PHYSICS

BOOKS - MTG PHYSICS (BENGALI ENGLISH)

QUESTION PAPER 2013

Category I

1. The equation of state of a gas is given by $\left(P+\frac{a}{V^3}\right)\left(V-b^2\right)=cT$, where P, V, R are pressure, volume and temperature respectively, and

a,b,c are constants. The dimensions of a and b are respectively

A. ML^8T^{-2} and $L^{3/2}$

B. ML^5T^{-2} and L^3

C. ML^5T^2 and L^6

D. ML^6T^{-2} and $L^{3/2}$

Answer:

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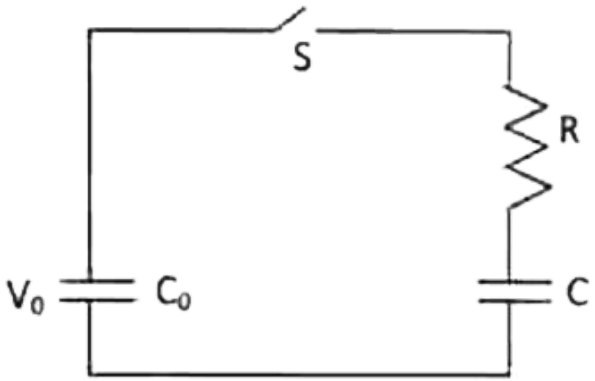
2. A capacitor of capacitance C_0 is charged to a potential V_0 and is connected with another capacitor

of capacitance C as shown. After closing the switch S, the common potential across the two capacitors becomes V, The capacitance C is given by



A. $\frac{c_0(V_0 - V)}{V_0}$

B. $\frac{c_0(V - V_0)}{V_0}$

C. $\frac{c_0(V + V_0)}{V}$

D. $\frac{c_0(V_0 - V)}{V}$

Answer:

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3. The r.m.s speed of the molecules of a gas at $100^\circ C$ is v. The temperature at which the r.m.s speed will be $\sqrt{3}v$ is

A. $546^\circ C$

B. $646^\circ C$

C. $746^\circ C$

D. $846^\circ C$

Answer:

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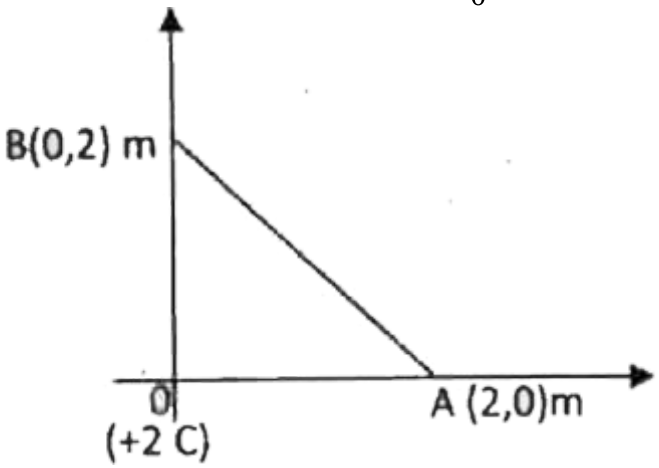
4. As shown in the figure below, a charge +2C is situated at the origin O and another charge +5C is on the x-axis at the point A. The later charge from the point A is then brought to a point B on the y-axis. The word done is (given $\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 m/F$)



A. $45 \times 10^9 J$

B. $90 \times 10^9 J$

C. zero

D. $-45 \times 10^9 J$

Answer:

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5. A frictionless piston-cylinder based enclosure contains some amount of gas at a pressure of 400kPa. Then heat is transferred to the gas at constant pressure in a quasi-static process. The piston moves up slowly through a height of 10cm. If the piston has a cross-sectional area of $0.3m^2$, the work done by the gas in this process is

A. 6kJ

B. 12kJ

C. 7.5 kJ

D. 24 kJ

Answer:

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6. An electric cell of e.m.f E is connected across a copper wire of diameter d and length l. The drift velocity of electrons in the wire is v_d. If the length of

the wire is changed to 2l, the new drift velocity of electrons in the copper wire will be

A. v_d

B. $2v_d$

C. $v_d / 2$

D. $v_d / 4$

Answer:

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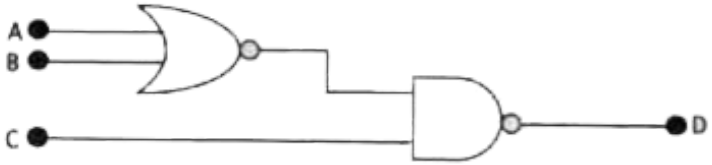
7. A NOR gate and a NAND gate are connected as shown in the figure. Two different sets of inputs are

given to this set up. In the first case, the inputs to the gates are A=0, B=0, C=0. In the second case, the inputs are A=1, B=0, C=1. The output D in the first case and second case respectively are



A. 0 and 0

B. 0 and 1

C. 1 and 0

D. 1 and 1

Answer:

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8. A bar magnet has a magnetic moment of 200 $A.m^2$. The magnet is suspended in a magnetic field of $0.30NA^{-1}m^{-1}$. The torque required to rotate the magnet from its equilibrium position through an angle of 30°, will be

A. 30Nm

B. $30\sqrt{3}Nm$

C. 60N m

D. $60\sqrt{3}Nm$

Answer:

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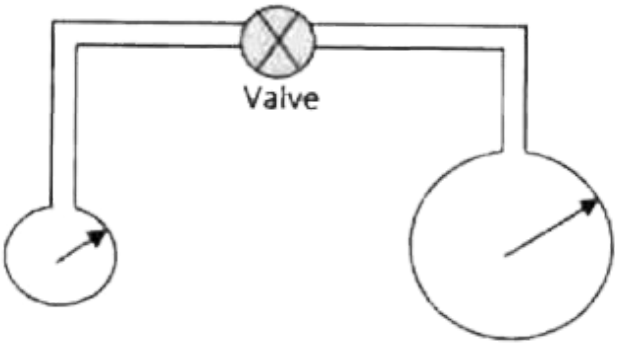
9. Two soap bubbles of radii r and 2r are connected by a capillary tube-value arrangement as shown in the diagram. The value is now opened. Then which one of the following will result



A. the radii of the bubbles will remain unchanged

B. the bubbles will have equal radii

C. the radius of the smaller bubble will increase and that of the bigger bubble will decrease

D. the radius of the smaller bubble will decrease and that of the bigger bubble will increase

Answer:

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10. An ideal mono-atomic gas of given mass is heated at constant pressure. In this process, the fraction of supplied heat energy used for the increase of the internal energy of the gas is

A. $3/8$

B. $3/5$

C. $3/4$

D. $2/5$

Answer:

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11. The velocity of a car travelling on a straight road is $36kmh^{-1}$ at an instant of time. Now travelling with uniform acceleration for 10s, the velocity becomes exactly double. If the wheel radius of the car is 25cm,

then which of the following numbers is the closest to the number of revolutions that the wheel makes during this 10s?

A. 84

B. 95

C. 126

D. 135

Answer:

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12. Two glass prisms P_1 and P_2 are to be combined together to produce dispersion without deviation. The angles of the prisms P_1 and P_2 are selected as 4° and 3° respectively. If the refractive index of prism P_1 is 1.54, then that of P_2 will be

A. 1.48

B. 1.58

C. 1.62

D. 1.72

Answer:

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13. The ionization energy of the hydrogen atom is 13.6eV. The potential energy of the electron in n=2 state of hydrogen atom is

A. $+3.4eV$

B. $-3.4eV$

C. $+6.8eV$

D. $-6.8eV$

Answer:

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14. Water is flowing in streamline motion through a horizontal tube. The pressure at a point in the tube is p where the velocity of flow is v. At another point, where the pressure is p/2, the velocity of flow is [density of water $= \rho$]

A. $\sqrt{v^2 + \frac{p}{\rho}}$

B. $\sqrt{v^2 - \frac{p}{\rho}}$

C. $\sqrt{v^2 + \frac{2p}{\rho}}$

D. $\sqrt{v^2 - \frac{2p}{\rho}}$

Answer:

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15. A wire of initial length L and radius r is stretched by a length l. Another wire of same material but with initial length 2L and radius 2r is stretched by a length 2l. The ratio of the stored elastic energy per unit volume in the first and second wire is,

A. $1:4$

B. $1:2$

C. $2:1$

D. $1:1$

Answer:

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16. A current of 1A is flowing along positive x-axis through a straight wire of length 0.5m placed in a region of a magnetic field given by $\vec{B} = \left(2\hat{i} + 4\hat{j}\right)$T. The magnitude and the direction of the force experienced by the wire respectively are

