JEE Main 2024 Jan 31 Physics (Shift 2 Question Paper)

PHYSICS

Section-A

1. A light string passing over a smooth light fixed pulley connects two blocks of masses m_1 and m_2. If the acceleration of the system is $\frac{g}{8}$, then the ratio of masses is:

(1) $\frac{9}{7}$

(2) $\frac{8}{1}$

(3) $\frac{4}{3}$

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

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2. A uniform magnetic field of 2×10^{-3} T acts along the positive Y-direction. A rectangular loop of sides 20 cm and 10 cm with a current of 5 A is in the Y-Z plane. The current is in the anticlockwise sense with reference to the negative X-axis. Magnitude and direction of the torque is:
(1) 2×10^{-4} N-m along positive Z-direction
(2) 2×10^{-4} N-m along negative Z-direction
(3) 2×10^{-4} N-m along positive X-direction
(4) 2×10^{-4} N-m along positive Y-direction

3. The measured value of the length of a simple pendulum is 20 cm with 2 mm accuracy. The time for 50 oscillations was measured to be 40 seconds with 1 second resolution. From these measurements, the accuracy in the measurement of acceleration due to gravity is $N\%$. The value of N is:
(1) 4
(2) 8
(3) 6
(4) 5

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4. Force between two point charges q_1 and q_2 placed in vacuum at r cm apart is F. Force between them when placed in a medium having dielectric constant $K = 5$ at $r/5$ cm apart will be:
(1) $F/25$
(2) $5F$

(3) $F/5$
(4) $25F$

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5. An AC voltage $V = 20\sin(200\pi t)$ is applied to a series LCR circuit which drives a current $I = 10\sin(200\pi t + \pi/3)$. The average power dissipated is:
(1) 21.6 W
(2) 200 W
(3) 173.2 W
(4) 50 W

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6. When unpolarized light is incident at an angle of 60° on a transparent medium from air, the reflected ray is completely polarized. The angle of refraction in the medium is:
(1) 30°
(2) 60°
(3) 90°
(4) 45°

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7. The speed of sound in oxygen at S.T.P. will be approximately: (Given, $R = 8.3\,\mathbf{JK}^{-1}$, $\gamma = 1.4$)
(1) $310\,\mathrm{m/s}$
(2) $333\,\mathrm{m/s}$
(3) $341\,\mathrm{m/s}$
(4) $325\,\mathrm{m/s}$

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8. A gas mixture consists of 8 moles of argon and 6 moles of oxygen at temperature T. Neglecting all vibrational modes, the total internal energy of the system is:
(1) $29RT$
(2) $20RT$
(3) $27RT$
(4) $21RT$

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9. The resistance per centimeter of a meter bridge wire is r, with $X\,\Omega$ resistance in the left gap. Balancing length from the left end is at 40 cm with $25\,\Omega$ resistance in the right gap. Now the wire is replaced by another wire of

$2r$ **resistance per centimeter. The new balancing length for the same settings will be at:**
(1) 20 cm
(2) 10 cm
(3) 80 cm
(4) 40 cm

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10. Given below are two statements:
Statement I: Electromagnetic waves carry energy as they travel through space and this energy is equally shared by the electric and magnetic fields.
Statement II: When electromagnetic waves strike a surface, a pressure is exerted on the surface.
In the light of the above statements, choose the most appropriate answer from the options given below:
(1) Statement I is incorrect but Statement II is correct.
(2) Both Statement I and Statement II are correct.
(3) Both Statement I and Statement II are incorrect.
(4) Statement I is correct but Statement II is incorrect.

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11. In a photoelectric effect experiment, a light of frequency 1.5 times the threshold frequency is made to fall on the surface of photosensitive material. Now, if the frequency is halved and intensity is doubled, the number of photoelectrons emitted will be:
(1) Doubled
(2) Quadrupled
(3) Zero
(4) Halved

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12. A block of mass $5\,\text{kg}$ is placed on a rough inclined surface as shown in the figure.

If $\vec{F_1}$ is the force required to just move the block up the inclined plane and $\vec{F_2}$ is the force required to just prevent the block from sliding down, then the value of $|\vec{F_1} - \vec{F_2}|$ is: [Use $g = 10\,\text{m/s}^2$]
(1) $25\sqrt{3}\,\text{N}$
(2) $50\sqrt{3}\,\text{N}$
(3) $\frac{5\sqrt{3}}{2}\,\text{N}$
(4) $10\,\text{N}$

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13. By what percentage will the illumination of the lamp decrease if the

current drops by 20%?
(1) 46%
(2) 26%
(3) 36%
(4) 56%

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14. If two vectors $\vec{A}$ and $\vec{B}$ having equal magnitude R are inclined at an angle θ, then:
(1) $|\vec{A}-\vec{B}| = \sqrt{2}R\sin\left(\frac{\theta}{2}\right)$
(2) $|\vec{A}+\vec{B}| = 2R\sin\left(\frac{\theta}{2}\right)$
(3) $|\vec{A}+\vec{B}| = 2R\cos\left(\frac{\theta}{2}\right)$
(4) $|\vec{A}-\vec{B}| = 2R\cos\left(\frac{\theta}{2}\right)$

