how the magnitude of the net force *F* exerted on charge *P* by the positive charge varies with the distance *x*,





40. The figure shows the distribution of electric field lines outside a spherical object. An electric field exists around it as shown in the figure. This spherical object could be
(1) A positively charged conducting sphere.
(2) A negatively charged conducting sphere.
(3) A charged conducting sphere placed in an external electric field.
(4) An isolated negatively charged insulating sphere.
(5) An empty space with no net charge.

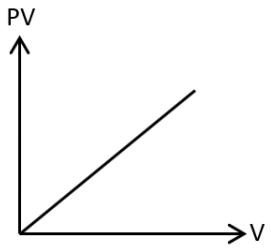


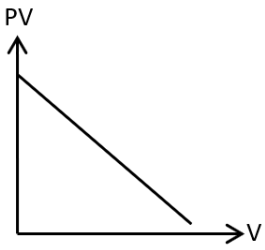
41. An ideal gas is contained in a vessel. Assume that no heat exchange can occur between the vessel and the surroundings. If the internal energy of the gas decreases by an amount equal to the work done by the system,
(1) the thermal process must be an isothermal expansion.
(2) the thermal process must be an adiabatic expansion.
(3) the thermal process must be an adiabatic compression.
(4) the thermal process must be an isobaric compression.
(5) the temperature of the system must increase

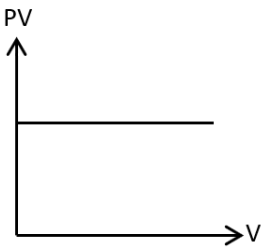
42. Two vessels of identical dimensions, made of two different metals *A* and *B*, are filled with equal amounts of ice at 0 °C and closed with a lid. The time taken for the ice in the two vessels to melt completely is 20 min and 35 min, respectively. If the temperature of the surrounding environment remains constant, the ratio of the **thermal conductivity of metal *A* to the thermal conductivity of metal *B*** is,

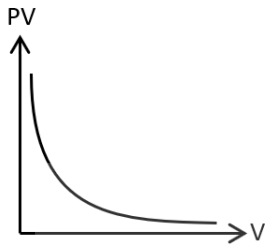
(1) $\frac{4}{7}$ (2) $\frac{16}{49}$ (3) $\frac{7}{4}$ (4) $\frac{49}{16}$ (5) $\frac{21}{5}$

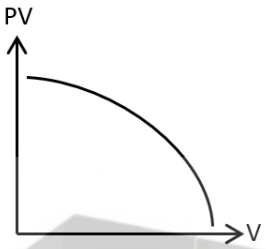
43. Which of the following graph represents the behavior of an ideal gas?

(1) 

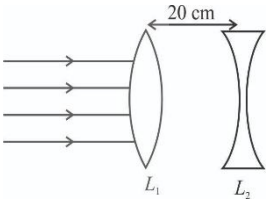
(2) 

(3) 

(4) 

(5) 

44. A parallel beam of light enters a thin converging lens (L_1) of focal length 30 cm and travels towards a thin diverging lens (L_2) of focal length 20 cm, which is placed at a distance of 20 cm from (L_1). At what position is the final image formed by this combination located?



(1) On the L_1 (2) 13.3 cm right from L_1
(3) 20 cm right from L_2 (4) On the L_2
(5) At the infinity

45. The half-life of a radioactive element is 10 days. After 30 days, the ratio of the remaining undecayed nuclei to the initial number of nuclei,

(1) $\frac{1}{2}$ (2) $\frac{1}{4}$ (3) $\frac{1}{3}$ (4) $\frac{1}{8}$ (5) $\frac{1}{16}$

46. Figure (A) shows a case of capillary rise in a clean glass capillary tube immersed in water. If a small hole is now made at P as shown in the figure:

(1) Water flows out through hole P while the water meniscus remains at Q.
(2) Water does not flow out through hole P while the water meniscus remains at Q.
(3) Water flows out through hole P until the water meniscus drops from Q to P.
(4) Air enters the tube through hole P while the water meniscus is at Q.
(5) Water flows out through hole P and the water meniscus comes to a position between Q and P

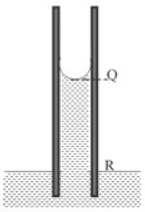


Figure (A)

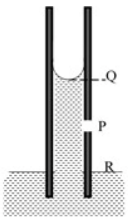
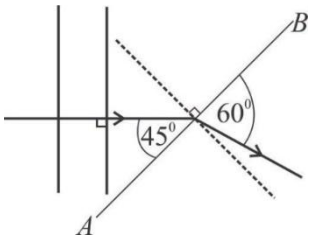


Figure (B)

47. The figure shows a straight wavefront of a water wave traveling across a deep-to-shallow water interface *AB*. The velocity of the water wave in deep water is 0.08 m s^{-1}. Its velocity in shallow water would be,(Take $\sqrt{2}$ =1.4)

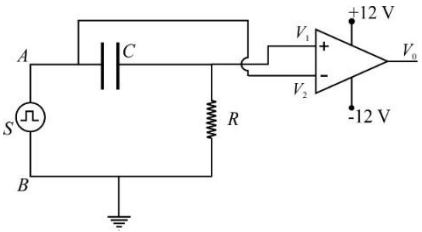


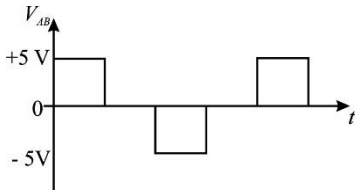
(1) 0.06 m s^{-1} (2) 0.11 m s^{-1}
(3) 0.24 m s^{-1} (4) 0.40 m s^{-1}
(5) 0.46 m s^{-1}

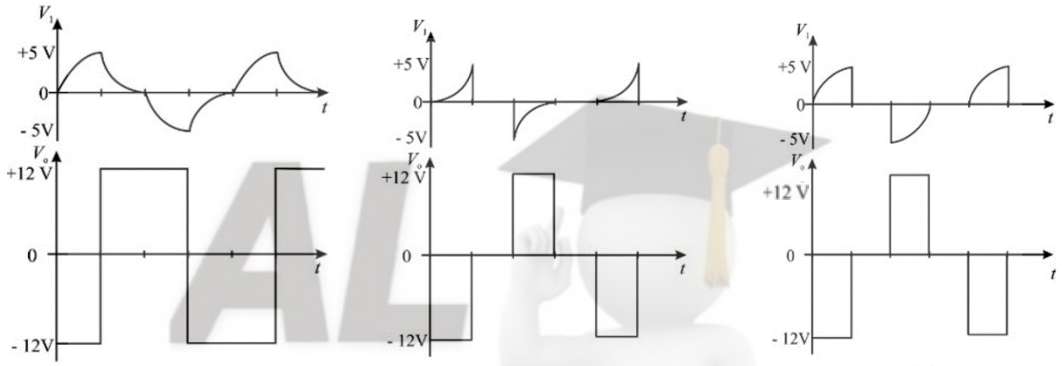
48. A meson consists of;

(1) Three quarks.
(2) Three antiquarks.
(3) One quark and one antiquark.
(4) Two quarks.
(5) One lepton and one quark.