A. $\sqrt{18}N$, along positive z-axis

B. $\sqrt{20}N$, along positive x-axis

C. 2N, along positive z-axis

D. 4N, along positive y-axis

Answer:

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17. Two spheres of the same material, but of radii R and 3R are allowed to fall vertically downwards through a liquid of density σ. The ratio of their terminal velocities is

A. $1:3$

B. $1:6$

C. $1:9$

D. $1:1$

Answer:

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18. S_1 and S_2 are the two coherent point sources of light located in the xy-plane at points (0, 0) and $(0, 3\lambda)$ respectively. Here λ is the wavelength of light. At which one of the following points (given as coordinates), the intensity of interference will be maximum?

A. $(3\lambda, 0)$

B. $(4\lambda, 0)$

C. $(5\lambda/4, 0)$

D. $(2\lambda/3, 0)$

Answer:

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19. An alpha particle $\left({}^{4}He\right)$ has a mass of 4.00300 amu. A proton has a mass of 1.00783 amu and a neutron as a mass of 1.00867 amu respectively. The binding energy of alpha particle estimated from these data is the closest to

A. 27.9 MeV

B. 22.3 MeV

C. 35.0 MeV

D. 20.4 MeV

Answer:

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20. Four small objects each of mass m are fixed at the corners of a rectangular wire-frame of negligible mass and of sides a and b $(a > b)$. If the wire frame is now rotated about an axis passing along the side of length b, then the amount of inertia of the system for this axis of rotation is

A. $2ma^2$

B. $4ma^2$

C. $2m\left(a^2+b^2\right)$

D. $2m\left(a^2-b^2\right)$

Answer:

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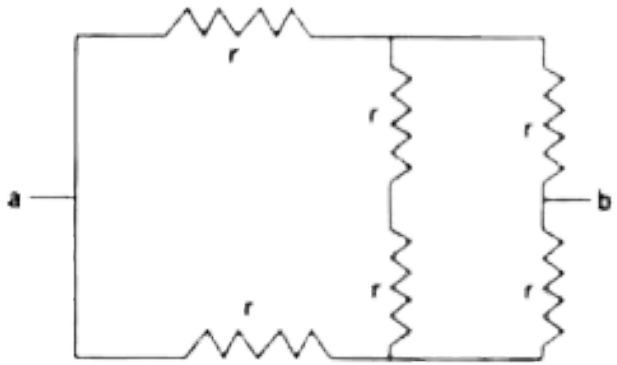
21. The equivalent resistance between the points a and b of the electrical network shown in the figure is



A. 6r

B. 4r

C. 2r

D. r

Answer:

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22. The de Broglie wavelength of an electron (mass $= 1 \times 10^{-30} kg$, charge $= 1.6 \times 10^{-19} C$) with a kinetic energy of 200eV is (Planck's constant $= 6.6 \times 10^{-34} Js$)

A. $9.60 \times 10^{-11} m$

B. $8.25 \times 10^{-11} m$

C. $6.25 \times 10^{-11} m$

D. $5.00 \times 10^{-11} m$

Answer:

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23. An object placed at a distance of 16cm from a convex lens produces an image of magnification $m(m > 1)$. If the object is moved towards the lens by 8cm then again an image of magnification m is obtained. The numerical value of the focal length of the lens is

A. 12cm

B. 14cm

C. 18cm

D. 20cm

Answer:

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24. The number of atoms of a radioactive substance of half-life T is N_0 at t= 0. The time necessary to decay from $N_0/2$ atoms to $N_0/10$ atoms will be

A. $\frac{5}{2}T$

B. T ln 5

C. $T\ln\left(\frac{5}{2}\right)$

D. $T\frac{\ln 5}{\ln 2}$

Answer:

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25. A travelling acoustic wave of freqency 500Hz is moving along the positive x-direction with a velocity of $300ms^{-1}$. The phase difference between two points x_1 and x_2 is 60°. Then the minimum separation between the two points is

A. 1mm

B. 1cm

C. 10cm

D. 1m

Answer:

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26. A mass M at rest is broken into two pieces having masses m and (M-m). The two masses are then separated by a distance r. The gravitational force between them will be the maximum when the ratio of the masses [m: (M-m)] of the two parts is

A. $1:1$

B. $1:2$

C. $1:3$

D. $1:4$

Answer:

