1. Find $\omega$, $k_o$, $\lambda_o$, $n$, $k$, $\lambda$, $u_p$, $\alpha = 2k''$ (the power attenuation constant), and $\delta_s$ if:

(a) $f = 500 \text{ MHz}$ and $\epsilon_r = 8$.
(b) $f = 500 \text{ MHz}$ and $\epsilon_r = 8 - j5$.
(c) $f = 6.9 \text{ GHz}$ and $\epsilon_r = 8 - j5$.
(d) $f = 6.9 \text{ GHz}$ and $\epsilon_r = 30 - j10$.

Remember that $n$ and $k$ are complex in general. Consider writing a short MATLAB code to verify your calculations. Consider organizing your answers in a table.

2. Given a medium with some refractive index $n$:

(a) what happens to the power attenuation constant $\alpha = 2k''$ as the frequency increases?
(b) what happens to the skin depth $\delta_s$ as the frequency increases?

3. Again visit the simulation “Wave on a String” on the PHET website. Set to “No End.” Set to “Oscillate.” Use the setting shown in Figure 1. What material electrical property (constitutive property) is analogous to “damping” in the simulation?

4. Consider the ocean surface to be the $x$-$y$ plane at $z = 0$ and that $z$ increases as you travel farther away from the surface, deeper into the ocean. A uniform plane wave is propagating in the $+\hat{z}$ direction. The constitutive parameters of sea water are $\epsilon_r = 82$, $\mu_r = 1$, and the conductivity $\sigma = 6 \text{ S m}^{-1}$. If the magnetic field at $z = 0^+$ (just inside the ocean, so we are not concerned with surface effects) is

$$\mathbf{H}(z = 0^+, t) = \hat{y} 150 \cos \left(4\pi \times 10^3 t + \frac{\pi}{9}\right) \text{ mA m}^{-1}$$

(1)

(a) find the time harmonic form of the magnetic field, $\tilde{\mathbf{H}}(z)$, for $z > 0$;
(b) find the time harmonic form of the electric field, $\tilde{\mathbf{E}}(z)$, for $z > 0$;
(c) find the real, time–dependent electric fields $\mathbf{H}(z, t)$ and $\mathbf{E}(z, t)$, for $z > 0$;
(d) determine at what depth the electric field is 5% of its value at $z = 0^+$.

5. Consider the soil surface to be the $x$–$y$ plane at $z = 0$ and that $z$ increases as you travel farther away from the surface, deeper into the soil.

(a) Make a single MATLAB figure of the ratio $|S_{av}(z)|/|S_{av}(z = 0^+)|$ as a function of $z$ for two soils, one with $\epsilon_r = 5 - j$ and one with $\epsilon_r = 25 - j5$, at 1.4 GHz.
(b) Create a duplicate figure with the ratio expressed in dB.

6. Use “Radio Waves” on the PHET website to explore wave motion. Play and experiment. Then answer the following.

(a) Even though the radiation propagating away from the radio station antenna is traveling through air (which can be approximated well by free–space), the magnitude of the field decreases. Why? Hint: think about energy conservation, a control volume around the transmitting antenna, and the surface area of this control volume as the control volume gets larger and larger.
(b) Considering your answer to 6a, what is one limitation of using a uniform plane wave approximation of a true spherical wave?


(a) What is the nickname of the vehicles that will replace the shuttle and eventually take the U.S. back to the Moon? Is this a derogatory name? Why or why not?
(b) What event does the article point to as the real instigator of “The vision?” Why?
(c) What is your opinion: is it important for an organization to have “a vision?”
(d) How long did it take Apollo to get to the Moon, and how much did NASA’s budget increase in the process?
(e) Has the President and Congress followed through on commitments? Support your answer with actions described in the article.
(f) Why are some skeptical about the science return on missions to the Moon?
(g) What does U.S. Representative Bart Gordon of Tennessee say about NASA’s other core missions?
(h) Who is the current NASA Administrator?