

ALL INDIA TEST SERIES**IIT - JAM – 2027 (Physics)****Full Length Test – 01****TIME: 3 HOURS****MAXIMUM MARKS: 100**

Section A: This section contains a total of 30 Multiple Choice Questions (MCQ) carrying one or two marks each. Each MCQ type question has four choices out of which only one choice is the correct answer.

There will be negative marking @ $\frac{1}{3}$ rd for one marks MCQ and $\frac{2}{3}$ rd negative marks for two marks MCQ for each wrong answer.

Section B: This section contains a total of 10 Multiple Select Questions (MSQ) carrying two marks each. Each MSQ type question is similar to MCQ but with a difference that there may be one or more than one choice(s) that are correct out of the four given choices. The candidate gets full credit if he/she selects all the correct answers only and no wrong answers.

Section C: This section contains a total of 20 Numerical Answer Type (NAT) questions carrying one or two marks each. For these NAT type questions, the answer is a signed real number which needs to be entered using the virtual keyboard on the monitor. No choices will be shown for these types of questions.

Note: There will be no negative marking for Section B and Section C.

Learn Physics in Right Way

MULTIPLE CHOICE QUESTIONS (MCQ)**Q1-Q10 Carry One Mark each. (1/3 negative marks for each wrong answer)**

Q1. There are two thin spherical shells with a common center and radii R_1 and R_2 . The one with radius R_1 carries a surface charge σ_1 and the one with radius R_2 carries surface charge σ_2 . Which of the following holds good, when the electric potential at the center of the sphere is zero.

- (a) $\frac{R_2}{R_1} = \frac{\sigma_1^2}{\sigma_2^2}$ (b) $\frac{R_2}{R_1} = \frac{\sigma_2}{\sigma_1}$ (c) $\frac{R_2}{R_1} = -\frac{\sigma_1}{\sigma_2}$ (d) $\frac{R_2}{R_1} = -\frac{\sigma_2}{\sigma_1}$

Q2. The solution of the differential equation $\frac{d^2y}{dt^2} - y = 0$, subject to the boundary conditions $y(0) = 1$ and $y(\infty) = 0$ is

- (a) e^t (b) $-e^t$ (c) e^{-t} (d) $-e^{-t}$

Q3. If the output (Y) of the logic circuit shown in the figure is 1, the input could be

- (a) $A = 1, B = 1, C = 1, D = 0$
(b) $A = 1, B = 1, C = 0, D = 0$
(c) $A = 1, B = 0, C = 1, D = 1$
(d) $A = 0, B = 1, C = 1, D = 1$

Q4. Two gases separated by an impermeable but movable partition are allowed to freely exchange energy. At equilibrium, the two sides will have the same

- (a) pressure and temperature (b) volume and temperature
(c) pressure and volume (d) volume and energy

Q5. Which of the following statements is correct for Zinc Blende (ZnS) crystal structure?

- (a) It is body centred cubic lattice with two atom basis
(b) It is face centred cubic lattice with one atom basis
(c) It is face centred cubic lattice with two atom basis
(d) It is simple cubic lattice with two basis

Q6. Which of the following magnetic vector potentials gives rise to a uniform magnetic field $-B_0 \hat{k}$?

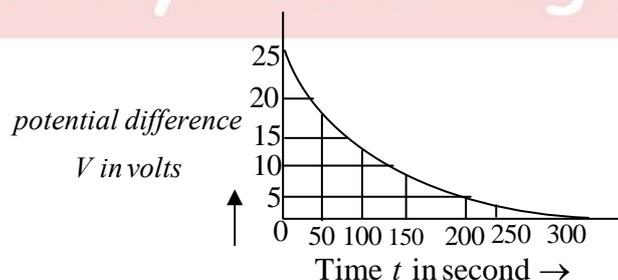
- (a) $B_0 z \hat{k}$ (b) $\frac{B_0}{2} (y \hat{i} + x \hat{j})$ (c) $\frac{B_0}{2} (-y \hat{i} + x \hat{j})$ (d) $-B_0 x \hat{j}$

