IV
II
III

1) Short Questions (Showing work can get you partial credit)

(Circle the Correct Response):

a) If 2.5 milli-Joules of energy is is stored in a solenoid of length 12 cm, area 6.0 cm^2 and 400 turns of wire, how much current is passing through the solenoid? (3 pts)

I) 4.52 Amps
II) 12.0 Amps
III) 1.58 Amps
IV) 2.23 Amps
~~V) 18.6 Amps~~

$$U = \frac{1}{2} L I^2$$

$$L = \mu_0 n^2 A \ell = \mu_0 \left(\frac{N}{\ell}\right)^2 A \ell = \mu_0 N^2 \frac{A}{\ell}$$

$$= \left(4\pi \times 10^{-7} \frac{T m}{A}\right)\frac{(400)^2}{12 cm} \cdot 6 cm^2 \; \frac{1 m}{100 cm} = 1.005 \times 10^{-3} H$$

$$U = \left(\frac{1.005 \times 10^{-3} H}{2}\right) I^2 \qquad I = \sqrt{\frac{2.5 \times 10^{-3} J (2)}{1.005 \times 10^{-3} H}}$$

$$= 2.23 A$$

b) In 0.30 *seconds* the magnetic field inside a loop of wire decreases from 0.12 T to 0.08 T. If the loop of wire has a resistance of 1.1 Ohms and carries a current of 0.15 Amps due to the EMF induced in the wire, what is the area of the loop (whose normal vector lies along the direction of the changing B field)(3 pts.)

I) 0.62 m^2
II) 1.2 m^2
III) 0.41 m^2
IV) 2.4 m^2
V) 1.61 m^2

$$IR = |\mathcal{E}| = \frac{\Delta BA}{\Delta t} = \left|\frac{\Delta B}{\Delta t}\right| A \text{ in this case}$$

$$A = \frac{IR}{\left(\frac{\Delta B}{\Delta t}\right)} = \frac{(0.15 A)(1.1 \Omega)}{\left(\frac{0.12T - 0.08T}{.35}\right)}$$

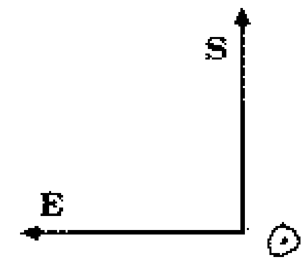
$$= 1.2375 m^2$$

c) A laser beam passes from air to glass. What happens to the frequency of this light?(2 pts)

I) Increases
II) Decreases
III) Stays the same

1) Short Questions (continued)

d) In which direction is this Magnetic Field pointing for this traveling electromagnetic wave?(2 pts)



I) Up
II) Down
III) Into the Page
IV) Out of the Page

right hand rule

e) In the Jameco Electronics catalog, a solar cell is on sale! This solar cell delivers a voltage of 12.18V at a current of 0.141A in direct sunlight and is 1 square foot in size. About how much total power does the sun put out if you assume this solar cell is 100 percent efficient? (The distance from the earth to the sun is about $1.5 \times 10^{11} m$)(3 pts)

$$\left(\begin{matrix}\text{Intensity of sun} \\ \text{at earth}\end{matrix}\right) \approx \frac{(12.18V)(0.141A)}{\left(12in \cdot .0254\frac{m}{in}\right)^2} = 18.5\frac{W}{m^2}$$

This is only a small slice of a huge sphere, assume sun is isotropic

$$P_{sun} = \left(\begin{matrix}I_{sun} \\ @\,earth\end{matrix}\right)\left(\begin{matrix}\text{area of} \\ \text{sphere at earth}\end{matrix}\right) = 18.5\frac{W}{m^2}\left(4\pi\left(1.5\times10^{11}m\right)^2\right) = 5.23\times10^{24}$$

actual is about 4×10^{26} (cell is not quite 100% eff!)

f) Red light and Green light are sent through a prism and the green light gets bent more than the red light. Which color of light travels more slowly in the prism? (2 pts.)

RED GREEN

not bent at all is the fastest

(Show your work, 12 points each.)

2) One way to increase or decrease the size of a light beam is to use a complimentary set of lenses. One lens has a focal length of f = 30 cm and the other lens has a focal length of f = -7.5 cm. As shown in the figure below, a beam is incident from the left and emerges to the right 4 times smaller that when it started. What is x, the distance between the 2 lenses you need to produce this?

