Instructor, A **section 118**

SFU Department of Physics

phys102q – Fall 2004 – Assignment 7.
Due Thr, Nov 11, 2004 at 23:59hrs. CAPA ID is **5263**

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1. [1 pt.] The electric field of an electromagnetic wave is given by;

E=8.35×10^{2}sin(7.85×10$^6\pi$(x-3.0×10^8t))

where everything is in SI units. What is the wave's frequency?

2. [1 pt.] What is the amplitude of the magnetic field associated with this TEM wave?

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3. [1 pt.] A beam of TEM harmonic waves has an irradiance of 16.80W/m^2. What is the amplitude of the electric field?

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4. [1 pt.] A woman stands between a vertical mirror 0.65m tall and a distant tree whose height is H. She is 2.90m from the mirror, and the tree is 17.8m from the mirror. If she sees the tree just fill the mirror, how tall is tree?

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5. [1 pt.] Sunlight strikes a piece of crown glass at an angle of incidence of 34.8 degrees. Calculate the difference in the angle of refraction between a red (660nm) and a violet (410nm) ray within the glass. The index of refraction for the red and the violet is n = 1.520 and n = 1.538, respectively.

6. [1 pt.] What is the minimum angle of incidence at which the red ray can hit the other side of the glass, where the ray is not refracted but total internally reflected.

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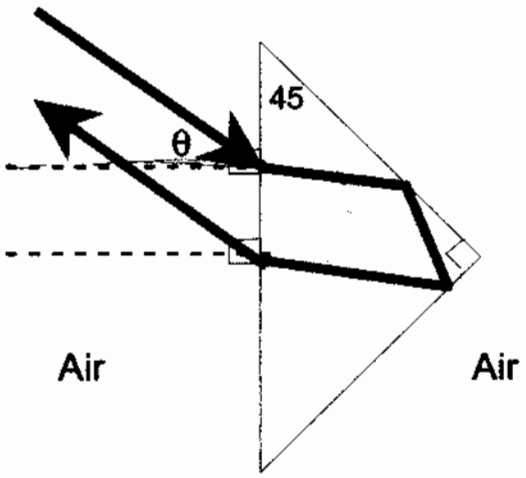
7. [1 pt.] A corner reflector is to be made from a triangular prism with index of refraction n=2.02, as shown in the diagram below. What is the maximum angle with respect to the normal to the front surface of the prism, θ, such that total reflection will occur? (Note: figure is not accurate; the angle of the first reflection should be equal to the angle of incidence.)



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8. [1 pt.] At 11:00hrs a 1.8-m-long vertical stick in air casts a shadow 1.2m long. If the same stick is placed in a flat bottomed pool of salt water half the height of the stick, how long is the shadow on the floor of the pool? (for this pool, n=1.54.)

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9. [1 pt.] A beam of white light, whose frequencies are mixed with equal intensity, is travelling within a piece of glass and impinges on a boundary to the air at an angle of incidence θ. The index of refraction of the glass increases with increasing angular frequency according to

$$n^2 = 1 + \frac{C}{\omega_0^2 - \omega^2 - C},$$

where C=443×10^{30}rad^2/s^2 and ω_0^2=600×10^{30}rad^2/s^2. At what angle of incidence should the light approach the boundary if we wish to allow only frequencies of ω=2.9×10^{15}rad/s (red light) and below to pass through to the air?

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10. [1 pt.] A point source of light is located 4.80m below the surface of a large lake of clear toxic fluid (Lake Ontario, where n=1.64.) Find the area of the largest circle on the pool's surface through which light coming directly from the source can emerge.

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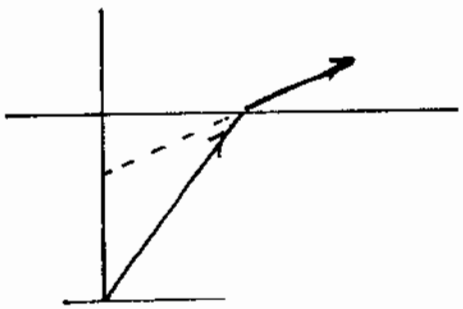
11. [1 pt.] Consider the following statements and consider which are true and which are false. (If, for example, 'B' is true and the rest are false then answer 'FTFFF' - No spaces, no commas.)