- Q7.** There are two baskets. Basket I contains 3 red and 4 blue balls while Basket II contains 4 red and 3 blue balls. A ball is transferred from box I to box II and then a ball from box II is drawn, what is the probability that it is blue?
- (a) $\frac{17}{56}$ (b) $\frac{19}{56}$ (c) $\frac{21}{56}$ (d) $\frac{25}{56}$
- Q8.** A satellite moves around a planet in a circular orbit at a distance R from its centre. The time period of revolution of the satellite is T . If the same satellite is taken to an orbit of radius $\frac{R}{4}$ around the same planet, the time period would be
- (a) $8T$ (b) $4T$ (c) $\frac{T}{4}$ (d) $\frac{T}{8}$
- Q9.** Consider a beam of light of wavelength λ incident on a system of a polarizer and an analyzer. The analyzer is oriented at 45° to the polarizer. When an optical component is introduced between them, the output intensity becomes zero. (Light is incident normally on all components. The optical component is
- (a) a full wave plate (b) a half wave plate
(c) a quarter wave plate (d) an ordinary glass plate
- Q10.** A plane wave traveling with a velocity c_1 in a medium of density ρ_1 is incident normally on an interface with another medium of density ρ_2 in which the wave velocity is c_2 . If the fraction of energy transmitted is $\frac{4\rho_1\rho_2c_1c_2}{(\rho_1c_1 + \rho_2c_2)^2}$. The fraction of energy reflected is equal to (assuming no absorption):
- (a) $\frac{\rho_1c_1 - \rho_2c_2}{\rho_1c_1 + \rho_2c_2}$ (b) $\frac{\rho_1c_1 - \rho_2c_2}{(\rho_1c_1 + \rho_2c_2)^2}$
(c) $\frac{(\rho_1c_1 - \rho_2c_2)^2}{\rho_1c_1 + \rho_2c_2}$ (d) $\left[\frac{\rho_1c_1 - \rho_2c_2}{\rho_1c_1 + \rho_2c_2} \right]^2$

Multiple Choice Questions (MCQ)

Q11-Q30 Carry Two Mark each. (1/3 negative marks for each wrong answer)

- Q11.** The figure shows an experimental plot for discharging of a capacitor in an RC circuit. The time constant τ of this circuit lies between:



- (a) 150sec and 200sec (b) 0sec and 50sec
(c) 50sec and 100sec (d) 100sec and 150sec

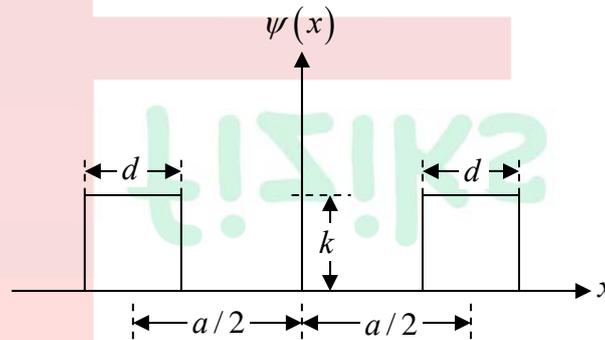
Q12. The solution of the differential equation for $y(t)$: $\frac{d^2y}{dt^2} - y = 2 \cosh(t)$, subject to the initial conditions $y(0)=0$ and $\left. \frac{dy}{dt} \right|_{t=0} = 0$, is

- (a) $\frac{1}{2} \cosh(t) + t \sinh(t)$ (b) $-\sinh(t) + t \cosh(t)$
(c) $t \cosh(t)$ (d) $t \sinh(t)$

Q13. Which among the following sets of Maxwell relations is correct? (U-internal energy, H-enthalpy, A-Helmholtz free energy and G-Gibbs free energy)

- (a) $T = \left(\frac{\partial U}{\partial V} \right)_S$ and $P = \left(\frac{\partial U}{\partial S} \right)_V$ (b) $V = \left(\frac{\partial H}{\partial P} \right)_S$ and $T = \left(\frac{\partial H}{\partial S} \right)_P$
(c) $P = - \left(\frac{\partial G}{\partial V} \right)_T$ and $V = \left(\frac{\partial G}{\partial P} \right)_S$ (d) $P = - \left(\frac{\partial A}{\partial S} \right)_T$ and $S = \left(\frac{\partial A}{\partial P} \right)_V$

Q14. The wave function $\psi(x)$ of a particle is as shown below



Here k is a constant, and $a > d$. Find the value of k such that ψ is normalized

- (a) $k = \frac{1}{\sqrt{d}}$ (b) $k = \frac{1}{\sqrt{2d}}$ (c) $k = \frac{1}{2\sqrt{d}}$ (d) $k = \sqrt{\frac{2}{d}}$

Q15. There are three planets in circular orbits around a star at distances $a, 4a$ and $64a$, respectively. At time $t = t_0$, the star and the three planets are in a straight line. The period of revolution of the closest planet is T . If after a time αT from $t = t_0$, they are again in the same straight line then the value of α is

- (a) 64 (b) 512 (c) 512·8 (d) 8T

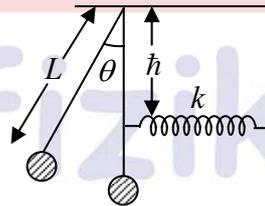
Q16. A charged particle in a uniform magnetic field $\vec{B} = B_0 \hat{e}_z$ starts moving from the origin with velocity $\vec{v} = (3\hat{e}_x + 2\hat{e}_z) m/s$. The trajectory of the particle and the time t at which it reaches 2 meters above the xy -plane are

(\hat{e}_x, \hat{e}_y and \hat{e}_z are unit vectors in Cartesian-coordinate system)

- (a) Helical path; $t = 2/3$ s (b) Helical path; $t = 1$ s
(c) Circular path; $t = 1$ s (d) Circular path; $t = 2/3$ s

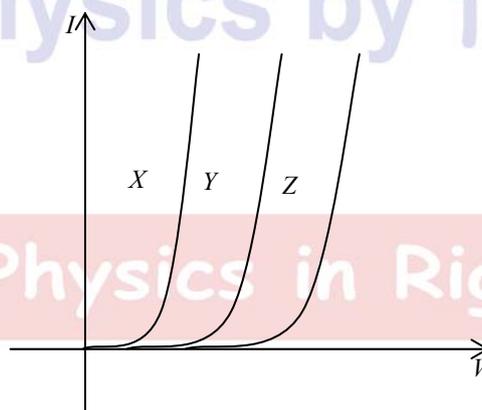
- Q17.** The fraction of volume unoccupied in the diamond cubic crystal is
 (a) $\frac{8 - \sqrt{3}\pi}{16}$ (b) $\frac{16 - \sqrt{3}\pi}{16}$ (c) $\frac{\sqrt{3}\pi}{16}$ (d) $\frac{16 - \sqrt{3}\pi}{8}$
- Q18.** Consider N non-interacting, distinguishable particles in a two-level system at temperature T . The energies of the levels are 0 and ε , where $\varepsilon > 0$. In the high temperature limit ($k_B T > \varepsilon$), what is the population of particles in the level with energy ε ?
 (a) $\frac{N}{2}$ (b) N (c) $\frac{N}{4}$ (d) $\frac{3N}{4}$
- Q19.** A 3×3 matrix has elements such that its trace is 11 and its determinant is 36. The eigenvalues of the matrix are all known to be positive integers. The largest eigenvalues of the matrix is
 (a) 18 (b) 12 (c) 9 (d) 6
- Q20.** A solid disc of mass m and radius a is rolling with a linear speed v on a flat surface without slipping. The magnitude of the angular momentum of the sphere on the surface is
 (a) $\frac{2}{3}mav$ (b) $\frac{3}{2}mav$ (c) mav (d) $\frac{1}{2}mav$
- Q21.** The value of refractive indices for ordinary and extraordinary rays n_o and n_e for calcite are 1.642 and 1.478 respectively; then phase retardation for $\lambda = 6000 \text{ \AA}$ with the plate thickness 0.04 mm will be
 (a) 68° (b) 68 rad (c) 54° (d) 54 rad
- Q22.** Two identical wires A and B each of length ' l ', carry the same current I . Wire A is bent into a circle of radius R and wire B is bent to form a square of side ' a '. If B_A and B_B are the values of magnetic field at the centers of the circle and square respectively, then the ratio $\frac{B_A}{B_B}$ is:
 (a) $\frac{\pi}{16\sqrt{2}}$ (b) $\frac{\pi^2}{16}$ (c) $\frac{\pi^2}{8\sqrt{2}}$ (d) $\frac{\pi^2}{8}$
- Q23.** Differential equation of a damped oscillator is $\frac{d^2x}{dt^2} + \gamma \frac{dx}{dt} + \omega_0^2 x = 0$. For a lightly damped oscillation quality factor Q , the change in frequency caused by the damping is approximately
 (a) $\frac{\omega_0}{4Q^2}$ (b) $\frac{\omega_0^2}{8Q^2}$ (c) $\frac{\omega_0}{8Q^2}$ (d) $\frac{\omega_0}{2Q}$

