Physics 334 – Spring 2024
Due February 12.

Homework 03 – Rev A

SPN 3–01 – Mechanical Waves.
Note: You did parts 'a' and 'b' of this problem last week. Just copy your answers from your last homework (Except this time I give you a numerical value for A, please use that for parts b, c, and d). There is no need to show the previous work again. Physicists measured some guitar strings. A high-E string had a diameter of 0.25 mm while a G-string had a diameter of about 0.4 mm. Both were made of steel with density $\rho = 7000\ kg/m^3$.

[a] Both strings were tensioned to about 60 N. What are their respective wave speeds?
[b] The G string is attached to a guitar so that it is 80 cm long. This forces the wavelength when plucked to be $\lambda = 1.6\ m$. Write an equation in the form $f(z,t) = Re\ \tilde{\mathrm{A}}\ exp(ikz - \omega t)$ if we assume $\lambda = 1.6\ m$. Also $|\tilde{\mathrm{A}}| = 1\ mm$. Fill in the constants correctly. Let $A = 10^{-4}\ m$
[c] The guitar is heavily modified so that the high-E and the G can be tied together and tensioned. The G is plucked and a wave described by your answer to part "b" is launched toward the E string. Write the equation for the reflected wave. Get the amplitude right.
[d] As above, write the equation for the transmitted wave.

SPN 3–02 – Poynting Vector.
Last week's homework included Griffiths 8-1. It was really two problems, one based on Example 7.13 and the other based on problem 7.62. I told you that 7.62 was not required. This week, do the part of 8-1 that involves 7.62. If you submitted it last week, just please put a note saying that on your paper so we know to go back to your last homework to look for it.

SPN 3–03 – Optical Flux.
In earth orbit the solar intensity is about 1400 W/m^2.

[a] What is the electric field magnitude in sunlight?
[b] What is the magnetic field magnitude?
[c] What are the values of k and ω for green light?

SPN 3–04 – Optical Flux 2.
The total optical power emitted by the sun is about 4.0×10^{26} W.

[a] What is the intensity of sunlight at the surface of Venus? Of Neptune?
[b] A solar sail is a circle 5 m in radius and is made of black material. Assume it masses 10 g. What acceleration would it feel if it were at the orbit of Venus? Of Neptune?
[c] How do your answers change if the sail is made of perfectly reflective aluminum? Why?

SPN 3–05 A beam of light from a helium-neon laser enters a lake.

(a) Assume $\mu \simeq \mu 0$ in water, and that $n = 1.33$. What are ϵ and ϵ_r?
(b) What is the speed of light in water?
(c) What are λ and ω for this laser light in water? (Feel free to Google HeNe laser for λ in air/vacuum)
(d) What is the value of the wavenumber (k) for the light in air?
(e) What is the value of the wavenumber (k) for the light in water?

SPN 3–06 – EM Wave Equation.
Copy down equation 9.41. (Gee that was hard!). Show the following:

[a] $\vec{E} = E_0 exp(i\vec{k} \cdot \vec{r} - \omega t)$ is a solution to 9.41 and what relation between ω and $\vec{k}$ that forces
[b] In the simpler case where $\vec{k} = k\hat{z}$, show that $\vec{E}_z = 0$, but that E_x and E_y are allowed to be non-zero. (I did this in class on 2/5 ... do you remember?)

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SPN 3–07 – Monochromatic Plane Waves.
Do Griffiths 9.9.

SPN 3–08 – EM Reflection and Transmission.
The index of refraction of sapphire in visible wavelengths is about 1.8 and for glass it is about 1.5. A telescope optic is made by sticking a piece of glass to a piece of sapphire.

[a] Assume $\mu = \mu_0$ in both materials above. What are ϵ and ϵ_r? in each material?
[b] A beam of intensity 1 kW/m^2 passes at normal incidence from the glass to the sapphire. What intensity is reflected back?
[c] What are the electric fields of both the incident and reflected beam?