## HCU (M.Sc.) PAPER 2017

## SECTION - A

**Q1.** The period of the function $f(t)=\cos\left(\frac{t}{3}\right)+\cos\left(\frac{t}{4}\right)$ is

(a) $6\pi$ (b) $8\pi$ (c) $2\pi$ (d) $24\pi$

**Q2.** The eigenvalues of the matrix $A=\begin{bmatrix}\cos\theta & -\sin\theta\\ \sin\theta & \cos\theta\end{bmatrix}$ are

(a) $e^{\pm i\theta}$ (b) $e^{\pm 2i\theta}$ (c) $e^{\pm 3i\theta}$ (d) $e^{\pm i\theta/2}$

**Q3.** The value of $\sin i$ is

(a) $e$ (b) $\frac{1}{2}i\left(e^{-1}-e\right)$ (c) $\frac{1}{2i}\left(e+e^{-1}\right)$ (d) $\frac{1}{2}i\left(e-e^{-1}\right)$

**Q4.** The value of the integral $\int_{-\infty}^{\infty} x^3 e^{-\alpha x^2}dx$ is equal to

(a) $\left(\frac{\pi}{\alpha}\right)^{1/2}$ (b) $\left(\frac{\pi}{\alpha}\right)^{3/2}$ (c) 0 (d) $\infty$

**Q5.** A rocket of proper length $40\,m$ is observed to be $32\,m$ long as it passes an observer. The rocket's speed relative to the observer is

(a) $0.2c$ (b) $0.4c$ (c) $0.6c$ (d) $0.8c$

**Q6.** A particle is moved from a point $(0, 1, 2)$ to $(1, 0, 1)$ by a constant force given by $6\hat{i}-2\hat{j}+3\hat{k}$ where $\hat{i},\hat{j},\hat{k}$ are orthogonal unit vectors. The work done by this force is

(a) 5 units (b) 0 units (c) 4 units (d) 9 units

**Q7.** A particle moves in a plane elliptical orbit described by the positive vector $\vec{r}=\hat{i}\,2b\sin\omega t+\hat{j}b\cos\omega t$. The angle between the velocity and acceleration at time $t=\pi/2\omega$ is

(a) $30°$ (b) $45°$ (c) $60°$ (d) $90°$

**Q8.** A spherically symmetric mass distribution of radius $R$ is described by the density:

$$\rho(r,\theta,\phi)=\begin{cases}\dfrac{\rho_0}{2\pi r}, & r\le R\\ 0\ , & r>R\end{cases}$$

The gravitational potential $\Phi$ due to this mass distribution at a distance $r(r>R)$ from the centre of the spherical mass is given by

(a) $G\rho_0R^2/2r$ (b) $G\rho_0R^2/r$ (c) $\pi G\rho_0R^2/r$ (d) 0

**Q9.** Waves in deep water travel with a phase velocity given by $v_p^2=g/k$, where $g$ is the acceleration due to gravity and $k=2\pi/\lambda$ is the wave number. The group velocity of the waves is

(a) $\frac{1}{2}v_p$ (b) $v_p$ (c) $v_p^2$ (d) $\frac{v_p}{3}$

**Q10.** The intensities of two sound waves are $0.4W/m^2$ and $10W/m^2$, respectively. One of them is louder than the other (in decibels –dB) by

(a) 10 dB (b) 1.4 dB (c) 140 dB (d) 14 dB

**Q11.** The lattice specific heat of a metal at low temperature is proportional to

(a) $T$ (b) $T^2$ (c) $T^3$ (d) $T^4$

**Q12.** Which of the following equations is not true in general?

(a) $dU=\left(\frac{\partial U}{\partial T}\right)_V dT+\left(\frac{\partial U}{\partial V}\right)_T dV$ (b) $C_p-C_V=\left[\left(\frac{\partial U}{\partial V}\right)_T+p\right]\left(\frac{\partial V}{\partial T}\right)_p$

(c) $dU=C_VdT$ (d) $C_V=\left(\frac{\partial U}{\partial T}\right)_V$

**Q13.** For a gas at constant temperature and pressure, equilibrium corresponds to

(a) Maximum Gibbs free energy (b) Maximum Helmholtz energy

(c) Maximum enthalpy (d) Maximum internal energy

**Q14.** In the Michelson interferometer, the bands in the interference pattern can be shifted by displacing the mirror. If the wavelength of light used in the experiment is $546\,nm$, for shifting 100 bands in the interference pattern, the mirror is to be displaced by a distance of

(a) $54.6\,\mu m$ (b) $27.3\,\mu m$ (c) $546\,nm$ (d) $273\,nm$

**Q15.** The refractive index of diamond is 2.47 and that of window glass is 1.51. Which of the following statements is then correct?

(a) Light travels faster in window glass by $7.72\times 10^{7}\ ms^{-1}$.

(b) Light travels faster in diamond by $7.72\times 10^{7}\ ms^{-1}$.

(c) Light travels with same speed in window glass and diamond.

(d) Light does not travel in diamond.

**Q16.** Dispersion of electromagnetic waves

(a) Results from the fact that waves of different frequencies travel at different speeds in a medium.

(b) Refers to the phenomenon wherein a ray travels from one medium to another.

(c) Refers to the scattering of waves by particles dispersed in a medium.

(d) Accounts for the fact that the sky is blue.

**Q17.** Using Abbe's diffraction limit, the limit of resolution of a microscope $d$ is related to the numerical aperture $(NA)$ of the objective lens as

(a) $d=\frac{NA}{\lambda}$ (b) $d=\frac{\lambda}{NA}$ (c) $d=\frac{\lambda}{2NA}$ (d) $d=\frac{2NA}{\lambda}$

**Q18.** The electric potential $V$ in a region is given by $V=2x+3y-z$. The electric field strength is then given by

(a) $2\hat{i}+3\hat{j}+\hat{k}$ (b) $2\hat{i}+3\hat{j}-\hat{k}$. (c) $-2\hat{i}-3\hat{j}+\hat{k}$. (d) $-2\hat{i}-3\hat{j}-\hat{k}$.

**Q19.** A point charge of $6.0\,nC$ is located at the centre of a cube, each side of which is $2\,m$ long. The electric flux passing through each of the cube is equal to

(a) $113\frac{N\cdot m^2}{C}$ (b) $1.13\frac{N\cdot m^2}{C}$ (c) $11.3\frac{N\cdot m^2}{C}$ (d) $0.113\frac{N\cdot m^2}{C}$

**Q20.** Two hollow charged spheres of radii $R_1$ and $R_2$ have equal surface charge density. If the potentials of the charged spheres on their surfaces are $V_1$ and $V_2$, respectively, then $V_1/V_2$ is equal to

(a) $\frac{R_2}{R_1}$ (b) $\left(\frac{R_2}{R_1}\right)^2$ (c) $\left(\frac{R_1}{R_2}\right)^2$ (d) $\left(\frac{R_1}{R_2}\right)$

**Q21.** In a uniform magnetic field, the net magnetic force on a current loop is

(a) Zero (b) Infinite

(c) Attractive and finite (d) Repulsive and finite

**Q22.** Which of the following statements is correct?

(a) BJT is a voltage controlled device and FET is a current controlled device.

(b) BJT is a current controlled device and FET is a voltage controlled device.

(c) Both BJT and FET are voltage controlled devices.

(d) Both BJT and FET are current controlled devices.

**Q23.** In a series LCR circuit, the voltage across the resistor leads the applied voltage by $45°$. Then which of the following statement is correct?

(a) Capacitive reactance is equal to the inductive reactance.

(b) Capacitive reactance is greater than the inductive reactance.

(c) Capacitive reactance is less than the inductive reactance.

(d) The total reactance is greater than the value of pure resistance.

**Q24.** In quantum mechanics, the infinite square well potential can be considered to represent a system with

(a) All unbound states (b) All bound states

(c) Both bound and unbound states (d) Neither bound nor unbound states

**Q25.** If two operators commute, then

(a) Their eigenvalues cannot be measured.

(b) They have the same eigenvalue.

(c) They can have the same eigenfunction.

(d) They are not quantum mechanical operators.

