X3.4a 115

PHYS-115(4) (Kaldon-26364) **Name** S O L U T I O N

WMU - Spring 2005

Exam 3A - 100,000 points

Rev. 03/30/05 We.A6

State Any Assumptions You Need To Make – Show All Work – Circle Any Final Answers
Use Your Time Wisely – Work on What You Can – Be Sure to Write Down Equations
Short Answers Should Be Short! – Feel Free to Ask Any Questions

EXAM 3 [FORM - A]

PHYS-115 (KALDON-4)

SPRING 2005

WMU

Wait – Is It Getting Warmer?

Can it be…

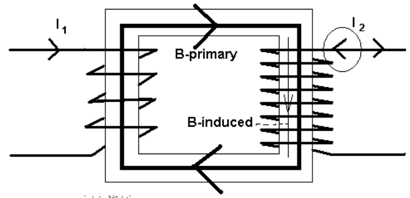
Spring?

YES!

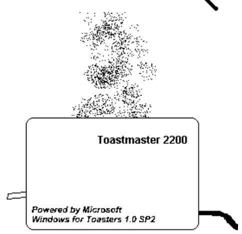
(Because Construction Season Has Started On US-131)

My AC Circuits Are Just Going Through a Phase (50,000 points)

1.) An A.C. transformer is shown below. (a) If at some time t_0 the primary current I_1 is decreasing and going to the right as shown, then explain whether the induced current of the secondary, I_2 , goes to the LEFT or to the RIGHT. You should sketch in the relevant magnetic field B_1 from the primary coil, and the induced magnetic field B_2 from the secondary coil to get full points. (b) Finally, if $V_{1,\,rms} = 117\ Volts$, then find $V_{2,\,rms}$.



$$V_2 = \frac{N_2}{N_1} V_1 = \frac{(8)}{(4)}(117 volts) = 234 volts$$



(c) The heating element of a toaster (R = 12.8 Ω) can be unfolded to be a single coil with an inductance, $L = 252\ mH$. If this toaster is plugged into an AC wall outlet, with $V_{rms} = 117\ volts$ and $f = 60.0\ Hz$, where $\omega = 377\ rad/sec$, find the inductive reactance, X_L, of the heating element.

$$X_L = \omega L = (377 rad/\sec)(0.252 H) = 95.00\Omega$$

(d) What capacitance C could be used with this toaster so as to cancel the effects of the inductive reactance of this toaster?

$$X_L = X_C = \frac{1}{\omega C} = 95.00\Omega$$

$$C = \frac{1}{\omega X_C} = \frac{1}{(377 rad/\sec)(95.00\Omega)}$$

$$= 0.00002792 F = 2.792 \times 10^{-5} F = 27.92 \mu F$$

(e) Find the impedance Z if the frequency is changed to $f = 25.0\ Hz$. *If you didn't get an answer to (d), use C = 1.00F.*

$$\omega = 2\pi f = 2\pi(25.0 Hz) = 157.1 rad/\sec$$

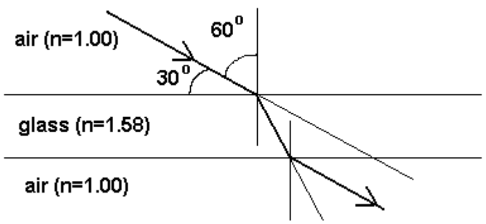
$$X_L = \omega L = (157.1 rad/\sec)(0.252 H) = 39.59\Omega$$

$$X_C = \frac{1}{\omega C} = \frac{1}{(157.1 rad/\sec)(2.792 \times 10^{-5} F)} = 228.0\Omega$$

$$Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{(12.8\Omega)^2 + (39.59\Omega - 228.0\Omega)^2} = 188.5\Omega$$

I Can See Clearly Now (50,000 points)

2.) (a) A perfectly flat piece of glass (known as parallel-plano in the optics business) has air on both sides of it as shown. Calculate and sketch on the diagram what happens to the twice refracted light ray when it gets back into the air. *Ignore all reflections*.

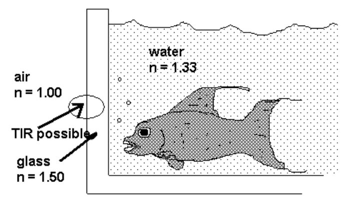


$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

$$\sin\theta_2 = \frac{n_1 \sin\theta_1}{n_2}$$

$$\theta_2 = \sin^{-1}\left(\frac{n_1 \sin\theta_1}{n_2}\right) = \sin^{-1}\left(\frac{1.00 \sin 60°}{1.58}\right) = 33.2°$$

(b) A fish lives in fresh water, $n = 1.33$, in a fish tank made of glass, $n = 1.50$. The fish is trying to look through the water and glass to the outside world of air. At which interface is there a possibility of Total Internal Reflection? And what is the critical angle θ_c at this interface?



$$\theta_c = \sin^{-1}\left(\frac{n_1}{n_2}\right) = \sin^{-1}\left(\frac{1.00}{1.50}\right) = 41.8°$$

Going from Water to Glass is low to high, so no TIR possible.

Going from Glass to Air is high to low, so YES, TIR possible.

(c) In *Papillon*, the classic movie about life on a French tropical prison island, Dustin Hoffman had to play a character with really bad vision. His glasses were *really* thick –+5.00 diopters. But since Hoffman didn't need to wear glasses, he was fitted with special contact lenses that canceled out the effect of the glasses. Find the focal length of the contact lenses. *By the way, the combination of glasses and contacts made Hoffman look convincingly bad visioned.*

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} \quad OR \quad \frac{1}{f} = D_1 + D_2$$

$$f_{flat\ glass} = \infty$$

$$0 = D_1 + D_2$$

$$D_2 = 0 - D_1 = -5.00 diopters$$

$$f_2 = \frac{1}{D_2} = \frac{1}{-5.00 diopters} = -0.2000m = -20.00cm$$

(d) A sodium vapor light shines bright with a yellow light which has a wavelength $\lambda = 555\ nm = 5.55 \times 10^{-7}\ m$. Find the frequency of this light in vacuum.

$$c = f\lambda$$

$$f = \frac{c}{\lambda} = \frac{2.998 \times 10^8 m/s}{5.55 \times 10^{-7} m} = 5.402 \times 10^{14} Hz$$

(e) An object 10.0 cm high is located 20.0 cm from a positive, converging, biconvex lens with a focal length $f = +8.00\ cm$. Calculate the position q and the height h' of the real, inverted image produced. *You don't have to sketch anything below.*

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$$

$$\frac{1}{q} = \frac{1}{f} - \frac{1}{p} = \frac{1}{8.00cm} - \frac{1}{20.0cm} = 0.07500cm^{-1}$$

$$q = \frac{1}{0.07500cm^{-1}} = 13.33cm$$

$$M = -\frac{q}{p} = \frac{h'}{h}$$

$$h' = -\frac{q}{p}h = -\frac{(13.33cm)}{(20.0cm)}(10.0cm) = -6.665cm$$

We have a positive converging lens, shown in the sketch as a biconvex lens below, where $p > 2f$ (20.0cm > 16.0cm).

That makes the image show up as:

$f < q < 2f$ (8.00cm < 13.33cm < 16.0cm)

And we will get a Real Inverted Reduced Image

and $|h'| < h$ (6.665cm < 10.0cm), so this works.

You weren't asked to draw this, but this is what it would look like: