1. a). $\Delta\nu_{FSR} = 1.8\ GHz.$

b). $\Delta\nu_{FSR} = \dfrac{c}{2d}$

$$d = \frac{c}{2\Delta\nu_{FSR}} = \frac{3\cdot 10^8\ m/s}{2\cdot 1.8\cdot 10^9\ 1/s} = 0.083\ m = 8.3\ cm.$$

c). $\dfrac{\Delta\nu}{\nu} = -\dfrac{\Delta d}{d}$ $\qquad \Delta\nu = \dfrac{\Delta\nu_{FSR}}{2}$

$$\Delta d = -\frac{d}{\nu}\Delta\nu = -\frac{\cancel{d}}{\nu}\times\frac{c}{4\cancel{d}} = -\frac{c}{4\nu} = -\frac{\lambda_0}{4} = -147\ nm.$$

d). $T_{FP}(\delta) = \dfrac{1}{1+F\sin^2\frac{\delta}{2}}$

$$\delta = \frac{4\pi d}{\lambda_0}.$$

$$F = \frac{4R}{(1-R)^2} = \frac{4\cdot 0.99}{0.01^2} \approx 4\cdot 10^4.$$

$$\frac{T(0)}{T(\pi)} = 1+F \approx 4\cdot 10^4.$$

e). $\mathcal{F} = \dfrac{\pi\sqrt{F}}{2} \approx 314.$

f). $\Delta\nu_{FWHM} = \dfrac{\Delta\nu_{FSR}}{\mathcal{F}} = \dfrac{1.8\ GHz}{314} = 5.73\ MHz.$

2. a). $k_x = 10^7\ 1/m$

$k_z = \sqrt{3}\cdot 10^7\ 1/m$

$k_i = \sqrt{k_x^2+k_z^2} = 2\cdot 10^7\ 1/m.$

b). $\vec{k}_i = k_x\hat{x} + k_z\hat{z} = 2\cdot 10^7\ 1/m \times \left(\dfrac{\hat{x}+\sqrt{3}\hat{z}}{2}\right).$

c). $\omega = 3\cdot 10^{15}\ rad/s$

$\nu = 4.77\cdot 10^{14}\ Hz = \dfrac{\omega}{2\pi}.$

d). $k_i = \dfrac{\omega}{c}n_i = \dfrac{\omega}{c}\sqrt{\varepsilon_i}$

$$\varepsilon_i = \left(\frac{k_i}{\omega/c}\right)^2 = \left(\frac{2\cdot\cancel{10^7}\ 1/m\cdot\cancel{3}\cdot\cancel{10^8}\ m/s}{\cancel{3}\cdot\cancel{10^{15}}\ 1/s}\right)^2 = 4.$$

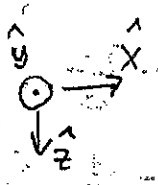
e). $B_i = \frac{E_i}{c/\sqrt{\varepsilon_i}} = \left(4\cdot 10^{-8} \underbrace{\frac{V\cdot s}{m^2}}_{\text{Tesla}}\right) \times \cos\left[\left(10^7\, 1/m\right)x + \left(\sqrt{300}\cdot 10^6\, 1/m\right)z - \left(3\cdot 10^{15}\, \frac{1}{s}\right)\right]$

$\frac{c}{\sqrt{\varepsilon_i}} = 1.5\cdot 10^8\ m/s$

$\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$

$i\vec{k}\times\vec{E} = i\omega\vec{B}$

$\vec{B} = \vec{k}\times\vec{E} \longrightarrow \vec{B} \uparrow\uparrow +\hat{y}.$



f). $k_x = \frac{1}{2}k_i = k_i \sin\theta_i$

$\theta_i = 30^\circ = \sin^{-1}\frac{1}{2}$

$2\sin 30^\circ = \frac{2}{\sqrt{3}}\sin\theta_t.$

$\sin\theta_t = \frac{\sqrt{3}}{2}$

$\theta_t = 60^\circ.$

$\theta_i + \theta_t = 90^\circ \rightarrow$ Brewster angle.

g). p-polarization: $E_z = 0$ at Brewster angle.

3. a). 0.

b). 0.

c). 2 parallel QWPs = 1 HWP.

I_0.

d). Circular pol. after 1st QWP.
Becomes linear at +45° wrt OA of the 2nd QWP.
This is at -45° wrt to 2nd polarizer.
$I_0/2$.

e). 0.