Alternate way

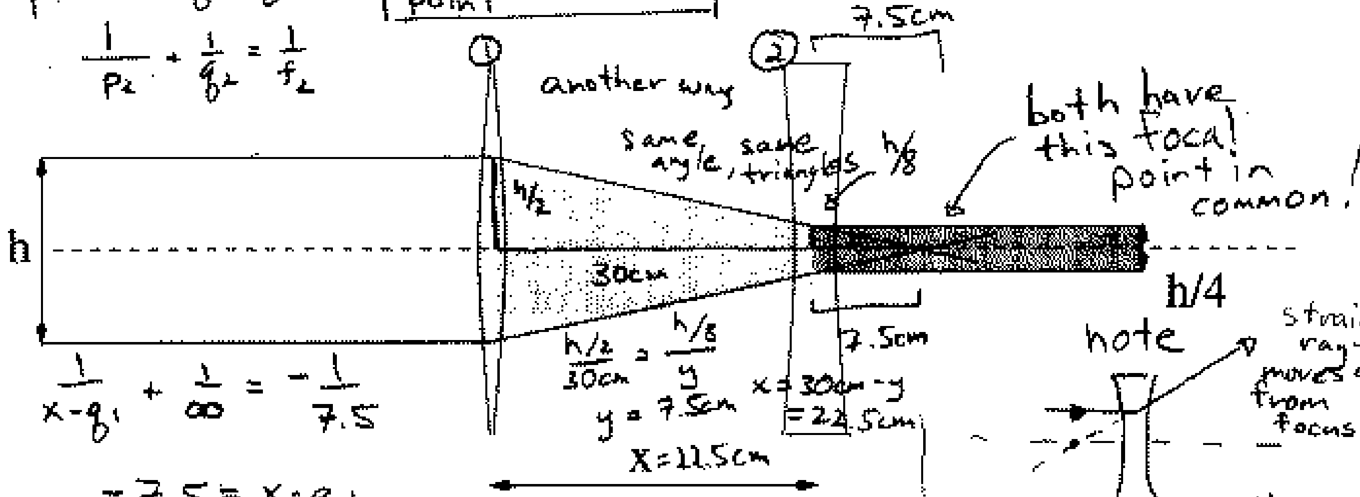
$p_1 = \infty$, $q_1 = f_1$

$p_2 = x - q_1$, $q_2 = \infty$

$\frac{1}{p_2} + \frac{1}{q_2} = \frac{1}{f_2}$

Most important
① infinite source converges to focal point
② infinite source diverges from focal point

