

AIPMT 2012 Mains — Physics Question Paper with Solutions

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

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1. The dimensions of $(\mu_0 \epsilon_0)^{-1/2}$ are

- (A) $[L^{1/2} T^{-1/2}]$
- (B) $[L^{-1} T]$
- (C) $[LT^{-1}]$
- (D) $[L^{1/2} T^{1/2}]$

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2. A stone is dropped from a height h . It hits the ground with a certain momentum P . If the same stone is dropped from a height 100% more than the previous height, the momentum when it hits the ground will change by

- (A) 68%
- (B) 41%
- (C) 200%
- (D) 100%

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3. A car of mass m is moving on a level circular track of radius R . If μ_s represents the static friction between the road and tyres of the car, the maximum speed of the car in circular motion is given by

- (A) $\sqrt{\mu_s m R g}$
- (B) $\sqrt{R g / \mu_s}$
- (C) $\sqrt{m R g / \mu_s}$
- (D) $\sqrt{\mu_s R g}$

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4. A car of mass m starts from rest and accelerates so that the instantaneous power delivered to the car has a constant magnitude P_0 . The instantaneous velocity of this car is proportional to

- (A) $t^2 P_0$
- (B) $t^{1/2}$
- (C) $t^{-1/2}$
- (D) $t/\sqrt{m}$

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5. Three masses are placed on the x -axis : 300 g at origin, 500g at $x = 40$ cm and 400g at $x = 70$ cm. The distance of the centre of mass from the origin is :

- (A) 40 cm
- (B) 45 cm
- (C) 50 cm
- (D) 30 cm

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6. If v_e is escape velocity and v_o is orbital velocity of a satellite for orbit close to the earth's surface, then these are related by

- (A) $v_o = \sqrt{2} v_e$
- (B) $v_o = v_e$
- (C) $v_e = \sqrt{2} v_o$
- (D) $v_e = \sqrt{2} v_o$

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7. A slab of stone of area 0.36 m^2 and thickness 0.1 m is exposed on the lower surface to steam at 100°C . A block of ice at 0°C rests on the upper surface of the slab. In one hour 4.8 kg of ice is melted. The thermal conductivity of slab is (Given latent heat of fusion of ice = $3.36 \times 10^5 \text{ J kg}^{-1}$)

- (A) $1.24 \text{ J/m/s/}^\circ\text{C}$
- (B) $1.29 \text{ J/m/s/}^\circ\text{C}$
- (C) $2.05 \text{ J/m/s/}^\circ\text{C}$
- (D) $1.02 \text{ J/m/s/}^\circ\text{C}$

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8. The equation of a simple harmonic wave is given by $y = 3 \sin (\pi/2)(50t - x)$, where x and y are in metres and t is in seconds. The ratio of maximum particle velocity to the wave velocity is

- (A) 2π
- (B) $(3/2)\pi$
- (C) 3π
- (D) $(2/3)\pi$

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9. A train moving at a speed of 220 m s^{-1} towards a stationary object emits a sound of frequency 1000 Hz . Some of the sound reaching the object gets reflected back to the train as echo. The frequency of the echo as detected by the driver of the train is (speed of sound in air is 330 m s^{-1})

- (A) 3500 Hz
- (B) 4000 Hz
- (C) 5000 Hz
- (D) 3000 Hz

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10. A parallel plate capacitor has a uniform electric field E in the space between the plates. If the distance between the plates is d and area of each plate is A , the energy stored in the capacitor is

- (A) $(1/2)\epsilon_0 E^2$
- (B) $E^2 Ad/\epsilon_0$
- (C) $(1/2)\epsilon_0 E^2 Ad$
- (D) $\epsilon_0 E Ad$

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11. Two metallic spheres of radii 1 cm and 3 cm are given charges of $-1 \times 10^{-2} \text{ C}$ and $5 \times 10^{-2} \text{ C}$, respectively. If these are connected by a conducting wire, the final charge on the bigger sphere is

- (A) $2 \times 10^{-2} \text{ C}$
- (B) $3 \times 10^{-2} \text{ C}$
- (C) $4 \times 10^{-2} \text{ C}$
- (D) $1 \times 10^{-2} \text{ C}$

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12. A proton carrying 1 MeV kinetic energy is moving in a circular path of radius R in uniform magnetic field. What should be the energy of an α -particle to describe a circle of same radius in the same field?

