1. Express the wave function for one-dimensional harmonic waves in terms of the following parameters:

starting place ↘

$y(x) = A\cos(k(x - vt) + \phi)$

or

$y(x) = A\cos(kx - \omega t + \phi)$

   - Frequency and wavelength
   - Period and wavelength
   - Angular frequency and wave vector

1) $y(x) = A\cos\left(\frac{2\pi x}{\lambda} - 2\pi\nu t + \phi\right)$

2) $y(x) = A\cos\left(\frac{2\pi x}{\lambda} - \frac{2\pi}{T}t + \phi\right)$

3)

$\omega\left(t - \frac{x}{c}\right) = \omega t - \frac{\omega x}{c}$

2. Consider the plane electromagnetic wave in vacuum (in SI units) given by the expressions:
$E_x = 0$
$E_y = 4\cos[2p * 10^{14}(t - x/c) + p/2]$
$E_z = 0$

not sure about $p \to \pi$?

but $k \cdot v = \omega$

and $v = \frac{\omega}{k} = \lambda \cdot \nu$

   - Calculate the frequency, wavelength, direction of motion, amplitude, initial phase angle, and polarization of the wave.
   - Write an expression for the magnetic flux density.

4 ← amplitude

initial phase angle → $\pi/2$

polarization → y-direction

so since

$\omega = 2\pi \cdot 10^{14}$ $\omega = 2\pi\nu$

then $\nu = 10^{14}$ Hz

$\lambda = \frac{2\pi}{k} = \frac{2\pi c}{\omega}$

but also $\lambda = \frac{v}{\nu}$

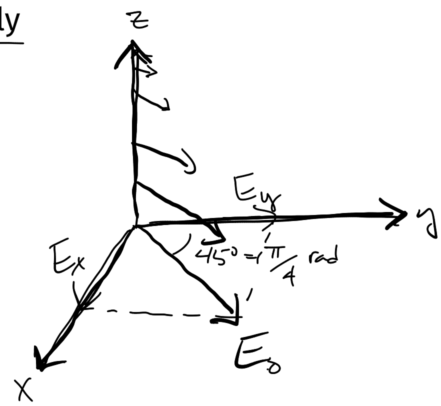
so $\lambda = \frac{c}{10^{14}} = \frac{3 \cdot 10^{8}}{10^{14}}$

$= 3 \cdot 10^{-6}$

$= 3\,\mu m$

3. Write an expression for the $\vec{E}$ and $\vec{B}$ fields that constitute a plane harmonic wave traveling in the $+z$-direction. The wave is linearly polarized with its plane of vibration at 45° to the yz-plane.

$$\vec{k} = k_z \hat{z}$$



$$E_x = \frac{E_0\sqrt{2}}{2}\cos(k_z z - \omega t)$$

$$E_y = \frac{E_0\sqrt{2}}{2}\cos(k_z z - \omega t)$$

$$E_z = 0$$

$$\vec{B} = \frac{\vec{k}\times\vec{E}}{\omega} = \begin{vmatrix} \hat{x} & \hat{y} & \hat{z} \\ 0 & 0 & k_z \\ E_x & E_y & 0 \end{vmatrix}$$

4. A 500-nm harmonic EM wave, whose electric field is in the z-direction, is traveling in the y-direction in vacuum. ↳ $n=1$, $v=c$

$$\vec{k} = 1.26\cdot 10^{7}\,\frac{\text{rad}}{\text{m}}\,\hat{z}$$

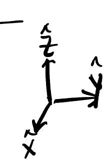
- What is the frequency of the wave?
- Determine both v and k for this wave. → $v = c$, $k = \frac{2\pi}{\lambda} = 1.26\cdot 10^{7}\,\frac{\text{rad}}{\text{m}}$
- If the electric field amplitude is 700 V/m, what is the amplitude of the magnetic field? → $|B| = \frac{|E|}{c} = \frac{700\,\text{V/m}}{3\cdot 10^{8}\,\text{m/s}} = \underline{2.3\cdot 10^{-6}\,\text{T}}$
- Write an expression for both $E(t)$ and $B(t)$ given that each is zero at $x = 0$ and $t = 0$. Put in all the appropriate units.

