Ap

QP CODE 210142

PILLAI COLLEGE OF ENGINEERING

Subject: Engineering Physics – I Branch : Comp/ IT **Time: 02.00 Hours**

Max. Marks: 45 **Date: 31-05-2022**

N.B. (1) Q.1 is compulsory

(2) Attempt any two from the remaining three questions

Q.1.	Attempt all	M
a)	What is de Broglie's hypothesis of matter waves ? Calculate de Broglie wavelength of an electron accelerated through potential difference of 120 volts from rest.	3

Solution

"EVERY MOVING PARTICLE WILL HAVE A WAVE ASSOCAITED WITH IT, WHICH IS CALLED A PILOT/ MATTER /BROGILE WAVE"

According to Planck's quantum theory, the energy of a photon of a radiation of frequency ν and wavelength λ is $E = h\nu$ ...(i)

According to Einstein's mass-energy relation,

$$E = mc^2 \ldots(ii)$$

From (i) and (ii), we obtain

$$h\nu = mc^2$$

$$\therefore m = \frac{h\nu}{c^2} \quad \ldots(iii)$$

Since each photon moves with the same velocity c,

the momentum of photon, p = Mass × Velocity

That is,

$$p = \frac{h\nu}{c^2} \times c = \frac{h\nu}{c} = \frac{h}{\frac{c}{\nu}} = \frac{h}{\lambda}$$

$$\boxed{\lambda = \frac{h}{p}} \quad \ldots(iv)$$

Equation (iv) is equally applicable to both the photons of radiation and other material particles.

Data Potential Difference (V) = 120 V

To find : de-Broglie wavelength (λ)

$$\lambda = \frac{12.27}{\sqrt{V}} \text{ Å}$$

$$\lambda = \frac{12.27}{\sqrt{120}} \text{ Å} = 1.12 \text{ Å}$$

b)	What is Josephson effect in superconductors ? What are SQUIDS ?	3

c) Derive Einstein's mass-energy equivalence relation. **3**

$$m = \frac{m0}{\sqrt{1-\frac{v^2}{c^2}}}$$

Consider Newton's second law of motion in non-relativistic mechanics. Consider a body of mass 'm' moving with a velocity v and force F acting in the same direction as velocity v. The work done(dW) to put the body in motion is the change in kinetic energy in the particle (dk).

dk = dW $= \vec{F} \,.\, \overrightarrow{ds}$ (where $\overrightarrow{ds}$ is the displacement)

Force is defined as the rate of change of momentum . Hence $\vec{F} = \frac{dp}{dt}$

dk = dW $= \vec{F} \,.\, \overrightarrow{ds}$ (where $\overrightarrow{ds}$ is the displacement)

$= \frac{dp}{dt} \,.\, \overrightarrow{ds}$

dk $= dp$ .v

For a non relativistic particle p=mv

$dp = m\,dv + v\,dm$

Substituting in the above equation,

$$dk = mv\ dv + v^2\, dm$$

RHS of Equation is equal, hence

$$dk = c^2\, dm$$

$$\int_0^k dk = \int_{m_0}^{m} c^2\, dm$$

$$[k-0] = [m - m_0] \,.\, c^2$$

$$k = m\,c^2 - m_0 .\, c^2$$

$$k + m_0 .\, c^2 = m\,c^2$$

In the above equation $m_0 .\, c^2$ is the rest mass energy of the particle.

$$\text{Kinetic Energy} + m_0 .\, c^2 = \text{Energy}$$

$$\text{Kinetic Energy} + \textit{Rest mass Energy} = \text{Energy}$$

$$\text{Energy (E)} = m\,c^2$$

Einstein's Mass Energy Relation is E= mc^2

d) A wedge shaped air film having an angle of 0.02° is illuminated by monochromatic light and fringes are observed vertically through a microscope. The distance measured between consecutive bright fringes is 0.15 cm. Calculate the wavelength of light used. **3**

Soln

$\alpha = 0.02^\circ = \frac{0.02 \times \pi}{180} = 3.49 \times 10^{-4}$

$\pi^c = 180^\circ$

$x = 0.02$

$\beta = 0.15\ cm$

$\beta = \frac{\lambda}{2\mu\alpha}$

$\lambda = 0.15 \times 2 \times 3.49 \times 10^{-4} = 1.047 \times 10^{-4}\ cm$

e) Find the divergence of a vector field $\vec{A} = x^2\vec{i} + x^2y^2\vec{j} + 24x^2y^2z^3\vec{k}$. Is the field solenoidal ? **3**

$\nabla = \hat{i}\frac{\partial}{\partial x} + \hat{j}\frac{\partial}{\partial y} + \hat{k}\frac{\partial}{\partial z} \qquad \bar{A} = x^2\hat{i} + x^2y^2\hat{j} + 24x^2y^2z^3\hat{k}$

$\nabla \cdot \vec{A} = \left(\hat{i}\frac{\partial}{\partial x} + \hat{j}\frac{\partial}{\partial y} + \hat{k}\frac{\partial}{\partial z}\right) \cdot \left(x^2\hat{i} + x^2y^2\hat{j} + 24x^2y^2z^3\hat{k}\right)$

$= \frac{\partial}{\partial x}(x^2) + \frac{\partial}{\partial y}(x^2y^2) + \frac{\partial}{\partial z}(24x^2y^2z^2)$

$= 2x + 2yx^2 + 48x^2y^2z$

NOT A SOLENOID since $\nabla \cdot \bar{A} \neq 0$

Q.2. **Attempt all**

a) Define gradient of a scalar field , curl of a vector field and show that curl of gradient is zero. **4**

$$\nabla \times (\nabla \cdot \phi) = \begin{vmatrix} i & j & k \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ \frac{\partial \phi}{\partial x} & \frac{\partial \phi}{\partial y} & \frac{\partial \phi}{\partial z} \end{vmatrix}$$

$= \hat{i}\left(\frac{\partial^2 \phi}{\partial y \cdot \partial z} - \frac{\partial^2 \phi}{\partial y\, \partial z}\right) - \hat{j}$

$= 0$

b) Discuss the formation of Newton's rings, derive the expression for radius of an n^{th} dark ring. Why are rings crowded away from the centre ? **5**

$$D_n^2 = 4nR\lambda \qquad D_n \propto \sqrt{n}$$

$$D_5 - D_4 = 0.236\sqrt{\lambda R}$$

$$D_{15} - D_{14} = 0.131\sqrt{\lambda R}$$

$$D_{25} - D_{24} = 0.101\sqrt{\lambda R}$$

c)	Obtain one dimensional Schrodinger time independent equation. $$-\frac{\hbar^2}{2m}\nabla^2\psi + V_{(x)}\cdot\psi_{(x)} = E\cdot\psi_{(x)}$$	6
Q.3.	**Attempt all**	
a)	Write a short note on Meisener effect in superconductors. Distinguish between Type-I and Type-II superconductors.	4
b)	For a quantum particle trapped in infinitely deep potential well, derive expression for energy. Comment on zero point energy. $E_n = n^2h^2/8mL^2$	5
c)	For a thin parallel transparent film obtain the conditions for constructive and destructive interference for reflecting side when monochromatic light is incident on it from air.	6
4.	**Attempt all**	
a)	An electron has kinetic energy 1.5 KeV. Its position is determined within 20 nm. Estimate the uncertainty in the simultaneous measurement of momentum of the electron.	4

$$E = 1.5\,\text{keV} = 1.5\times10^{3}\,\text{eV} = 1.5\times10^{3}\times1.6\times10^{-19}\,\text{J}$$

$$\Delta x = 20\,\text{nm} = 20\times10^{-9}\,\text{m}$$

$$\Delta x_{max}\cdot\Delta p_{min} = \frac{h}{2\pi}$$

$$\Delta p_{min} = \frac{6.63\times10^{-34}}{2\pi\times20\times10^{-9}} = 5.27\times10^{-27}$$

$$E = \frac{p^2}{2m} \qquad p = \sqrt{2mE} = \sqrt{2\times9.11\times10^{-31}\times1.5\times10^{3}\times1.6\times10^{-19}}$$

$$= 2.09\times10^{-23}\,\text{kg m/s}$$

Accuracy $\frac{\Delta p}{p}\times100\% = 2.5\%$ 0.02

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(Autonomous) (Accredited 'A+' by NAAC)

END SEMESTER EXAMINATION

SECOND HALF 2021(Supplementary)

BRANCH: FE (COMP/IT)

	$\mu_f = \sqrt{\mu_g}$ $\quad t = \frac{\lambda}{4\mu_f}$	
b)	What is Antireflection coating? What should be the refractive index and minimum thickness of coating ?	**5**
c)	i) Derive Maxwell's 1st and 3rd equations. ii) A 1 meter long rod is moving along its length with velocity **0.8*c*** w.r.t. the earth. Calculate its length as it appears to an observer on the earth. $\nabla \cdot E = \frac{\rho}{\epsilon_0}$ $\quad \nabla \times E = -\frac{\partial B}{\partial t}$ $L = L'\sqrt{1-\frac{v^2}{c^2}}$ $L = 1 = \sqrt{1-0.8^2}$ ~~$\gamma = \frac{1}{\sqrt{1-0.8^2}} = 1.66$ or $\frac{5}{3}$~~ $L = \sqrt{1-0.8^2} = 0.6$ $\left(\frac{3}{5}\right)$	**6**