- (A) 2 MeV
- (B) 1 MeV
- (C) 0.5 MeV
- (D) 4 MeV

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13. A magnetic needle suspended parallel to a magnetic field requires $\sqrt{3}$ J of work to turn it through 60° . The torque needed to maintain the needle in this position will be

- (A) $2\sqrt{3}$ J
- (B) 3 J
- (C) $\sqrt{3}$ J
- (D) $(3/2)$ J

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14. The instantaneous values of alternating current and voltage in a circuit are given as

$$i = (1/\sqrt{2}) \sin(100\pi t) \text{ ampere}$$

$$e = (1/\sqrt{2}) \sin(100\pi t + \pi/3) \text{ volt}$$

The average power in watts consumed in the circuit is

- (A) $1/4$
- (B) $\sqrt{3}/4$
- (C) $1/2$
- (D) $1/8$

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15. The ratio of amplitude of magnetic field to the amplitude of electric field for an electromagnetic wave propagating in vacuum is equal to :

- (A) the speed of light in vacuum
- (B) reciprocal of speed of light in vacuum
- (C) the ratio of magnetic permeability to the electric susceptibility of vacuum
- (D) unity

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16. For the angle of minimum deviation of a prism to be equal to its refracting angle, the prism must be made of a material whose refractive index :

- (A) lies between $\sqrt{2}$ and 1
- (B) lies between 2 and $\sqrt{2}$
- (C) is less than 1
- (D) is greater than 2

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17. A rod of length 10 cm lies along the principal axis of a concave mirror of focal length 10 cm in such a way that its end closer to the pole is 20 cm away from the mirror. The length of the image is :

- (A) 10 cm
- (B) 15 cm
- (C) 2.5 cm
- (D) 5 cm

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18. If the momentum of electron is changed by P, then the de Broglie wavelength associated with it changes by 0.5%. The initial momentum of electron will be

- (A) 200P
- (B) 400P
- (C) P/200
- (D) 100P

19. Two radiations of photons energies 1 eV and 2.5 eV, successively illuminate a photosensitive metallic surface of work function 0.5 eV. The ratio of the maximum speeds of the emitted electrons is :

- (A) 1 : 4
- (B) 1 : 2
- (C) 1 : 1
- (D) 1 : 5

20. The transition from the state $n = 3$ to $n = 1$ in a hydrogen like atom results in ultraviolet radiation. Infrared radiation will be obtained in the transition from :

- (A) $2 \rightarrow 1$
- (B) $3 \rightarrow 2$
- (C) $4 \rightarrow 2$
- (D) $4 \rightarrow 3$

21. The half life of a radioactive nucleus is 50 days. The time interval ($t_2 - t_1$) between the time t_2 when $2/3$ of it has decayed and the time t_1 when $1/3$ of it had decayed is

- (A) 30 days
- (B) 50 days
- (C) 60 days
- (D) 15 days

22. The input resistance of a silicon transistor is $100\ \Omega$. Base current is changed by $40\ \mu\text{A}$ which results in a change in collector current by $2\ \text{mA}$. This transistor is used as a common emitter amplifier with a load resistance of $4\ \text{k}\Omega$. The voltage gain of the amplifier is

- (A) 2000
- (B) 3000
- (C) 4000
- (D) 1000

Answer key and explanations

1. Answer: (C) $[\text{LT}^{-1}]$

Since $c = 1/\sqrt{\mu_0\epsilon_0}$, the quantity $(\mu_0\epsilon_0)^{-1/2}$ is simply the speed of light and has dimensions $[\text{LT}^{-1}]$. The inverse $[\text{L}^{-1}\text{T}]$ would be the dimensions of $\sqrt{(\mu_0\epsilon_0)}$ itself.

2. Answer: (B) 41%

Momentum on hitting the ground is $P = mv/(2gh)$. Doubling the height multiplies P by $\sqrt{2} \approx 1.414$, an increase of about 41%. Doubling the momentum (100%) would need four times the height.

3. Answer: (D) $\sqrt{(\mu_s Rg)}$

Static friction supplies the centripetal force: $mv^2/R \leq \mu_s \cdot mg$, so $v_{\text{max}} = \sqrt{(\mu_s Rg)}$. The mass cancels, so expressions containing m cannot be right.

4. Answer: (B) $t^{1/2}$

With constant power, the work done equals the kinetic energy gained: $P_{\text{ot}} = \frac{1}{2}mv^2$, so $v = \sqrt{(2P_{\text{ot}}/m)}$ and $v \propto t^{1/2}$. The velocity grows ever more slowly, not linearly or as t^2 .

5. Answer: (A) 40 cm

$x_{\text{cm}} = (300 \times 0 + 500 \times 40 + 400 \times 70)/(300 + 500 + 400) = 48000/1200 = 40\ \text{cm}$. Forgetting the 300 g mass at the origin in the denominator gives a larger, wrong value.

6. Answer: (D) $v_e = \sqrt{2} v_0$

Near the surface, orbital speed $v_0 = \sqrt{GM/R}$ and escape speed $v_e = \sqrt{(2GM/R)}$, so $v_e = \sqrt{2} \cdot v_0$. The escape speed is the larger one, so $v_0 = \sqrt{2} \cdot v_e$ is reversed.

7. Answer: (A) 1.24 J/m/s/°C

Heat rate = $mL/t = (4.8 \times 3.36 \times 10^5)/3600 = 448$ W. Setting $KA\Delta T/d = 448$ gives $K \times 0.36 \times 100/0.1 = 360K = 448$, so $K \approx 1.24 \text{ J m}^{-1} \text{ s}^{-1} \text{ }^\circ\text{C}^{-1}$.