$\lambda = 500$ nm, so $\nu = \frac{c}{\lambda} = \frac{3\cdot 10^{8}\,\text{m/s}}{500\cdot 10^{-9}\,\text{m}} = 6\cdot 10^{14}$ Hz → $\omega = 2\pi\cdot f = 3.77\cdot 10^{15}\,\text{rad/s}$

$$E_x(t) = 700\,\frac{\text{V}}{\text{m}}\cos\left(1.26\cdot 10^{7}\,\frac{\text{rad}}{\text{m}}\cdot z - 3.77\cdot 10^{15}\,\frac{\text{rad}}{\text{s}}\,t\right)$$

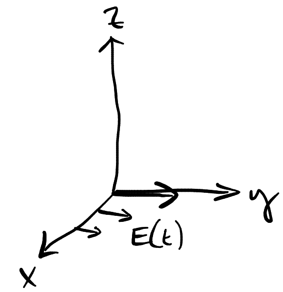
$$B_y(t) = \frac{700\,\frac{\text{V}}{\text{m}}}{3\cdot 10^{8}\,\frac{\text{m}}{\text{s}}}\cos\left(1.26\cdot 10^{7}\,\frac{\text{rad}}{\text{m}}\cdot z - 3.77\cdot 10^{15}\,\frac{\text{rad}}{\text{s}}\,t\right)$$

$$\vec{B} = \frac{\vec{k}\times\vec{E}}{\omega} = \frac{k_z\hat{z}\times E_x\hat{x}}{\omega} = \frac{E_x}{c}(+\hat{y})$$



$$B_y(t) = 2.33\,\text{T}\cdot\cos\left(1.26\cdot 10^{7}\,\frac{\text{rad}}{\text{m}}\cdot z - 3.77\cdot 10^{15}\,\frac{\text{rad}}{\text{s}}\,t\right)$$

5. Consider a linearly polarized plane electromagnetic wave traveling in the $+x$-direction in free space having as its plane of vibration the xy-plane. Given that its frequency is 5 MHz and its amplitude is $E_0 = 0.05\,\text{V/m}$



- Find the period and wavelength of the wave.
- Write an expression for $E(t)$ and $B(t)$.
- ~~Find the flux density, $< S >$, of the wave.~~

$\nu = 5 \cdot 10^6\,\text{Hz}$ $\quad \frac{1}{\nu} = T = 2 \cdot 10^{-7}\,\text{s}$ ✓

$\lambda \cdot \nu = c$

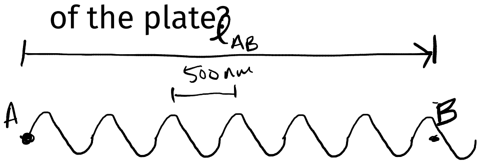
$\lambda = \frac{c}{\nu} = \frac{3 \cdot 10^8\,\text{m/s}}{5 \cdot 10^6\,\text{Hz}} = 60\,\text{m}$

$E_x = 0$

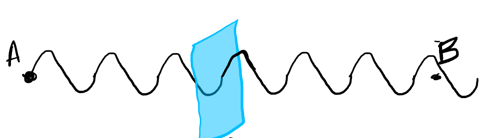
$E_y = 0.05\,\frac{\text{V}}{\text{m}} \cos\left(\frac{2\pi}{60\,\text{m}} x - \frac{2\pi}{2 \cdot 10^{-7}\,\text{s}} t\right)$

$E_z = 0$

6. A light wave travels from point A to point B in vacuum. Suppose we introduce into its path a flat glass plate ($n = 1.50$) of thickness $L = 1.00\,\text{mm}$. If the vacuum wavelength is 500 nm, how many waves span the space from A to B with and without the glass in place? What phase shift is introduced with the insertion of the plate?



$\frac{l_{AB}}{\lambda_{vac}}$ = # of wavelengths from A to B in vacuum



$\lambda_{glass} = \frac{\lambda_{vac}}{n} = \frac{500\,\text{nm}}{1.50} = 333\,\text{nm}$

$\frac{l_{AB} - 1.00\,\text{mm}}{\lambda_{vac}} + \frac{1.00\,\text{mm}}{\lambda_{glass}}$

$\frac{l_{AB}}{\lambda_{vac}} - \frac{1.00\,\text{mm}}{\lambda_{vac}} + \frac{1.00\,\text{mm} \cdot n}{\lambda_{vac}}$

wavelengths from A to B w/ glass in the way

$\frac{l_{AB} - 1.00\,\text{mm} + 1.00\,\text{mm} \cdot n}{\lambda_{vac}} = \boxed{\frac{l_{AB} + 1.00\,\text{m}(n-1)}{\lambda_{vac}}}$