Register Number:
DATE:

ST. JOSEPH'S UNIVERSITY, BANGALORE-27
M.Sc. PHYSICS – II SEMESTER
SEMESTER EXAMINATION – APRIL 2023
(Examination conducted in May 2023)

PHBC 8121: MODERN PHYSICS AND ELECTRICITY

Time: 1 hour **Maximum Marks:25**

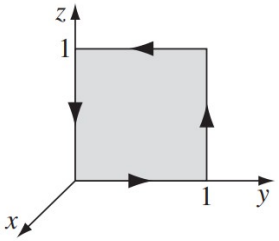
This question paper contains 2 parts and 2 printed pages.

Answer any 5 questions with atleast two questions from each part. The fifth question can be answered from any of the two parts. (5X5=25)

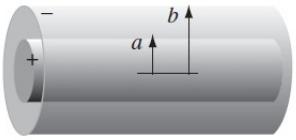
Part-A

1. Show that $\vec{F} = yz\,\hat{x} + zx\,\hat{y} + xy\,\hat{z}$ can be written both as the gradient of a scalar and as the curl of a vector. Find the scalar and vector potentials for this function. Are these potentials unique?

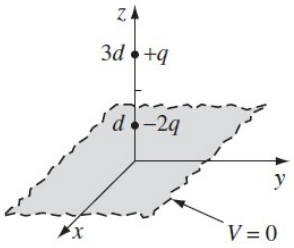
2. Write down the Stoke's theorem and verify it for the function $\vec{v} = (2xz + 3y^2)\,\hat{j} + (4y^2)\,\hat{k}$, using the square surface as shown in the figure.



3. A long coaxial cable carries a uniform volume charge density ρ on the inner cylinder (radius a), and a uniform surface charge density on the outer cylindrical shell (radius b). This surface charge is negative and is of just the right magnitude that the cable as a whole is electrically neutral. Find the electric field in each of the three regions: (i) inside the inner cylinder (s < a), (ii) between the cylinders (a < s < b), (iii) outside the cable (s > b). Plot |**E**| as a function of s.



4. The xy plane is a grounded conductor. Find the force on the -2q charge as shown in figure using the method of images.



Part-B

5. Find the de Broglie wavelengths of (a) a 46 grams golf ball with a velocity of 30 ms^{-1}, and (b) an electron with a velocity of 10^7 ms^{-1}.

6. Solve the Schrodinger's equation for a free particle and obtain an expression for the velocity of quantum mechanical wave function in terms of the velocity of the particle it represents.

7. A free particle, which is initially localised in the range $-a<x<a$ is released at time t=0:

$$\psi(x,0)=\begin{cases} A, if -a<x<a \\ 0, otherwise \end{cases}$$

Where A and a are positive real constants.
Normalise $\psi(x,0)$and find $\Phi(k)$. Sketch them for large and small values of a.

8. a) If a photon has a wavelength equal to the Compton wavelength of the particle show that the photon energy is equal to the rest mass energy of the particle.
b) A free particle has the initial wave function given by

$$\psi(x,0)=A\,e^{-ax^2}$$

Where A and a are constants (a is real and positive). Normalise $\psi(x,0)$ (2+3)