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27. A shell of mass 5M, acted upon by no external force and initially at rest, bursts into three fragments of mass M, 2M and 2M respectively. The first two fragments move in opposite directions with velocity of magnitudes 2V and V respectively. The third fragment will

A. move with a velocity V in a direction perpendicular to the other two

B. move with a velocity 2V in the direction of velocity of the first fragment

C. be at rest

D. move with a velocity V in the direction of velocity of the second fragment

Answer:

28. A bullet of mass m travelling with a speed v hits a block of mass M initially at rest and gets embedded in it. The combined system is free to move and there is no other force acting on the system. The heat generated in the process will be

A. zero

B. $\frac{mv^2}{2}$

C. $\frac{Mmv^2}{2(M-m)}$

D. $\frac{mMv^2}{2(M+m)}$

Answer:

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29. A particle moves along X-axis and its displacement at any time is given by $x(t) = 2t^3 - 3t^2 + 4t$ in SI units. The velocity of the particle when its acceleration is zero, is

A. $2.5ms^{-1}$

B. $3.5ms^{-1}$

C. $4.5ms^{-1}$

D. $8.5ms^{-1}$

Answer:

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30. A planet moves around the sun in an elliptical orbit with the sun at one of its foci. The physical quantity associated with the motion of the planet that remains constant with time is

A. velocity

B. centripetal force

C. linear momentum

D. angular momentum

Answer:

31. The fundamental frequency of a closed pipe is equal to the frequency of the second harmonic of an open pipe. The ratio of their lengths is

A. $1:2$

B. $1:4$

C. $1:8$

D. $1:16$

Answer:

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32. A particle of mass M and charge q is released from rest in a region of uniform electric field of magnitude E. After a time t, the distance travelled by the charge is S and the kinetic energy attained by the particle is T. Then, the ratio T/S

A. remains constant with time t

B. varies linearly with the mass M of the particle

C. is independent of the charge q

D. is independent of the magnitude of the electric field E

Answer:

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33. An alternating current in a circuit is given by I=20 sin $(100\pi t + 0.05\pi)$A. The r.m.s value and the frequency of current respectively are,

A. 10A & 100Hz

B. 10A & 50Hz

C. $10\sqrt{2}A$ & 50Hz

D. $10\sqrt{2}A$ & 100Hz

Answer:

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34. The specific heat c of a solid at low temperature shows temperature dependence according to the relation $c = DT^3$ where D is a constant and T is the temperature in kelvin. A piece of this solid of mass m

kg is taken and its temperature is raised from 20K to 30K. The amount of heat required in the process in energy units is

A. $5 \times 10^4 Dm$

B. $(33/4) \times 10^4 Dm$

C. $(65/4) \times 10^4 Dm$

D. $(5/4) \times 10^4 Dm$

Answer:

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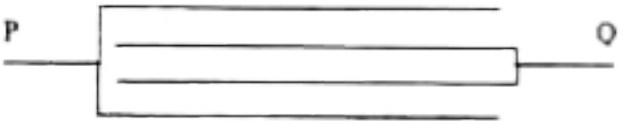
35. Four identical plates each of AREA a are separated by a distance d. The connection is shown below. What is the capacitance between P and Q ?



A. $2a\varepsilon_0 / d$

B. $a\varepsilon_0 / (2d)$

C. $a\varepsilon_0 / d$

D. $4a\varepsilon_0 / d$

Answer:

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36. The least distance of vision of a longsighted person is 60cm. By using a spectacle lens, this distance is reduced to 12cm. The power of the lens is

A. $+5.0D$

B. $+(20/3)D$

C. $-(10/3)D$

D. $+2.0D$

Answer:

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37. A particle is acted upon by a constant power. Then, which of the following physical quantity remains constant?

A. speed

B. rate of change of acceleration

C. kinetic energy

D. rate of change of kinetic energy

Answer:

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38. A particle of mass M and charge q, initially at rest, accelerated by a uniform electric field E through a distance D and is then allowed to approach a fixed static charge Q of the same sign. The distance of the closest approach of the charge q will then be

A. $\frac{qQ}{4\pi\varepsilon_0 D}$

B. $\frac{Q}{4\pi\varepsilon_0 ED}$

C. $\frac{qQ}{2\pi\varepsilon_0 D^2}$

D. $\frac{Q}{4\pi\varepsilon_0 E}$

Answer:

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39. In an n-p-n transistor

A. the emitter has higher degree of doping compared to that of the collector

B. the collector has higher degree of doping compared to that of the emitter

C. both the emitter and collector have same degree of doping

D. the base region is most heavily doped.

Answer:

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40. At two different places the angles of dip are respectively 30° and 45°. At these two places the ratio of horizontal component of earth's magneitc field is

A. $\sqrt{3}:\sqrt{2}$

B. $1:\sqrt{2}$

C. $1:2$

D. $1:\sqrt{3}$

Answer:

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41. Two vectors are given by $\overrightarrow{A} = \hat{i} + 2\hat{j} + 2\hat{k}$ and $\overrightarrow{B} = 3\hat{i} + 6\hat{j} + 2\hat{k}$. Another vector $\overrightarrow{C}$ has the same magnitude as $\overrightarrow{B}$ but has the same direction as $\overrightarrow{A}$. Then which of the following vectors represents $\overrightarrow{C}$?

A. $\frac{7}{3}\left(\hat{i} + 2\hat{j} + 2\hat{k}\right)$

B. $\frac{3}{7}\left(\hat{i} - 2\hat{j} + 2\hat{k}\right)$

C. $\frac{7}{9}\left(\hat{i} - 2\hat{j} + 2\hat{k}\right)$

D. $\frac{9}{7}\left(\hat{i} + 2\hat{j} + 2\hat{k}\right)$

Answer:

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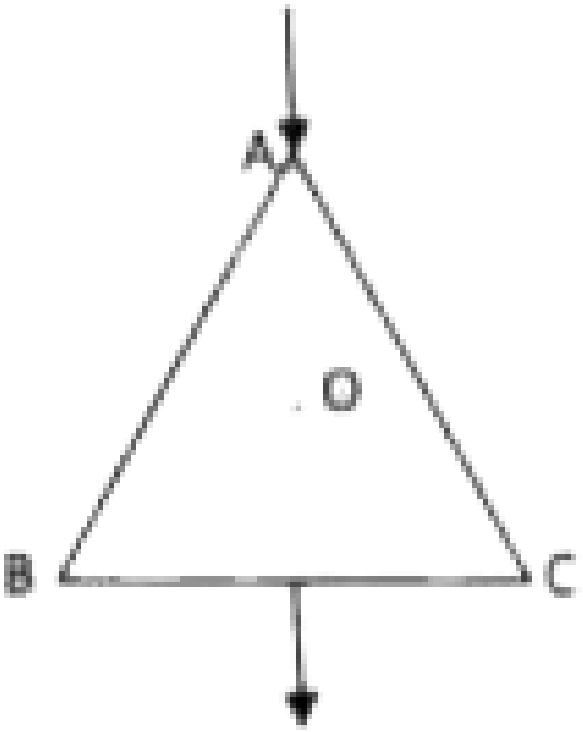
42. An equilateal triangle is made by uniform wires AB, BC, CA. A current I enters at A and leaves from the mid point of BC. If the length of each side of the triangle is L, the magnetic field B at the centroid O of

the triangle is



A. $\frac{\mu_0}{4\pi}\left(\frac{4l}{L}\right)$

B. $\frac{\mu_0}{2\pi}\left(\frac{4l}{L}\right)$

C. $\frac{\mu_0}{4\pi}\left(\frac{2l}{L}\right)$

D. zero

Answer:

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43. A car moving at a velocity of $17ms^{-1}$ towards an approaching bus that blows a horn at a frequency of 640Hz on a straight track. The frequency of this horn appears to be 680 Hz to the car driver. If the velocity of sound in air is $340ms^{-1}$, then the velocity of the approaching bus is

A. $2ms^{-1}$

B. $4ms^{-1}$

C. $8ms^{-1}$

D. $10ms^{-1}$

Answer:

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44. A particle is moving with a uniform speed v in a circular path of radius r with the centre at O. When the particle moves from a point P to Q on the circle such that $\angle POQ = \theta$, then the magnitude of the change in velocity is

A. $2v\sin(2\theta)$

B. zero

C. $2v \sin\left(\frac{\theta}{2}\right)$

D. $2v \cos\left(\frac{\theta}{2}\right)$

Answer:

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Category Ii

1. Two simple harmonic motions are given by $x_1 = a \sin \omega t + a \cos \omega t$ and $x_2 = a \sin \omega t + \frac{a}{\sqrt{3}} \cos \omega t$

