

AIPMT 2010 Mains — Physics Question Paper with Solutions

24 Physics questions as set in the paper · answers checked by RankUp

AIPMT 2010 Mains · Q61

1. A current loop consists of two identical semicircular parts each of radius R , one lying in the x - y plane and the other in x - z plane. If the current in the loop is i . The resultant magnetic field due to the two semicircular parts at their common centre is

- (A) $\mu_0 i / (2\sqrt{2} R)$
- (B) $\mu_0 i / (2R)$
- (C) $\mu_0 i / (4R)$
- (D) $\mu_0 i / (\sqrt{2} R)$

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2. Two parallel metal plates having charges $+Q$ and $-Q$ face each other at a certain distance between them. If the plates are now dipped in kerosene oil tank, the electric field between the plates will

- (A) Become zero
- (B) Increase
- (C) Decrease
- (D) Remain same

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3. The electric field at a distance $3R/2$ from the centre of a charged conducting spherical shell of radius R is E . The electric field at a distance $R/2$ from the centre of the sphere is

- (A) Zero
- (B) E
- (C) $E/2$
- (D) $E/3$

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4. A student measures the distance traversed in free fall of a body, initially at rest in a given time. He uses this data to estimate g , the acceleration due to gravity. If the maximum percentage errors in measurement of the distance and the time are e_1 and e_2 respectively, the percentage error in the estimation of g is

- (A) $e_2 - e_1$
- (B) $e_1 + 2e_2$
- (C) $e_1 + e_2$
- (D) $e_1 - 2e_2$

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5. When monochromatic radiation of intensity I falls on a metal surface, the number of photoelectron and their maximum kinetic energy are N and T respectively. If the intensity of radiation is $2I$, the number of emitted electrons and their maximum kinetic energy are respectively

- (A) N and $2T$
- (B) $2N$ and T
- (C) $2N$ and $2T$
- (D) N and T

6. The electric field of an electromagnetic wave in free space is given by $E = 10 \cos(10^7 t + kx) \hat{j}$ V/m, where t and x are in seconds and metres respectively. It can be inferred that

- (a) The wavelength λ is 188.4 m**
- (b) The wave number k is 0.33 rad/m**
- (c) The wave amplitude is 10 V/m**
- (d) The wave is propagating along $+x$ direction**

Which one of the following pairs of statements is correct?

- (A) (c) & (d)
- (B) (a) & (b)
- (C) (b) & (c)
- (D) (a) & (c)

7. The speed of light in media M_1 and M_2 is 1.5×10^8 m/s and 2.0×10^8 m/s respectively. A ray of light enters from medium M_1 to M_2 at an incidence angle i . If the ray suffers total internal reflection, the value of i is

- (A) Equal to $\sin^{-1}(2/3)$
- (B) Equal to or less than $\sin^{-1}(3/5)$
- (C) Equal to or greater than $\sin^{-1}(3/4)$
- (D) Less than $\sin^{-1}(2/3)$

8. A ray of light is incident on a 60° prism at the minimum deviation position. The angle of refraction at the first face (i.e., incident face) of the prism is

- (A) Zero
- (B) 30°
- (C) 45°
- (D) 60°

9. For transistor action

- (a) Base, emitter and collector regions should have similar size and doping concentrations.**
- (b) The base region must be very thin and lightly doped.**
- (c) The emitter-base junction is forward biased and base-collector junction is reverse biased.**
- (d) Both the emitter-base junction as well as the base collector junction are forward biased.**

Which one of the following pairs of statements is correct?

- (A) (d), (a)
- (B) (a), (b)
- (C) (b), (c)
- (D) (c), (d)

10. The speed of a projectile at its maximum height is half of its initial speed. The angle of projection is

- (A) 60°
- (B) 15°
- (C) 30°
- (D) 45°

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11. From a circular disc of radius R and mass $9M$, a small disc of mass M and radius $R/3$ is removed concentrically. The moment of inertia of the remaining disc about an axis perpendicular to the plane of the disc and passing through its centre is

- (A) $(40/9) MR^2$
- (B) MR^2
- (C) $4 MR^2$
- (D) $(4/9) MR^2$

AIPMT 2010 Mains · Q74

12. A particle moves in x-y plane according to rule $x = a \sin \omega t$ and $y = a \cos \omega t$. The particle follows

- (A) An elliptical path
- (B) A circular path
- (C) A parabolic path
- (D) A straight line path inclined equally to x and y-axes

AIPMT 2010 Mains · Q75

13. A closely wound solenoid of 2000 turns and area of cross-section $1.5 \times 10^{-4} \text{ m}^2$ carries a current of 2.0 A. It is suspended through its centre and perpendicular to its length, allowing it to turn in a horizontal plane in a uniform magnetic field 5×10^{-2} tesla making an angle of 30° with the axis of the solenoid. The torque on the solenoid will be

- (A) $3 \times 10^{-3} \text{ N m}$
- (B) $1.5 \times 10^{-3} \text{ N m}$
- (C) $1.5 \times 10^{-2} \text{ N m}$
- (D) $3 \times 10^{-2} \text{ N m}$

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14. The decay constant of a radio isotope is λ . If A_1 and A_2 are its activities at times t_1 and t_2 respectively, the number of nuclei which have decayed during the time $(t_1 - t_2)$ is

- (A) $A_1 t_1 - A_2 t_2$
- (B) $A_1 - A_2$
- (C) $(A_1 - A_2)/\lambda$
- (D) $\lambda(A_1 - A_2)$

AIPMT 2010 Mains · Q78

15. The binding energy per nucleon in deuterium and helium nuclei are 1.1 MeV and 7.0 MeV, respectively. When two deuterium nuclei fuse to form a helium nucleus the energy released in the fusion is

- (A) 23.6 MeV
- (B) 2.2 MeV
- (C) 28.0 MeV
- (D) 30.2 MeV

AIPMT 2010 Mains · Q79

16. The electron in the hydrogen atom jumps from excited state ($n = 3$) to its ground state ($n = 1$) and the photons thus emitted irradiate a photosensitive material. If the work function of the material is 5.1 eV, the stopping potential is estimated to be (the energy of the electron in n th state $E_n = -13.6/n^2 \text{ eV}$)

- (A) 5.1 V
- (B) 12.1 V
- (C) 17.2 V
- (D) 7 V

17. If c_p and c_v denote the specific heats (per unit mass) of an ideal gas of molecular weight M , then (where R is the molar gas constant)

- (A) $c_p - c_v = R/M^2$
- (B) $c_p - c_v = R$
- (C) $c_p - c_v = R/M$
- (D) $c_p - c_v = MR$

18. A condenser of capacity C is charged to a potential difference of V_1 . The plates of the condenser are then connected to an ideal inductor of inductance L . The current through the inductor when the potential difference across the condenser reduces to V_2 is

- (A) $[C(V_1 - V_2)^2/L]^{(1/2)}$
- (B) $C(V_1^2 - V_2^2)/L$
- (C) $C(V_1^2 + V_2^2)/L$
- (D) $[C(V_1^2 - V_2^2)/L]^{(1/2)}$

19. A solid cylinder and a hollow cylinder, both of the same mass and same external diameter are released from the same height at the same time on a inclined plane. Both roll down without slipping. Which one will reach the bottom first?

- (A) Both together only when angle of inclination of plane is 45°
- (B) Both together
- (C) Hollow cylinder
- (D) Solid cylinder

20. The thermo e.m.f. E in volts of a certain thermo-couple is found to vary with temperature difference θ in $^\circ\text{C}$ between the two junctions according to the relation $E = 30\theta - \theta^2/15$. The neutral temperature for the thermo-couple will be

- (A) 450°C
- (B) 400°C
- (C) 225°C
- (D) 30°C

21. (a) Centre of gravity (C.G.) of a body is the point at which the weight of the body acts

(b) Centre of mass coincides with the centre of gravity if the earth is assumed to have infinitely large radius

(c) To evaluate the gravitational field intensity due to any body at an external point, the entire mass of the body can be considered to be concentrated at its C.G.

(d) The radius of gyration of any body rotating about an axis is the length of the perpendicular dropped from the C.G. of the body to the axis

Which one of the following pairs of statements is correct?

- (A) (d) and (a)
- (B) (a) and (b)
- (C) (b) and (c)
- (D) (c) and (d)

22. The magnetic moment of a diamagnetic atom is

- (A) Much greater than one
- (B) 1
- (C) Between zero and one
- (D) Equal to zero

23. A thin circular ring of mass M and radius r is rotating about its axis with constant angular velocity ω . Two objects each of mass m are attached gently to the opposite ends of a diameter of the ring. The ring now rotates with angular velocity given by

- (A) $(M + 2m)\omega/(2m)$
- (B) $2M\omega/(M + 2m)$
- (C) $(M + 2m)\omega/M$
- (D) $M\omega/(M + 2m)$

24. A monoatomic gas at pressure P_1 and volume V_1 is compressed adiabatically to $1/8$ th of its original volume. What is the final pressure of the gas?

- (A) $64 P_1$
- (B) P_1
- (C) $16 P_1$
- (D) $32 P_1$

Answer key and explanations

1. Answer: (A) $\mu_0 i/(2\sqrt{2} R)$

Each semicircle gives $\mu_0 i/(4R)$ at the centre, half the field of a full loop. Because the two semicircles lie in perpendicular planes, their fields are perpendicular, so the resultant is $\sqrt{2} \times \mu_0 i/(4R) = \mu_0 i/(2\sqrt{2} R)$. Simply adding the two fields gives $\mu_0 i/(2R)$, which wrongly treats them as parallel.

2. Answer: (C) Decrease

With fixed charges $\pm Q$ the field between the plates is $\sigma/(K\epsilon_0)$ in a dielectric instead of σ/ϵ_0 in air.

Kerosene has $K > 1$, so the field decreases. The charge on isolated plates does not change, so the field cannot remain the same.

3. Answer: (A) Zero

All the charge of a conducting shell sits on its surface, and by Gauss's law the enclosed charge for any point inside ($r = R/2$) is zero, so the field there is zero. The value E at $3R/2$ only describes points outside the shell and does not scale down inside.

4. Answer: (B) $e_1 + 2e_2$

For free fall from rest $h = \frac{1}{2}gt^2$, so $g = 2h/t^2$. Maximum relative errors add with their powers: $\Delta g/g = \Delta h/h + 2\Delta t/t$, giving $e_1 + 2e_2$. Subtracting errors ($e_1 - 2e_2$) is wrong because maximum errors always add.

5. Answer: (B) $2N$ and T

Doubling intensity doubles the number of photons per second, so the number of photoelectrons doubles to $2N$. The maximum kinetic energy depends only on frequency and work function ($h\nu - \phi$), so it stays T . Doubling the kinetic energy would need a change in frequency, not intensity.

6. Answer: (D) (a) & (c)

Here $\omega = 10^7$ rad/s, so $k = \omega/c = 10^7/(3 \times 10^8) = 0.033$ rad/m and $\lambda = 2\pi/k \approx 188.4$ m; the amplitude is 10 V/m. So the wavelength and amplitude statements are correct. The wave number is 0.033, not 0.33 rad/m, and the phase ($\omega t + kx$) means the wave travels along $-x$, not $+x$.

7. Answer: (C) Equal to or greater than $\sin^{-1}(3/4)$

Refractive indices are $\mu_1 = c/v_1 = 2$ and $\mu_2 = c/v_2 = 1.5$. The critical angle satisfies $\sin C = \mu_2/\mu_1 = 3/4$, so total internal reflection needs i equal to or greater than $\sin^{-1}(3/4)$. The value $\sin^{-1}(2/3)$ is obtained by wrongly using $1/\mu_1$ ratios; TIR never occurs for angles smaller than the critical angle.

8. Answer: (B) 30°

At minimum deviation the ray passes symmetrically, so $r_1 = r_2$ and $r_1 + r_2 = A$. Hence $r_1 = A/2 = 60^\circ/2 = 30^\circ$. Taking 60° confuses the refraction angle with the prism angle itself.

9. Answer: (C) (b), (c)

A transistor works because the base is very thin and lightly doped, and in active mode the emitter-base junction is forward biased while the collector-base junction is reverse biased. The regions are deliberately unequal in size and doping, and forward-biasing both junctions puts the transistor in saturation, not normal transistor action.

10. Answer: (A) 60°

At the highest point only the horizontal component $u \cos \theta$ remains. Setting $u \cos \theta = u/2$ gives $\cos \theta = 1/2$, so $\theta = 60^\circ$. An angle of 30° would leave a speed of $(\sqrt{3}/2)u$ at the top.

11. Answer: (A) $(40/9) MR^2$

Full disc: $I_1 = (9M)R^2/2$. Removed disc: $I_2 = M(R/3)^2/2 = MR^2/18$. Remaining $I = 81MR^2/18 - MR^2/18 = 80MR^2/18 = (40/9)MR^2$. Answers like $4MR^2$ come from subtracting $MR^2/2$ instead of using the small disc's own radius $R/3$.

12. Answer: (B) A circular path

Squaring and adding $x = a \sin \omega t$ and $y = a \cos \omega t$ gives $x^2 + y^2 = a^2(\sin^2 \omega t + \cos^2 \omega t) = a^2$, the equation of a circle of radius a . An ellipse would need unequal amplitudes, and a straight line would need the two motions to be in phase.

13. Answer: (C) $1.5 \times 10^{-2} \text{ N m}$

Magnetic moment $m = NIA = 2000 \times 2.0 \times 1.5 \times 10^{-4} = 0.6 \text{ A m}^2$. Torque $\tau = mB \sin 30^\circ = 0.6 \times 5 \times 10^{-2} \times 0.5 = 1.5 \times 10^{-2} \text{ N m}$. Using $\cos 30^\circ$ or dropping the factor N leads to the other values.

14. Answer: (C) $(A_1 - A_2)/\lambda$

Activity $A = \lambda N$, so $N_1 = A_1/\lambda$ and $N_2 = A_2/\lambda$. The number decayed between the two instants is $N_1 - N_2 = (A_1 - A_2)/\lambda$. The difference $A_1 - A_2$ alone is a difference of decay rates, not a number of nuclei.

15. Answer: (A) 23.6 MeV

Binding energy of two deuterons $= 2 \times (2 \times 1.1) = 4.4 \text{ MeV}$; of helium-4 $= 4 \times 7.0 = 28.0 \text{ MeV}$. Energy released $= 28.0 - 4.4 = 23.6 \text{ MeV}$. 28.0 MeV is just the helium binding energy without subtracting that of the reactants.

16. Answer: (D) 7 V

Photon energy for $n = 3 \rightarrow 1$ is $13.6(1 - 1/9) = 12.09 \text{ eV}$. Maximum kinetic energy $= 12.09 - 5.1 \approx 7.0 \text{ eV}$, so the stopping potential is about 7 V. 12.1 V forgets to subtract the work function.

17. Answer: (C) $c_p - c_v = R/M$

For one mole, $C_p - C_v = R$ (Mayer's relation). Specific heats per unit mass are molar heats divided by M , so $c_p - c_v = R/M$. ' $c_p - c_v = R$ ' applies to molar specific heats, not per unit mass.

18. Answer: (D) $[C(V_1^2 - V_2^2)/L]^{(1/2)}$

In the LC circuit energy is conserved: $\frac{1}{2}CV_1^2 = \frac{1}{2}CV_2^2 + \frac{1}{2}LI^2$. So $I = [C(V_1^2 - V_2^2)/L]^{(1/2)}$. Using $(V_1 - V_2)^2$ instead of $V_1^2 - V_2^2$ treats the voltage drop wrongly, and omitting the square root gives I^2 rather than I .

19. Answer: (D) Solid cylinder

For rolling without slipping $a = g \sin \theta / (1 + k^2/R^2)$. The solid cylinder has $k^2/R^2 = 1/2$ and the hollow one 1, so the solid cylinder has the larger acceleration and reaches first at any angle. Masses being equal does not make them arrive together because the mass distribution differs.

20. Answer: (C) 225°C

Neutral temperature is where E is maximum: $dE/d\theta = 30 - 2\theta/15 = 0$, so $\theta = 225^\circ\text{C}$. 450°C is the temperature of inversion (twice the neutral temperature), where E becomes zero again.

21. Answer: (B) (a) and (b)

The weight of a body acts at its centre of gravity, and if g is uniform over the body (earth of infinite radius) the centre of gravity coincides with the centre of mass, so the first two statements are correct. The gravitational field of a body at an external point can be found by concentrating its mass at one point only for spherically symmetric bodies, and the radius of gyration is defined by $I = Mk^2$, not as the distance from the C.G. to the axis.

22. Answer: (D) Equal to zero

In a diamagnetic atom the orbital and spin magnetic moments of the electrons cancel completely, so the net (permanent) magnetic moment is zero. A moment between zero and one or greater than one would describe paramagnetic or ferromagnetic atoms.

23. Answer: (D) $M\omega/(M + 2m)$

No external torque acts, so angular momentum is conserved: $Mr^2\omega = (M + 2m)r^2\omega'$, giving $\omega' = M\omega/(M + 2m)$. Adding mass increases the moment of inertia, so the angular velocity must fall; expressions bigger than ω such as $(M + 2m)\omega/M$ are wrong.

24. Answer: (D) 32 P_1

For an adiabatic process PV^γ is constant with $\gamma = 5/3$ for a monoatomic gas. $P_2 = P_1(V_1/V_2)^\gamma = P_1 \times 8^{(5/3)} = P_1 \times 2^5 = 32P_1$. $64P_1$ would correspond to $\gamma = 2$, and $16P_1$ to $\gamma = 4/3$.

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