H - 09

ENTRANCE EXAMINATION, FEBRUARY 2015

QUESTION PAPER BOOKLET

M.Sc. (PHYSICS)

Marks: 75

Time: 2.00 hrs.

Hall Ticket No.:

I. Please enter you **Hall Ticket Number on Page 1 of this question paper and on the OMR sheet** without fail.

II. Read carefully the following instructions:

1. This Question paper has 2 Sections: **Section A** and **Section B**
2. **Section A** consists of 25 objective type questions of one mark each. **There is negative marking of 0.33 mark for every wrong answer.** The marks obtained by the candidate in this Section will be used for resolving the tie cases.
3. **Section B** consists of 50 objective type questions of one mark each. **There is no negative marking in this Section.**
4. Answers are to be marked on the OMR answer sheet following the instructions provided there upon. An example is shown below

   100. (A) (B) (C) ●

5. Only non programmable Scientific Calculators are permitted. Mobile phone based calculators are not permitted. Logarithmic tables are not allowed.
6. Hand over the OMR sheet at the end of the examination to the invigilator.

This book contains 24 pages

III. Values of physical constants:
$c = 3 \times 10^8$ m/s; $h = 6.63 \times 10^{-34}$ J.s; $k_B = 1.38 \times 10^{-23}$ J/K
$e = 1.6 \times 10^{-19}$ C; $\mu_\circ = 4\pi \times 10^{-7}$ Henry/m; $\epsilon_\circ = 8.85 \times 10^{-12}$ Farad/m

SECTION - A

1. The unit vector parallel to the resultant of the vectors $\vec{r}_1 = 2\hat{\imath} + 4\hat{\jmath} - 5\hat{k}$ and $\vec{r}_2 = \hat{\imath} + 2\hat{\jmath} + 3\hat{k}$ is given by

   A. $\frac{1}{3}\hat{\imath} + \frac{1}{6}\hat{\jmath} - \frac{1}{2}\hat{k}$.

   B. $\frac{3}{7}\hat{\imath} + \frac{6}{7}\hat{\jmath} - \frac{2}{7}\hat{k}$.

   C. $\frac{2}{7}\hat{\imath} - \frac{3}{7}\hat{\jmath} + \frac{6}{7}\hat{k}$.

   D. $3\hat{\imath} + 6\hat{\jmath} - 2\hat{k}$.

2. The solution to the differential equation $\frac{d^2x}{dt^2} = t^2$ is given by

   A. $x = \frac{t^3}{3} + A$.

   B. $x = \frac{t^3}{3} + At + B$.

   C. $x = \frac{t^4}{12} + At + B$.

   D. $x = \frac{t^3}{3} + \frac{t^2}{2} + A$.

   where A and B are constants.

3. If $T = \sin x \sin y \sin z$, $\nabla^2 T$ is given by

   A. 0.

   B. $-2 \sin x \sin y \sin z$.

   C. $3 \sin x \sin y \sin z$.

   D. $-3 \sin x \sin y \sin z$.

4. A force $F = -A(x^2\boldsymbol{i} + y\boldsymbol{j})$ is irrotational. The potential energy function associated with it is given by

   A. $U = A\left(\frac{x^3}{3} + \frac{y^2}{2}\right)$.

   B. $U = A\left(\frac{x}{3} + \frac{y^2}{2}\right)$.

   C. $U = A\left(\frac{x^3}{3} + \frac{y}{2}\right)$.

   D. $U = A\left(\frac{x}{3} + \frac{y^3}{2}\right)$.

5. A bead moves outward with constant speed u along the spoke of a wheel. It starts from the centre at $t = 0$. The angular position of the spoke is given by $\theta = \omega t$, where ω is a constant. The acceleration of the bead is given by

   A. $ut\omega^2\hat{r} + u\omega\hat{\theta}$.

   B. $u\hat{r} + ut\omega\hat{\theta}$.

   C. $ut\omega^2\hat{r} + ut\omega\hat{\theta}$.

   D. $-ut\omega^2\hat{r} + 2u\omega\hat{\theta}$.

6. A solid cylinder and a hollow cylinder are placed at the same height at the top of a long incline and released at the same time.

   A. Both the cylinders reach the bottom together.

   B. Solid cylinder reaches the bottom first.

   C. Hollow cylinder reaches the bottom first.

   D. Any one of them can reach the bottom first.

7. A large vertical drum spins so fast that a ball inside it, is pinned to the wall. What is the minimum steady angular velocity ω which prevents the ball from falling to the bottom of the drum? (The radius of the drum is R, the mass of the ball is M and μ is the co-efficient of friction.)

   A. $\omega^2 \geq \dfrac{Mg}{R}$

   B. $\omega^2 \geq \dfrac{g}{\mu R}$

   C. $\omega^2 \geq \dfrac{g}{MR}$

   D. $\omega^2 \geq \dfrac{\mu g}{R}$

8. The equation of traveling wave is given as: $y = 10\cos\left(\dfrac{\pi}{5\text{cm}}x - \dfrac{\pi}{20\text{s}}t\right)$. What is the speed of the wave?

   A. 1 cm/s

   B. 0.5 cm/s

   C. 0.25 cm/s

   D. 0.1 cm/s

9. Two sound sources oscillate in phase with a frequency of 100 Hz. At a point 5 m from one source and 5.85 m from the other, the amplitude of the sound from each source separately is A. What is the phase difference of the two waves at that point? (Assume that the speed of sound is 343 m/s.)

   A. 99°

   B. 45°

   C. 60°

   D. 89°

10. It is given that surface tension of water is 0.072 N/m and its density is 10^3 kg/m^3. What is the height to which water will rise in a tube of diameter 0.2 mm?

    A. 14.7 cm

    B. 34.2 cm

    C. 29.4 cm

    D. 1.27 cm

11. An air bubble of diameter 2 mm rises steadily through a solution of density 1750 kg/m^3 at the rate of 0.35 cm/sec. If the density of air is negligible, what is the coefficient of viscosity of the solution?

    A. 1 poise

    B. 11 poise

    C. 20 poise

    D. 4 poise

12. Internal energy of an ideal gas changes when

    A. temperature changes.

    B. volume changes.

    C. entropy changes.

    D. pressure changes.

13. A gas expands adiabatically and reversibly to a temperature T_A. If the same expansion happens adiabatically, but irreversibly, the final temperature is T. Then

    A. $T > T_A$.

    B. $T < T_A$.

    C. $T = T_A$.

    D. T can take any value independent of T_A.

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14. A cylinder fitted with a piston contains an ideal gas at 500 Kilo Pascals and occupies a volume of 0.2 m^3. The gas expands isothermally to a pressure of 100 Kilo Pascals. The work done by the gas is

    A. 160.9 KJ.

    B. 1609.0 KJ.

    C. 16.09 KJ.

    D. 5×10^4 KJ.

15. The sun delivers about 1000 W/cm^2 of electromagnetic flux to the earth's surface. Assume 7% conversion efficiency of the solar panel of dimensions 8m × 20m. If the radiation is incident normally, the solar power converted for use is

    A. 11.42×10^4 W.

    B. 11.35×10^4 W.

    C. 1.56×10^4 W.

    D. 1.12×10^4 W.

16. The angle of refraction for a light beam incident on a heavy flint glass ($n = 1.65$) at the polarizing angle is given by

    A. 31.22°.

    B. 30.25°.

    C. 28.20°.

    D. 33.41°.

17. A radio pulse from a doppler radar reflects off an aircraft in mid-flight. If the frequency of the reflected radio pulse is less than the original one, then which of the following statements is true?

    A. The aircraft is not moving.

    B. The aircraft is moving away from the radar.

    C. The aircraft is moving towards the radar.

    D. Something is wrong with the radar.

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18. The total charge within a sphere of radius r in a charge cloud is given by: $q\frac{r^2}{a^2}\left(e^{\frac{-r}{a}} - e^{\frac{-2r}{a}}\right)$. The electric field at the surface of the above sphere is given by

A. $\frac{q}{4\pi\epsilon_0 a^2}(e^{-r/a} - e^{r/a})$.

B. $\frac{q}{\epsilon_0 a^2}(e^{-r/a} - e^{-2r/a})$.

C. $\frac{q}{\epsilon_0 a^2}(e^{-2r/a} - e^{-r/2a})$.

D. $\frac{q}{4\pi\epsilon_0 a^2}(e^{-r/a} - e^{-2r/a})$.

19. The electric field in the x-y plane is given by $\vec{E} = \hat{\imath}8x - \hat{\jmath}4y$. Then the equation for the lines of force is given by

A. $xy^2 =$ constant.

B. $x^2y =$ constant.

C. $x^2 + y =$ constant.

D. $xy =$ constant.

20. Consider Maxwell's equation: $\vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$. If φ is the scalar potential and $\bar{A}$ is the vector potential, then $\bar{E}$ can be written as

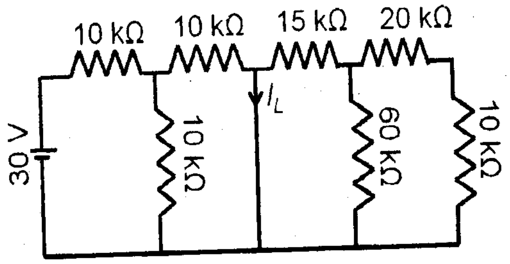
A. $-\vec{\nabla}\phi - \vec{\nabla} \times \vec{A}$.

B. $-\vec{\nabla}\phi - \frac{\nabla \vec{A}}{\partial t}$.

C. $-\frac{\partial \phi}{\partial t} - \vec{\nabla} \times \vec{A}$.

D. $-\vec{\nabla}\phi - \frac{\partial}{\partial t}(\vec{\nabla} \times \vec{A})$.

21. What is the current I_1, flowing in the circuit shown in the following figure?



A. Infinite

B. 1 mA

C. 0.5 mA

D. Zero

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22. A 50 Hz sinusoidal signal is applied to the input of a full-wave rectifier. The frequency of the output signal is

    A. 100 Hz.

    B. 50 Hz.

    C. 70.7 Hz.

    D. 0 Hz.

23. In a Bipolar Junction Transistor (BJT), the base-width is kept thinner than Emitter and Collector width. This is to

    A. reduce the base current.

    B. increase the base current.

    C. increase the emitter current.

    D. decrease the collector current.

24. If ψ_1 and ψ_2 are two independent solutions of the time-independent Schrödinger equation, which of the following is also a solution of the same Schrödinger equation?

    A. $\psi_1 \times \psi_2$

    B. ψ_1/ψ_2

    C. $\psi_1 \pm \psi_2$

    D. $(\psi_1\psi_2)^{1/2}$

25. If H_1 and H_2 are Hamiltonians of two noninteracting systems with wave functions ψ_1 and ψ_2 and energies E_1 and E_2 respectively, the total wave function Ψ and energy E of the composite system are given by

    A. $\Psi = \psi_1 + \psi_2, \ \ E = E_1 + E_2$.

    B. $\Psi = \psi_1\psi_2, \ \ E = E_1E_2$.

    C. $\Psi = \psi_1 + \psi_2, \ \ E = E_1E_2$.

    D. $\Psi = \psi_1\psi_2, \ \ E = E_1 + E_2$.

SECTION - B

26. What value of α will make the matrix $\begin{pmatrix} 1 & 0 & 0 \\ 0 & \alpha & -\alpha \\ 0 & \alpha & \alpha \end{pmatrix}$ orthogonal?

A. $\sqrt{2}$

B. 1

C. $1/\sqrt{2}$

D. 1/2

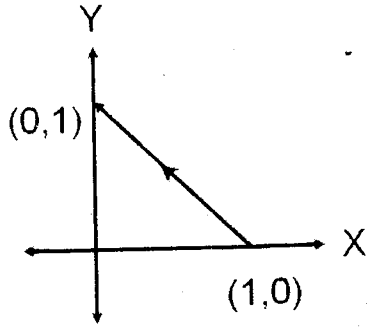
27. The value of the integral of the function $f(x, y) = x^2 + y^2$ integrated along a straight line from (1,0) to (0,1) as shown in the figure is

A. $-\frac{2}{3}$.

B. $+\frac{2}{3}$.

C. $\frac{1}{2}$.

D. $-\frac{1}{2}$.



28. If $abc = P$ and $A = \begin{bmatrix} a & b & c \\ c & a & b \\ b & c & a \end{bmatrix}$, where A is an orthogonal matrix, then the value of $a + b + c$ is

A. 2.

B. P.

C. $2P$.

D. ± 1.

29. The general solution to the differential equation $\frac{d^2y}{dx^2} - \frac{2dy}{dx} + 2y = 0$, is

A. $e^x[A\cos x + iB\sin x]$

B. $e^{ix}[A\cos x + iB\sin x]$

C. $e^{ix}[A\cos x - iB\sin x]$

D. $e^x[A\cos x - iB\sin x]$

where A and B are arbitrary constants.

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30. In the complex z-plane, the equation $|z| = 2\,|z-1|$ represents

A. a circle of radius $\frac{2}{3}$.

B. a circle of radius $\frac{1}{2}$.

C. a circle of radius $\frac{3}{2}$.

D. a straight line through (0,0) and (1,1).

31. The power series $\sum_{n=1}^{\infty}(-1)^n n^2 x^n$ converges for

A. $-1 < x < 1$.

B. $-1 \leq x \leq 1$.

C. $-1 < x \leq 1$.

D. $-1 \leq x < 1$.

32. On changing variable from x to t where $t = \log x$, the differential equation: $x^2\frac{d^2y}{dx^2} + \alpha x\frac{dy}{dx} + \beta x = 0$, becomes

A. $e^{2t}\,\frac{d^2y}{dt^2} + \alpha e^t\,\frac{dy}{dt} + \beta y = 0$.

B. $\frac{d^2y}{dt^2} + \alpha\,\frac{dy}{dt} + \beta y = 0$.

C. $\frac{d^2y}{dt^2} + \alpha\,\frac{dy}{dt} + (\alpha + \beta)y = 0$.

D. $\frac{d^2y}{dt^2} + (\alpha - 1)\,\frac{dy}{dt} + \beta y = 0$.

33. A uniform drum of radius 0.5 m, mass 40 kgs rolls (without slipping) down an incline of angle 5°. If the drum starts from rest from a height of 29.4 metres, the speed of its centre of mass will be

A. 39.2 m/s.

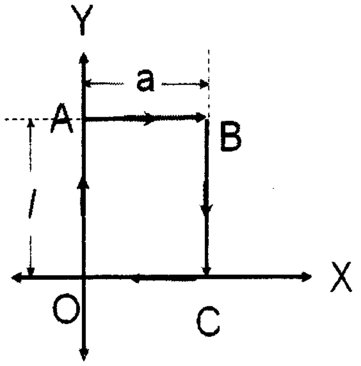
B. 19.6 m/s.

C. 32.6 m/s.

D. 25.5 m/s.

34. A mass M is moving along a closed rectangular path of length l along the y-direction and a along the x-direction (as shown in the figure) under the influence of the force $\vec{F} = bv_0\left(1 - \frac{x^2}{a^2}\right)\hat{j}$.

The work done is given by



A. zero.

B. bv_0l.

C. bv_0a.

D. bv_0al.

35. A force field $\vec{F} = (3x - y + z)\hat{i} + (x + y - z^2)\hat{j} + (3x - 2y + 4z)\hat{k}$ N is acting on a particle of mass m. The particle moves in a circular path of radius 5 m with a constant speed of 5 m/s in the x-y plane. The centre of the orbit is the origin. The change in the kinetic energy as a particle completes one rotation is given by

A. 25 J.

B. 25π J.

C. 50π J.

D. 50 J.

36. A particle moves along a trajectory whose displacement is given by

$$\vec{r}(t) = \cos(\omega t)\hat{i} + \sin(\omega t)\hat{j} + t\hat{k}, \qquad \text{with } \omega = 1.$$

The path of the particle is a

A. parabola, with direction of motion to the right of the origin.

B. parabola, with direction of motion to the left of the origin.

C. hyperbola, with direction of motion to the right of the origin.

D. hyperbola, with direction of motion to the left of the origin.

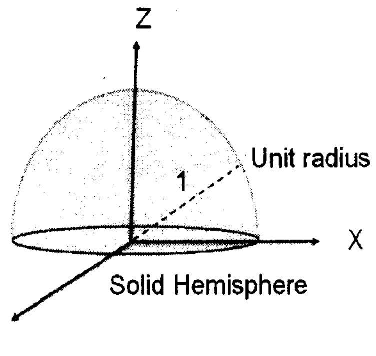
37. The centre of mass of a solid hemisphere (as shown in figure) of unit radius is given by

A. $(0, 0, \frac{3}{8})$

B. $(0, \frac{3}{8}, 0)$

C. $(1, \frac{3}{8}, 1)$

D. $(0, 0, \frac{2}{3})$



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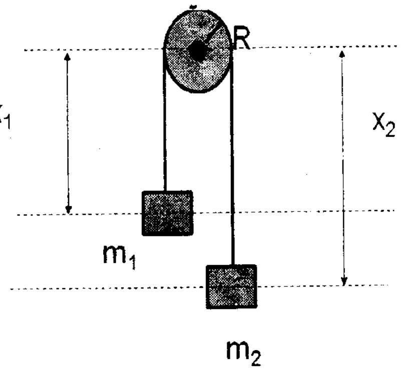
38. A particle of mass m starts at rest from the top of a smooth fixed hemisphere of radius a. The angle at which the particle leaves the hemisphere is equal to

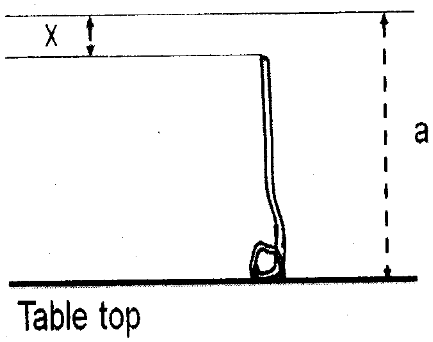
A. $\cos^{-1}(1/3)$.
B. $\pi/2$.
C. $\cos^{-1}(2/3)$.
D. $\sin^{-1}(2/3)$.