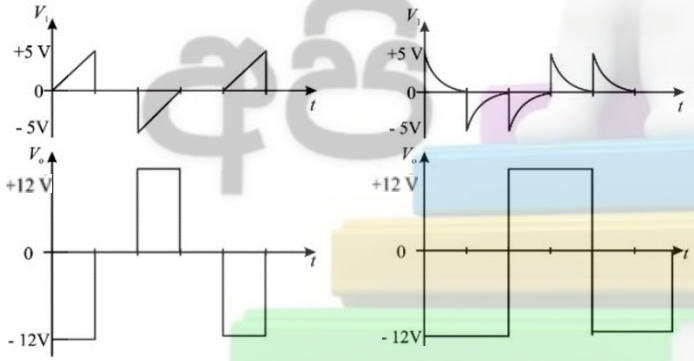
49. A rectangular alternating pulsating voltage signal of $\pm 5V$ (V_{AB}) is applied between terminals *A* and *B* of a circuit consisting of a resistor *R* and an uncharged capacitor *C* connected in series, at time $t = 0$. The common terminal of *R* and *C* is connected to the **non-inverting input** terminal of an operational amplifier circuit. When the **inverting input** terminal of the amplifier is connected to the other side of the capacitor, which graphs most correctly represent the possible variations of voltage V_1 at the **non-inverting** input terminal and voltage V_0 at the output terminal of the operational amplifier with respect to time.





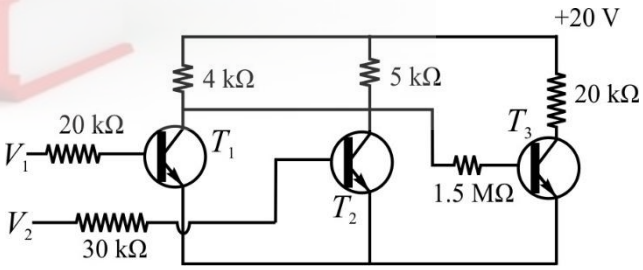


(1) (2) (3)



(4) (5)

50. The figure below shows a circuit containing three identical silicon transistors T_1 ,T_2 and T_3. Their DC current gain is $\beta = 100$. When voltages of 0 V and 3 V are applied to the input terminals V_1 and V_2 of the circuit in the situations mentioned below. Which of the following correctly indicates the values of the collector currents I_{C_1} , I_{C_2} and I_{C_3} flowing through transistors T_1 ,T_2 and T_3 respectively, and the value of the output voltage V_0 of transistor T_3 ? (Assume the base-emitter forward bias voltage V_{BE} = 0.7 V for each of these transistors.)



	V_1 (V)	V_2 (V)	Ic_1 (mA)	Ic_2 (mA)	Ic_3 (mA)	V_o / V
(1)	3.0	0	5.0	4.0	1.0	20
(2)	0	0	0	0	0	20
(3)	0	3	0	9.0	1.0	0
(4)	3.0	3.0	4.5	4.5	0	20
(5)	3.0	0	9.0	0	0	0

අධ්‍යාපන, උසස් අධ්‍යාපන සහ වෘත්තීය අධ්‍යාපන අමාත්‍යාංශය
கல்வி, உயர்கல்வி மற்றும் தொழிற்கல்வி அமைச்சு
Ministry of Education, Higher Education and Vocational Education

අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය, 2026 උපකාරක තක්සේරුව
General Certificate of Education (Adv. Level) Exam, 2026 Supportive Assessment

භෞතික විද්‍යාව II Chemistry II	**01**	**E**	**II**	**13** ශ්‍රේණිය **Grade 13**	*පැය තුනයි* ***Three hours***

Name : – .....

Extra reading time
10 minutes

Important:

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

A - Structured Essay

Answer all questions on this paper itself. Your answers should be written in the spaces provided on the question paper. Please note that this space is sufficient to write your answers and that long answers are not expected.

Section B - Essay

This section consists of **six questions** and you should answer only **four questions**. Use the paper provided for this purpose.

- After the time allotted for the entire question paper has expired, attach Section **A** and Section **B** so that they form one answer sheet and hand it over to the invigilator.
- You are allowed to take **only Section B** of the question paper out of the examination hall.

Part	Q. num	marks
A	1	
	2	
	3	
	4	
B	5	
	6	
	7	
	8	
	9 (A)	
	9 (B)	
	10 (A)	
	10 (B)	
	Total	
	In words	

See page two

Part A- Structured Essay
Answer **all four** questions **on this paper** itself

Do not write in this column

01.(i) (*a*) Draw the experimental setup used to determine the mass (*m*) of an object using the meter ruler in the physics lab, in the given space.

(*b*) What amount of mass (m_o), do you choose here for the known mass?

.....

.....

(*c*) Explain the reason for your selection in (i) (*b*).

.....

.....

(ii) The center of gravity of the meter ruler provided for the experiment was at 51 cm mark. Further to select the known mass m_o set of slotted masses (110 g) were given. A student performed the following experiment to determine the suitable known mass. He balanced the ruler at the center of gravity and the unknown mass *m* was hung at 40 cm (say *x*) from the center of gravity. Then with 70 g mass the balance length was 43 cm while the balance length became 39 cm when the mass was 80 g.

(a) Which mass do you use for the known mass m_o?

.....

(b) In this experiment which side do you select to hang the unknown mass *m*? Whether it is in 0- 51 cm arm or 51- 100 cm arm?

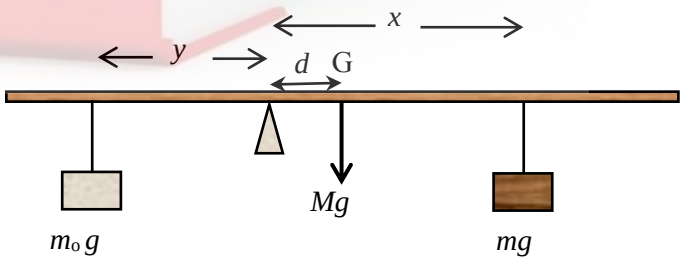
.....

(c) What are the values of *x* that you select if you are supposed to get 5 sets of readings?

.....

