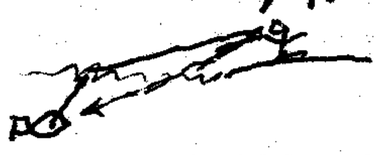
7. When rifle fishing, do you aim at, above, or below the image of a fish in the water, and WHY?

Aim below to compensate for refraction



8. A soap bubble with n=1.33 strongly reflects 550 nm light. What is its thickness?

Constructive $2nt = (m+1/2)\lambda_0$ pick $m=0$

$t = \frac{\lambda_0}{4n} = \frac{550nm}{4(1.33)} = 103\,nm$

9. What would happen to 550 nm light falling on a thin film of oil on water with the same thickness as the film in problem 8?

destructive interference, no relative π phase shift due to reflection.

Long Questions (20 points each), drop the low one.

1. A laser emits a beam with a diameter of 5.00 mm and a wavelength of 1.50 micrometers. The beam travels in empty space in the z direction, and has a power of 2.00 kW.

a) Write down an expression for the electric field of the laser as a function of position and time.

$E(z,t) = E_0 \sin(kz-\omega t)$ need E_0, k, ω

$k = \frac{2\pi}{\lambda} = 4.19\times10^{6}\,1/m$, $\omega = ck = 1.26\times10^{15}\,1/s$

$I = P/\pi r^2 = \frac{2000W}{\pi(0.0025m)^2} = 1.02\times10^{8}\,W/m^2 = \frac{1}{2}\varepsilon_0 c E_0^2$

so $E_0 = 2.77\times10^{5}\,V/m$

$E(z,t) = (2.77\times10^{5}\,V/m)\sin((4.19\times10^{6}\,1/m)z - (1.26\times10^{15}\,1/s)t)$

b) How much energy per unit volume is in the beam?

$u = I/c = 0.34\,J/m^3$

c) If the beam strikes a perfectly absorbing circular disc of diameter 2.5 mm, which lies perpendicular to the beam, how much force does it exert?

pressure $\rightarrow$ $P_r = \frac{F}{A} = I/c$ $\quad A = \pi\left(\frac{0.0025}{2}\right)^2 = 4.91\times10^{-6}\,m^2$ (Laser bigger than disc, use disc area)

$F = (0.34\,J/m^3)(4.91\times10^{-6}\,m^2) = 1.67\times10^{-6}\,N$

d) How much energy does the disc absorb in 10.0 s?

$I = \frac{Power}{Area}$ so $Power = IA = (1.02\times10^{8}\,W/m^2)(4.91\times10^{-6}\,m^2)$

$= 500\,W$

$Energy = Power \times time = 5000\,J$