AIEEE 2009 Physics Paper

PART A - PHYSICS

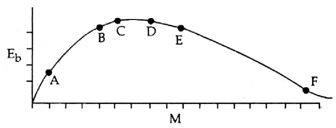
This question contains Statement- 1 and Statement-2 Of the four choices given after the statements, chooze the one that best describes the two statements.

1. Statement1 : For a charged particle moving from point P to point Q, the net work done by an electrostatic field on the particle is independent of the path connecting point P to point Q.

Statement 2 : The net work done by a conservative force on an object moving along a closed loop is zero.

(1) Statement-1 is true, Statement-2 is false.
(2) Statement-1 is true, Statement-2 is true; Statement -2 is the correct explanation of Statement-1
(3) Statement-1 is true, Statement-2 is true; Statement -2 is not the correct explanation of Statement-1
(4) Statement-1 is false, Statement-2 is true.

1. (2)

2. 

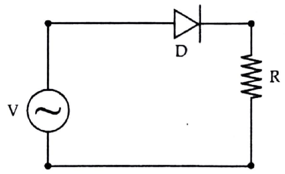
The above is a plot of binding energy pernucleon E_b, against the nuclear mass M; A, B, C, D, E, F correspond to different nuclei. Consider four reactions:

(i) $A + B \to C + \varepsilon$ (ii) $C \to A + B + \varepsilon$ (iii) $D + E \to F + \varepsilon$ and (iv) $F \to D + E + \varepsilon$, Where ε is the energy released ? In which reactions is ε positive?

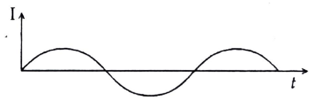
(1) (i) and (iv) (2) (i) and (iii) (3) (ii) and (iv) (4) (ii) and (iii)

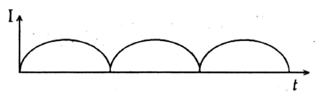
2. (4) Reaction releases energy if binding energy per nucleon increases.

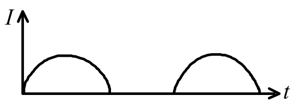
3. A $p-n$ junction (D) shown in the figure can act as a rectifier. An alternating current source (V) is connected in the circuit.

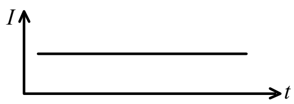


The current (I) in the resistor (R) can be shown by:

(1) 

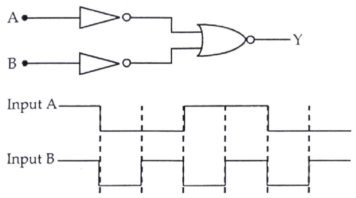
(2) 

(3) 

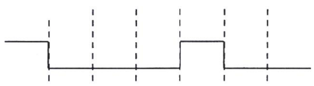
(4) 

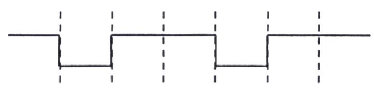
3. (3) Diode acts as half-wave rectifier.

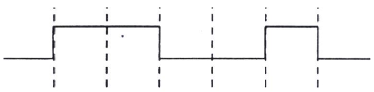
4. The logic circuit shown below has the input waveforms 'A' and 'B' as shown. Pick out the correct output waveform.

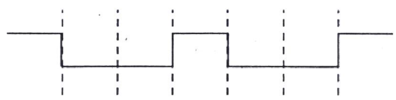


Output is :

(1) 

(2) 

(3) 

(4) 

4. (1)

5. If x, v and a denote the displacement, the velocity and the acceleration of a particle executing simple harmonic motion of time period T, then, which of the following does not change with time?

(1) $a^2T^2 + 4\pi^2v^2$ (2) aT / x (3) $aT + 2\pi v$ (4) aT / v

5. (1) Using $a^2 + \omega^2 v^2$ = constant gives (1).
$aT / x = (-\omega^2 x)\ T / x = -\omega^2 T$ = constant is true but does not make sense at $x = 0$.

