1. Consider the function:

$$\Psi(x,t) = e^{-(3x+2t)^2}\cos(240x+120t)$$

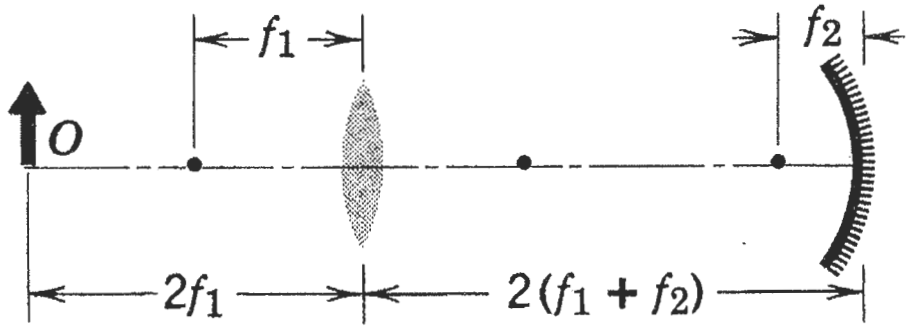
Is it a solution of the one dimensional wave equation? If so, what is the speed of propagation? Please explain. (6%)

2. A bottom-weighted vertical pole extends 2 m from the bottom of a swimming pool to a point 0.5m above the water. Sunlight is incident at 45° .What is the length of the shadow of the pole on the bottom of the pool? (6%) The refractive index of water is 1.33.

3. Consider the plight of an astronaut floating in free space with only a 10-W lantern (inexhaustibly supplied power). How long will it take to reach a speed of 20 m/s using the radiation as propulsion? (6%) The astronaut's total mass is 100kg.

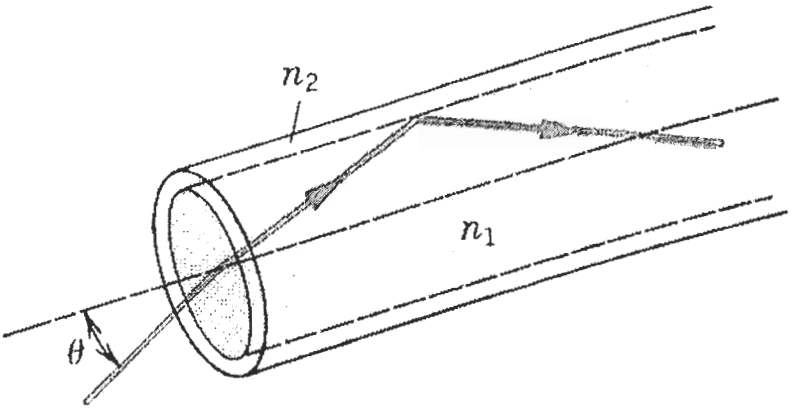
4. (a) At what angle of incidence will the light reflected from water be completely polarized? (5%) (b) Does the angle depend on the wavelength of light? Please explain. (3%) The refractive index of water is 1.33.

5. An erect object is placed a distance in front of a converging lens equal to twice the focal length f_1 of the lens. On the other side of the lens is a converging mirror of focal length f_2 separated from the lens by a distance $2(f_1+f_2)$. (a) Find the location, nature, and relative size of the final image (magnification), as seen by an eye looking toward the mirror through the lens. (6%)(b) Draw the appropriate ray diagram. (3%)

