PHY 385 Optics Test 1, version 1.

1. C 2. A 3. G 4. E 5. A 6. C

v.2: 1. A 2. D 3. A 4. B 5. E 6. C

LA1. $c = \lambda f \Rightarrow \lambda = \frac{c}{f}, \quad f = \frac{c}{\lambda} = \frac{3\times10^8}{520\times10^{-9}}$

v.2: f = [illegible] 6.7

$$\boxed{f = 5.8\times10^{14}\ s^{-1}} \quad \text{or} \quad \boxed{\omega = 3.6\ \frac{rad}{s}}$$

(v.2: 4.2)

LA2. $I = \frac{c\epsilon_0}{2} E_0^2 \Rightarrow E_0 = \sqrt{\frac{2I}{c\epsilon_0}} = \sqrt{\frac{2(1.37\times10^3)}{(3\times10^8)(8.85\times10^{-12})}}$

$$\boxed{E_0 = 1020\ V/m}$$

LA3 (a) $n_1 \sin\theta_i = n_2 \sin\theta_t$

$\theta_t = \sin^{-1}\left(\frac{n_1}{n_2}\sin\theta_0\right) = \sin^{-1}(1.5 \sin 33.69)$

$$\boxed{\theta_t = 56.3°}$$

(b) $r_\perp = \frac{n_1\cos\theta_i - n_2\cos\theta_t}{n_1\cos\theta_i + n_2\cos\theta_t} = \frac{1.5\cos 33.69 - \cos 56.31}{1.5\cos 33.69 + \cos 56.31}$

$r_\perp = 0.385$

$R = r_\perp^2 = 0.148$

$I_r = I_i R = (3.85)0.148$

$$\boxed{I_r = 0.57\ W/m^2}$$

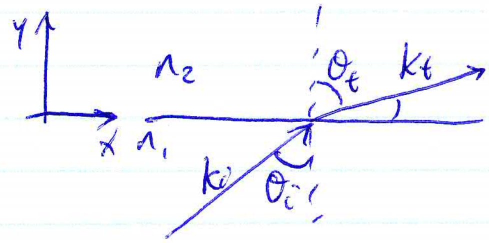
(c) Note $\theta_c = \sin^{-1}\left(\frac{n_1}{n_2}\right) = \sin^{-1}\left(\frac{1}{1.5}\right) = 42°$

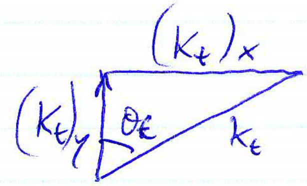
$\theta_i > \theta_c \Rightarrow$ Total internal reflection

$$\Rightarrow \boxed{I_r = I_i = 3.85\ W/m^2}$$

Test 1, version 1 (2)

LA3
(d)





Transmitted beam:

$$\vec{E}_t = \vec{E}_0 e^{i(\vec{k}_t \cdot \vec{r} - \omega t)}$$

$$\vec{E}_t = \vec{E}_0 e^{i(k_t \sin\theta_t x + k_t \cos\theta_t y - \omega t)} \quad (*)$$

Snell's Law: $n_1 \sin\theta_i = \cancel{n_2}^{\,1} \sin\theta_t$

$$\sin\theta_t = n_1 \sin\theta_i$$

$$\cos\theta_t = \sqrt{1 - \sin^2\theta_t} = \underbrace{\sqrt{1 - n_1^2 \sin^2\theta_i}}_{\text{negative}}$$

$$\Rightarrow \quad \cos\theta_t = i\sqrt{n_1^2 \sin^2\theta_i - 1}$$

(*) becomes:

$$\vec{E}_t = \vec{E}_0 e^{i(k_t n_1 \sin\theta_i x + i k_t \sqrt{n_1^2 \sin^2\theta_i - 1}\, y - \omega t)}$$

$\frac{c}{n_2} = \frac{\omega}{k_t}$, $\omega = \frac{2\pi c}{\lambda_0}$

$\Rightarrow k_t = \frac{2\pi n_2}{\lambda_0}$

Set $k' = k_t n_1 \sin\theta_i$

$$\beta = k_t \sqrt{n_1^2 \sin^2\theta_i - 1}$$

$$\vec{E}_t = \vec{E}_0 \left(e^{-\beta y}\right) e^{i(k' x - \omega t)}$$

where $\beta = \frac{2\pi n_2}{\lambda_0} \sqrt{n_1^2 \sin^2\theta_i - 1} = \underbrace{\frac{2\pi}{600\times 10^{-9}}}_{1.05\times 10^7} \underbrace{\sqrt{(1.5 \sin 80)^2 - 1}}_{1.087}$

$$\boxed{\beta = 1.1\times 10^7 \text{ m}^{-1}}$$