6. In an optics experiment, with the position of the object fixed, a student varies the position of a convex lenss and for each position, the screen is adjusted to get a clear image of the object. A graph between the object distance u and the image distance v, from the lens, is plotted using the same scale for the two axes. A straight line passing through the origin and making an angle of 45° with the x-axis meets the experimental curve at P. The coordinates of P will be:

(1) $(2f, 2f)$ (2) $\left(\frac{f}{2}, \frac{f}{2}\right)$ (3) (f, f) (4) $(4f, 4f)$

6. (1) $u = v$ when both are $2f$.

7. A thin uniform rod of length l and mass m is swinging freely about a horizontal axis passing through its end. Its maximum angular speed is ω. Its centre of mass rise to a maximum height of

(1) $\frac{1}{3}\frac{l^2\omega^2}{g}$ (2) $\frac{1}{6}\frac{l\omega}{g}$ (3) $\frac{1}{2}\frac{l^2\omega^2}{g}$ (4) $\frac{1}{6}\frac{l^2\omega^2}{g}$

7. (4) $(1/2)\,(ml^2 / 3)\,\omega^2 = mgh \Rightarrow h = \omega^2 l^2 / (6g)$.

8. Let $P(r) = \frac{Q}{\pi R^4} r$ be the charge density distribution for a solid sphere of radius R and total charge Q. For a point 'p' inside the sphere at distance r_1 from the centre of the sphere, the magnitude of electric field is:

(1) 0 (2) $\frac{Q}{4\pi \in_0 r_1^2}$ (3) $\frac{Q r_1^2}{4\pi \in_0 R^4}$ (4) $\frac{Q r_1^2}{3\pi \in_0 R^4}$

8. (3) $q_{enclosed} = \int_0^{r_1} \frac{Qx}{\pi R^4} . 4\pi x^2 dx = \frac{Q r_1^4}{R^4}$ $\therefore E = Kq_{enclosed} / r_1^2 = Q r_1^2 / 4\pi\varepsilon_0 R^4$

9. The transition from the state $n = 4$ to $n = 3$ in a hydrogen like atom results in ultraviolet radiation. In frared radiation will be obtained in the transition from:

(1) $2 \to 1$ (2) $3 \to 2$ (3) $4 \to 2$ (4) $5 \to 4$

9. (4) Lesser energy is only for the transition $5 \to 4$.

10. One kg of a diatomic gas is at a pressure of 8×10^4 J Nm^{-2}. The density of the gas is 4 kg m^{-3}. What is the energy of the gas due to its thermal motion?

(1) 3×10^4 J (2) 5×10^4 J (3) 6×10^4 J (4) 7×10^4 J

10. (2) KE $= (5 / 2)\, nRT = (5 / 2)\, (1 / M)\, RT$ & $RT / M = p / \rho = 2 \times 10^4$
$\Rightarrow$ KE $= (5 / 2) \times 2 \times 10^4 = 5 \times 10^4$ J

This question contains Statement-1 and Statement-2. Of the four choices given after the statements, choose the one that best describes the two statements.

11. Statement 1 : The temperature dependence of resistance is usually given as $R = R_0 (1 + \alpha\Delta t)$. The resistance of a wire changes from 100 Ω to 150 Ω when its temperature is increased from 27°C to 227°C. This implies that $\alpha = 2.5 \times 10^{-3}$ / °C.

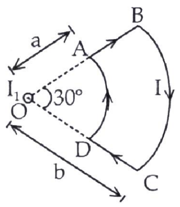
Statement 2 : $R = R_0 (1 + \alpha\Delta t)$ is valid only when the change in the temperature ΔT is small and $\Delta R = (R - R_0) << R_0$.

(1) Statement -1 is true, Statement -2 is false.
(2) Statement -1 is true, Statement-2 is true; Statement -2 is the correct explanation of Statement - 1
(3) Statement-1 is true, Statement -2 is true; Statement-2 is not the correct explanation of Statement - 1.
(4) Statement -1 is false, Statement-2 is true.

11. (4)

Directions: Question numbers 12 and 13 are based on the following paragraph.

A current loop *ABCD* is held fixed on the plane of the paper as shown in the figure. The arcs *BC* (radius = *b*) and *DA* (radius = *a*) of the looop are joined by two straight wires *AB* and *CD*. A steady current *I* is flowing in the loop. Angle made by *AB* and *CD* at the origin *O* is 30°. Another straight thin wire with steady current I_1 flowing out of the plane of the paper is kept at the origin.