The ratio of the amplitudes of first and second

motion and the phase difference between them are respectively

A. $\sqrt{\frac{3}{2}}$ and $\frac{\pi}{12}$

B. $\frac{\sqrt{3}}{2}$ and $\frac{\pi}{12}$

C. $\frac{2}{\sqrt{3}}$ and $\frac{\pi}{12}$

D. $\sqrt{\frac{3}{2}}$ and $\frac{\pi}{6}$

Answer:

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2. A small mass m attached to one end of a spring with a negligible mass and an unstretched length L,

executes vertical oscilllations with angular frequency ω_0. When the mass is rotated with an angular speed ω by holding the other end of the spring at a fixed point, the mass moves uniformly in a circular path in a horizontal plane. Then the increase in length of the spring during this rotation is

A. $\frac{\omega^2 L}{\omega_0^2 - \omega^2}$

B. $\frac{\omega_0^2 L}{\omega^2 - \omega_0^2}$

C. $\frac{\omega^2 L}{\omega_0^2}$

D. $\frac{\omega_0^2 L}{\omega^2}$

Answer:

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3. A cylindrical block floats vertically in a liquid of density ρ_1 kept in a container such that the fraction of volume of the cylinder inside the liquid is x_1. Then some amount of another immiscible liquid of density $\rho_2(\rho_2 < \rho_1)$ is added to the liquid in the container so that the cylinder now floats just fully immersed in the liquids with x_2 fraction of volume of the cylinder inside the liquid of density ρ_1. The ratio ρ_1 / ρ_2 will be

A. $\dfrac{1 - x_1}{x_1 - x_2}$

B. $\dfrac{1 - x_1}{x_1 + x_2}$

C. $\dfrac{x_1 - x_2}{x_1 + x_2}$

D. $\frac{x_2}{x_1} - 1$

Answer:

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4. A sphere of radius R has a volume density of charge $\rho = kr$, where r is the distance from the centre of the sphere and k is constant. The magnitude of the electric field which exists at the surface of the sphere is given by (ε_0 = permittivity of free space)

A. $\frac{4\pi k R^4}{3\varepsilon_0}$

B. $\frac{kR}{3\varepsilon_0}$

C. $\frac{4\pi kR}{\varepsilon_0}$

D. $\frac{kR^2}{4\varepsilon_0}$

Answer:

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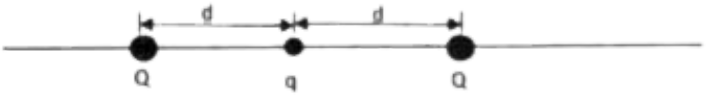
5. A particle of mass M and charge q is at rest at the midpoint between two other fixed similar charges each of magnitude Q placed a distance 2d apart. The system is collinear as shown in the figure. The particle is now displaced by a small amount

$x(x < < d)$ along the line joining the two charges and is left to itself. It will now oscillate about the mean position with a time period (ε_0= permittivity of free space)



A. $2\sqrt{\frac{\pi^3 M\varepsilon_0 d}{Qq}}$

B. $2\sqrt{\frac{\pi^2 M\varepsilon_0 d^3}{Qq}}$

C. $2\sqrt{\frac{\pi^3 M\varepsilon_0 d^3}{Qq}}$

D. $2\sqrt{\frac{\pi^3 M\varepsilon_0}{qQd^3}}$

Answer:

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6. A body is projected from the ground with a velocity $\vec{v} = \left(3\hat{i} + 10\hat{j}\right) ms^{-1}$. The maximum height attained and the range of the body respectively are (given $g = 10ms^{-2}$)

A. 5m and 6m

B. 3m and 10m

C. 6m and 5m

D. 3m and 5m

Answer:

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7. The stopping potential for photoelectrons from a metal surface is V_1 when monochromatic light of frequency v_1 is incident on it. The stopping potential becomes V_2 when monochromatic light of another frequency is incident on the same metal surface. If h be the Planck's constant and e be the charge of an electron, then the frequency of light in the second case is

A. $v_1 - \frac{e}{h}(V_2 + V_1)$

B. $v_1 + \frac{e}{h}(V_2 + V_1)$

C. $v_1 - \frac{e}{h}(V_2 - V_1)$

D. $v_1 + \frac{e}{h}(V_2 - V_1)$

Answer:

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8. A cell of e.m.f E is connected to a resistance R_1 for time t and the amount of heat generated in it is H. If the resistance R_1 is replaced by another resistance R_2 and is connected to the cell for the same time t, the amount of heat generated in R_2 is 4H. Then the internal resistance of the cell is