39. The Lagrangian of Atwood's machine (shown in the figure, where $m_2 > m_1$) is given by



A. $\frac{1}{2}m_1\dot{x}_1^2 + \frac{1}{2}m_2\dot{x}_x^2 + m_1gx_1 + m_2gx_2$.
B. $\frac{1}{2}m_1\dot{x}_1^2 + \frac{1}{2}m_2\dot{x}_x^1 - m_1gx_1 + m_2y_2$.
C. $\frac{1}{2}(m_1 + m_2)\dot{x}_1^2 - (m_1 + m_2)gx_1$.
D. $\frac{1}{2}(m_1 + m_2)\dot{x}_1^2 - (m_1 - m_2)gx_1$.

40. Consider a rope of mass per unit length ρ and length a, suspended just above a table as shown in figure. If the rope is released from rest at the top, the force on the table when a length x of the rope has dropped to the table is



A. ρxg.
B. $2\rho xg$.
C. $3\rho xg$.
D. $4\rho xg$.

41. An object of unit mass orbits in a central potential given by $U(r)$. Its orbit is $r = a\exp(-b\phi)$ with $b > 0$. The relationship between the angular momentum and the total energy E is given by

A. $E = -\frac{L^2}{2}(b^2 + 1) + U(r)$.
B. $E = \frac{L^2}{2r^2}(b^2 + 1) + U(r)$.
C. $E = \frac{L}{r}(b + 1) + U(r)$.
D. $E = \frac{a^2L^2}{r^2}(b + 1) + U(r)$.

42. A wave is propagating in a string of tension T and mass per unit length μ. The traveling wave can be described as $y(x,t) = A\sin(kx - \omega t)$. What is the kinetic energy in one wavelength (λ) of the traveling wave?

A. $\frac{2TA^2\pi^2}{\lambda}$

B. $TA^2\pi^2/\lambda$

C. $TA^2\pi^2/2\lambda$

D. $TA^2\pi^2/4\lambda$

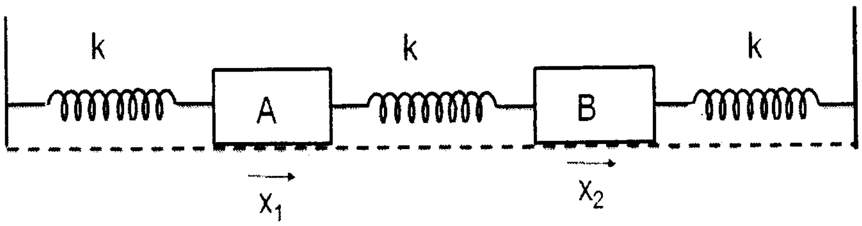
43. Consider the figure as shown. A and B have equal masses m and all the springs have the same spring constant k. What are the normal frequencies for the system, if the oscillations are assumed to be small?

A. $\sqrt{\frac{k}{m}}, \sqrt{\frac{2k}{m}}$

B. $\sqrt{\frac{k}{2m}}, \sqrt{\frac{k}{m}}$

C. $\sqrt{\frac{k}{m}}, \sqrt{\frac{3k}{m}}$

D. $\sqrt{\frac{k}{m}}, \sqrt{\frac{k}{m}+1}$



44. A violin string is held under tension T. What will be fractional change in the frequency of its fundamental mode of vibration if the tension is increased by the amount δT?

A. $\frac{\delta T}{T^2}$

B. $\frac{\delta T}{\sqrt{T}}$

C. $\frac{\delta T}{T}$

D. $\frac{\delta T}{2T}$

45. One can estimate the resonant frequencies of the human ear canal of length 2.2 cm, that are in the range of human hearing. How many resonant frequencies lie in this range? Speed of sound is given as 343 m/s.

A. 3

B. 4

C. 5

D. 6

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46. One end of a 100 cm long wire (without load) is fixed and a mass of 2 kg is attached to the other end. The mass is kept moving with uniform speed in a horizontal circle of radius 60 cm. What is the strain of the wire if the radius of the wire is 0.032 cm and Young's modulus is 2×10^{11} dynes/cm^2?

A. 0.032×10^{-2}

B. 32×10^{-2}

C. 0.32×10^{-2}

D. 3.2×10^{-2}

47. What will be density of lead under a pressure of 20,000 N/cm^2? (Density of lead = 11.5 gm/cm^3 and bulk modulus of lead = 0.80×10^{10} N/m^2.)

A. 11.69 gm/cc.

B. 14.19 gm/cc.

C. 13.89 gm/cc.

D. 15.98 gm/cc.

48. The excess of pressure inside a spherical soap bubble of radius 1 cm is balanced by that due to a column of oil of specific gravity 0.9 gm/cm^3 and height 1.36 mm. What is the surface tension T?

A. $T \approx 3.06 \times 10^{-3}$ N/m

B. $T \approx 23.0 \times 10^{-2}$ N/m

C. $T \approx 3.06 \times 10^{-2}$ N/m

D. $T \approx 30.6 \times 10^{-4}$ N/m

49. A big drop is formed by coalescing 1000 small droplets of water. By how many times will the surface energy decrease?

A. 100

B. 10

C. 5

D. 30

50. A plate of area 100 cm^2 and thickness 2 mm is placed on the upper surface of some castor oil. If the coefficient of viscosity is 15.5 poise, what is the horizontal force necessary to move the plate with a velocity 3 cm/sec?

A. 10.2 N

B. 0.13 N

C. 2.3 N

D. 0.23 N

51. The velocity of water in a river is 10 km/hr near the surface. If the river is 5 m deep, what is the shearing stress between the horizontal layers of water? (The coefficient of viscosity of water $= 10^{-2}$ poise.)

A. 10^{-3} N/m^2

B. 10^{-5} N/m^2

C. 10 N/m^2

D. 10^{-1} N/m^2

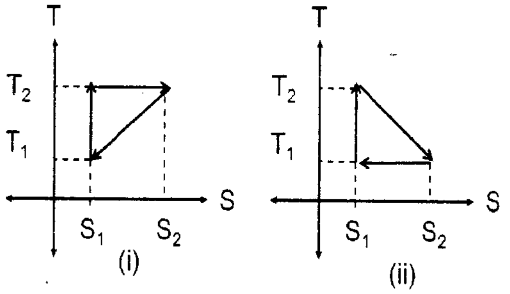
52. The figures shown represent two engines in $T-S$ phase plane. Let η_a and η_b denote the efficiencies of the engines (i) and (ii), respectively. Then

A. $\eta_b > \eta_a$.

B. $\eta_a > \eta_b$.

C. $\eta_a = \eta_b$.

D. $\eta_a \geq \eta_b$.



53. The relation between pressure and volume of an ideal gas in a reversible process is given by $P = aV + b$, where $a = -\frac{31}{56}$ Pascal/meter^3, $b = \frac{255}{7}$ Pascals. The volume at which the temperature attains maximum is

A. 32.9 m^3.

B. 329.7 m^3.

C. 0.329 m^3.

D. 20.7 m^3.

54. Clausius -Clapeyron equation for liquid-gas transition is given by: $\frac{d\rho}{d\tau} = \frac{1}{T(v_g - v_l)}$. If $v_g \gg v_l$ and $\rho v_g = RT$, the expression for saturated vapour pressure is given by

A. $\rho = \text{constant} \times e^{1/RT}$.

B. $\rho = \text{constant} \times e^{-1/RT}$.

C. $\rho = 0$.

D. $\rho = \text{constant}$.

55. For a nonmagnetic insulator, the specific heat is proportional to

A. T.

B. T^2.

C. T^3.

D. $e^{-\alpha/k_BT}$.

56. Consider the superposition of two sinusoidal waves given by: $y_1 = 4\sin(3x - 2t)\, cm$ and $y_2 = 4\sin(3x + 2t)\, cm$. The maximum displacement of the resultant motion at $x = 2.3$ cm is

A. 8.65 cm.

B. 1.61 cm.

C. 4.63 cm.

D. 7.60 cm.

57. A total of 25 fringes move across the field of view when one of the mirrors of the Michelson interferrometer is moved by a distance d. If the interferrometer is illuminated by a laser of wavelength 632.8 nm, the distance by which the mirror is moved is

A. 79.1 μm.

B. 38.6 μm.

C. 57.3 μm.

D. 158.2 μm.

58. A parallel light beam of diameter d is incident on a convex lens of focal length f. The emerging beam from this lens passes again through another lens of focal length $2f$, kept at a distance $3f$ from first lens. The diameter of the output beam is

A. d.

B. $2d$.

C. not related with d.

D. $\frac{1}{2}d$.

59. Consider a uniformly charged disc of radius a and surface charge density σ. Consider a point P on the axis of the disc at a distance z from the disc. The potential at P is given by

A. $\frac{\sigma}{\epsilon_0}\frac{1}{z^2}$.

B. $\frac{\sigma}{2\epsilon_0}\left[\sqrt{a^2+z^2}-z\right]$.

C. $\frac{\sigma}{\epsilon_0}\left[\sqrt{a^2+z^2}-\sqrt{a^2-z^2}\right]$.

D. $\frac{\sigma}{\epsilon_0}\left[\sqrt{a^2+z^2}-a\right]$.

60. A charge q is distributed uniformly over the surface of a thin circular insulating disc of radius a. The potential at the rim of the disc is given by