- Q24.** Across a first order phase transition, the free energy is
- proportional to the temperature
 - a discontinuous function of the temperature
 - a continuous function of the temperature but its first derivative is discontinuous
 - such that the first derivative with respect to temperature is continuous
- Q25.** A pendulum of length L and mass ' m ' is attached to a spring of spring constant k at height h from top as show in the figure. The time period of the pendulum is



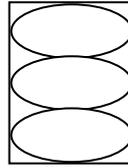
- $2\pi\sqrt{\frac{mL^2}{mgL + kh^2}}$
- $2\pi\sqrt{\frac{mgL + kh^2}{mL^2}}$
- $2\pi\sqrt{\frac{mL^2}{mgL + kh}}$
- $2\pi\sqrt{\frac{mL^2}{mgh + kL^2}}$

- Q26.** The I - V Characteristics of three types of diodes at the room temperature, made of semiconductors X , Y and Z are shown in the figure. Assume that the diodes are uniformly doped and identical in all respects except their materials. If E_{gX} , E_{gY} and E_{gZ} are the band gaps of X , Y and Z respectively, then

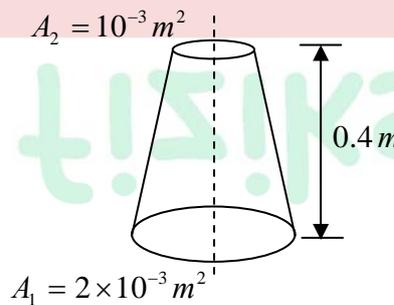


- $E_{gX} > E_{gY} > E_{gZ}$
- $E_{gX} = E_{gY} = E_{gZ}$
- $E_{gX} < E_{gY} < E_{gZ}$
- no relation among these band gaps exists

- Q27.** The Lissajous figure when two vibration at right angle to each other i.e. $x = \cos \omega_1 t$ and $y = \sin \omega_2 t$ superimpose is given as



- (a) $\omega_1 : \omega_2 = 3:1$ and $\phi = 0$ (b) $\omega_1 : \omega_2 = 1:3$ and $\phi = \pi/2$
 (c) $\omega_1 : \omega_2 = 3:2$ and $\phi = \pi/2$ (d) $\omega_1 : \omega_2 = 3:1$ and $\phi = \pi/2$
- Q28.** A particle of mass m is moving in $x - y$ plane. At any given time t , its position vector is given by $\vec{r}(t) = 3 \cos \omega t \hat{i} + 4 \sin \omega t \hat{j}$ where ω is a constant. If the angular momentum of the particle is
- (a) $9m\omega\hat{k}$ (b) $10m\omega\hat{k}$ (c) $11m\omega\hat{k}$ (d) $12m\omega\hat{k}$
- Q29.** A uniformly tapering vessel is filled with a liquid of 900 kg/m^3 . The net force acting on the base is



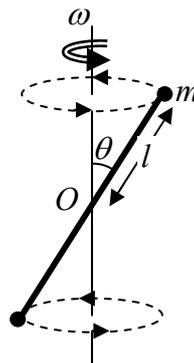
- (a) 4.2 (b) 7.2 (c) 8.2 (d) 10.2
- Q30.** A body of mass m strikes to another body at rest of mass $\frac{m}{9}$. Assuming the impact to be inelastic the fraction of the initial kinetic energy transformed into heat during the contact is
- (a) 0.1 (b) 0.2 (c) 0.5 (d) 0.64

Multiple Select Type Questions (MSQ)

Q31-Q40 Carry Two Marks each (No negative marking for any wrong answer)

- Q31.** A 150Ω resistor, a $10 \mu\text{F}$ capacitor and a 0.1 H inductor are connected in series to an a.c. source operating at an angular frequency ω . The a.c. source is operated at a peak voltage of $300\sqrt{2} \text{ V}$ and a frequency equal to half the resonance frequency of the circuit. Then which of the following statements are true.
- (a) The circuit is operating at 10^3 rad/s
 (b) The peak value of current in the circuit is 2 A
 (c) The phase difference between the current and voltage is 60°
 (d) The peak value of voltage across the inductor is 100 V