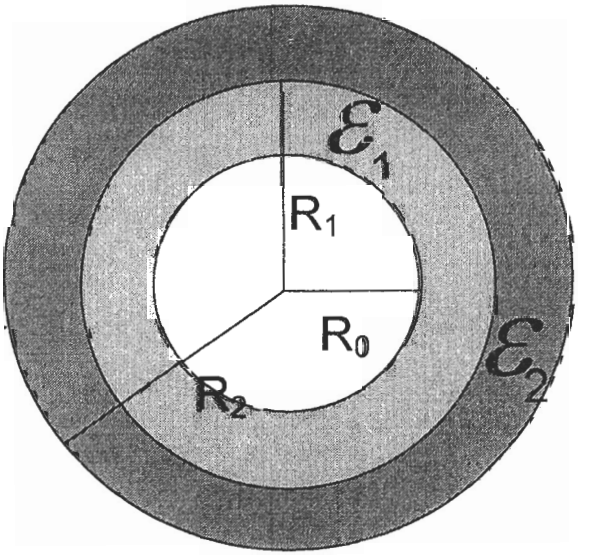


6. An optical fiber consists of a glass core (index of refraction n_1) surrounded by a coating (index of refraction $n_2<n_1$). Suppose a beam of light enters the fiber from air at an angle θ with the fiber axis as shown in the following figure. Show that the greatest possible value of θ for which a ray can be propagated down the fiber is given by (5%)

$$\theta = \sin^{-1}\sqrt{n_1^2 - n_2^2}$$



7. A spherical capacitor consists of an inner conducting sphere of radius R_0 and an outer conducting sphere of radius R_2. The space in-between is filled with two dielectric media of permittivity $\varepsilon_1, \varepsilon_2$ separated at radius R_1, as shown in the following figure.



(a) Calculate the total capacitance. (10%)

(b) If the inner conducting sphere has the electric potential of V and the outer

conducting sphere has the potential –V. Find the electric fields in dielectric regions. (10%)

8. A uniform plane wave is incident normally from a lossless medium 1 onto another lossless medium 2 through a plane boundary z = 0 in z-direction. The intrinsic impedances of medium 1 and 2 are η_1, η_2, respectively. The incident electric and magnetic filed intensity phasors are $E_i(z) = a_x E_{i0} e^{-j\beta_1 z}$, $H_i(z) = a_y \frac{E_{i0}}{\eta_1} e^{-j\beta_1 z}$
   (a) By finding the electric filed intensity and magnetic field intensity of the reflected and transmitted waves, derive the expressions of the reflection coefficient and transmission coefficient in terms of the intrinsic impedances. (show your work) (3 %)
   (b) Find the expressions of the electric field intensity and magnetic field intensity in media 1 and 2. (3 %)
   (c) Derive the time-average Poynting vectors in media 1 and 2. (3 %)
   (d) What is the relation between the reflection coefficient and the transmission coefficient ? (3 %)
   (e) What would happen to the incident wave if medium 2 is a perfect conductor? What would happen if the impedances of two media are perfectly matched? (3 %)

9. Consider a Faraday disk generator consisting of a circular metal disk rotating with a constant angular velocity ω in a uniform and constant magnetic field B that is parallel to the axis of rotation. The radius of the disk is b.
   (a) Find the expression of the open-circuit voltage V0 generated. (3 %)
   (b) What would be the voltage generated if the axis of rotation is tiled with an angle of π/6? (2 %)

10. A coaxial transmission line consists of a nonmagnetic inner conductor of radius $r = a$ and a nonmagnetic outer conductor between radius $2a < r < 4a$, as designated by Regions A and C, respectively, in the following plot. Region B between $a < r < 2a$ is filled with a nonmagnetic electric insulator. A dc electric current I flows in the inner conductor along the z direction and returns from the outer conductor in the $-z$ direction. The current distributes uniformly in both inner and outer conductors.

(a) What is the magnetic flux density in the inner conductor (Region A)? (2 %)

(b) What is the magnetic flux density between the two conductors (Region B)? (2%)

(c) What is the magnetic flux density in the outer conductor (Region C)? (3%)

(d) What is the magentic flux density in the regon $r > 4a$? (2%)

(e) What is the magnetic energy per unit length stored in Region A? (2%)

(f) What is the magnetic energy per unit length stored in Region B? (2%)

(g) What is the magnetic energy per unit length stored in Region C? (3%)

(h) What is the inductance per unit length of this coaxial transimission line? (4%)