Make a sketch of the graph that you expect in this experiment how do you determine the unknown mass using the graph

(iii) The figure given here shows the setup used to determine the unknown mass as well as the mass of the meter ruler. Here *G* is the center of gravity of the meter ruler and *d* (constant) is the distance to the center of gravity from the knife edge.



(a) Write down an expression for the balance situation using the symbols given above.

.....

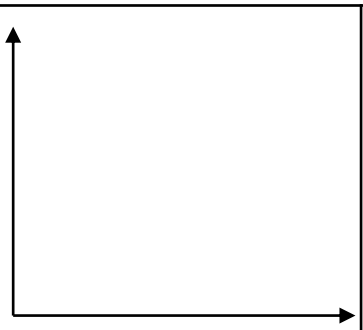
(b) Rearrange the above relation for the determination of mass *m* of the object and the mass of the meter ruler *M* using the graphical method.

.....

.....

Do not write in this column

(c) Make a rough sketch of the graph that you expect.



(d) How do you determine the unknown mass m using the graph?

.....

.....

.....

.....

.....

(e) How do you determine the mass M of the ruler using the graph?

.....

.....

(f) Which length do you use for d out of 5 cm 10 cm and 15 cm

.....

(iv) You are provided with a twine thread (of thickness about 2 mm) and a thin string (thickness about 0.5 mm) with sufficient length.

(a) Which string do you select to hang masses?

.....

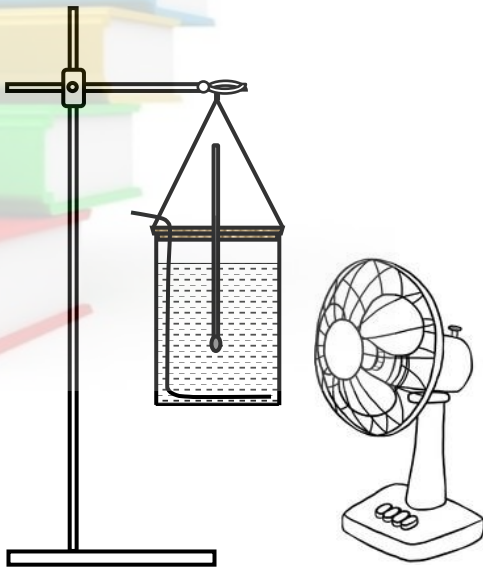
(b) What is the error of measurements if you use the twine thread?

.....

(c) What is the error of measurements if you use the thin string?

.....

02. Following figure shows an arrangement used to determine the specific heat capacity of a liquid using the method of cooling at the physics lab.



(i) (*a*) What are the measurements that you take during the experiment? (Use appropriate symbols for each of the measurement you mention)

.....

.....

.....

.....

.....

.....

.....

(*b*) Write down the expression that can be used to determine the specific heat capacity of the liquid c_l using the specific heat capacity of water c_w and the specific heat capacity of calorimeter c.

.....

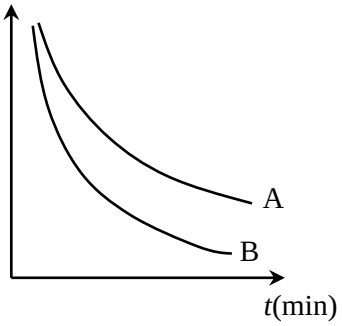
.....

Do not write in this column

(*c*) Two curves shown in the figure are cooling curves obtained for the water and coconut oil. Identify each of two curves.

A – .....

B – .....



(ii) (*a*) Up to which level do you fill the calorimeter with water?

.....

(*b*) Explain the reason for your answer above.

.....

.....

(*c*) In this experiment do you use equal volumes of coconut oil and water or equal masses of coconut oil and water?

.....

.....

(*d*) What is the reason for your answer in (ii) (*c*)?

.....

.....

(iii) (*a*) You are provided with three thermometers for the experiment. 0 – 100 °C thermometer with 0.2 °C of least count, 0 – 100 °C thermometer with 0.5 °C of least count and 0 – 100 °C thermometer with 1.0 °C of least count. Which thermometer do you use in this experiment?

.....

(*b*) State reason for your selection in (iii) (*a*) except the percentage error of measurements.

.....

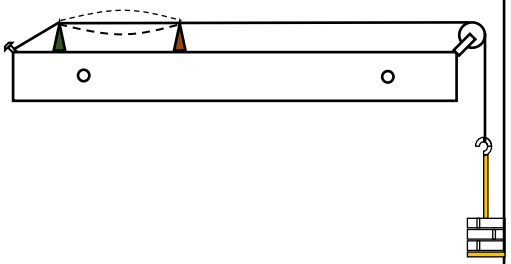
(iv) State two techniques that you can use to make the calculation more accurate when the calculations are rendered using the graphical method.

.....

.....

03. (i) The figure shows a sonometer arrangement that can be used to determine the frequency of an unknown tuning fork. The following list contains some apparatus that you can use for this purpose.

Sonometer, tuning fork of unknown frequency, a set of 5kg slotted mass, few light paper riders.



(a) What are the other instruments and items requiring for this experiment?

.....

.....

Do not write in this column

(b) Briefly mention the steps of your experiment.

.....

.....

.....

.....

.....

(c) Write down the relationship to be used in this experiment and identify its symbols.

.....

.....

.....

(d) Rearrange above relations to plot a graph.

.....

(e) How do you determine the unknown frequency using the graph?

.....

.....

(ii)(a) Here you must select masse to hang by the sonometer, state three basic factors to be confirmed before you start taking measurements.

.....

.....

.....

(b) What is the technique you use to get the most accurate fundamental resonance length for the first time?

.....

.....

(c) State the technique you use to confirm that the resonance length got in (ii) (b) is the fundamental resonance length.

.....

.....

(iii) You are provided with two wires made of same material with different diameter 0.3 mm and 1.0 mm.

(*a*) Which wire do you use for the sonometer wire here?

.....

(*b*) State the reason for this.

.....

(iv) There are two possible errors in the determination of resonance length.

(*a*) Name these two errors.

.....

.....

(*b*) State the technique that you can use to eliminate each of the above errors.

.....

Do not write in this column

.....

04. Apparatus used to determine the internal resistance *r* and electro motive force *E* of a dry cell are shown

(i) (a) draw the how you connect this apparatus appropriately for the above purpose.

(b) State your opinion on the suitable type of voltmeter and ammeter in this experiment?

I. voltmeter :

.....

.....

II. Ammeter

.....

.....

(ii). Consider the electromotive force of the cell as *E*, internal resistance as *r*, voltmeter reading *V* and ammeter reading *I*.

(*a*) Write down the relationship between above parameters and rearrange it to plot a graph for the determination of *E* and *r*.

.....