A)If one stands by a swimming pool, a person standing in the pool will seem to have short legs. T.
B)Light travels slower in glass than it does in a vacuum. T.
C)White light that is reflected from a surface will be separated into a visible spectrum. F
D)When light enters a medium with a lower index of refraction, the ray is bent farther away from the line normal to the boundary. T.
E)The path of a ray of light between two points is the path that maximizes the travel time. F



Physics 102

CAPA Set #7 Solutions

1. $E = E_0 \sin(kx - \omega t) = E_0 \sin(k x - 2\pi f \cdot t)$

Compared with: $E = 8.35 \times 10^{2} \cdot \sin(7.85 \times 10^{6} \pi x - 2.36 \times 10^{15} \pi t)$

$$2\pi f = 2.36 \times 10^{15} \pi .$$

$$f = \frac{2.36 \times 10^{15} \pi}{2\pi} = 1.18 \times 10^{15} \text{ Hz} .$$

2.

$$B_0 = \frac{E_0}{c} = \frac{8.35 \times 10^{2}}{3.00 \times 10^{8}} = 2.78 \times 10^{-6} \text{ T} .$$

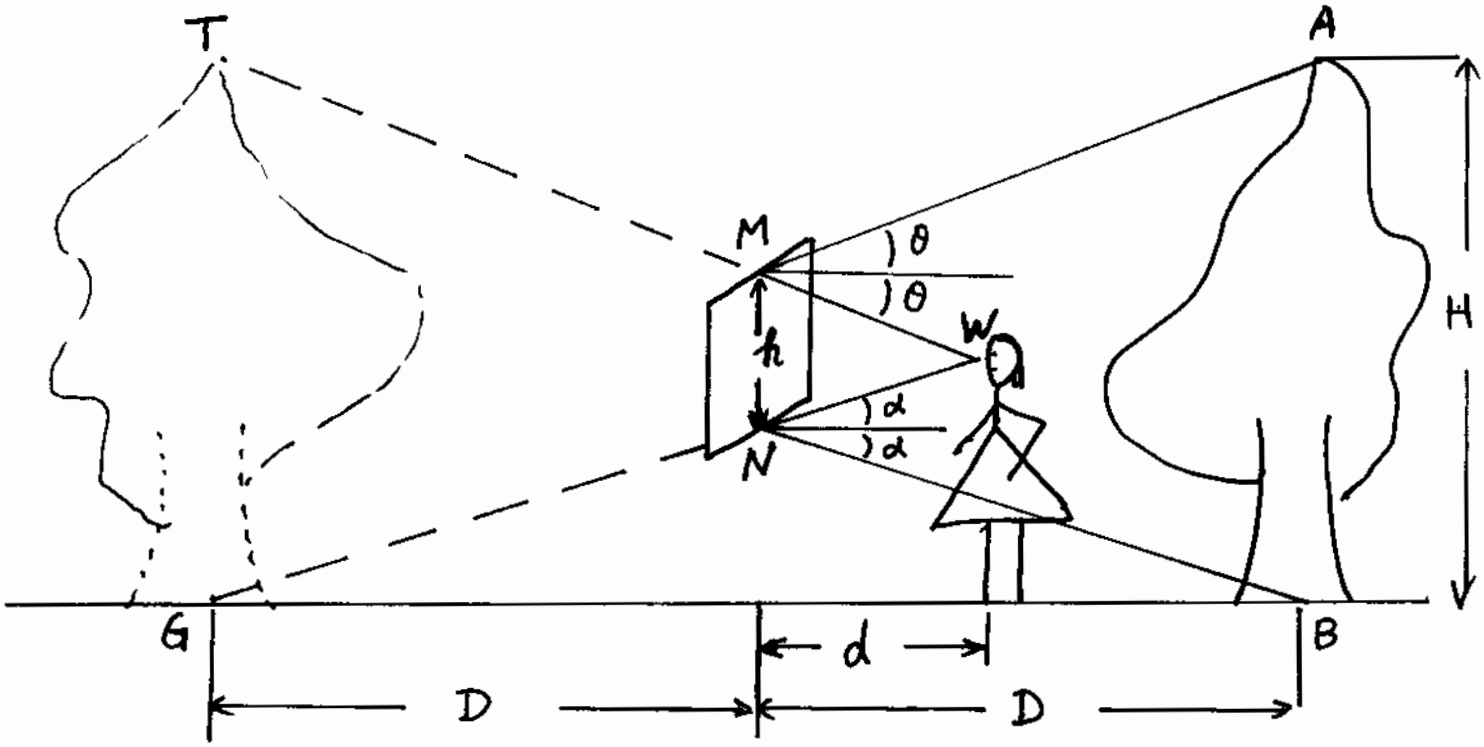
3.

