

Duration: 1 hour

(a) Given that $\mathbf{F} = xy\hat{x} + 2yz\hat{y} + 3xz\hat{z}$, calculate the circulation of \mathbf{F} around the closed path shown in Figure 1.

(b) Positive charge Q is distributed uniformly along the positive x -axis from $x = 0$ to $x = a$. A positive charge q is located on the same axis at $x = a + r$. (i) Calculate the electric field produced by the charge distribution Q at points on axis for $x > a$. (ii) Calculate the force that the charge distribution Q exerts on q . (iii) What happens when $r \gg a$.

(c) A vacuum diode consists of a cylindrical cathode with radius 0.062 cm, mounted coaxially within a cylindrical anode 0.557 cm in radius. The potential of anode is 360 V higher than the cathode. An electron leaves the surface of cathode with zero initial speed. Find its speed when it strikes the anode? (2+3+2)

(i) A certain coaxial cable consists of a solid copper wire, radius a , surrounded by a concentric copper tube of inner radius c . The space between is partially filled (from b out to c) with material of dielectric constant κ . Find the capacitance per unit length of this cable.

(ii) A conducting sphere of radius R carries a charge Q . Calculate the total energy stored in the surrounding space. What happens in the limit $R \rightarrow 0$? (5+3)

3. A very long cylinder of linear dielectric material (radius a , susceptibility χ_e) is placed in an otherwise uniform electric field \mathbf{E}_0 , with the axis perpendicular to \mathbf{E}_0 . Find the resulting field within the cylinder. (5)



Figure 1

Constants:
 $e = 1.60 \times 10^{-19}$ C

$m_e = 9.11 \times 10^{-31}$ Kg

$\epsilon_0 = 8.85 \times 10^{-12}$ C²/Nm²