SCHOOL OF ENGINEERING AND TECHNOLOGY
D.C. COURT JUNCTION, DIMAPUR
END-TERM EXAMINATIONS, SEPTEMBER-DECEMBER 2022

Course: Code:	GIT02	Semester:	I	Total:	60 Marks
Course: Name:	Engineering Physics-I			Time:	3 hours

(Write only the question number on the answer script)

Part – A

Q.1. Answer the following questions $10 \times 1 = 10$

a. A man is standing on a disc at a distance of $2m$ from the disc's origin. The disc itself is rotating at constant angular speed of $3\ rad/s$. The speed of the man with respect to the ground is 6 m/s.

b. According to quantum mechanics, the lowest energy of a simple harmonic oscillator with mass m and spring constant C is 0.

c. Suppose a force $\vec{F} = 2\hat{i} + \hat{j} - \hat{k}$ N gets on particle at a displacement of $\vec{r} = -\hat{i} + \hat{j} + 3\hat{k}$ m from the origin. The torque of the particle around the origin is (give the vector expression) $-2\hat{i} - \hat{j} - 5\hat{k}$ N m.

d. If Δp is the uncertainty in the momentum and Δx is the uncertainty in the position of a particle, Heisenberg's uncertainty principle states that $\Delta x \cdot \Delta p \geq h/4\pi$.

e. According to quantum mechanics, the total energy of a particle bound inside a potential takes a discrete set of values.

f. A ball of mass 3 kg is moving in the positive X-direction with a speed of $2\ m/s$. Soon, it collides with a ball of mass 1 kg also moving in the positive X direction with a speed of $3\ m/s$. Suppose that after collision the two balls stick together and continue moving in the positive X direction. Their joint speed is $8/3$ m/s.

g. In a quantum mechanical simple harmonic oscillator, the probability of finding particle in the ground state around the equilibrium position is greater than the probability of finding it near the classical endpoints of its motion.

h. In a quantum mechanical simple harmonic oscillator, the probability of finding a particle in the ground state around the equilibrium position is _____ than the probability of finding it near the classical endpoints of its motion.

i. In Young's double slit experiment, the central interference fringe is dark.

j. In Newton's rings experiment, the central interference fringe is dark.

k. In QM stationary states are also called _____ states. They are states with single energy.

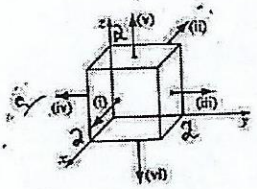
(b) What is the minimum uncertainty $\Delta\nu$ in the frequency of the emitted photon?

(c) Almost all the excited caesium atoms give out photons at a wavelength of around $\lambda = 8.5\times10^{-7}$ m. What is the fractional uncertainty in the frequency of the photon, also called the natural fractional width of the caesium emission line?

d. Suppose monochromatic coherent light of wavelength $\lambda = 500$ nm is passed through a narrow slit. A Fraunhofer diffraction pattern is formed on a screen 5 m away.

(a) The distance on the screen between the centres of the first dark fringes on either side of the central bright fringe is 20 mm. What is the width a of the slit?

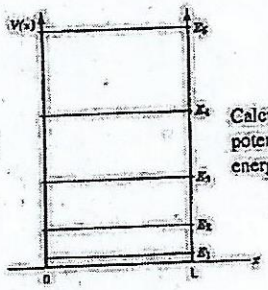
(b) Let I_0 denote the intensity of the central bright fringe. What is the intensity at a point 15 mm away from the centre of the pattern?



Test Gauss' divergence theorem for the vector field

$$v = xz\hat{i} - 2yz\hat{j} + 3z^2\hat{k}$$

over the cube of side length 2 as shown in the figure.



f. Calculate the possible wavefunctions of a particle in a box i.e. in an infinite potential well. The well ranges from $x = 0$ to $x = L$. Show that the allowed energy values are discrete and obtain an expression for them.

Part – B

Q.2. Answer any five questions $5 \times 4 = 20$

a. Find the moment of inertia of a solid cylinder of mass M, radius R and length L around its own axis.

b. Consider Young's double slit experiment where the slits are 0.6 mm apart and the screen is 2 m away from the slits. The fourth bright fringe is at a distance of 1 cm from the central fringe. Find the wavelength of the light.

c. Find the centre of mass of a carbon dioxide molecule CO_2. For simplicity assume that the two carbon-oxygen bonds subtend an angle of 120°, each bond has a length of 10^{-9} m and the oxygen atom is $\frac{4}{3}$ times heavier than a carbon atom.

d. State the fundamental theorem of gradients in vector calculus. Do not forget to define all the terms.

e. Find the distance between the second bright ring and the dark ring just outside it for a Newton's rings experiment with a plano convex lens of radius of curvature R using coherent monochromatic light of wavelength λ.

f. State Stokes' theorem in vector calculus. Do not forget to define all the terms too.

Part – C

Q.3. Answer any five questions $5 \times 6 = 30$

a. Consider a simple pendulum consisting of a bob of mass 2 kg suspended from a light string of length 2 m. The pendulum is oscillating in a plane. The bob's speed at the bottommost point of its trajectory is 0.2 m/s. What is the maximum angle from the vertical attained by the bob during the course of its oscillation?

b. Calculate the de Broglie wavelengths of:

1. A foot ball of mass 0.5 kg moving at a speed of 10 m/s;
2. An α particle of mass 6.6×10^{-27} kg with kinetic energy of 1.6×10^{-16} J.

In which case above, will it be easier to detect wave properties like interference?

c. A caesium atom in a caesium vapour lamp can radiate at any time after it is excited from its lowest energy or ground state. The average excited atom has a lifetime of about 10^{-10} s., i.e., some time during this period it emits a photon and is deexcited i.e. comes back to its ground state.

(a) What is the minimum uncertainty ΔE in the energy of the excited state of the atom?