$$I = 16.8 \text{ W/m}^2 = c \varepsilon_0 \cdot (E^2)_{ave} = c \varepsilon_0 E_{rms}^2$$

$$E_{rms} = \sqrt{\frac{I}{c \varepsilon_0}} = \sqrt{\frac{16.8}{3.00 \times 10^{8} \times 8.85 \times 10^{-12}}} = 79.5$$

$$E_0 = \sqrt{2}\, E_{rms} = 112 \text{ N/C} .$$

4.



~~Tree AB and wid~~

The image of the tree AB is TG.

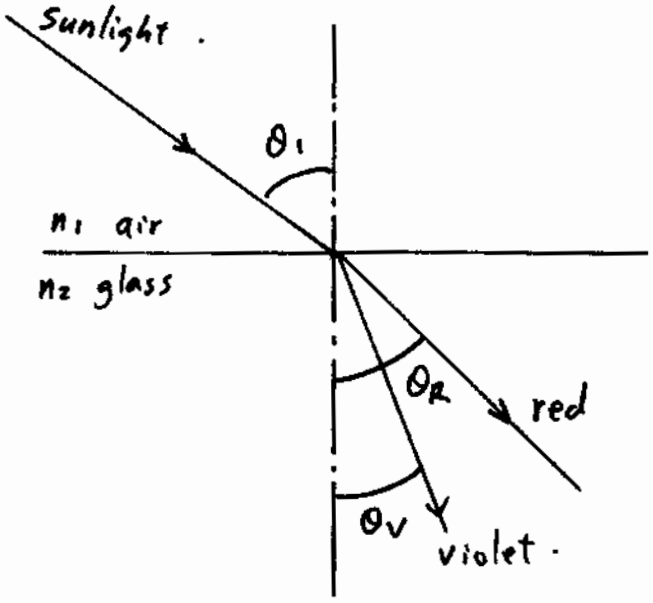
Since the mirror is vertically oriented, $MN \parallel TG$.

$\therefore \quad \Delta TWG \sim \Delta MWN$

$$\frac{H}{h} = \frac{d+D}{d}$$

$$H = \frac{(d+D)\,h}{d} = \frac{(2.9 + 17.8)(0.65)}{2.9} = 4.64 \text{ m}.$$

5.



$\theta_1 = 34.8°$

angle of refraction:

$$\theta_2 = \sin^{-1}\left(\frac{n_1}{n_2} \cdot \sin\theta_1\right)$$

Red:

$$\theta_R = \sin^{-1}\left(\frac{1.00}{1.520} \sin 34.8°\right)$$

$$= 22.053°$$

Violet:

$$\theta_V = \sin^{-1}\left(\frac{1.00}{1.538} \cdot \sin 34.8°\right)$$

$$= 21.782°$$

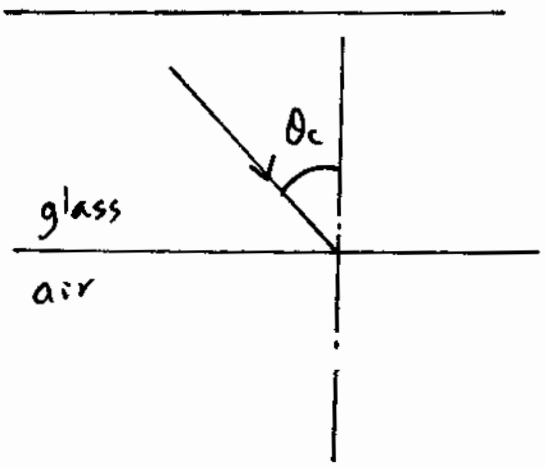
$$\Delta\theta = \theta_R - \theta_V = 0.271°$$

6. critical angle for red.