A. $\frac{q}{\pi^2 a\epsilon_0}$.

B. $\frac{q}{4\pi^2\epsilon_0 a}$.

C. $\frac{q}{\pi a^2\epsilon_0}$.

D. $\frac{q}{4\pi^2 a^2\epsilon_0}$.

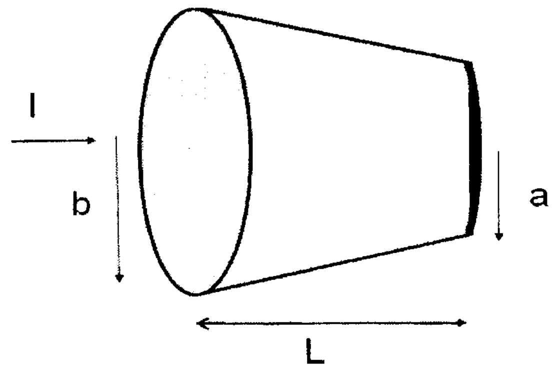
61. Current I is passing through a conical shaped copper wire of resistivity ρ as shown in the figure. If L is the length of the wire, b is the front radius and a is the back radius of the wire, what is the resistance of the wire?

A. $\frac{\rho L}{\pi ab}$

B. $\frac{\rho L}{\pi(a+b)}$

C. $\frac{\rho L}{\pi\left(\frac{a+b}{2}\right)}$

D. $\frac{\rho L}{\pi\left(\frac{a+b}{ab}\right)}$



62. A very long wire carrying charge q per unit length is held parallel to an infinite conducting plane at a distance h from it. What is the force of attraction per unit length?

A. $\frac{q^2}{4\pi\epsilon_0 h}$

B. $\frac{-q^2}{4\pi\epsilon_0 h}$

C. $\frac{q^2}{2\pi\epsilon_0 h}$

D. $\frac{-q^2}{2\pi\epsilon_0 h}$

63. The potential in a medium is given by $\phi(r) = \frac{q}{4\pi\epsilon_0}\frac{e^{-r/\lambda}}{r}$. The charge density for $r \neq 0$ is given by

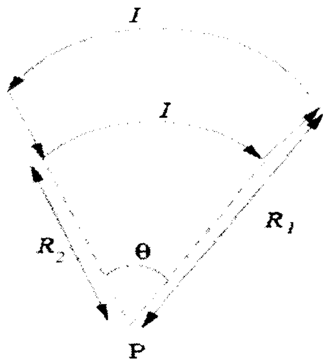
A. $-\frac{q}{\epsilon_0} e^{-r/\lambda}$.

B. $-\frac{q}{4\pi r\lambda^2} e^{-r/\lambda}$.

C. $-\frac{q}{4\pi\epsilon_0 r\lambda^2} e^{-r/\lambda}$.

D. $-\frac{q}{4\pi\epsilon_0} e^{-2r/\lambda}$.

64. What is the magnetic field ($\vec{B}$) produced at point P (center of the arcs) due to the current I in the close loop as shown in figure?



A. $\vec{B} = \frac{-\mu_0 I\theta}{4\pi}\left[\frac{1}{R_1} - \frac{1}{R_2}\right]\hat{k}$

B. $\vec{B} = \frac{-\mu_0 I\theta}{4\pi}\left[\frac{1}{R_1} + \frac{1}{R_2}\right]\hat{k}$

C. $\vec{B} = \frac{-\mu_0 I\theta}{4\pi}\left[\frac{1}{R_2} + \frac{1}{R_1}\right]\hat{k}$

D. $\vec{B} = \frac{-\mu_0 I\theta}{4\pi}\left[\frac{1}{R_2} - \frac{1}{R_1}\right]\hat{k}$

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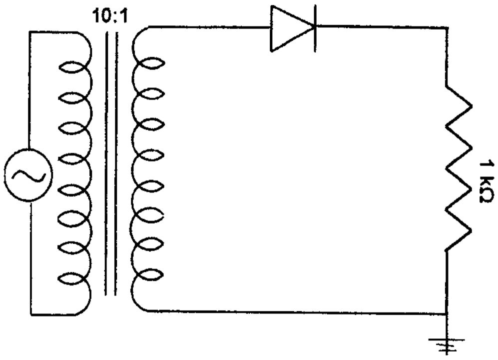
65. In the circuit given below, the diode can be considered as ideal. The peak secondary voltage and the D.C. load voltage respectively are then given by

