<u>**Homework Set 1**</u>

General homework instructions:
  Students may work together, but may not turn in identical homework solutions. Each student must write his/her solutions independently.
  On calculations: show your work, legibly. Just giving the final result will not earn credit --- show how you obtained the result.
  On Essay Questions: students may work together and may obtain information from the Internet. However, each student must write an independent essay in his/her own words. Cut-and-Paste from the Internet is <u>forbidden</u>. Directly quoting from sources (with or without footnotes) is also <u>forbidden</u>.

<u>**Exercises; due Wednesday 9/9**</u>

E1. The velocity of an electromagnetic wave in empty space is c, with $c = 1/\sqrt{\mu_0 \varepsilon_0}$. What are the values of μ_0 (permeability) and ε_0 (permittivity) of empty space? Using these values, calculate c.

E2. Consider this electromagnetic wave:
$$\mathbf{E}(\mathbf{x}, t) = \hat{\mathbf{i}} \; f(z - ct) \quad \text{and} \quad \mathbf{B}(\mathbf{x}, t) = \hat{\mathbf{j}} \; f(z - ct)/c$$
$$\text{where } f(\varsigma) = A\sin\left(\frac{2\pi\varsigma}{\lambda}\right)\exp\left(-\varsigma^2/a^2\right)$$

for some parameters λ and a. Assume a is large compared to λ.
(a) Sketch a graph of $E_x(z,0)$ (i.e., let x = y = 0 and t = 0).
(b) Sketch a graph of $E_x(z,t)$ for t = 10λ/c.
Your sketches should be qualitatively correct.

E3. (a) Define "dielectric". (b) List 5 examples of dielectric materials.

<u>**Problems; due Wednesday 9/9**</u>

P1. The energy densities of the electric and magnetic fields are
$$u_E = \frac{\varepsilon_0}{2} E^2 \quad \text{and} \quad u_M = \frac{B^2}{2\mu_0}.$$
The energy flux is the Poynting vector **S** defined by
$$\mathbf{S} = \frac{1}{\mu_0}\mathbf{E} \times \mathbf{B}.$$
(a) Determine <u_E> and <u_M> for a harmonic electromagnetic wave.
[The notation < > means averaged over time for one or more field oscillations.]
(b) Prove that <u_E>=<u_M>.
(c) Prove that <S>=<u> c where u is the total field energy density.
(d) What are the units of <S>?

P2. Consider a harmonic electromagnetic wave with $<S>$ = 1370 W/m^2. [This is the value of the **solar constant.**] Then calculate the amplitudes of the electric and magnetic field oscillations, i.e., E_0 and B_0.

P3. Write a short essay (2 paragraphs) that describes two practical applications of ultraviolet radiation. Use good grammar. The essay must be legible—preferably typed.

P4. Light is incident from air into glass. The angle of incidence is 45 degrees and the angle of refraction is 30 degrees. Calculate the **speed of light** in the glass.

P5. Consider a harmonic light wave propagating through water. The index of refraction of water is 1.33. Calculate the **current density** $\mathbf{J}(\mathbf{x}$,t) in the water. [Hint: The current is due to time-varying polarization of water molecules.]