

**Possibly Useful Information:**  $\mu_0 = 4\pi \times 10^{-7} \text{ N/A}^2$   $e = 1.60 \times 10^{-19} \text{ C}$   $c = 3.00 \times 10^8 \text{ m/s}$

**Problem 1** Multiple Choice (3 points each)

\_\_\_\_\_ [i] A series RCL circuit is driven at a frequency below its resonance frequency. What is the sign of the phase angle? (a)  $\phi < 0$  (b)  $\phi = 0$  (c)  $\phi > 0$  (d) It cannot be determined.

\_\_\_\_\_ [ii] A transformer is connected to a standard outlet. Suppose the primary coil has 600 turns and carries an rms current of 4A. If the secondary coil has 300 turns, then what is the rms voltage and rms current in the secondary coil? (a) 60V and 2A (b) 60V and 4A (c) 60V and 8A (d) 120V and 2A (e) 120V and 4A (f) 120V and 8A (g) 240V and 2A (h) 240V and 4A (i) 240V and 8A

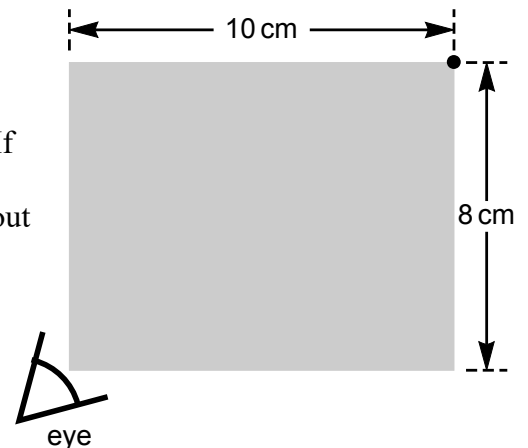
**Problem 2** At a distance of 25m from an isotropic 100 MHz radio source the intensity is  $120 \text{ W/m}^2$ .

(a) What is the rms electric field at 25m? (6 points)

(b) Over a 2 hour period, what is the momentum given to a  $4 \text{ cm} \times 4 \text{ cm}$  surface (at the 25m distance) perpendicular to the source that reflects  $3/4$  of the energy? (6 points)

(c) What is the total power transmitted by the source? (6 points)

**Problem 3** A plastic rectangular solid has dimensions  $2 \text{ cm} \times 8 \text{ cm} \times 10 \text{ cm}$ . If one places an eye at the center of the short edge one can see the opposite edge through one face but not through the other. What does this imply about the refractive index of the solid?



**Problem 4** A solenoid has 600 turns, a 3cm diameter and a length of 95cm. (6 points each)

(a) If this solenoid carries a 8A current then what is the energy stored in the solenoid?

(b) Suppose this solenoid is rotated in a uniform magnetic field to generate an AC voltage equivalent to that of a standard outlet. What magnitude must the magnetic field have and what angular frequency of rotation is needed?

**Problem 5** Consider a  $10\Omega$ , a  $50\mu\text{F}$  capacitor and a  $80\text{mH}$  inductor connected in series across a standard outlet.

(6 points each)

(a) By what angle is the voltage ahead of the current in this circuit?

(b) What is the rms voltage across the capacitor?

(c) What is the power dissipated *in the inductor* (only the inductor), in the capacitor and in the resistor? There are three answers?

**Problem 6**

(a) A 50mW laser produces a polarized beam of 600nm light. If this laser light is reflected normally off a perfect mirror, then what is the net force of the radiation on the mirror? (7 points)

(b) At  $t=0$  an  $80\mu\text{F}$  capacitor is given a charge of  $200\mu\text{C}$  and is connected across a 50mH inductor. What is the earliest time when the current is its maximum value (just the magnitude) and what is that maximum value? (7 points)

(d) After how many time constants has a discharging capacitor lost 95% of its charge? (6 points)

**Problem 7** A long solenoid has a square cross-section with sides of length  $\ell$ ,  $n$  turns per length has the  $z$ -axis as its central axis. Suppose this sits entirely inside a flat circular coil of radius  $R$  with  $N$  turns in the  $xy$ -plane.

What is the mutual inductance between the solenoid and coil? (7 points)

