



Register Number:  
DATE:

ST. JOSEPH'S COLLEGE (AUTONOMOUS), BANGALORE-27  
M.Sc. PHYSICS – II SEMESTER  
SEMESTER EXAMINATION – APRIL 2022  
(Examination conducted in July 2022)  
**PHBC 8121/PHBC8120 : MODERN PHYSICS AND ELECTRICITY**

Time: 1.5 hours

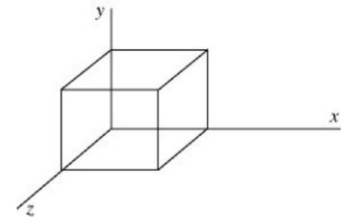
Maximum Marks:35

This question paper contains 2 parts and 2 printed pages.

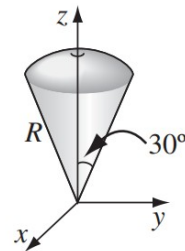
- Each question carries 5 marks.
- Answer any 7 questions with atleast three question from each part. The last question can be answered from any one of the two parts. (5X7=35)

**Part-A**

1. Find the angle between adjacent face diagonals of a cube of side 1 unit as shown in the figure.



2. Write the divergence theorem and verify it for the function  $\vec{v} = r^2 \sin \theta \hat{r} + 4r^2 \cos \theta \hat{\theta} + r^2 \tan \theta \hat{\phi}$  using the volume of an ice-cream cone shown in the figure. The top surface of the cone is spherical with radius R.



3. Show that the electric field is related to electric potential as  $\vec{E} = -\vec{\nabla} V$  and explain the advantages of potential formulation.
4. Using Gauss's law, find the field inside and outside a uniformly charged solid sphere of radius R with charge density  $\rho$  and total charge 'q'.
5. Consider two concentric spherical shells of radii 'a' and 'b' with  $b > a$ . Suppose the inner one carries charge 'q' and the outer one carries charge '-q' (both uniformly distributed over the surface) then calculate the energy of this configuration. Given that the work done over the entire space is given as  $W = \frac{\epsilon_0}{2} \int E^2 d\tau$  where  $\vec{E}$  is the electric field.

### **Part-B**

6. X-rays of wavelength  $1.4 \text{ \AA}$  are scattered from a block of carbon. What will be the wavelength of scattered x-rays at (i)  $180^\circ$ , (ii)  $90^\circ$ , and (iii)  $0^\circ$ ?
7. The speed of a bullet ( $m=50 \text{ gm}$ ) and the speed of an electron ( $m=9.1 \times 10^{-31} \text{ kg}$ ) are measured to be the same, namely  $300 \text{ m/s}$ , with an uncertainty of  $0.01\%$ . With what fundamental accuracy could we have located the position of each, if the position is measured simultaneously with the speed in the same experiment?
8. Show that the velocity of the group of matter waves is just equal to the velocity of the particle whose motion they govern.
9. Beginning with Schrodinger's time-dependent wave equation, derive Schrodinger's time-independent wave equation and show that for stationary states the probability density is constant in time.
10. Solve Schrodinger's equation for free particle and show that the quantum mechanical wave function travels half the speed of the particle it represents.