- Q32.** A two-state quantum system has energy eigenvalues $\pm \epsilon$ corresponding to the normalized states $|\psi_{\pm}\rangle$. At time $t=0$, the system is in quantum state $\frac{1}{\sqrt{2}}[|\psi_{+}\rangle + |\psi_{-}\rangle]$. Which of the following is correct .
- (a) Average value of energy $\langle E \rangle$ is 0
 (b) the probability to find energy ϵ and $-\epsilon$ not same
 (c) error in measurement of E is 0
 (d) The wave function after time $t = h/(6\epsilon)$ is $\psi = \frac{1}{\sqrt{2}}\left[|\psi_{+}\rangle e^{-\frac{i\pi}{3}} + |\psi_{-}\rangle e^{\frac{i\pi}{3}}\right]$
- Q33.** An object of mass m with non-zero angular momentum J is moving under the influence of gravitational force of a much larger mass (ignore drag). Which of the following statement(s) is (are) correct?
- (a) If the total energy of the system is negative, then the orbit is either circular or elliptical
 (b) The motion of m always occurs in a two-dimensional plane but angular momentum is not conserved
 (c) If the total energy of the system is 0, then the orbit is a parabola
 (d) If the area of the particle's bound orbit is S , then its time period is mS/J
- Q34.** In polarization, which of the parameter remains constant
- (a) frequency (b) wavelength (c) phase (d) intensity
- Q35.** An electric dipole with moment $\vec{P} = p_0 \hat{e}_z$ placed at the origin where p_0 is a constant of appropriate dimensions and \hat{e}_x, \hat{e}_y and \hat{e}_z are unit vectors in Cartesian coordinate system. Which of the following statements are true.
- (a) potential falls as $\frac{1}{r^2}$, where r is the distance from origin
 (b) a spherical surface centered at origin is an equipotential surface
 (c) electric flux through a spherical surface enclosing the origin is zero
 (d) radial component of \vec{E} is zero on the xy - plane.
- Q36.** A thin massless rod of length $2l$ has equal point masses m attached at its ends (see figure).
 The rod is rotating about an axis passing through its centre and making angle θ with it.
 Which one is correct?

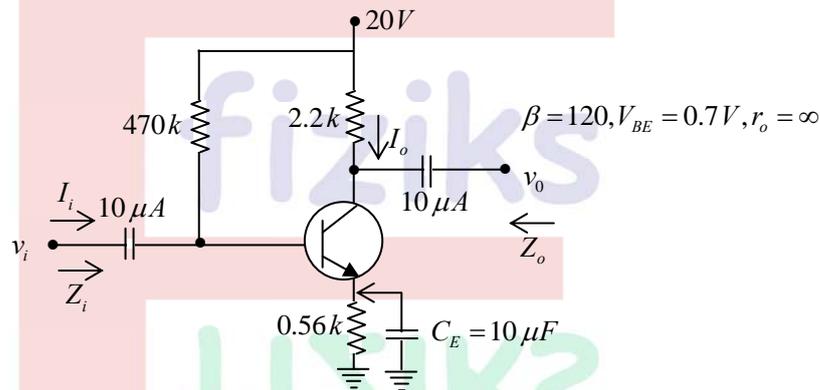


- (a) Moment of inertia about axis of rotation is $2ml^2$
- (b) Angular momentum about O is $2m\omega l^2 \sin \theta$
- (c) Torque on the system about O is $2m\omega^2 l^2 \cos \theta$
- (d) Torque on the system about O is $m\omega^2 l^2 \sin 2\theta$

Q37. Which of the following quantities is zero on an average for the molecules of an ideal gas in equilibrium?

- (a) any component of momentum
- (b) magnitude of momentum
- (c) x component of velocity
- (d) speed

Q38. For the network shown in figure, which of the following statements are true: (use $r_e = 6\Omega$)



- (a) Input impedance is $0.72k\Omega$
- (b) Output impedance is $2.2k\Omega$
- (c) Voltage gain is ≈ -367
- (d) Current gain is ≈ 120

Q39. Which of the following statements is true?

- (a) Six α -decay and four β^- -decay occurs before ${}^{232}_{90}\text{Th}$ achieves stability; the final product in the chain being ${}^{208}_{82}\text{Pb}$
- (b) A radioactive nucleus has a half life of 100 years. If the number of nuclei $t = 0$ is N_0 , then $\frac{7}{8}N_0$ number of nuclei have decayed in 300 years.
- (c) The atomic ratio between uranium isotopes ${}^{238}\text{U}$ and ${}^{234}\text{U}$ in a mineral sample is found to be 1.8×10^4 . Then the half life of ${}^{234}\text{U}$ and ${}^{238}\text{U}$ is 2.5×10^5 years and 4.5×10^9 years.
- (d) A radioactive sample containing N_0 nuclei emits N α -particle per second on decaying. The half life of the sample is $0.693 \frac{N}{N_0}$.

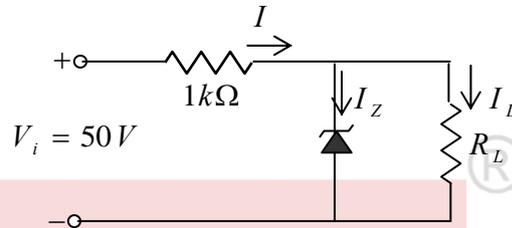
Q40. A Plane electromagnetic wave is travelling in free space along the positive z -direction. The maximum electric field along the x -direction is 100 V/m , then which of the following statements are true

- (a) The intensity of the wave is 0.132 W/m^2
- (b) The intensity of the wave is 13.2 W/m^2
- (c) The amplitude of magnetic induction B is $3.3 \times 10^{-8} \text{ tesla}$
- (d) The amplitude of magnetic induction B is $3.3 \times 10^{-7} \text{ tesla}$

Numerical Answer Type Questions (NAT)

Q41-Q50 Carry One Mark each (No negative marking for any wrong answer).

Q41. For the given zener diode network, the maximum value of load resistance R_L that will maintain output voltage to $15V$ is _____ Ω ($V_Z = 15V, I_{ZM} = 32mA$)



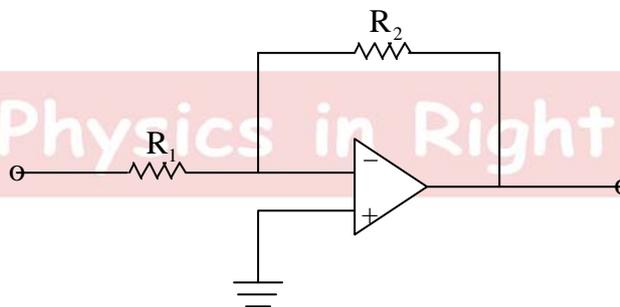
Q42. X -ray of energy $50keV$ strikes an electron initially at rest. The change in wavelength of the X -ray scattered at angle 90° is, approximately _____ $\times 10^{-12}$ meter.
(Given, $h = 6.63 \times 10^{-34} J-s, m = 9.11 \times 10^{-31} kg$)

Q43. The degenerate eigenvalue of the matrix $\begin{bmatrix} 4 & -1 & -1 \\ -1 & 4 & -1 \\ -1 & -1 & 4 \end{bmatrix}$ is (your answer should be an integer) _____

Q44. A particle of mass m is moving along the positive x direction under a potential $V(x) = \frac{1}{2}x^2 + \frac{1}{2x^2}$. The value of mechanical energy at stable equilibrium point is _____

Q45. The number of 5th nearest neighbours in face centred cubic lattice are _____

Q46. In an inverting operational amplifier the resistance R_1 and R_2 is $20k\Omega$ and $200k\Omega$ respectively. Then the voltage gain in dB is _____



Q47. If ${}_{92}U^{235}$ captures a thermal neutron and releases $160MeV$ and if the resulting fission fragments have mass numbers 138 and 95, the kinetic energy of the lighter fragment is _____ MeV

Q48. The total power emitted by a spherical black body of radius R at a temperature T is P_1 . Let P_2 be the total power emitted by another spherical black body of radius $\frac{R}{2}$ kept at temperature $2T$. The ratio, $\frac{P_1}{P_2}$ is _____. (Give your answer upto two decimal places)

Q49. If the material has $\mu_0 = 1.556$ and $\mu_E = 1.544$ at a wavelength of 6000 \AA , then the minimum thickness of a quarter wave plate is _____ cm .