8. Answer: (B) $(3/2)\pi$

$y = 3 \sin(25\pi t - \pi x/2)$, so $A = 3$ m, $\omega = 25\pi$ rad/s, $k = \pi/2 \text{ m}^{-1}$. Wave speed = $\omega/k = 50$ m/s and maximum particle speed = $A\omega = 75\pi$ m/s, giving a ratio of $75\pi/50 = 3\pi/2$.

9. Answer: (C) 5000 Hz

The object receives $f_1 = f \cdot v/(v - u)$ and reflects it; the moving driver then hears $f_2 = f_1(v + u)/v = f(v + u)/(v - u) = 1000 \times 550/110 = 5000$ Hz. Treating only one Doppler shift gives 3000 Hz, which is wrong.

10. Answer: (C) $(1/2)\epsilon_0 E^2 Ad$

Energy density between the plates is $\frac{1}{2}\epsilon_0 E^2$ and the field occupies volume Ad , so $U = \frac{1}{2}\epsilon_0 E^2 Ad$. The expression $\frac{1}{2}\epsilon_0 E^2$ alone is energy per unit volume, not total energy.

11. Answer: (B) $3 \times 10^{-2} \text{ C}$

Total charge = $-1 \times 10^{-2} + 5 \times 10^{-2} = 4 \times 10^{-2}$ C. When connected the spheres reach the same potential, so charge divides in the ratio of radii 1 : 3, giving the bigger sphere $\frac{3}{4} \times 4 \times 10^{-2} = 3 \times 10^{-2}$ C.

12. Answer: (B) 1 MeV

$r = \sqrt{(2mK)/(qB)}$, so for the same r and B , $K \propto q^2/m$. For an α -particle $q^2/m = (2e)^2/(4m_p) = e^2/m_p$, the same as the proton, so it needs the same 1 MeV.

13. Answer: (B) 3 J

Work to turn from 0° to 60° is $W = MB(1 - \cos 60^\circ) = MB/2 = \sqrt{3} \text{ J}$, so $MB = 2\sqrt{3} \text{ J}$. The torque to hold it there is $\tau = MB \sin 60^\circ = 2\sqrt{3} \times \sqrt{3}/2 = 3$ (in N m).

14. Answer: (D) 1/8

Peak values are $1/\sqrt{2}$, so $I_{\text{rms}} = V_{\text{rms}} = 1/2$. The phase difference is $\pi/3$, so $P = V_{\text{rms}} \cdot I_{\text{rms}} \cdot \cos \phi = \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} = 1/8$ W. Using peak values instead of rms values gives a larger, wrong answer.

15. Answer: (B) reciprocal of speed of light in vacuum

In vacuum $E_0 = cB_0$, so $B_0/E_0 = 1/c$, the reciprocal of the speed of light. The speed of light itself is the ratio E_0/B_0 , the reverse.

16. Answer: (B) lies between 2 and $\sqrt{2}$

$\mu = \sin((A + \delta m)/2)/\sin(A/2)$; with $\delta m = A$ this becomes $\mu = \sin A/\sin(A/2) = 2\cos(A/2)$. For a real emergent ray $A/2$ ranges between 0 and 45° , so μ lies between $\sqrt{2}$ and 2 .

17. Answer: (D) 5 cm

The near end at 20 cm = $2f$ images at 20 cm. For the far end, $u = -30$ cm: $1/v = 1/f - 1/u = -1/10 + 1/30$, so $v = -15$ cm. The image extends from 15 cm to 20 cm, a length of 5 cm.

18. Answer: (A) 200P

$\lambda = h/p$ gives $|\Delta\lambda/\lambda| = \Delta p/p$ for small changes. So $0.005 = P/p_0$ and $p_0 = P/0.005 = 200P$. $P/200$ inverts the relation.

19. Answer: (B) 1 : 2

Maximum kinetic energies are $1 - 0.5 = 0.5$ eV and $2.5 - 0.5 = 2$ eV, a ratio of 1 : 4. Speed goes as $\sqrt{KE}$, so the speeds are in the ratio 1 : 2; 1 : 4 is the energy ratio, not the speed ratio.

20. Answer: (D) $4 \rightarrow 3$

Infrared needs a much smaller energy gap than the ultraviolet $3 \rightarrow 1$ line. The energy factors ($1/n_1^2 - 1/n_2^2$) are $3/4$ for $2 \rightarrow 1$, $5/36$ for $3 \rightarrow 2$, $3/16$ for $4 \rightarrow 2$ and only $7/144$ for $4 \rightarrow 3$, so $4 \rightarrow 3$ (Paschen-type) is the infrared one; $3 \rightarrow 2$ and $4 \rightarrow 2$ are visible for hydrogen.

21. Answer: (B) 50 days

When $1/3$ has decayed, $2/3$ remains; when $2/3$ has decayed, $1/3$ remains. The undecayed amount halves between these instants, which takes exactly one half-life, 50 days.

22. Answer: (A) 2000

Current gain $\beta = \Delta I_c/\Delta I_b = 2 \text{ mA}/40 \text{ } \mu\text{A} = 50$. Voltage gain = $\beta \times R_L/R_{in} = 50 \times 4000/100 = 2000$.

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