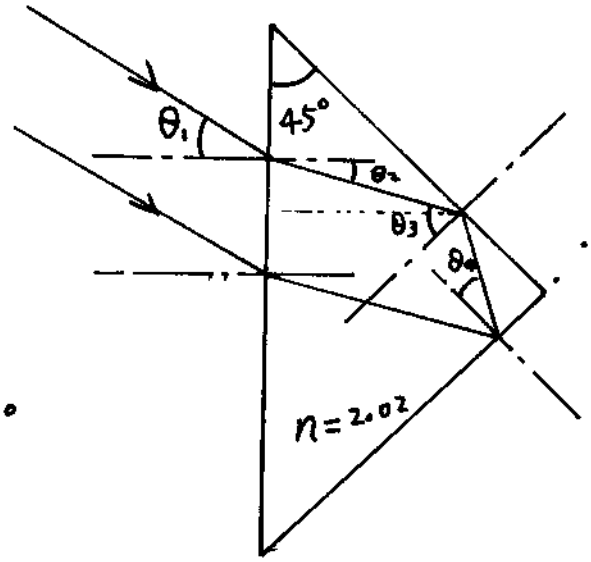
$$\theta_c = \sin\left(\frac{n_a}{n_g}\right)$$

$$= \sin^{-1}\left(\frac{1.00}{1.520}\right)$$

$$= 41.1°.$$



7.



Critical angle for total reflection inside the prism:

$$\theta_c = \sin^{-1}\left(\frac{1.00}{n}\right)$$

$$= \sin^{-1}\left(\frac{1.00}{2.02}\right) = 29.67^\circ$$

From the diagram:

$$\theta_3 = 45^\circ + \theta_2 > \theta_c. \quad \text{(always)}$$

$$\theta_4 = 90^\circ - \theta_3 = 45^\circ - \theta_2.$$

Minimum θ_4 for Total reflection: $\theta_4 = \theta_c$

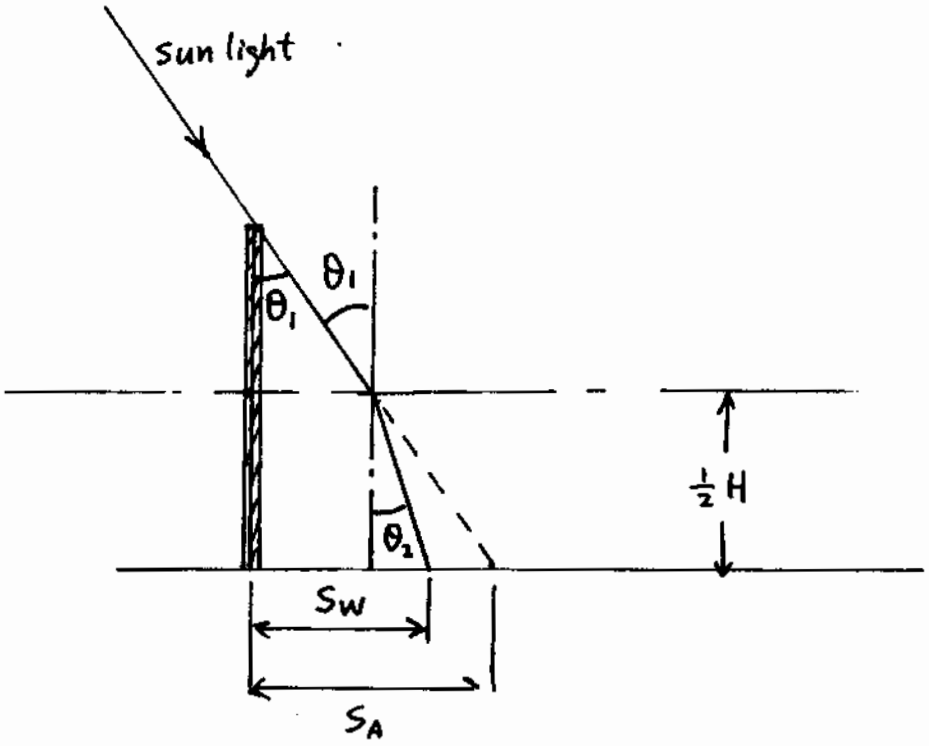
Then, $\theta_2 = 45^\circ - \theta_c = 45^\circ - 29.67^\circ = 15.33^\circ$

Maximum θ_1: $\theta_1 = \sin^{-1}\left(\frac{n}{n_1} \cdot \sin\theta_2\right)$

$$= \sin^{-1}\left(\frac{2.02}{1.00} \sin 15.33^\circ\right)$$

$$= 32.3^\circ$$

8.



Angle of incidence:

$$\theta_1 = \tan^{-1}\left(\frac{S_A}{H}\right)$$

$$= \tan^{-1}\left(\frac{1.2}{1.8}\right)$$

$$= 33.69^\circ$$

Angle of refraction:

$$\theta_2 = \sin^{-1}\left(\frac{n_1}{n_2}\sin\theta_1\right)$$

$$= \sin^{-1}\left(\frac{1.00}{1.54}\cdot\sin 33.69^\circ\right)$$

$$= 21.11^\circ$$

Length of shadow in water:

$$S_W = \frac{1}{2}S_A + \frac{1}{2}H\cdot\tan\theta_2 = \frac{1}{2}(1.2) + \frac{1}{2}(1.8)\cdot\tan 21.11^\circ$$

$$= 0.948\ m.$$

9.

$$n = \sqrt{1 + \frac{443\times10^{30}}{600\times10^{30} - (2.9\times10^{15})^2 - 443\times10^{30}}} = 1.995$$

$$\theta_c = \sin^{-1}\left(\frac{1.00}{1.995}\right) = 30.1^\circ$$

10.

$$\theta_c = \sin^{-1}\left(\frac{1.00}{1.64}\right)$$

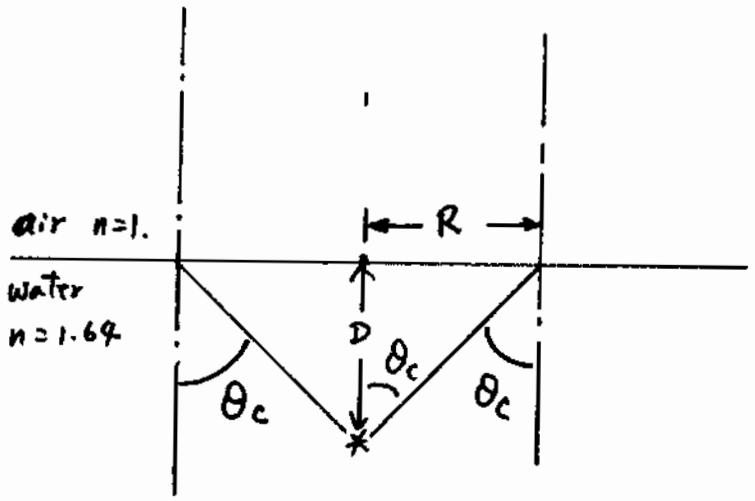
$$= 37.57^\circ$$

$$R = D \cdot \tan\theta_c$$

$$= 4.80 \times \tan 37.57^\circ$$

$$= 3.693 \text{ m}.$$

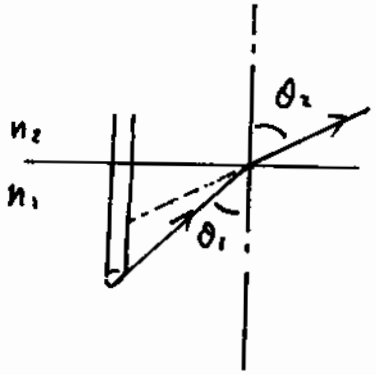
$$\text{Area} = \pi R^2 = 42.8 \text{ m}^2$$



11.

A). The legs seem to be shorter in water.

(T) ∵ when $n_1 > n_2$, $\theta_1 > \theta_2$.



B). $v = c/n$ $\quad n > 1$ in glass.

(T) $\quad \therefore \quad v < c$.

C). No! Dispersion occurs when light is refracted.

(F).

D). (T)

E). The path will minimise the travel time.

(F).