x= 22.5cm

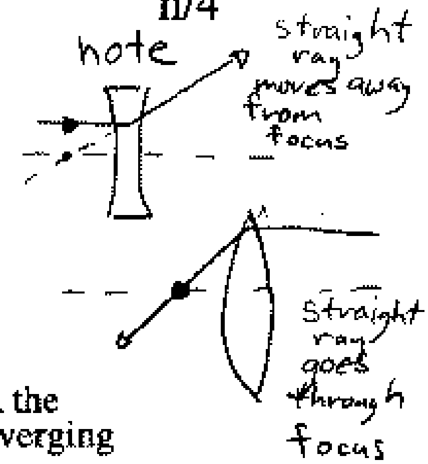


$\frac{1}{x-q_1} + \frac{1}{\infty} = -\frac{1}{7.5}$

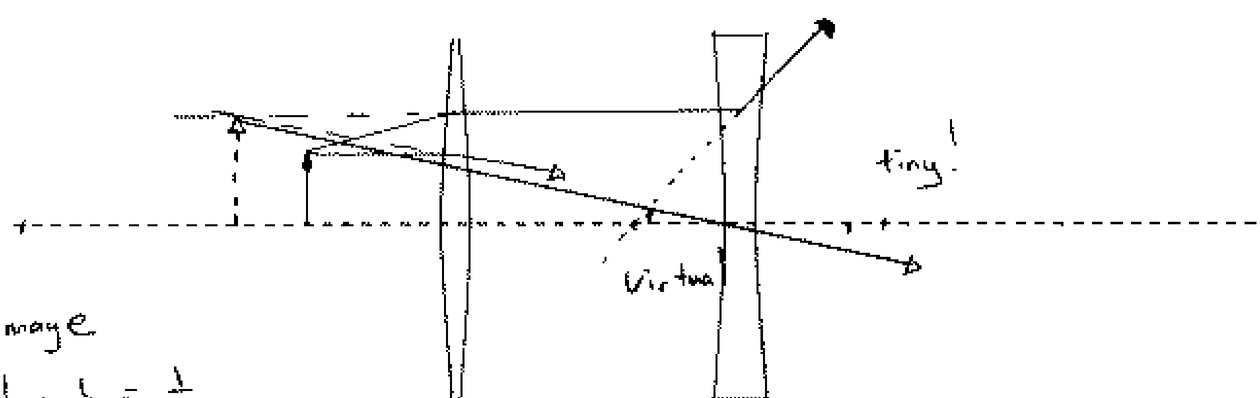
$-7.5 = x - q_1$

$x = q_1 - 7.5$

$= 30 - 7.5 = 22.5cm$



Now suppose I move the diverging lens to a position 20cm from the converging lens, and place an object 10 cm to the left of the converging lens. Where is the final image? Is it real or virtual?



1st image

$\frac{1}{10} + \frac{1}{q_1} = \frac{1}{30}$

$\frac{1}{q_1} = -\frac{2}{30}$

$q_1 = -15cm$

$p_2 = 35cm$

$\frac{1}{35} + \frac{1}{q_2} = \frac{-1}{7.5}$

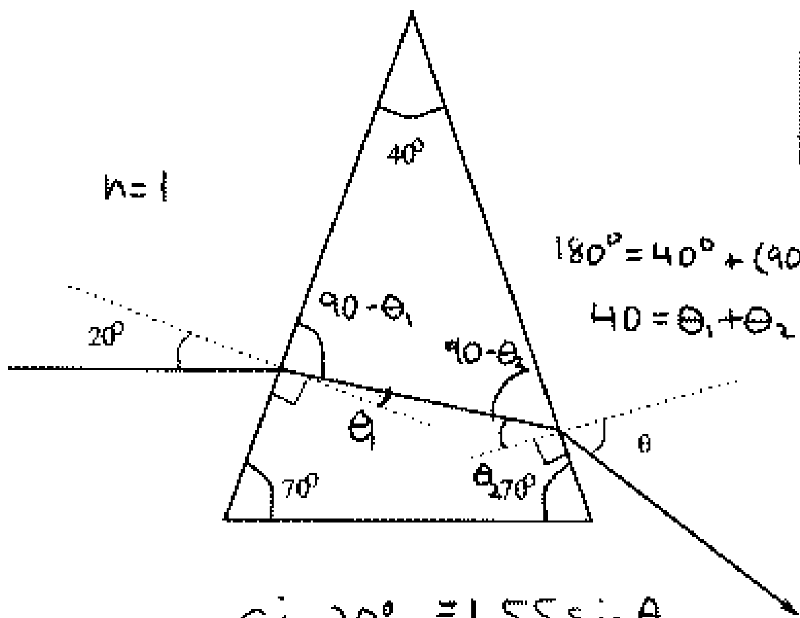
$q_2 = -\left(\frac{7.5(35)}{7.5+35}\right) = -6.18cm$

q_{final} = −6.18cm

real   virtual

3) Refraction (15 points) The prism shown in the figure below has an index of refraction of 1.55. Light is incident at an angle of 20.0 degrees. Determine the angle θ at which the light emerges.

$\theta = $ 45.2°
(10 pts)



$180° = 40° + (90° - \theta_1) + (90° - \theta_2)$

$40 = \theta_1 + \theta_2$

$\sin 20° = 1.55 \sin\theta_1$

$\theta_1 = \sin^{-1} \frac{\sin 20°}{1.55} = 12.75°$

$\theta_2 = 40° - 12.75° = 27.25°$

$1.55 \sin\theta_2 = \sin\theta$

$\theta = \sin^{-1}(1.55 \sin 27.25°) = 45.2°$

The index of refraction in the crystal changes for different wavelengths of light.
For which colors is there total internal reflection at the " \ " surface. (5 pts.)