.....

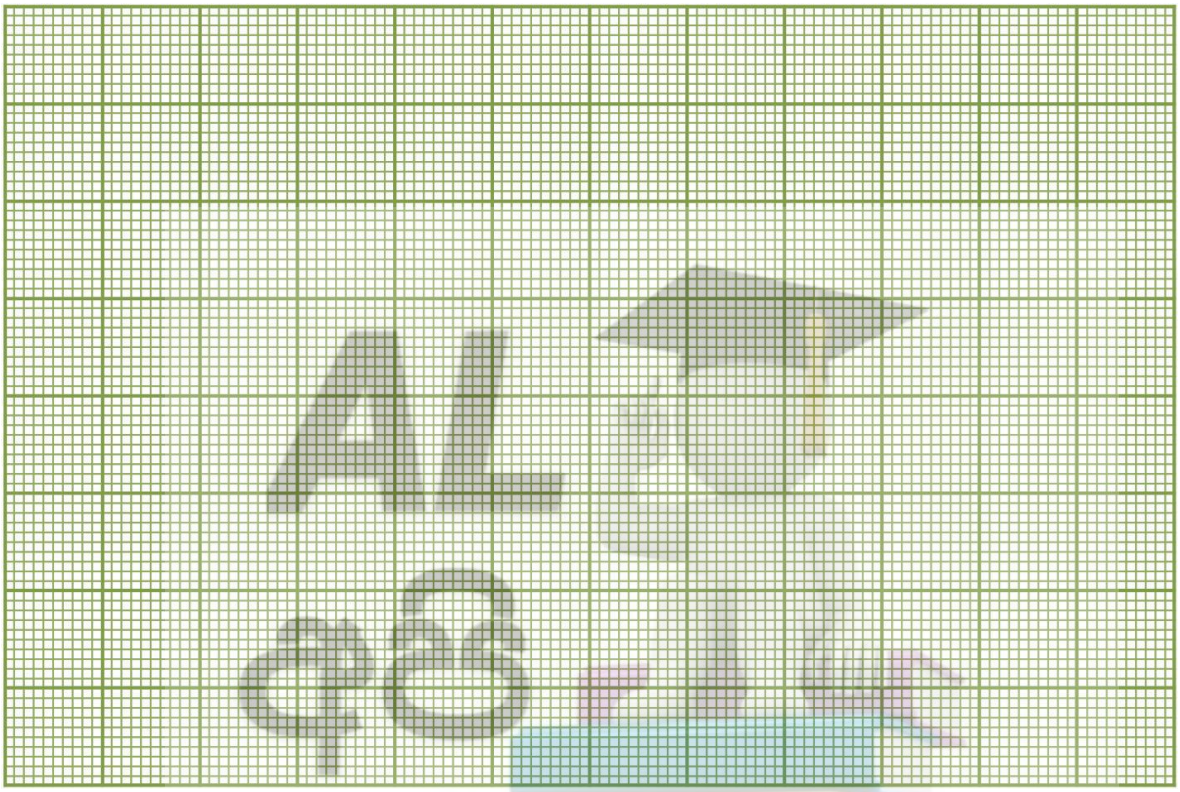
.....

.....

Do not write in this column

(*b*). Followings are the readings obtained by a student from such an experiment. Plot the graph on the graph paper given below.

I (mA)	20	40	60	80	100	120
V (V)	1·47	1·44	1·41	1·38	1·36	1.32



(*c*) Determine the internal resistance *r* from the graph.

……

……

(*d*) Determine the emf *E* of the cell using the graph.

……

……

(iii) (*a*) Why it is important to use a tap key in this experiment.

……

(*b*) You are provided with 10 Ω and 50 Ω standard resistors. Which one do you use for *R* here? Explain your reason.

……

……

Do not write in this column

(*c*) Explain why it is important to use *R* having being provided with a 100 Ω rheostat too.

……

……

(*d*) Which part of the circuit is more suitable to connect the tap key *K*? Whether it is the part with voltmeter and dry cell or the part with rheostat, *R* and ammeter?

……

(*e*) State the reason for your answer in (iii) (d).

……

……

අධ්‍යාපන, උසස් අධ්‍යාපන සහ වෘත්තීය අධ්‍යාපන අමාත්‍යාංශය
கல்வி, உயர்கல்வி மற்றும் தொழிற்கல்வி அமைச்சு
Ministry of Education, Higher Education and Vocational Education

අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය, 2026 උපකාරක තක්සේරුව
General Certificate of Education (Adv. Level) Exam, 2026 Supportive Assessment

භෞතික විද්‍යාව II Physics II	01	E	II	13 ශ්‍රේණිය Grade 13

Esaay - Part B

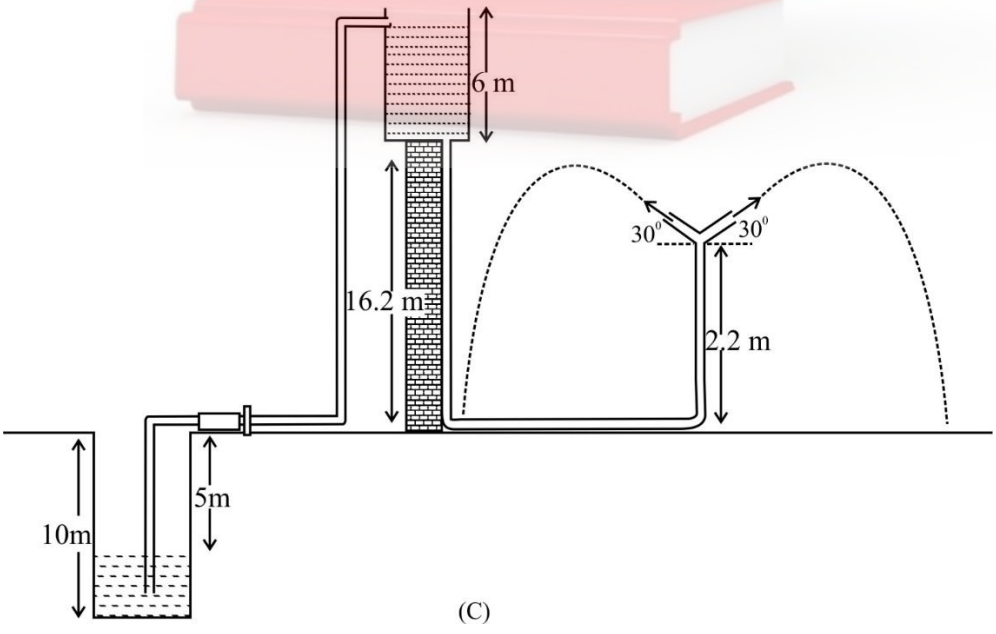
Answer only four questions. ($g = 10\ ms^{-2}$)

5. (a) (i) Consider a container of water as shown in the figure (*A*). There is a small whole the wall *h* below the water surface. Initially a cork is fixed to the hole.

Figure (*B*) shows the instant where the cork is just removed. Show that the force on the water (surface) at the hole due to pressure is given by $F = h\rho ga$. Here, ρ is the density of water and a is the cross-sectional area of the hole.

(A) (B)

(ii) Considering kinetic energy of water flow out through the hole show that the speed of water coming out from the hole is given by $v = \sqrt{2gh}$.



(C)

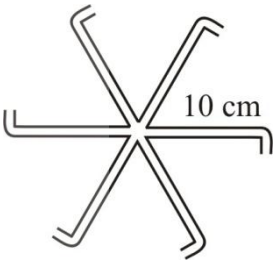
(b) The figure shows a water decoration in a garden. There are 6 identical small pipes of cross-sectional area 5 mm^2 connected symmetrically each of 30^0 inclined to the horizontal. The vertical drain pipe provides water to the decoration which is 2.2 m above the ground. The decoration is watered by a tank which is filled to 6 m, lies 16.2 m above the ground. The density of water is 1000 kg m^{-3}.

(i) Find the speed of water coming out from the above water decoration.
(ii) Find the mass of the water drain out from the water decoration in one second.
(iii) Find the time taken by water flow out through an inclined tube to fall on the ground. Also find the horizontal range of water. ($\sqrt{3} = 1.7$)

(*c*) (i)The tank is filled by a water pump pumping water form a well where water level is 5 m below the ground level. Cross sectional area of the outlet of the pump is 4 cm^2. If the water level of the tank remains unchanged, find the speed of water at the outlet of the pump.

(ii)Find the minimum power of the pump to keep the water level at the tank unchanged.

(*d*) Assume that the 6 outlet tubes mentioned above are not inclined but lying on a horizontal plane as shown in the figure. Their ends are bent as shown such that the water out in the same horizontal plane. Then the system is fixed at the top of water outlet so that it can spin in a horizontal plane. Considering the moment when water just start to flow,



(*a*) Find the torque acting on the setup.
(*b*) Find the initial angular acceleration of the setup.
[the moment of inertia of the setup is 0.4 kg m^2]

6. A musical instrument maker intends to create an open organ pipe with a fundamental frequency of 256 Hz at room temperature (27°C). To test this design, they use a resonance tube apparatus with one end closed by water. When a tuning fork with a frequency of 512 Hz is used, the first resonance is obtained at a water column length of 16.0 cm.

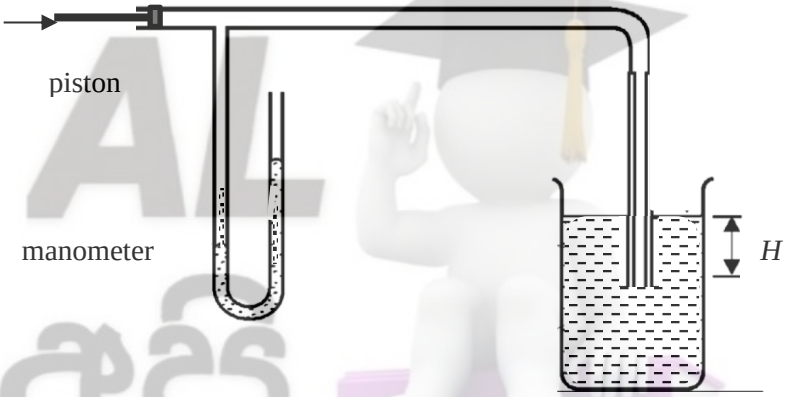
(a) Describe the nature of vibration at the open and closed ends of a pipe closed at one end, at the fundamental resonance condition.
(b) Using the data obtained from the resonance tube experiment, calculate the wavelength of a 512 Hz sound (neglecting the end correction of the tube)
(c) Using that, calculate the velocity of sound at the time the experiment was conducted.
(d) If the second resonance length was found to be 49.5 cm, taking the end correction of the tube into account, recalculate the wavelength using both the first and second resonance lengths.
(e) Calculate the end correction (*e*) for this tube.
(f) Recalculate the velocity of sound in air using the corrected wavelength, and compare it with the value of the velocity of sound in air obtained in part (c), and explain the reason for the difference.
(g) Now, a manufacturer wants to design an open pipe with a fundamental frequency of 256 Hz, given that the velocity of sound is 330 ms^{-1} at a temperature of 27°C. Calculate the required length of the organ pipe for this purpose.
(h) State the relationship between the length of a closed pipe and the length of an open pipe that produce the same fundamental frequency.
(i) Calculate the length of a closed pipe that produces the same fundamental frequency of 256 Hz.
(j) When this instrument is taken to a place where the temperature is 37°C, calculate the new fundamental frequency of the open pipe created in part (vii) (without changing the length). Take $\sqrt{\frac{31}{30}}$ =1.02.

(k) Using your answer from part (j), explain why instruments sound slightly 'out of tune' when the temperature changes, and suggest how musicians practically avoid this.

7. (a) (i) Write an expression for the pressure difference Δp across a spherical meniscus in terms of the surface tension T of the liquid and the radius r of the cone.

(ii) Using the pressure difference across the spherical meniscus, derive an expression for the capillary rise h of a thin vertical tube of radius r, one end of which is immersed in a liquid of density ρ and surface tension T. Assume that the angle of contact between the liquid and the tube is zero.

(b) A diagram of an apparatus used in the manufacture of soaps and detergents to determine the surface tension of those products is given below. The lower end of a thin vertical capillary tube of radius 0.4 mm is dipped at a depth H from the surface of a liquid of density 1000 kg m^{-3} and surface tension T. Then a manometer and a piston are connected to its upper end as shown in the figure. The density of the manometer liquid is 800 kg m^{-3}. Now, a compressive force is applied very slowly on the piston.



(i) When a compressive force is applied on the piston, write down the changes that occur in
I. the manometer and
II. the capillary tube
separately.

(ii) At some point, it was observed that the difference between the liquid levels in the manometer was reached to a maximum value of 9 cm and then it dropped to 4 cm. Explain the reason for this change in the reading of the manometer.

(iii) I. Draw a diagram of the meniscus and its position in the capillary tube, when the maximum difference between the liquid levels in the manometer is observed.
II. Find the pressure increased in the capillary tube due to the force applied on the piston at this instant.

(iv) What is the depth H of the lower end of the capillary tube from the surface of the liquid?
(v) Calculate the surface tension of the liquid.
(vi) If the angle of contact is zero, then what is the initial capillary rise (before the piston is pushed)?

(c) Before the capillary tube is dipped in the liquid container in the above setup, the piston was removed and a soap film was formed on the end where the piston was attached. Then the lower end of the capillary tube was dipped in the liquid container as in (b) above. Then, a difference of 2.5 mm was formed between the liquid levels in the manometer.

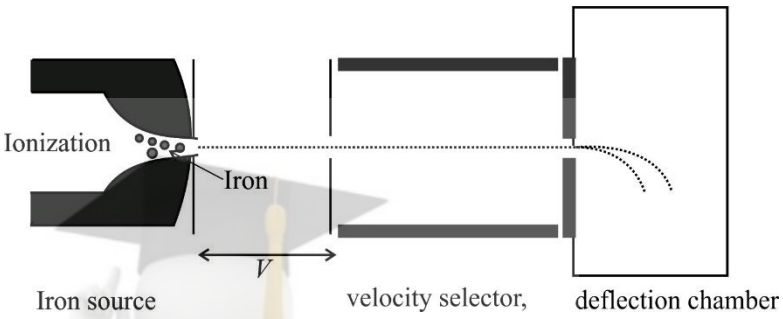
(i) What changes can be observed in
I. the capillary tube and
II. the soap film?

(ii) What is the new capillary rise in the capillary tube?

(iii) Calculate the surface tension of the soap if the radius of the tube with the soap film is 5 mm.

8. In nuclear physics and chemistry, a Mass Spectrometer is widely used to separate and identify isotopes based on their mass-to-charge ratio. A typical configuration consists of three key sections: an ion source, a velocity selector, and a deflection chamber (mass analyzer). A bundle of positive ions, each having a mass m and a charge + q, start from rest at the ion source and are accelerated through a potential difference V before entering the velocity selector. Inside the velocity selector, a uniform electric field of intensity E acts vertically upwards, and a uniform magnetic field of flux density B_1 acts perpendicularly out of the paper.

(a) Obtain an expression for the velocity v the ions as they leave the potential difference V and enter the velocity selector, in terms of q, V, and m.



(b) Inside the velocity selector,

(i) State the directions of the electric force and the magnetic force acting on a positive ion.

(ii) If only ions coming with a certain specific velocity v_0 pass through the velocity selector traveling in a straight line without deflection, derive an expression for v_o in terms of B_1 and E.

(iii) Explain the direction of deflection whether in the direction of the electric field or opposite to it for ions with velocities $v < v_o$ and ions with velocities $v > v_o$.

(c) The ions leaving the velocity selector with a straight-line velocity v_o next enter the mass analyzer chamber, where only a uniform magnetic field of flux density B_2 acts perpendicularly into the paper.

(i) What is the shape of the path traversed by the ions inside this chamber?

(ii) Derive an expression for the radius R of this path in terms of m, v_o, q and B_2.

(iii) Using the results above, derive an equation for the mass (m) of the ion in terms of q, V, B_2 and R. Your expression must be independent of E.

(d) This apparatus is used to separate two isotopes of carbon, ^{12}C and ^{14}C. Both ions carry a charge of $+e$.

(i) Derive an expression for the distance (Δx) between the two spots where these isotopes strike the detector, in terms of their masses m_{12}, m_{14}, and other constants.

(ii) Which isotope will travel in a path with a larger radius? Give reasons.

(e) The following experimental data were recorded in the above setup,

Accelerating potential difference (V) = 500 V

Magnetic flux density of the mass analyzer (B_2) = 0.2 T

Elementary charge (e) = 1.6×10^{-19} C

Mass of a ^{12}C ion (m_{12}) = 2.0×10^{-26} kg

Mass of a ^{14}C ion (m_{14}) = 2.3×10^{-26} kg

(i) Calculate the radius of the path (R_{12}) for ^{12}C ions inside the deflection chamber in centimeters (cm).

(ii) Find the distance (Δx) between the two impact points of the isotopes on the detector strip in millimeters (mm). (Take $\sqrt{1.15} \approx 1.07$)

09. Answer either part (A) or part (B) only.

Part (A)

(a) Write an expression for the resistance between the two ends of a conducting rod of length L, cross-sectional area A, and resistivity ρ.

(b) A rectangular iron block has dimensions $1.2\,cm \times 1.2\,cm \times 15\,cm$.
(The resistivity of iron is $1 \times 10^{7}\ \Omega\, m$)

(i) What is the resistance of the block across the two square faces ($1.2\,cm \times 1.2\,cm$) ?

(ii) What is the resistance of the block across two opposite rectangular faces?

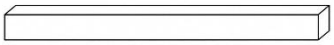


Figure (A)

(c) A current as small as 50 mA flowing near the heart can cause a person to be fatally electrocuted. An electrician working with sweaty hands is in good contact with two conductors, holding one in each hand. If his resistance is 2000 Ω, what could that fatal voltage be?

(d) One morning, a man walks barefoot on wet ground near a pylon carrying electric transmission lines during a picnic. Suddenly he falls to the ground. When his relatives, who were at the picnic and saw him fall, reach him a few seconds later, they find that he is experiencing ventricular fibrillation. The man dies before an emergency medical team with defibrillation equipment can reach him. The family then files a lawsuit against the electricity company, claiming that the victim was electrocuted due to an accidental current leakage from the pylon.

You are recruited as a member of the forensic medical team to investigate this death. 'Was it caused by a heart attack, or was it caused by an electric shock?

Upon investigating the electricity company's records, it is revealed that there was indeed an electrical fault in the pylon that morning. A current (I) leaked from a rod into the ground for approximately 1 second. Assume that the current spread uniformly (Hemispherically) into the ground. (See figure (B)). Let the resistivity of the ground be ρ, and the distance from the rod be r. Take $\pi \approx 3$ for all calculations)

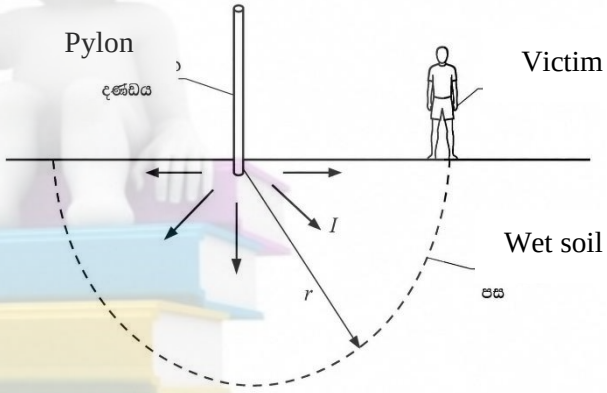


Figure (B)

(i) Derive an expression for current density (J)

(ii) Derive an expression for electric field intensity (E)

(iii) From your expression for the magnitude of the electric field, the potential difference between the lower end of the rod and a point at distance r is:

$$\Delta V = \frac{\rho I}{2\pi}\left(\frac{1}{b} - \frac{1}{r}\right)$$

where b is the radius of the lower end of the rod. Your investigation reveals that I = 100 A, ρ = 100 Ω m and b = 1.0 cm, and the victim was located at r = 10 m. At the location where the victim was standing:
(I) Find the current density.
(II) What is the magnitude of the electric field?
(III) What is the potential difference between the rod and the victim ?

(e) Figure (C) shows the electrical path where current travels up through one foot of the victim, through the trunk (including the heart), and down through the other foot.

(i) Assuming the leaking rod and feet are in the same line, and the distance between the feet is 0.5 m, find the potential difference between the man's feet using the given data.

(ii) Assuming the resistance of a foot on wet soil is 300 Ω and the resistance of the interior of the trunk is 1000 Ω, what was the current that flowed through the victim's body?

(iii) A current can cause the human heart to fibrillate when the current passing through the body is between 0.10 A and 1.00 A. Was the victim's fibrillation caused by the current leakage from the rod?

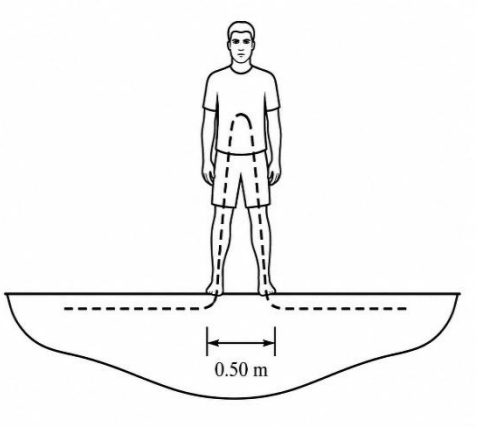


Figure (C)

Part (B)

Junction Field effect Transistor (JFET) is a three terminal semiconductor device in which current conduction is by one type of current carriers, i.e. electrons or holes. Since these devices are voltage-controlled ones, they can effectively replace vacuum pentodes (vacuum tubes) which had been used to perform transistor's tasks before semiconductor devices were invented. The need for JFETs arose because as modern electronic equipment's became increasingly transistorized, it became apparent that there were many functions in which bipolar transistors were unable to replace vacuum tubes.

(a) Figure (A) shows an **npn** Silicon transistor biased in common emitter configuration. Its dc current gain **β is 100** and forward biased voltage of BE junction is **0.7 V**

(i) Calculate the **base current (I_B)** in the transistor.

(ii) Calculate the **collector current (I_C)** and **collector voltage (V_C)** of the transistor.

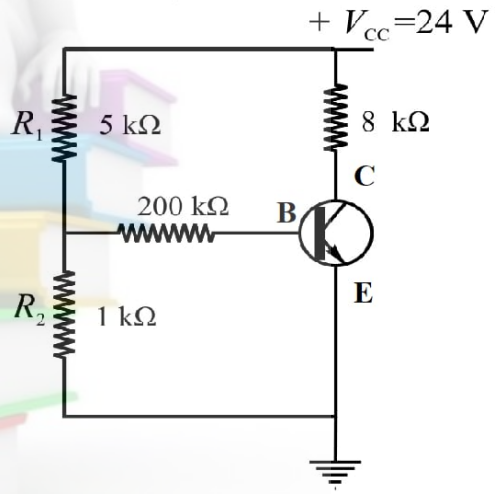


Figure (A)

(b) Figure (B) shows an **n-Chanel Junction Field Effect transistor (JFET)** biased using a voltage divider. In this circuit ***R_S* = *3.0* k Ω** and ***R_D*= *0.5* k Ω** . For this transistor, **transfer characteristic** is given in figure (C) and **output characteristic** obtained when **gate short-circuited to the source (V_{GS}= *0* V)** is given in figure (D).

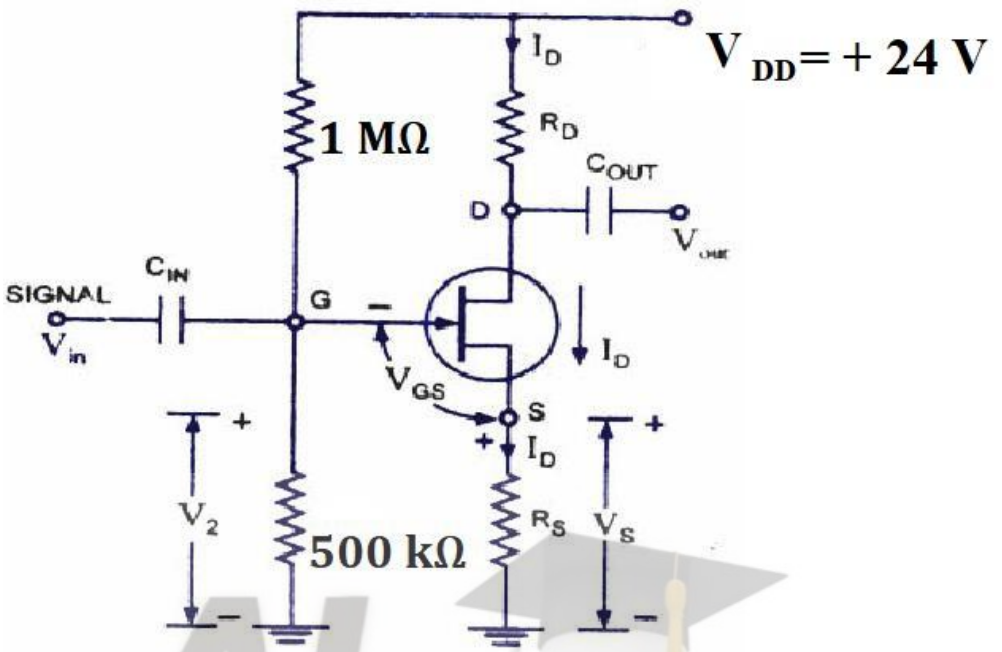


Figure (B)

(i) Define the following parameters used in analysis of JFET circuits.

I. Pinch off voltage (V_P)

II. Shorted Gate Drain current (I_{DSS})

III. Gate- Source cut-off voltage $(V_{GS(off)})$

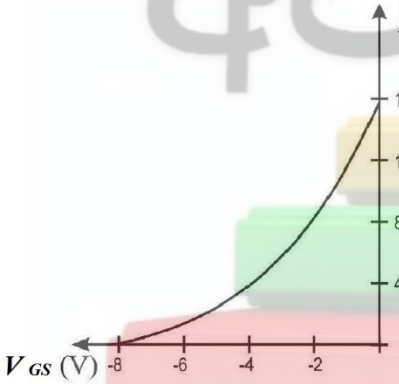


Figure (C)

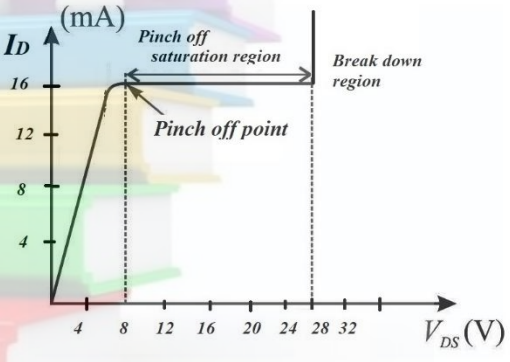


Figure (D)

(ii) Using above characteristics obtain the values of $\boldsymbol{V_P}$, $\boldsymbol{I_{DSS}}$ **and** $\boldsymbol{V_{GS(off)}}$

The Drain current I_D for a given V_{GS} represented by its **transfer characteristic** curve is given by the expression; $\boldsymbol{I_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_{GS(off)}}\right)^2}$

(iii) Calculate the **Gate voltage** $(\boldsymbol{V_G})$ of the transistor.

(iv) Calculate the **Drain current** $\boldsymbol{(I_D)}$ in the transistor.

(Use the relation $9x^2 - 100x + 256 = (x - 4)(9x - 64)$ in your calculation)

(v) It is recommended to use **Mid - point biasing** to bias JFET voltage amplifiers in many electronic circuits. In this biasing, **Drain current (I_D)** and **Drain voltage (V_D)** must satisfy the following conditions.

$$I_D = \frac{I_{DSS}}{2} \text{ and } V_D = \frac{V_{DD}}{2}$$

I. Find the **(V_{GS})** voltage required to satisfy the **Mid- point current** biasing condition.

II. Find the **maximum** value that can exist for the **Gate voltage (V_G)** to satisfy the **Mid-point voltage** biasing condition. (Give your answer to the nearest **integer**)

III. If the resistor R_1 in the biasing circuit remains unchanged at **1 MΩ**, calculate the **maximum value** of R_2 for satisfying the above conditions.

IV. If **20 k Ω** resistor is used for R_2, calculate the values of R_S and R_D in order to keep the transistor under Mid - point biasing conditions.

V. Calculate the V_{DS} voltage of the transistor under these conditions.

VI. Briefly explain why Mid-point biasing is preferred in JFET voltage amplifier biasing circuits.

VII. **Transconductance (g_m)** of a JFET amplifier is defined as the ratio of the **change in Drain current I_D** to **change in Gate-Source voltage** (V_{GS}). For a given value of V_{GS}, The value of transconductance is given by the following expression, $g_m = \frac{2I_{DSS}}{V_{GS(off)}}\left(1 - \frac{V_{GS}}{V_{GS(off)}}\right)$

Find the value of transconductance of the given JFET in **Siemens (S)** at its mid-point biasing. **(take $\sqrt{2} = 1.4$)**

VIII. An alternating voltage signal of amplitude $\pm$ **5 μV** is input into the Gate terminal of the transistor across a capacitor. Calculate the amplitude of the output voltage signal appears at the output terminal of the JFET amplifier.

10. Answer either part (A) or part (B) only.

Part (A)

Due to the increasing cost of electricity in Sri Lanka, many households have started using solar water heating systems. A typical solar water heater consists of a blackened metal collector, water pipes, a storage tank, and thermal insulation. During the daytime, solar radiation heats the water, which is then stored for domestic use. Answer the following questions based on the above situation.

(a) State three methods by which heat reaches from one place to another. Explain why one of these methods is impossible through space.

(b) Explain why the collector plate of a solar water heater is painted black and made with a dull surface.

(c) A solar heater raises the temperature of 120 kg of water from 28 °C to 68 °C. Calculate the thermal energy gained by the water. Specific heat capacity of water = 4200 J kg^{-1} K^{-1}

(d) The heated water expands slightly.

(i) Define the coefficient of volume expansion.

(ii) Explain why expansion joints are necessary in long metal pipes used in solar heating systems.

(e) A trapped volume of air inside the system initially has a pressure of 1.0×10^5 Pa and temperature of 27 °C. The temperature increases to 87 °C while the volume remains constant. Calculate the new pressure of the air.

(f) The water storage tank is covered with a thick layer of insulating material.
(i) Name two good thermal insulating materials.
(ii) Explain how insulation reduces heat loss by conduction and convection.

(g) Define relative humidity and explain why relative humidity is usually higher in the early morning than at midday.

(h) (i) The solar heater receives 8.0×10^6 J of solar energy during a day. The useful thermal energy stored in the water is found to be 6.0×10^6 J. Calculate the efficiency of the solar heating system.
(ii) State two factors that reduce its efficiency.

Part (B)

(a) State two experimental observations that could not be explained by classical wave theory and led to the development of quantum theory.

(b) Light of frequency 8.0×1014 Hz falls on a metal surface whose work function is 2.02 eV.
(i) State Einstein's photoelectric equation.
(ii) Calculate the maximum kinetic energy of emitted electrons.
Planck's constant, $h = 6.63\times10{-}34$ Js, 1 eV $= 1.6\times10{-}19$ J

(c) Using the photoelectric effect, explain why increasing the intensity of light does not cause photoelectric emission when the frequency of the incident light is below the threshold frequency.

(d) State the de Broglie hypothesis and explain the meaning of wave-particle duality.

(e) An electron accelerated through a potential difference of 10 kV is used in an electron microscope.
(i) Calculate the kinetic energy gained by the electron.
(ii) Explain why electron microscopes have a much higher resolving power than optical microscopes.

(f) The wavelength associated with an electron is given by the de Broglie equation.
(i) Write the de Broglie equation and identify the symbols used in it.
(ii) Describe one experiment that confirms the wave nature of electrons.

(g) Describe how X-rays are produced in an X-ray tube. Your answer should include:
- Thermionic emission
- Acceleration of electrons
- Production of X-rays

(h) A crystal structure is examined using X-ray diffraction.
(i) Explain why X-rays are suitable for crystal diffraction studies.
(ii) State one application of X-ray diffraction.

(i) A radioactive isotope used in cancer treatment has a half-life of 5 days. Initially, the activity of a sample is 1600 Bq. Calculate its activity after 15 days.

(j) Radioactive isotopes are widely used in medicine.
(i) State two medical applications of radioisotopes.
(ii) State two safety precautions that should be followed when handling radioactive materials.