## SECTION -B

**Q26.** The value of the integral $\int_0^1 \frac{dx}{\sqrt{(-\ln x)}}$ is

(a) $\pi$ (b) 0 (c) $\sqrt{\pi}$ (d) $\infty$

**Q27.** For what value of $\alpha$ will the following matrix be orthogonal?

$$\begin{pmatrix} 1 & 0 & 0 \\ 0 & \alpha & -\alpha \\ 0 & \alpha & \alpha \end{pmatrix}$$

(a) $\sqrt{2}$ (b) 1 (c) $1/\sqrt{2}$ (d) $-\sqrt{2}$

**Q28.** The eigenvectors of the matrix $A = \begin{bmatrix} 2 & -1 \\ -1 & 2 \end{bmatrix}$ are

(a) $a_1 = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$, $a_2 = \begin{bmatrix} -1 \\ 0 \end{bmatrix}$ (b) $a_1 = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$, $a_2 = \begin{bmatrix} 1 \\ -1 \end{bmatrix}$

(c) $a_1 = \begin{bmatrix} 2 \\ 0 \end{bmatrix}$, $a_2 = \begin{bmatrix} 0 \\ 2 \end{bmatrix}$ (d) $a_1 = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$, $a_2 = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$

**Q29.** If $\vec{V} = \vec{\nabla} \times \vec{A}$ and given that $\vec{V} = -\hat{k}$, then the vector $\vec{A}$ will be given by

(a) $-\hat{i} - y\hat{j} + \hat{k}$ (b) $\hat{i} + \hat{j} - \hat{k}$ (c) $5\hat{i} + \hat{j} - 2\hat{k}$ (d) $-y\hat{i} + \hat{j} + 5\hat{k}$

**Q30.** The value of the surface integral $\int_S (\vec{\nabla} \times \vec{A}) \cdot d\vec{S}$, where $\vec{A} = \hat{i}y + \hat{j}z + \hat{k}$ and $S$ is the surface defined by the paraboloid $z = 1 - x^2 - y^2$, with $z \geq 0$, is given by

(a) $0; \frac{\sigma R^2}{\varepsilon_0 r^2}$ (b) $\pi$ (c) 1 (d) $-1$

**Q31.** For $\lambda > 0$ and $\lambda \in R$, what are the eigenfunctions of the following differential equation $y'' + \lambda y = 0$, for the boundary conditions $y(0) = 0$, $y'(\pi) = 0$?

(a) $C_1 \cos\left(\frac{2n-1}{2}x\right)$ (b) $C_2 \sin\left(\frac{2n-1}{2}x\right)$

(c) $C_1 \cos(nx) + C_2 \sin(nx)$ (d) $C_1 \cos(2n-1)x + C_2 \sin(2n-1)x$

**Q32.** The Fourier series of the function $F(t)=\begin{cases}-1 & -\pi/\omega<t<0\\ +1 & 0<t<\pi/\omega\end{cases}$

in the interval $-\pi/\omega<t<\pi/\omega$ can be written as

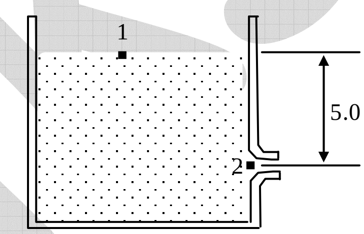
(a) $\frac{4}{\pi}\sum_{n=1}^{\infty}\frac{\sin(n\omega t)}{n}$ (b) $\frac{4}{\pi}\sum_{n=1}^{\infty}\frac{\cos(n\omega t)}{n}$

(c) $\frac{4}{\pi}\sum_{n=1}^{\infty}\frac{\sin(n\omega t)}{n}+\frac{4}{\pi}\sum_{n=1}^{\infty}\frac{\cos(n\omega t)}{n}$ (d) $\frac{4}{\pi}\sum_{n=1,3,5,\cdots}^{\infty}\frac{\sin(n\omega t)}{n}$

**Q33.** Consider a capillary tube of radius $r$ introduced in a liquid of density $\rho$ and surface tension $T$. The height $h$ of the liquid column in the capillary tube is given by

(a) $h=\frac{2T}{r\rho g}$ (b) $h=\frac{T}{r\rho g}$ (c) $h=\frac{T}{2r\rho g}$ (d) $h=\frac{4T}{r\rho g}$

**Q34.** How much volume of water will escape per minute from an open-top tank through an opening that is $3.0\,cm$ in diameter and $5.0\,m$ below the water level in the tank?