		θ
Red	n=1.55	45.2
Orange	n=1.65	50.8
Yellow	n=1.85	65°
Green	n=2.05	n/a
Blue	n=2.25	n/a

For this part

$\theta = \sin^{-1}\left(n \sin\left(40° - \sin^{-1}\left[\frac{\sin 20°}{n}\right]\right)\right)$

$\theta = \sin^{-1}(2.05 \cdot 0.506) > 1$

this won't work too

total internal Reflection

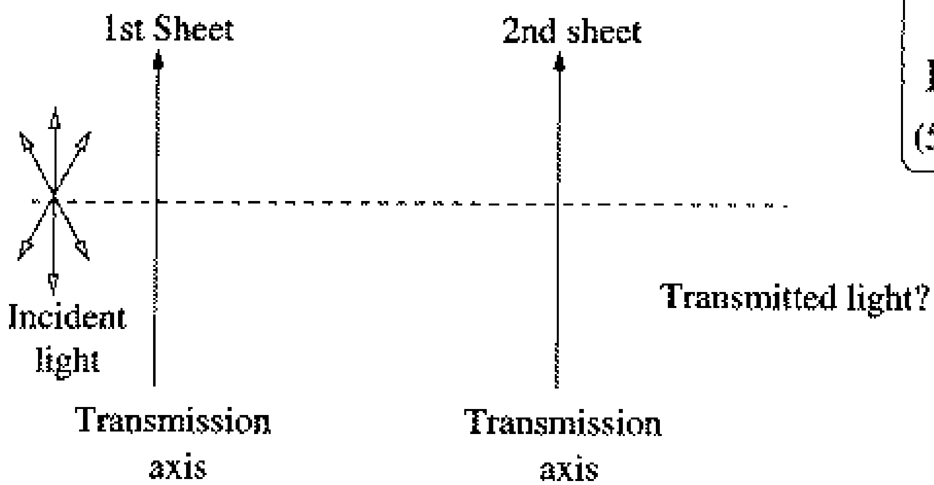
4) Polarization (15 points) (Show your work!)

Initially unpolarized light is incident upon 2 polarizers. These polarizers have their transmission axes oriented at 0 degrees relative to each other. If the incident light has an intensity of $I = 15.0\ W/m^2$ (light is moving to the right)

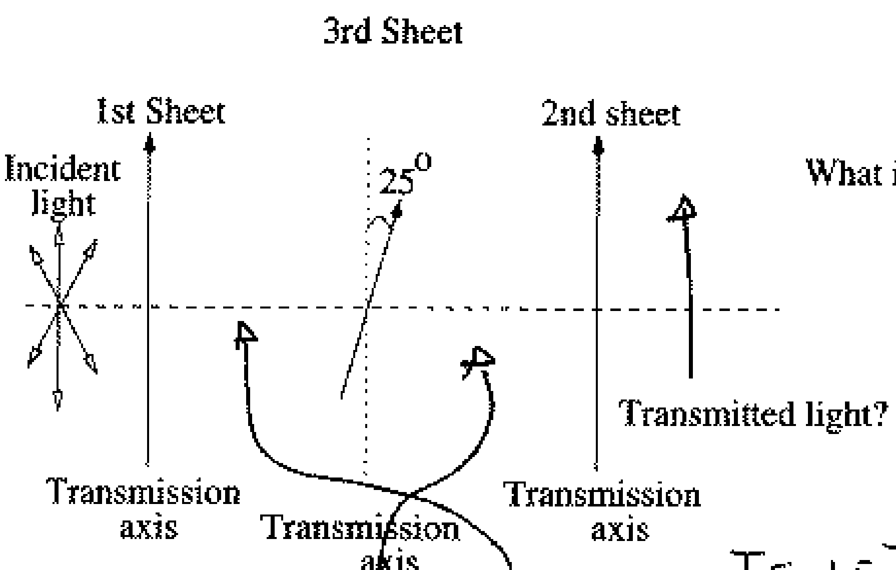
What is the intensity of the transmitted light?

$I = \frac{I_0}{2} = 7.5 \frac{W}{m^2}$

(5 pts.)



Now, a third sheet is inserted between the 1st and 2nd sheet at an angle of 25 degrees relative to the first sheet.(Indicate on the figure the direction of the transmitted Electric Field, if any. (2 pts.))



What is the intensity of the transmitted light?

$I = 5.06 \frac{W}{m^2}$

(8 pts.)

$I = \left(\frac{I_0}{2}\right) \cos^2 25^\circ$

$$I_{Final} = I \cos^2 25^\circ = \frac{I_0}{2} \cos^2 25^\circ \cos^2 25^\circ = 5.06 \frac{W}{m^2}$$