Q50. Let θ be a variable in the range $-\pi \leq \theta < \pi$. Now consider a function

$$\psi(\theta) = \begin{cases} 1 & \text{for } -\frac{\pi}{2} \leq \theta < \frac{\pi}{2} \\ 0 & \text{otherwise} \end{cases}$$

if its Fourier-series is written as $\psi(\theta) = \sum_{m=-\infty}^{\infty} C_m e^{-im\theta}$, then the value of $|C_3|^2$ (rounded off to three decimal places) is _____

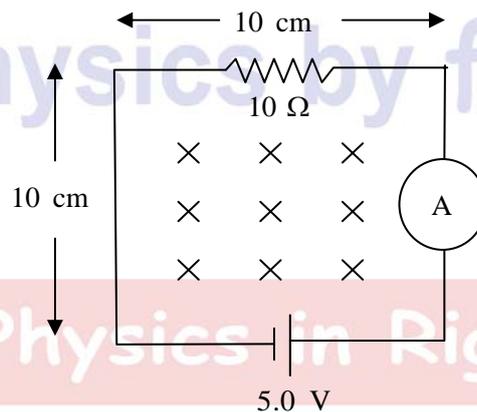
Numerical Answer Type Questions (NAT)

Q51-Q60 Carry Two Mark each (No negative marking for any wrong answer).

Q51. The circuit shown below is in a uniform magnetic field that is into the page and is decreasing in magnitude at the rate of 150 Tesla/sec .

The ammeter reads _____ Ampere.

(write upto two decimal point)



Q52. A particle of rest mass M is moving along the positive x -direction. It decays into two photons γ_1 and γ_2 as shown in the figure. The energy of γ_1 is 1 GeV and the energy of γ_2 is 0.82 GeV . The value of M (in units of $\frac{\text{GeV}}{c^2}$) is _____. (Give your answer upto two decimal places)

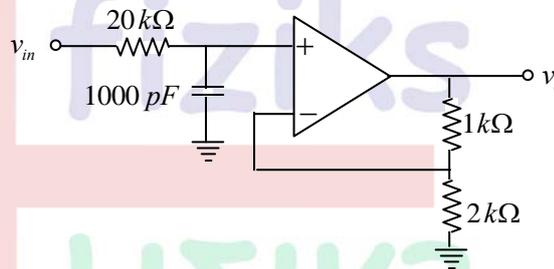
Q53. An engine (A) moving with speed 120 km/hr blow risen of frequency 450 Hz . Another engine (B) moving toward is speed 75 km/hr . The frequency of sound observes by observer sitting on engine (A) after it reflect back from engine (B) is _____ Hz (assume velocity of sound is 320 m/s).

Q54. Given

$$\frac{d^2 f(x)}{dx^2} - 2 \frac{df(x)}{dx} + f(x) = 0,$$

and boundary conditions $f(0) = 1$ and $f(1) = 0$, the value of $f(0.5)$ is _____ (up to two decimal places).

Q55. For the given circuit the frequency above which the gain will decrease by 20 dB per decade is _____ kHz (Answer must be a nearest integer)



Q56. At temperature T Kelvin (K), the value of the Fermi function at an energy 0.5 eV above the Fermi energy is 0.01 . Then T , to the nearest integer, is _____ ($k_B = 8.62 \times 10^{-5}\text{ eV/K}$)

Q57. A particle of mass m is moving in a potential $V(x) = \frac{1}{2} m \omega_0^2 x^2 + \frac{a}{2mx^2}$ where ω_0 and a are positive constants. The angular frequency of small oscillations for the simple harmonic motion of the particle about a stable minimum of the potential $V(x)$ is $\alpha \omega_0$ then the value of α is _____

Q58. A radioactive sample contains 1.00 g of radim ^{226}Ra , whose half life is 1622 years. Then the activity of the radon sample is _____ Curie

Q59. Monochromatic X - rays of wavelength 1.54 \AA are incident on a sample of copper crystal (FCC). The lattice constant of Cu is 3.6 \AA . The first XRD peak will appear at angle _____ degree (Answer up to two decimal places)

Q60. An air-conditioner maintains the room temperature at 27°C while the outside temperature is 47°C . The heat conducted through the walls of the room from outside to inside due to temperature difference is 7000 W . The minimum work done by the compressor of the air-conditioner per unit time is _____ W .