(a) $4.2\,m^3/\text{min}$ (b) $0.42\,m^3/\text{min}$

(c) $42.0\,m^3/\text{min}$ (d) $0.042\,m^3/\text{min}$

**Q35.** A block of mass $m$ tied to a string of length $l$ hangs from the ceiling of a room such that the mass moves in a circle of radius $r$ and the string makes an angle $\theta$ with the vertical. The period of circular motion of the mass is given by

(a) $2\pi\sqrt{\frac{l}{g}}$ (b) $2\pi\sqrt{\frac{l\cos\theta}{g}}$ (c) $2\pi\sqrt{\frac{l}{g\cos\theta}}$ (d) $2\pi\sqrt{\frac{l\sin\theta}{g}}$

**Q36.** A particle at rest is attracted towards the centre of force according to the relation $F=-mk^2/x^3$. The time required for the particle to reach the centre of force from a distance $d$ is given by

(a) $\frac{d^2}{k}$ (b) $\frac{d^2}{2k}$ (c) $\frac{2d^2}{k}$ (4) $\infty$

**Q37.** In plane polar coordinates, which of the following relations are true?

(a) $\frac{d\hat{r}}{d\theta}=\hat{\theta},\ \frac{d\hat{\theta}}{d\theta}=-\hat{r}$

(b) $\frac{d\hat{r}}{d\theta}=-\hat{\theta},\ \frac{d\hat{\theta}}{d\theta}=\hat{r}$

(c) $\frac{d\hat{r}}{d\theta}=\hat{r},\ \frac{d\hat{\theta}}{d\theta}=-\hat{\theta}$

(d) $\frac{d\hat{r}}{d\theta}=-\hat{r},\ \frac{d\hat{\theta}}{d\theta}=\hat{\theta}$

**Q38.** A particle of mass $m$ moves in an orbit under the influence of an attractive Coulomb force. The angular momentum of the particle is given by the constant $L$. The a real velocity of the particle is given by

(a) $\frac{L}{2m}$ (b) $\frac{2L}{m}$ (c) $\frac{L}{4m}$ (d) $\frac{2L}{3m}$.

**Q39.** A uniform solid sphere of mass $M$ and radius $R$ is fixed at a distance $h$ above a thin infinite sheet of mass density $\rho$. With what force does the sphere attract the sheet?

(a) $\frac{2\pi\rho GMR}{h}$ (b) $\frac{4\pi\rho GMR}{h}$ (c) $2\pi\rho GM$ (d) $4\pi\rho GM$

**Q40.** Energy eigenvalues of a two-state system, which is in thermal equilibrium with a heat bath at temperature $T$ are given by $E_1$ and $E_2$ (such that $E_2 > E_1 > 0$). What is the average energy of the system for $T \to 0$?

(a) $\frac{E_2 - E_1}{2}$ (b) $E_2$ (c) $\frac{E_1 + E_2}{2}$ (d) $E_1$

**Q41.** Consider a gas which obeys the Maxwell-Boltzman velocity distribution law. The most probable speed of a gas molecule is then given by

(a) $\sqrt{\frac{k_B T}{m}}$ (b) $\sqrt{\frac{k_B T}{2m}}$ (c) $\sqrt{\frac{2k_B T}{3m}}$ (d) $\sqrt{\frac{2k_B T}{m}}$

**Q42.** A possible ideal-gas cycle operates as follows:

(i) from an initial state $(P_1, V_1)$ the gas is cooled at constant pressure to $(P_1, V_2)$

(ii) the gas is heated at constant volume to $(P_2, V_2)$

(iii) the gas expands adiabatically back to $(P_1, V_1)$

The thermal efficiency of the engine is given by

(a) $1-\gamma\dfrac{(V_1/V_2)-1}{(P_2/P_1)-1}$ (b) $1+\gamma\dfrac{(V_1/V_2)-1}{(P_2/P_1)-1}$

(c) $(n_0'+n_e')/(n_0''+n_e'')$ (d) $\gamma\dfrac{(V_1/V_2)}{(P_2/P_1)-1}$.

where $\gamma\dfrac{C_P}{C_V}$.

**Q43.** An isolated system has $N$ non-interacting particles. If each particle can exist in three states, the entropy of the system according to Boltzmann's prescription is given by

(a) $Nk_B\ln 2$ (b) $Nk_B\ln 3$ (c) $k_B\ln(3N)$ (d) $3k_B\ln(N)$.

**Q44.** Two identical sound sources $A$ and $B$ are kept $1m$ apart under water and emit sound waves of frequency $3500\,Hz$ and are in phase with each other. A microphone is placed on a line parallel to $AB$ at a distance of $1km$ from $AB$. At what distance should the microphone be positioned to capture the maximum sound intensity?

(a) $466\,m$ and $1664\,m$ (b) $466\,m$ (c) $1664\,m$ (d) $1065\,m$

(Speed of sound in water $=1550\,m/s$)

**Q45.** Consider the superposition of two waves given by $y_1 = A\sin(kx-\omega t)$ and $y_2 = 3A\sin(kx+\omega t)$. The amplitudes of the resultant standing wave and traveling wave, respectively, are

(a) $4A$, 0 (b) $A$, $3A$ (c) 0, $4A$ (d) $2A$, $2A$

**Q46.** A whistle of frequency $540\,Hz$ rotates in a horizontal circle of radius $2\,m$ at an angular speed of $15.0\,rad/s$. The maximum and minimum frequencies heard by a listener, standing a long distance away at rest from the centre of the circle are respectively

(a) $594\,Hz$ and $495\,Hz$. (b) $540\,Hz$ and $540\,Hz$.

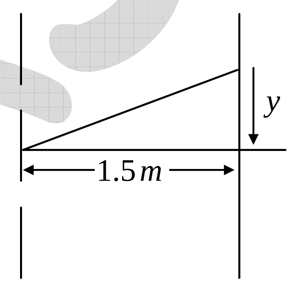
(c) $565.7\,Hz$ and $516.5\,Hz$. (d) $500\,Hz$ and $450\,Hz$.

(Speed of sound $= 330\,m/s$)

**Q47.** An open organ pipe is closed suddenly. As a result, the frequency of the second overtone of the closed pipe becomes higher by 100 vibrations/sec than that of the first overtone of the original pipe. The fundamental frequency of the open pipe is

(a) $100\,Hz$. (b) $200\,Hz$. (c) $250\,Hz$. (d) $150\,Hz$.

**Q48.** Monochromatic light of wavelength $600\,nm$ is incident on two slits of spacing $0.15\,mm$ and the resulting intensity pattern is observed on a screen $1.5\,m$ away. The location $(y)$ of the first maximum is at




(a) $6\,mm$ (b) $12\,mm$ (c) $3\,mm$ (d) $1.5\,mm$

**Q49.** Consider Newton's rings experiment in transmission observed using $589\,nm$ wavelength light. The space between the glass plate and Plano-convex lens of radius of curvature $10\,m$ is filled with a liquid. If the radius of the third bright ring is $3.65\,mm$, the refractive index of the liquid is

(a) 1.52 (b) 1.01 (c) 1.33 (d) 2.11

**Q50.** Consider a beam of light from a discharge tube falling onto a diffraction grating at normal incidence. If the maxima of spectral lines of wavelength $\lambda_1 = 6563\text{Å}$ and $\lambda_2 = 4102\text{Å}$ coincide in the direction $\theta = 41°$, the diffraction grating constant is

(a) $5\times10^{-6}\,m$ (b) $5\times10^{-9}\,m$ (c) $5\times10^{-3}\,m$ (d) $1\times10^{-6}\,m$

**Q51.** In photographing the Sun's spectrum, it was found that the yellow spectral line $\left(\lambda = 5890\text{Å}\right)$ in the spectra obtained from the left and right edges of the sun is displaced by $0.08\text{Å}$. The linear velocity of rotation of the solar disk is

(a) $0.3\times10^{-3}\, m/s$ (b) $3\times10^{8}\, m/s$ (c) $2\, m/s$ (d) $2\times10^{3}\, m/s$

**Q52.** A beam of light passing through a calcite quarter wave plate and a quartz quarter wave plate placed after it suffers a phase shift. The ratio of the thickness of the two plates in terms of their respective refractive indices is

(a) $\left(n_0' - n_e'\right)/\left(n_0'' - n_e''\right)$ (b) $n_0/n_e$

(c) $\left(n_0' + n_e'\right)/\left(n_0'' + n_e''\right)$ (d) $\left(n_0' - n_0''\right)/\left(n_e' - n_e''\right)$

**Q53.** Consider an object placed at a fixed distance $D$ from a screen. Real images are formed on the screen for two positions of a lens, separated by a distance $d$. The ratio between the sizes of the two images is given by

(a) $D^2/d^2$ (b) $\dfrac{\left(D-d\right)^2}{\left(D+d\right)^2}$ (c) $d^2/D^2$ (d) $\left(D-d\right)^2/D$

**Q54.** A parallel plate capacitor of plate area $0.2\, m^2$ and plate spacing of $1 cm$ is charged to $1000 V$ and is then disconnected from the battery. The plates are pulled apart to twice the initial plate spacing. The work required in this process is

(a) $17.7\times10^{-5}\, J$ (b) $8.85\times10^{-5}\, J$ (c) $5.9\times10^{-5}\, J$ (d) $4.43\times10^{-5}\, J$

**Q55.** If $R$ is the radius of a thin spherical shell and $\sigma$ is the surface charge density of the shell, then the values of the electric field at a distance $r$ from the centre of the shell for $r < R$ and $r > R$ are given respectively by

(a) $\dfrac{r^2\sigma}{\varepsilon_0 R^2}$; 0 (b) $\dfrac{R^2\sigma}{\varepsilon_0 r^2}$; 0 (c) 0; $\dfrac{\sigma R^2}{\varepsilon_0 r^2}$ (d) $\dfrac{R^2\sigma}{\varepsilon_0 r^2}$ everywhere.

**Q56.** Which of the following statements is true?

(a) An electrostatic field is irrotational.

(b) An electrostatic field is solenoidal.

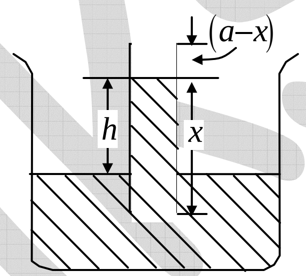
(c) An electrostatic field has to be both irrotational and solenoidal.

(d) An electrostatic field is neither irrotational nor solenoidal.

**Q57.** An electric dipole with $P_1 = \hat{z}P_1$ is located at the origin of a Cartesian coordinate system. A second dipole of dipole moment $P_2 = \hat{z}P_2$ is located on the $+z$ axis at a distance $r$ from the origin. What is the force between the two dipoles?

(a) $-\frac{P_1P_2}{\varepsilon_0 r^3}$ (b) $-\frac{3P_1P_2}{2\pi\varepsilon_0 r^4}$ (c) $-\frac{2P_1P_2}{\pi\varepsilon_0 r^4}$ (d) $\frac{P_1P_2}{2\pi\varepsilon_0 r^2}$

**Q58.** A capacitor consisting of two plane parallel plates separated by a distance $d$ is immersed vertically in a dielectric fluid of dielectric constant $K$ and density $\rho$. Let $b$ be the width and $a$ be the length of the plates and $x$ be the height of the fluid in the capacitor. Then the capacitance of the capacitor in (Gaussian units) is




(a) $\frac{b}{4\pi d}\left[(K-1)x+a\right]$.

(b) $\frac{b}{4\pi d}\left[Kx+(a-1)\right]$.

(c) $\frac{b}{4\pi d}\left[Ka+(1-x)a\right]$.

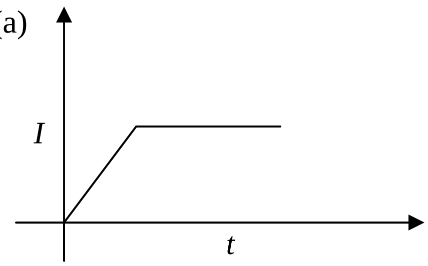
(d) $\frac{b}{4\pi d}\left[(K-a)x+ax\right]$.

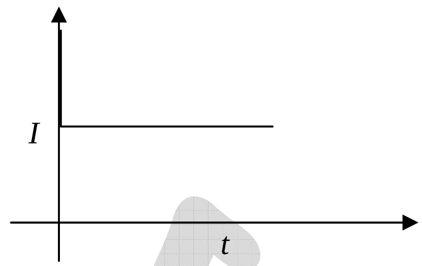
**Q59.** A circular loop of wire of radius $R$ lies in the $xy-$plane with its centre at the origin. The loop carries a steady current $I$ in the clockwise direction. The magnetic field at any point on the $z-$axis in the free space is of the form $\vec{B}=(0,\ 0,\ z)=B(z)\hat{k}$, where $\hat{k}$ is the unit vector in the $z-$direction. Then which equation does $B(z)$ satisfy?

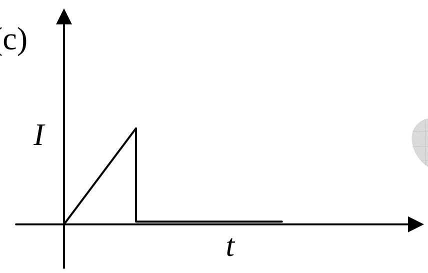
(a) $B(z)=-B(-z)$ (b) $\int_0^R dzB(z)=\mu_0 I$

(c) $\int_{-\infty}^{\infty} dzB(z)=\infty$ (d) $\int_{-\infty}^{\infty} dzB(z)=\mu_0 I$

**Q60.** A magnet, initially stationary, is pushed closer to a loop and then stopped. Which of the following graphs closely represent the variation of the current $I$ in the galvanometer detecting the current as a function of time $t$?

(a)



(b)



(c)
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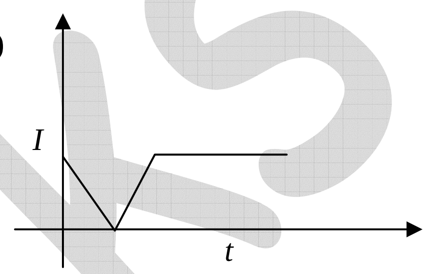



**Q61.** Which of the following statements is TRUE?

(a) Electrical forces do no work.
(b) Magnetic forces do no work.
(c) Mechanical forces do no work.
(d) Gravitational forces do no work.

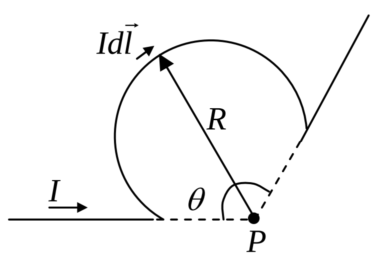
**Q62.** A segment of wire is bent into an arc of radius $R$ and it subtends an angle $\theta$ as shown in the figure. Point $P$ is the centre of the circular segment. The wire carries current $I$. The magnitude of the magnetic field at $P$ is given by

(a) $\frac{\mu_0 I}{2\theta R}$.

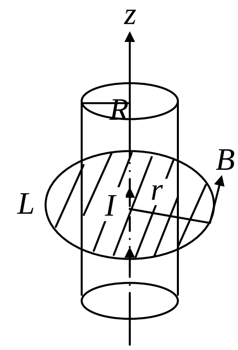
(b) $\frac{\mu_0 I\theta}{(2\pi)^2 R}$.

(c) $\frac{\mu_0 I\theta}{4\pi R}$.

(d) $\frac{\mu_0 I\theta}{4\pi R^2}$.



**Q63.** A cylindrical wire of permeability $\mu$ carries a steady current $I$. If the radius of the wire is $R$, what is the value of the magnetic field $B$ inside the wire?



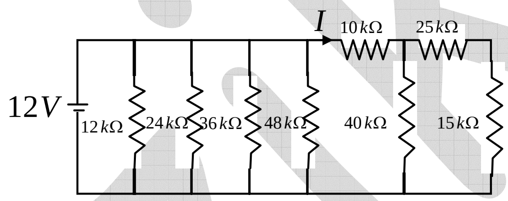

(a) $\frac{\mu_0 I}{4\pi r}\hat{e}_\theta$ (b) $\frac{\mu_0 I}{r}\hat{e}_\theta$

(c) $\frac{\mu_0 I}{2\pi r}\hat{e}_\theta$ (d) $\frac{\mu_0 I}{2r}\hat{e}_\theta$

**Q64.** Consider an $L-R$ circuit with $L = 30\,mH$, $R = 10\Omega$ and $V = 12V$. What is the current at $t = 0.001s$?

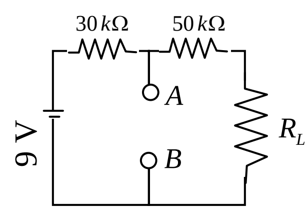
(a) $0.82\,A$ (b) $0.12\,A$ (c) $0.34\,A$ (d) $0.40\,A$