A. 31.1 V and 9.9 V.

B. 22 V and 9.9 V.

C. 22 V and 7.0 V.

D. 31.1 V and 7.0 V.



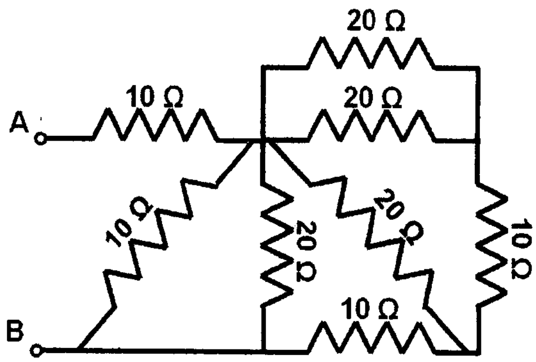
66. What is the effective resistance between points A and B?

A. $R_{ab} = 10\Omega$

B. $R_{ab} = 11\Omega$

C. $R_{ab} = 15\Omega$

D. $R_{ab} = 12\Omega$



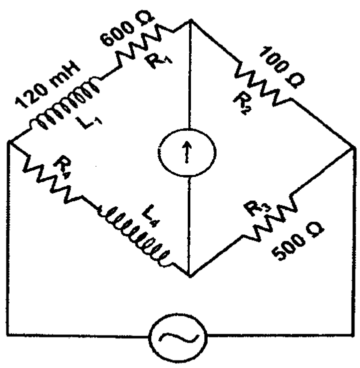
67. What are the values of R_4 and L_4, if the a.c. bridge shown in figure is balanced?

A. $R_4 = 720\Omega$ and $L_4 = 12$ mH

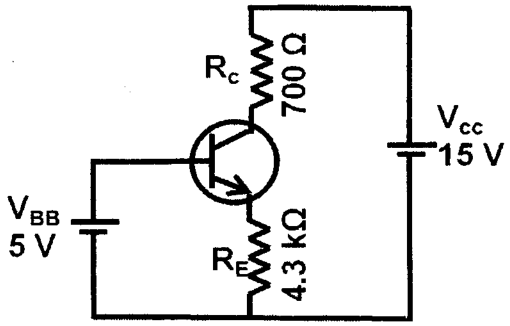
B. $R_4 = 3000\Omega$ and $L_4 = 24$ mH

C. $R_4 = 120\Omega$ and $L_4 = 600$ mH

D. $R_4 = 3000\Omega$ and $L_4 = 600$ mH



68. What is the operating point (V_{CE}, I_C) for the transistor circuit shown in figure? (Assume $I_C = I_E$ and $V_{BE} = 0.7\text{V}$.)



A. 5 V, 2 mA

B. 7.5 V, 1.5 mA

C. 7.5 V, 1 mA

D. 10 V, 1 mA

69. A particle of mass 1.40×10^5 kg has a relativistic momentum of magnitude 3.15×10^{13} kg m/s. How fast is the partilce traveling?

A. 2.68×10^8 m/s

B. 1.8×10^8 m/s

C. 3.3×10^{16} m/s

D. 3×10^8 m/s

70. A proton of rest mass 1.68×10^{-27} kg is traveling at 2.5×10^8 m/s. What is kinetic energy of the proton?

A. 1.18×10^{-10} J

B. 0.18×10^{-10} J

C. 2.18×10^{-27} J

D. 1.32×10^{-27} J

71. A spaceship passes you at a speed of 0.85 c. You measure its length to be 48.2 m. What is its length at rest?

A. 80 m

B. 100 m

C. 91.5 m

D. 81 m

72. Which of the following functions is the eigen-function of the operator, $-i\hbar \frac{d}{dx}$?

A. $\exp(ikx)$

B. $\cos(kx)$

C. $\sin(kx)$

D. $(\cos(kx) + \sin(kx))$

73. In a one dimensional problem, the normalized wave function for the ground state is given by $\psi = Ne^{-\alpha x^2}$, where N is the normalization constant. What is the value of N?

A. $\sqrt{\frac{\alpha}{\pi}}$

B. $\sqrt{\frac{\alpha}{2\pi}}$

C. $\sqrt{\frac{2\alpha}{\pi}}$

D. $\frac{\alpha}{\pi}$

74. Commutator of two Hermitian operators has to be

A. Hermitian.

B. anti-Hermitian.

C. unitary.

D. orthogonal.

75. A sample of radioactive isotopes contains two different nuclides, labeled A and B. Initially, the sample composition is 1:1. The half-life of A is 3 hours and that of B is 6 hours. What is the expected ratio A/B after 18 hours?

A. 1/6

B. 1/4

C. 1/8

D. 1/2