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

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

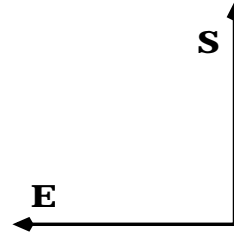c) A laser beam passes from air to glass. What happens to the frequency of this light?(2 pts)

  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)

S

E

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

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)

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

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?

X=

h

h/4

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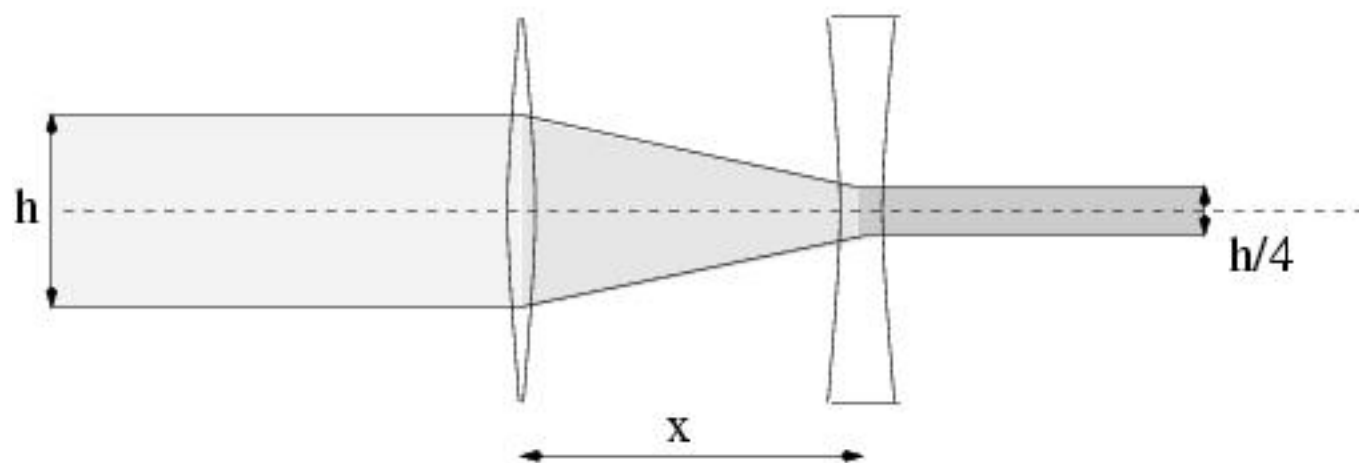
Now suppose I move the diverging lens to a position 20cm from the converging lens, and place an object 10 cm to the left of the converging lens. Where is the final image? Is it real or virtual?
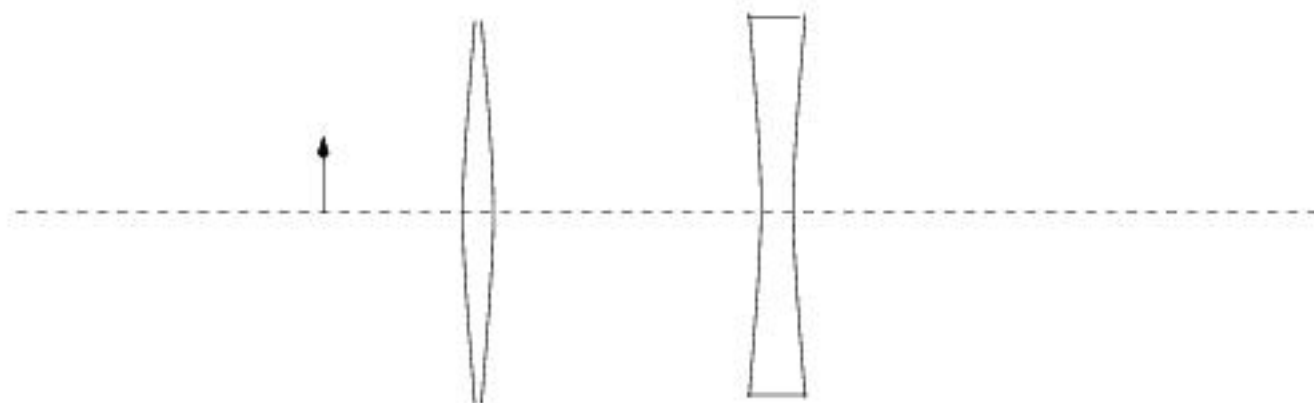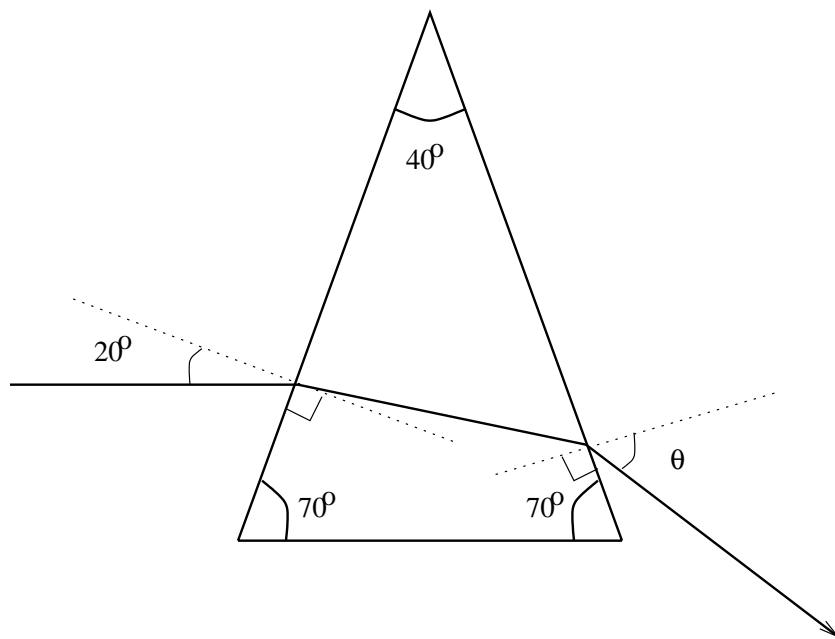
$q_{final} =$