**Q65.** Consider the circuit shown below. What is the current $I$ that is flowing through the $10\,k\Omega$ resistor?




(a) $1.2\,mA$ (b) $1.0\,mA$ (c) $0.4\,mA$ (d) $0.24\,mA$

**Q66.** The Thevenin's voltage (VTH) across the open terminals $A$ shown is $6V$. The Thevenin's resistance (RTH) across the open terminals $A$ and $B$ is



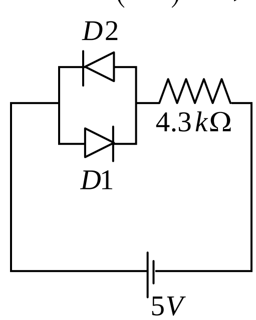

(a) $20\,k\Omega$.

(b) $10\,k\Omega$.

(c) $90\,k\Omega$.

(d) $18.75\,k\Omega$.

**Q67.** Diodes $D1$ and $D2$ shown in the circuit are practical silicon diodes. The voltage drop across the diode $D2$ and the power dissipated by this diode $(D2)$ are, respectively,



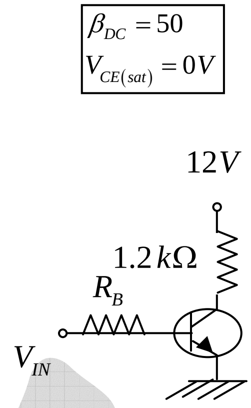

(a) $V_{D2} = 0.72V$ and $P_{D2} = 0W$.

(b) $V_{D2} = 5.0\,V$ and $P_{D2} = 0W$.

(c) $V_{D2} = 0.7V$ and $P_{D2} = 0.7\,mW$.

(d) $V_{D2} = 5.0\,V$ and $P_{D2} = 5W$.

**Q68.** The minimum value of base current $(I_B)$ required to saturate the transistor shown in the figure below is




(a) $0.2\,mA$.

(b) $10\,mA$.

(c) $1.2\,mA$.

(d) $0.12\,mA$.

**Q69.** Commutator of two Hermitian operators is always

(a) Hermitian (b) Anti-Hermitian.

(c) Unitary (d) Anti-Unitary.

**Q70.** A charged harmonic oscillator of mass $m$, charge $e$ and frequency $\omega$ is placed in an electric field $E$. The ground state energy of the oscillator changes due to the electric field by an amount.

(a) $\frac{e^2E^2}{4m\omega^2}$ (b) $\frac{e^2E^2}{2m\omega^2}$ (c) $\frac{2e^2E^2}{3m\omega^2}$ (d) $\frac{e^2E^2}{m\omega^2}$

**Q71.** The uncertainty product for the ground state of a simple harmonic oscillator is

(a) equal to $\hbar$ (b) equal to $\frac{\hbar}{2}$ (c) greater than $\frac{\hbar}{2}$ (d) less than $\frac{\hbar}{2}$

**Q72.** Which of the following statements is wrong?

(a) The eigenfunctions of a Hermitian operator belonging to different eigenvalues are orthogonal.

(b) The eigenfunctions of a Hermitian operator form a complete set of states.

(c) The Hamiltonian of a simple harmonic oscillator is Hermitian.

(d) The eigenvalues of a Hermitian operator are always positive integers.

**Q73.** A particle moves in a one-dimensional box of length $2\,nm$. It is given that the energy difference between the second and third excited states is $E$. The length of the box is now doubled. Then which of the following statements is true?

(a) $E$ increases by $4$ times (b) $E$ increases by $16$ times

(c) $E$ decreases by $4$ times (d) $E$ decreases by $8$ times

**Q74.** The energy radiated by a hydrogen atom as a result of a transition from $n=2$ to $n=1$ state is $E$. If the magnitude of the charges of the proton and electron are doubled, the energy radiated as a result of the same transition will be

(a) $2E$ (b) $4E$ (c) $8E$ (d) $16E$

**Q75.** Crystals exhibit Bragg's diffraction of visible light if the lattice constant of the crystals is of the order of

(a) $1\,nm$ (b) $50\,nm$ (c) $250\,nm$ (d) $500\,nm$