A. $\frac{2R_1 + R_2}{2}$

B. $\sqrt{R_1R_2}\dfrac{2\sqrt{R_2}-\sqrt{R_1}}{\sqrt{R_2}-2\sqrt{R_1}}$

C. $\sqrt{R_1R_2}\dfrac{\sqrt{R_2}-2\sqrt{R_1}}{2\sqrt{R_2}-\sqrt{R_1}}$

D. $\sqrt{R_1R_2}\dfrac{\sqrt{R_2}-\sqrt{R_1}}{\sqrt{R_2}+\sqrt{R_1}}$

Answer:

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9. 3 moles of a mono-atomic gas $(\gamma = 5/3)$ is mixed with 1 mole of a diatomic gas $(\gamma = 7/5)$. The value of γ for the mixture will be

A. $9/11$

B. $11/7$

C. $12/7$

D. $15/7$

Answer:

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10. A magnetic field $B = 2t + 4t^2$ (where t= time) is applied perpendicular to the plane of a circular wire of radius r and resistance R. If all the units are in SI the electric charge that flows through the circular wire during t=0s to t= 2s is

A. $\frac{6\pi r^2}{R}$

B. $\frac{20\pi r^2}{R}$

C. $\frac{32\pi r^2}{R}$

D. $\frac{48\pi r^2}{R}$

Answer:

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Category Iii

1. If E and B are the magnitudes of electric and magnetic fields respectively in some region of space, then the possibilities for which a charged particle

may move in that space with a uniform velocity of magnitude v are

A. E= vB

B. $E \neq 0, B = 0$

C. $E = 0, B \neq 0$

D. $E \neq 0, B \neq 0$

Answer:

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2. An electron of charge e and mass m is moving in a circular path of radius r with a uniform angular

speed ω. Then which of the following statements are correct ?

The equivalent current flowing in the circular path is proportional to r^2

The magnetic moment due to circular current loop is independent of m

The magnetic moment due to circular current loop is equal to 2e/m times the angular momentum of the electron

The angular momentum of the particle is proportional to the areal velocity of electron

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3. A biconvex lens of focal length f and radii of curvature of both the surface R is made of a material of refractive index n_1. This lens is placed in a liquid of refractive index n_2. Now this lens will behave like

A. either as a convex or as a concave lens depending solely on R

B. a convex lens depending on n_1 and n_2

C. a concave lends depending on n_1 and n_2

D. a convex lens of same focal length irrespective of R, n_1 and n_2

Answer:

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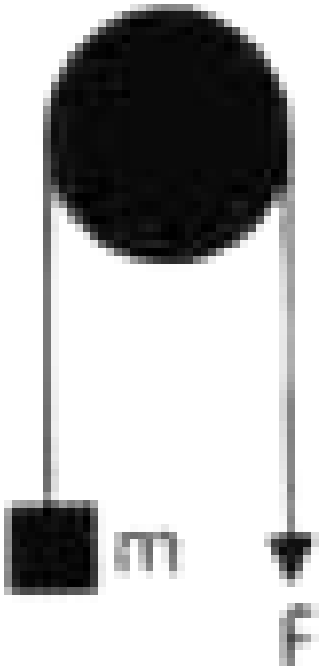
4. A block of mass (= 0.1kg) is hanging over a frictionless light fixed pulley by an inextensible string of negligible mass. The other end of the string is pulled by a constatn force F in the vertically downward direction. The linear momentum of the block increase by $2kgms^{-1}$ in 1s after the block

starts from rest. Then, (given $g = 10ms^{-2}$)



A. The tension in the string is F

B. The tension in the string is 3N

C. The work done by the tension on the block is 20J during this 1s

D. The work done against the force of gravity is 10J

Answer:

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5. A bar of length l carrying a small mass m at one of its ends rotates with a uniform angular speed ω in a vertical plane about the mid-point of the bar. During the rotation, at some instant of time when the bar is horizontal, the mass is detached from the bar but the bar continues to rotate with same ω. The mass moves vertically up, comes back and reaches the bar

at the same point. At that place, the acceleration due to gravity is g.

A. This is possible if the quantity $\frac{\omega^2 l}{2\pi g}$ is an integer

B. The total time of flight of the mass is proportional to ω^2

C. The total distance travelled by the mass in air is proportional to ω^2

D. The total distance travelled by the mass in air and its total time of flight are both independent on its mass

Answer: