Homework #7 solutions

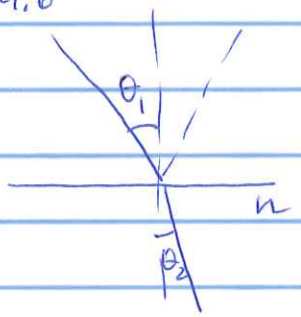
9.1

$$v = \frac{c}{n} = 1.28 \cdot 10^8 \text{ m/s}$$

$$Z = \sqrt{\mu_0/\varepsilon\varepsilon_0} = Z_0/n = 160\,\Omega$$

$$\lambda = \lambda_0/n = 269 \text{ nm}$$

9.6



$\theta_1 = 30°$ $\sin\theta_1 = 1/2$ $\cos\theta_1 = \sqrt{3}/2$

Snell's law $\sin\theta_1 = n \sin\theta_2$

$\sin\theta_2 = 1/3$ $\cos\theta_2 = 2\sqrt{2}/3$

Fresnel's equations for transmission and reflection

$$r_{\parallel} = \frac{n\cos\theta_1 - \cos\theta_2}{n\cos\theta_1 + \cos\theta_2} = 0.16$$

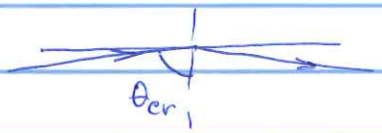
$$t_{\parallel} = \frac{2\cos\theta_1}{n\cos\theta_1 + \cos\theta_2} = 0.77$$

$$r_{\perp} = \frac{\cos\theta_1 - n\cos\theta_2}{\cos\theta_1 + n\cos\theta_2} = -0.24$$

$$t_{\perp} = \frac{2n\cos\theta_1}{\cos\theta_1 + n\cos\theta_2} = 0.76$$

9.10

$\sin\theta_{cr} = n$ $\theta_{cr} = \sin^{-1}(n) = \sin^{-1}(0.999) = 87.44°$



very grasing angle!

A1

$\lambda = 1.5\,cm$ $\quad k = \frac{2\pi}{\lambda} = 418\,m^{-1}$ $\quad \omega = \frac{2\pi c}{\lambda} = 1.26 \cdot 10^{11}\,rad/s$

$B_0 = \frac{E_0}{c} = 5.83 \cdot 10^{-7}\,T$ [Tesla]

Radiation pressure for a perfect reflector is twice higher than for a perfect absorber

$P = 2 \cdot I = E_0^2/c = 10^{-4}\,P_2$

A2

EM wave momentum density $p = I/c^2$

The momentum falling on an object of area A in time Δt

$\Delta p = p \cdot A \cdot c\,\Delta t = I/c^2 \cdot A \cdot c\,\Delta t = \frac{I \cdot A}{c} \cdot \Delta t = \frac{P}{c}\Delta t$ power

$\frac{\Delta p}{dt} = \frac{P}{c}$ momentum conservation: for an astronaut same change of her momentum

$F = ma = \frac{dP}{dt} = \frac{P}{c}$ $\quad a = \frac{P}{mc} = \frac{1000\,W}{70kg \cdot 3 \cdot 10^8\,m/s} = 4.7 \cdot 10^{-9}\,m/s$

Travel time across 10m: $t = \sqrt{2d/a} = 6.5 \cdot 10^4\,s$

18 hours!