SOLUTION 7 FOR 6.013

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Solution 7.1

a) The electron is accelerated by the system, the energy is conserved. So,

\[ W = F \cdot S = e\frac{V}{d} \cdot D = eV = \frac{1}{2}mv^2 \]

\[ v = \sqrt{2eV/m} = \sqrt{2 \times 1.6 \times 10^{-19} \times 20,000/9.1 \times 10^{-34}} = 8.39 \times 10^7 \text{[v/s]} \]

b) The time needed from deflection plates to anode is:

\[ t = d_1/v = d_2/v_v, \quad v_v = d_2 \cdot v/d_1 = v/4 \]

where \( d_1 = 40\text{cm}, \ d_2 = 10\text{cm}, \ v_v \) is vertical velocity, \( v \) is horizontal velocity component. The energy from the deflection plates:

\[ W = F \cdot S = eV_2^2 \cdot d_2/2 = eV_2/2 = \frac{1}{2}mv_v^2, \quad v_v = \sqrt{eV_2/m} \]

So,

\[ v_v = \sqrt{eV_2/m} = v/4 = \sqrt{2eV/m}/4 \]

\[ V_2 = V/8 = 2500\text{[volts]} \]

Solution 7.2

(a) The stored energy of the system \( W_e = \frac{1}{2}CV^2 = \frac{1}{2}C(Q/C)^2 = \frac{Q^2d}{2eWL} = \frac{eWLV^2}{2d} \)

The force: \( f = -\frac{dW_e}{dt} = -\frac{eWLV^2}{2d} \)

b) The capacitor is written as \( C = \frac{eWL}{d} = \frac{Q}{V} \)

\[ \frac{d}{dt} \frac{eWL}{d} = \frac{d}{dt} \frac{Q}{V}, \quad \frac{dL}{dt} \frac{eW}{d} = \frac{dQ}{dt} \frac{1}{V} = \frac{V}{R} \frac{1}{V} = \frac{1}{R} \]

\[ v = -\frac{dL}{dt} = -\frac{d}{RcW} \]
c) Please see the figure for the E line. Because the fringe field exists, there is force along the z direction.