

Problem 1 (33 Points):

(II) A 425-pF capacitor is charged to 135 V and then quickly connected to a 175-mH inductor.

Determine

(a) the frequency of oscillation,

$$\omega = 2\pi f = \sqrt{\frac{1}{LC}} \Rightarrow f = \frac{1}{2\pi} \sqrt{\frac{1}{LC}} = \frac{1}{2\pi} \sqrt{\frac{1}{(175 \times 10^{-3} \text{ H})(425 \times 10^{-12} \text{ F})}}$$

$$f = 18,450 \text{ Hz}$$

(11)

(b) the peak value of the current,

$$I = Q\omega = CV(2\pi f) = (425 \times 10^{-12} \text{ F})(135 \text{ V})(2\pi)(18,450 \text{ Hz})$$

$$= 6.653 \times 10^{-3} \text{ A}$$

(11)

and (c) the maximum energy stored in the magnetic field of the inductor.

$$U = \frac{1}{2} LI^2 = \frac{1}{2} (0.175 \text{ H})(6.653 \times 10^{-3} \text{ A})^2$$

$$= 3.87 \times 10^{-6} \text{ J}$$

(11)

Problem 2 (34 Points):

(II) (a) A 2.80-cm-high insect is 1.30 m from a 135-mm-focal-length lens. Where is the image, how high is it, and what type is it?

$$h_o = 2.80 \text{ cm} \quad d_o = 1.30 \text{ m} \quad f = 135 \text{ mm} \quad (1)$$

$$(3) \frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} \Rightarrow \frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o} \Rightarrow \frac{1}{d_i} = \frac{d_o - f}{d_o f} \Rightarrow d_i = \frac{d_o f}{d_o - f} \quad (3)$$

$$d_i = \frac{(1.30 \text{ m})(135 \times 10^{-3} \text{ m})}{(1.30 - 0.135) \text{ m}} = 0.1506 \text{ m} \rightarrow \text{real} \quad (1)$$

$$m = \frac{h_i}{h_o} = -\frac{d_i}{d_o} \Rightarrow h_i = -\frac{d_i h_o}{d_o} = -\frac{(0.1506 \text{ m})(2.80 \times 10^{-2} \text{ m})}{1.30 \text{ m}} = -0.324 \text{ m} \quad (2) \text{ smaller inverted}$$

f is positive \rightarrow lens is converging (2)

(b) What if $f = -135 \text{ mm}$

$$\frac{1}{f} = \frac{1}{d_i} + \frac{1}{d_o} \Rightarrow d_i = \frac{d_o f}{d_o - f} = \frac{(1.30 \text{ m})(-0.135 \text{ m})}{1.30 \text{ m} - (-0.135 \text{ m})} \quad (4)$$

$$= -0.1223 \text{ m} \quad (2)$$

$$h_i = -\frac{d_i h_o}{d_o} = -\frac{(-0.1223)(2.80 \times 10^{-2} \text{ m})}{1.30 \text{ m}} = 0.263 \text{ m} \quad (4)$$

Image virtual, upright smaller (in front of the lens) (4)

The lens is diverging (4)

Problem 3 (33 points):

(II) An electromagnetic wave has an electric field given by

$$E = \hat{i} (225 \text{ V/m}) \sin [(0.077 \text{ m}^{-1}) z - (2.3 \times 10^7 \text{ rad/s}) t]$$

(a) What are the wavelength and frequency of the wave?

$$k = \frac{2\pi}{\lambda} \Rightarrow \lambda = \frac{2\pi}{k} = \frac{2\pi}{0.077 \text{ m}^{-1}} = 81.60 \text{ m}$$

$$f = ? \quad \omega = 2\pi f \Rightarrow f = \frac{\omega}{2\pi} = \frac{2.3 \times 10^7 \text{ rad/s}}{2\pi \text{ rad}} = 3.661 \times 10^6 \text{ Hz}$$

(b) Write down an expression for the magnetic field.

$$c = \frac{E_0}{B_0} \Rightarrow B_0 = \frac{E_0}{c} = \frac{225 \text{ V/m}}{3 \times 10^8 \text{ m/s}} = 7.50 \times 10^{-7} \text{ T}$$

\vec{B} is travelling in the y direction, since \vec{E} is travelling in x and the wave is in z

$$\vec{B} = \hat{j} [(7.50 \times 10^{-7} \text{ T}) \sin (0.077 \text{ m}^{-1}) z - (2.3 \times 10^7 \text{ rad/s}) t]$$