HOMEWORK 3 – SOLUTIONS TO PROBLEMS

22 C 1: **a)** Voltages are out of phase, so the peak amplitudes occur at different times, ensuring that the amplitude of the resultant R-L-C waveform is not the sum the amplitudes of the constituent waveforms.

b) Yes. By Kirchhoff's loop rule, the instantaneous source voltage is the sum of the instantaneous voltage drops across each circuit element.

22 C 4: $X_c = \dfrac{1}{2\pi f C}$. So the reactance (the hindrance of charge flow) decreases with increasing AC frequency f. In the limit of arbitrary large f ($f \to \infty$), $X_C \to 0$, i.e. current flow is completely unhindered, as if the capacitor were replaced by in a highly conductive wire. This is the definition of a short circuit.

22 C5: $X_L = \omega L$. As ω becomes exceedingly high, the impedance becomes exceedingly low, which approaches the behavior of an open circuit at the location of the inductor.

22 MC 1: D. 0 Amps. The *average* current in any AC circuit is zero.

22 MC 10: Answer is C. This is the resonant frequency of the circuit, i.e. the frequency at which the circuit's current is greatest.

23 C 1: Radio waves can be polarized simply the choice of the antenna that produces them. Sound waves cannot be polarized, because they are longitudinal – the direction of oscillation is the as that of the propagation of the wave.

23 C 3: If an incident pulse has momentum P, the change momentum is as follows

reflection: $\Delta P = P_{incident} - P_{final} = P_{incident} - P_{reflected} = P - (-P) = 2P$
absorption: $\Delta P = P_{incident} - P_{final} = P - 0 = P$

The force delivered by each pulse is proportional to the change in its momentum. The pressure is proportional to the force, and thus is also proportional to the change in momentum. Hence, the pressure on a reflective is twice that on a perfectly absorbing one.

23 C 7: No. The speed of light in the atmosphere is very near that of light in a vacuum, because its index of refraction is very close to 1. Moreover, the atmosphere is a miniscule fraction of the distance between the earth and the sun.

23 MC 1: D. Wavelength would be halved, but speed would remain the same.

23 MC 3: A, B, E.

23 MC 7: A

23.10. Set Up: $c = 3.00 \times 10^8$ m/s. $c = f\lambda$ and $k = \frac{2\pi}{\lambda}$. Larger λ corresponds to smaller f and k.

Solve: **(a)** $f = \frac{c}{\lambda}$. UVA: 7.50×10^{14} Hz to 9.38×10^{14} Hz. UVB: 9.38×10^{14} Hz to 1.07×10^{15} Hz.

(b) $k = \frac{2\pi}{\lambda}$. UVA: 1.57×10^7 rad/m to 1.96×10^7 rad/m. UVB: 1.96×10^7 rad/m to 2.24×10^7 rad/m.

23.11. Set Up: $c = 3.00 \times 10^8$ m/s. $c = f\lambda$. $T = \frac{1}{f}$. $k = \frac{2\pi}{\lambda}$.

Solve: $f = \frac{c}{\lambda} = 3.0 \times 10^{18}$ Hz, $T = \frac{1}{f} = 3.3 \times 10^{-19}$ s, $k = 6.3 \times 10^{10}$ rad/m.

23.19. Set Up: Intensity is average power per unit area and power is energy per unit time. $I = \frac{1}{2}\epsilon_0 c E_{max}^2$ and $E_{max} = cB_{max}$.

Solve: **(a)** For the beam, energy $= Pt = (2.0 \times 10^{12}\text{ W})(4.0 \times 10^{-9}\text{ s}) = 8.0 \times 10^3\text{ J} = 8.0$ kJ. This is spread uniformly over 100 cells, so the energy given to each cell is 80 J.

(b) The cross sectional area of each cell is $A = \pi r^2$, with $r = 2.5 \times 10^{-6}$ m.

$$I = \frac{P}{A} = \frac{2.0 \times 10^{12}\text{ W}}{(100)\pi(2.5 \times 10^{-6}\text{ m})^2} = 1.0 \times 10^{21}\text{ W/m}^2$$

(c) $$E_{max} = \sqrt{\frac{2I}{\epsilon_0 c}} = \sqrt{\frac{2(1.0 \times 10^{21}\text{ W/m}^2)}{(8.85 \times 10^{-12}\text{ C}^2/\text{N}\cdot\text{m}^2)(3.00 \times 10^8\text{ m/s})}} = 8.7 \times 10^{11}\text{ V/m}.$$

$$B_{max} = \frac{E_{max}}{c} = 2.9 \times 10^3\text{ T}$$