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15. The mass number of a nucleus having radius equal to half of the radius of a nucleus with mass number 192 is:
(1) 24
(2) 32
(3) 40
(4) 20

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16. The mass of the moon is $\frac{1}{144}$ times the mass of a planet, and its diameter is $\frac{1}{16}$ times the diameter of the planet. If the escape velocity on the planet is v, the escape velocity on the moon will be:
(1) $\frac{v}{3}$
(2) $\frac{v}{4}$
(3) $\frac{v}{12}$
(4) $\frac{v}{6}$

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17. A small spherical ball of radius r, falling through a viscous medium of negligible density, has terminal velocity v. Another ball of the same mass but of radius $2r$, falling through the same medium, will have terminal velocity:
(1) $\frac{v}{2}$
(2) $\frac{v}{4}$
(3) $4v$
(4) $2v$

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18. A body of mass $2\,\text{kg}$ begins to move under the action of a time-dependent force

$\vec{F} = (6t\,\hat{i} + 6t^2\,\hat{j})$ N. The power developed by the force at time t is given by:
(1) $(6t^4 + 9t^5)$ W
(2) $(3t^3 + 6t^5)$ W
(3) $(9t^5 + 6t^3)$ W
(4) $(9t^3 + 6t^5)$ W

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19. The output of the given circuit diagram is:

A	B	Y
0	0	0
1	0	1
0	1	1
1	1	0

(1) As per Table 1
(2) As per Table 2
(3) As per Table 3
(4) As per Table 4

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20. Consider two physical quantities A and B related as:

$$E = \frac{B - x^2}{At}$$

where E, x, and t have dimensions of energy, length, and time, respectively. The dimension of AB is:
(1) $L^{-2}M^1T^0$
(2) $L^2M^{-1}T^1$
(3) $L^{-2}M^{-1}T^1$
(4) $L^0M^{-1}T^1$

Section-B

21. In the following circuit, the battery has an emf of 2 V and an internal resistance of $\frac{2}{3}\,\Omega$. The power consumption in the entire circuit is _____ W.

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22. Light from a point source in air falls on a convex curved surface of radius 20 cm and refractive index 1.5. If the source is located at 100 cm from the convex surface, the image will be formed at _____ cm from the object.

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23. The magnetic flux ϕ (in weber) linked with a closed circuit of resistance $8\,\Omega$ varies with time as $\phi = 5t^2 - 36t + 1$. The induced current in the circuit at $t = 2\,\text{s}$ is _____ A.

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24. Two blocks of mass $2\,\text{kg}$ and $4\,\text{kg}$ are connected by a metal wire going over a smooth pulley. The radius of the wire is $4.0 \times 10^{-5}\,\text{m}$, and Young's modulus of the metal is $2.0 \times 10^{11}\,\text{N/m}^2$. The longitudinal strain developed in the wire is $\frac{1}{\alpha\pi}$. The value of α is _____.

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25. A body of mass m is projected with a speed u making an angle of 45° with the ground. The angular momentum of the body about the point of projection, at the highest point, is expressed as $\frac{\sqrt{2}mu^3}{Xg}$. The value of X is _____.

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26. Two circular coils P and Q of 100 turns each have the same radius of $\pi\,\text{cm}$. The currents in P and Q are $1\,\text{A}$ and $2\,\text{A}$, respectively. P and Q are placed with their planes mutually perpendicular and their centers coincide. The resultant magnetic field induction at the center of the coils is $\sqrt{x}\,\text{mT}$, where $x =$ _____.

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27. The distance between charges $+q$ and $-q$ is $2l$, and between $+2q$ and $-2q$ is $4l$. The electrostatic potential at point P at a distance r from center O is:

$$-\alpha\left[\frac{q}{r^2}\right] \times 10^9\,\text{V},$$

where the value of α is _____.

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28. Two identical spheres, each of mass $2\,\text{kg}$ and radius $50\,\text{cm}$, are fixed at the ends of a light rod so that the separation between the centers is $150\,\text{cm}$. The moment of inertia of the system about an axis perpendicular to the rod and passing through its middle point is $\frac{x}{20}\,\text{kg·m}^2$, where the value of x is _____.

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29. The time period of simple harmonic motion of mass M in the given figure is:

$$\pi\sqrt{\frac{\alpha M}{5K}},$$

where the value of α is _____.

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30. A nucleus has mass number A_1 and volume V_1. Another nucleus has mass number A_2 and volume V_2. If the relation between mass numbers is $A_2 = 4A_1$, then:

$$\frac{V_2}{V_1} = \text{\_\_\_\_\_}.$$