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.


$\theta =$

(10 pts)

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.)

Red	n=1.55
Orange	n=1.65
Yellow	n=1.85
Green	n=2.05
Blue	n=2.25

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)
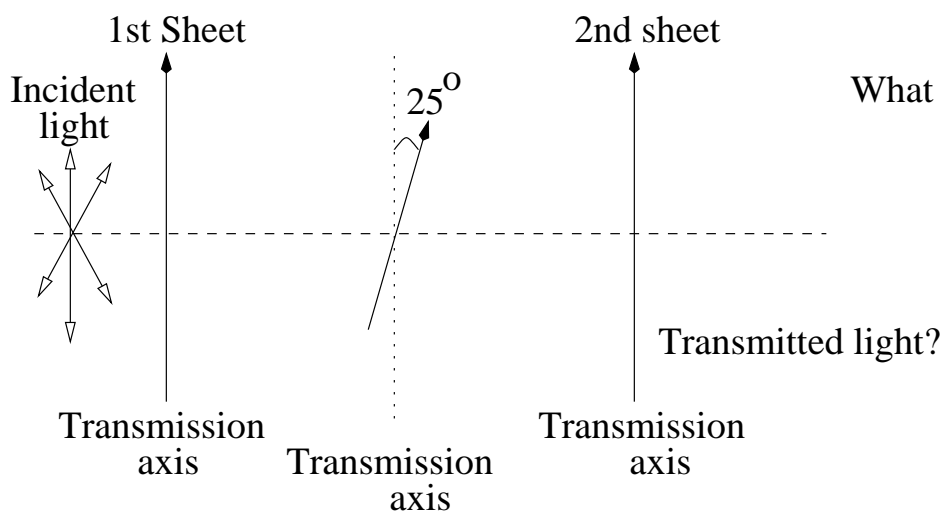
What is the intensity of the transmitted light?

I=

(5 pts.)

1st Sheet

2nd sheet

Incident
light

Transmitted light?

Transmission
axis
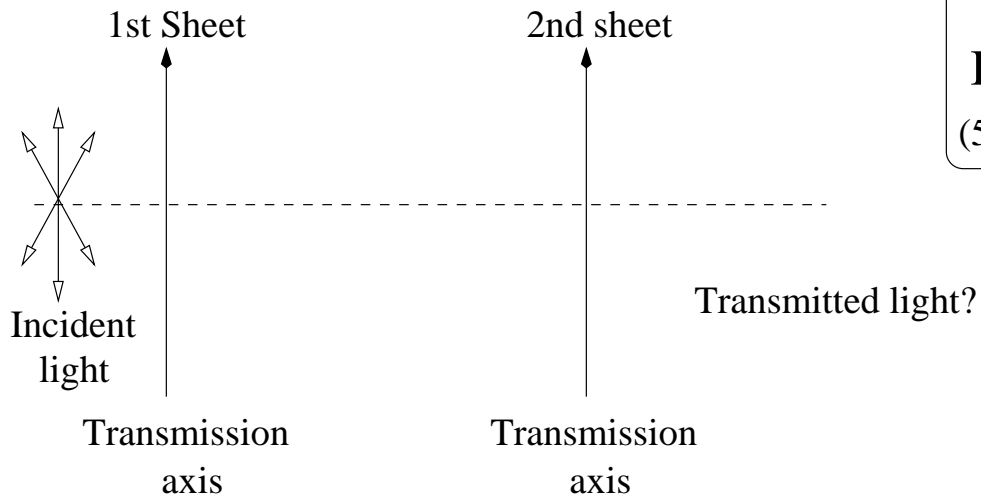
Transmission
axis

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.))

3rd Sheet

1st Sheet

2nd sheet

Incident
light

25°

What is the intensity of the transmitted light?

I=

(8 pts.)

Transmitted light?

Transmission
axis

Transmission
axis

Transmission
axis

Equations

$$I = \frac{dq}{dt}, \quad I = \int \vec{J} \cdot d\vec{A}, \quad V = IR, \quad P = IV, \quad \vec{F} = m\vec{a}$$

$$\phi_B = \int \vec{B} \cdot d\vec{A}, \quad \varepsilon = -\frac{d\phi_B}{dt}, \quad \phi_B = BA \; (sometimes), \quad \varepsilon = -L\frac{dI}{dt}$$

$$(Increasing) \quad I = I_0(1 - e^{-t/\tau}), \quad \tau = L/R, \quad (decreasing) \quad I = I_0 e^{-t/\tau}$$

$$\vec{F} = I\vec{l} \times \vec{B}, \quad d\vec{F} = I d\vec{l} \times \vec{B}, \quad \phi_E = \int \vec{E} \cdot d\vec{A}$$

$$\oint \vec{E} \cdot d\vec{s} = -\frac{d\phi_B}{dt}, \quad \oint \vec{B} \cdot d\vec{s} = \mu_0 \epsilon_0 \frac{d\phi_E}{dt} + \mu_0 I_{enclosed}, \quad I_{Displacement} = \epsilon_0 \frac{d\phi_E}{dt}$$

$$B = \mu_0 nI \quad (solenoid), \quad L = \mu_0 n^2 Al \quad (solenoid)$$

$$U_L = (1/2) \, LI^2, \quad U_C = (1/2) \, CV^2, \quad u_B = B^2/(2\mu_0), \quad u_E = \epsilon_0 E^2/2$$

$$c = E/B, \quad Pressure = S/c, \quad \vec{S} = (1/\mu_0) \, \vec{E} \times \vec{B}, \quad S_{av} = E_{max} B_{max}/(2\mu_0)$$

$$\vec{E} = \vec{E_0} \sin(kx - \omega t), \quad k = 2\pi/\lambda, \quad \omega = 2\pi f, \quad c_{vacuum} = \lambda f = 1/\sqrt{\epsilon_0 \mu_0}$$

$$n_1 \sin\theta_1 = n_2 \sin\theta_2 \; (Snell's \; Law), \quad \sin\theta_c = n_2/n_1, \quad n = c/v, \quad n_1\lambda_1 = n_2\lambda_2$$

$$E = E_0 \cos\theta_{polarizer}, \quad I = I_0 \cos^2\theta_{polarizer}, \quad \theta_{polarizer} = \theta_E - \theta_{axis}^{transmission}$$

$$I_{unpolarized} \rightarrow I_{unpolarized}/2, \quad Work = \int \vec{F} \cdot d\vec{l} = Fl, \quad Power = \frac{dW}{dt} = Fv$$

$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}, \quad M = -\frac{q}{p} = \frac{h'}{h}, \quad M_{overall} = M_1 \cdot M_2 \cdot M_3...$$

$$|f| = |R/2| \; (mirror), \quad \frac{n_1}{p} + \frac{n_2}{q} = \frac{n_2 - n_1}{R}, \quad \frac{1}{f} = (n-1)(\frac{1}{R_1} - \frac{1}{R_2})$$

Constants

$$\mu_0 = 4\pi \times 10^{-7} \, \frac{Tm}{A}$$
$$\epsilon_0 = 8.85 \times 10^{-12} \, \frac{C^2}{Nm^2}$$
$$c = 3.0 \times 10^8 \, m/s$$
$$g = 9.8 \, m/s^2$$