12. The magnitude of the magnetic field (B) due to the loop ABCD at the origin (O) is:

(1) zero (2) $\frac{\mu_0 I(b-a)}{24ab}$ (3) $\frac{\mu_0 I}{4\pi}\left[\frac{b-a}{ab}\right]$ (4) $\frac{\mu_0 I}{4\pi}\left[\frac{2(b-a)+\pi}{3(a+b)}\right]$

12. (2) *B* at 0 due to *AB* & *CD* = 0

$B_{at\ 0} = \mu_0 I / 2a\,((\pi/6)/2\pi) - \mu_0 I / 2b((\pi/6)/2\pi) = \mu_0 I\,(b-a)/24ab$

13. Due to the presence of the current I_1 at the origin:

(1) The forces on *AB* and *DC* are zero.
(2) The forces on *AD* and *BC* are zero.
(3) The magnitude of the net force on the loop is given by $\frac{I_1 I}{4\pi}\mu_0\left[\frac{2(b-a)+\pi}{3(a+b)}\right]$
(4) The magnitude of the net force on the loop is given by $\frac{\mu_0 I\, I_1}{24ab}(b-a)$

13. (2) $\vec{F}_{mag} \propto d\vec{l} \times \vec{B}$ & for AD & BC, Value of $d\vec{l} \times \vec{B} = 0$

14. A mixture of light, consisting of wavelength 590 nm and an unknown wavelength, illuminates Young's double slit and gives rise to two overlapping interference patterns on the screen. The central maximum of both lights coincide. Further, it is observed that the third bright fringe of known light coincides with the 4th bright fringe of the unknown light. From this data, the wavelength of the unknown light is

(1) 393.4 nm (2) 885.0 (3) 442.5 nm (4) 776.8 nm

14. (3) $3 \times (\lambda_{known} D / d) = 4 \times (\lambda_{unknown} D / d) \Rightarrow \lambda_{unknown} = (3/4) \times 590 = 442.5$ nm

15. Two points P and Q are maintained at the potentials of 10 V and $-4V$, respectively. The work done in moving 100 electrons from P to Q is :

(1) -9.60×10^{-17} J (2) 9.60×10^{-17} J

(3) -2.24×10^{-16} J (4) 2.24×10^{-16} J

15. (4) $WD = 14 \times 1.6 \times 10^{-19} \times 100 = 2.24 \times 10^{-16}$ J

16. The surface of a metal is illuminated with the light of 400 nm. The kinetic energy of the ejected photoelectrons was found to be 1.68 eV. The work function of the metal is :
(hc = 1240 eV. nm)

(1) 3.09 eV (2) 1.41 eV (3) 1.51 eV (4) 1.68 eV

16. (2) Work function = 1240 / 400 – 1.68 = 1.42 eV

17. A particle has an initial velocity of $3\hat{i} + 4\hat{j}$ and an acceleration of $0.4\hat{i} + 0.3\hat{j}$. Its speed after 10 s is :

(1) 10 units (2) $2\sqrt{2}$ units (3) 7 units (4) 8.5 units

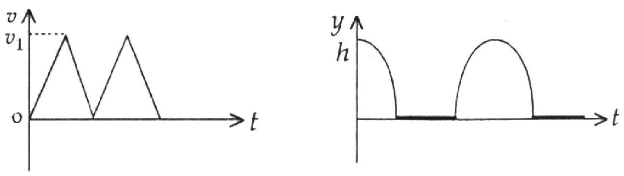
17. (2) $\bar{V} = (3 + 0.4 \times 10)i + (4 + 0.3 \times 10)j = 7i + 7j \quad \therefore |\bar{V}| = 7\sqrt{2}$

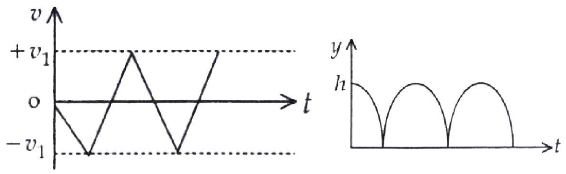
18. A motor cycle starts from rest and accelerates along a straight path at 2 m / s². At the starting point of the motor cycle there is a stationary electric siren. How far has the motor cycle gone when the driver hears the frequency of the siren at 94% of its value when the motor cycle was at rest ? (Speed of sound = 330 ms^{-1})

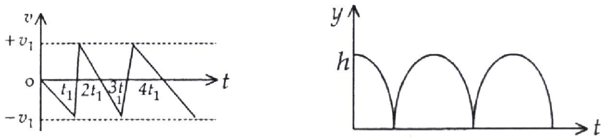
(1) 49 m (2) 98 (3) 147 m (4) 196 m

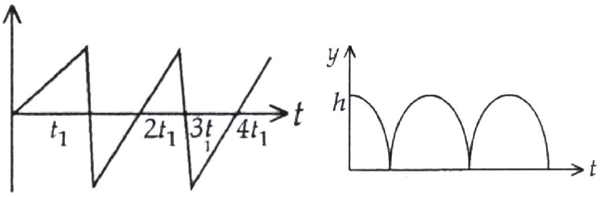
18. (2) $0.94 = (330 - 2t) / 330 \Rightarrow t = 9.9$ sec $\therefore S = (1/2) \times 2 \times (9.9)^2 = 98.01$ m.

19. Consider a rubber ball freely falling from a height $h = 4.9$ m onto a horizontal elastic plate. Assume that the duration of collision is negligible and the collision with the plate is totally elastic. Then the velocity as a function of time and the height as a function of time will be :

(1) 

(2) 

(3) 

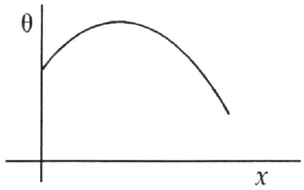
(4) 

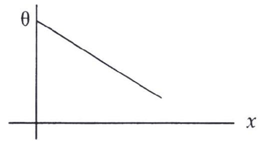
19. (3) / (4) Sudden change in velocity during collision.
If downward direction as positive for velocity & graph of (3) is not vertical, then (4) is correct.
If upward direction be considered positive as in the case in the graph of y vs. t & assuming that graph in (3) is vertical, then (3) is correct answer.

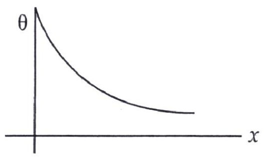
20. A charge Q is placed at each of the opposite corners of a square. A charge q is place at each of the other two corners. If the net electrical force on Q is zero, then Q / q equals **:**
(1) $-2\sqrt{2}$ (2) -1 (3) 1 (4) $-(1 / \sqrt{2})$

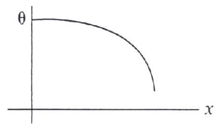
20. (1) $\sqrt{2}\,(kQq / S^2) + (kQ^2 / (\sqrt{2}S)^2) \Rightarrow Q / q = -2\sqrt{2}$

21. A long metallic bar is carrying heat from one of its ends to the other end under steady-state. The variation of temperature θ along the length x of the bar from its hot end is best described by which of the following figures ?

(1) 

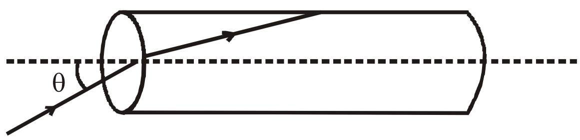
(2) 

(3) 

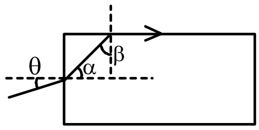
(4) 

21. (2) $H = -KA\,(d\theta / dx) \Rightarrow$ slope $= (d\theta / dx) =$ constant (at steady state)

22. A transparent solid cylindrical rod has a refractive index of $2 / \sqrt{3}$. it surrounded by air. A light ray is incident at the midpoint of one end of the rod as shown in the figure.



The incident angle θ for which the light ray grazes along the wall of the rod is **:**
(1) $\sin^{-1}(1 / 2)$ (2) $\sin^{-1}(\sqrt{2} / 2)$ (3) $\sin^{-1}(2 / \sqrt{3})$ (4) $\sin^{-1}(1 / \sqrt{3})$

22. (4) 

$1 . \sin\theta = (2/\sqrt{3}) \sin\alpha$

$\& \ (2/\sqrt{3}) \sin\beta = 1 . \sin 90° \Rightarrow \beta = 60°$

$\Rightarrow \alpha = 30° \Rightarrow \theta = \sin^{-1}(1/\sqrt{3})$

23. Three sound waves of equal amplitudes have frequencies $(v - 1)$, v, $(v + 1)$. They superpose to give beats. The number of beats produced per second will be **:**

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

23. (4)

24. The height at which the acceleration due to gravity becomes $g / 9$ (where g = the acceleration due to gravity on the surface of the earth) in terms of R, the radius of the earth, is **:**

(1) $2R$ (2) $R/\sqrt{2}$ (3) $R/2$ (4) $\sqrt{2}\,R$

24. (1) $GM/9R^2 = GM/(R+H)^2 \Rightarrow h = 2R$

25. Two wires are made of the same material and have the same volume. However wire 1 has cross-sectional area A and wire 2 has cross-sectional area $3A$. If the length of wire 1 increases by Δx on applying force F, how much force is needed to stretch wire 2 by the same amount ?

(1) F (2) $4F$ (3) $6F$ (4) $9F$

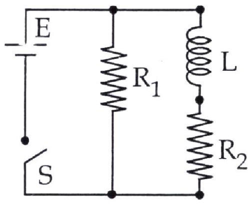
25. (4) $A' = 3A$, $l' = l/3$ $[\because Al = A'l']$

$\therefore y = Fl/A\Delta x = F'(l/3)/(3A)\Delta x \Rightarrow F' = 9F$

26. In a experiment the angles are required to be measured using an instrument. 29 divisions of the main scale exactly coincide with the 30 divisions of the vernier scale. If the smallest division of the main scale is half–*a*–degree (= 0.5°), then the least count of the instrument is **:**

(1) one minute (2) half minute (3) one degree (4) half degree

26. (1) $LC = 1$ MSD – 1 VSD $= 0.5° - (29/30) \times 0.5° = (0.5°/30) = 1'$

27. 

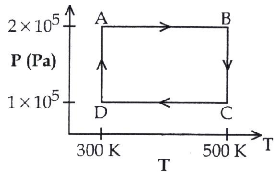
An inductor of inductance $L = 400$ mH and resistors of resistances $R_1 = 2\Omega$ and $R_2 = 2\Omega$ are connected to a battery of emf 12 V as shown in the figure. The internal resistance of the battery is negligible. The switch S is closed at $t = 0$. The potential drop across L as a function of time is **:**

(1) $6e^{-5t}$ V (2) $(12/t)e^{-3t}$ V (3) $6(1 - e^{-t/0.2})$V (4) $12\,e^{-5t}$ V

27. (4) $i = (E/R)(1 - e^{-Rt/L})$

$\therefore V_L = L(di/dt) = 12\,e^{-5t}$

Direction : Question numbers 28, 29 and 30 are based on the following paragraph. Two moles of helium gas are taken over the cycle ABCDA, as shown in the $P - T$ diagram.



28. Assuming the gas to be ideal the work done on the gas in taking it from A to B is **:**
(1) 200 R (2) 300 R (3) 400 R (4) 500 R

28. (3) Work done ***by*** the gas from A to $B = P\Delta V = nR\Delta T$
$= 2 \times R \times 200 = 400\ R$ (WORK DONE ON GAS IS NEGATIVE)

29. The work done on the gas in taking it from D to A is **:**
(1) –414 R (2) +414 R (3) –690 R (4) +690 R

29. (1) Work done ***on*** the gas from D to $A = 2R \times 300 \text{ in } (1 / 2) = -414\ R$
Work done ***by*** the gas from D to $A = 2R \times 300 \text{ in } (1 / 2) = -414\ R$

30. The net work done on the gas in the cycle ABCDA is **:**
(1) Zero (2) 276 R (3) 1076 R (4) 1904 R

30. (2) Net work done ***by*** the gas during ABCDA =
$2R \times 300 \ln (1 / 2) + 2R \times 500 \ln (2 / 1) \quad = 400\ R \ln 2 = 276\ R$
(WORK DONE ON GAS IS NEGATIVE)