Physics 302/572: Electromagnetic Theory II

Read: Griffiths 9.4-9.5

“G, PS” refer to Griffiths and Pollack & Stump books respectively. Problems with stars are not for credit and will NOT be graded.

Homework 5

Exercise 1 (G 9.21)
Calculate the reflection coefficient for light at an air-to-silver interface (μ₁ = μ₂ = μ₀, ε₁ = ε₀, σ = 6 × 10⁷ (Ω · m)⁻¹), at optical frequencies (ω = 4 × 10¹⁵/s).

Exercise 2 (PS 13.13)
The dispersion relation for deep water gravity waves is ω = √gk. Show that the group velocity is one-half the phase velocity.

Exercise 3 (G 9.22b)
In quantum mechanics, a free particle of mass m traveling in the x direction is described by the wave function

Ψ(x, t) = Ae^(i(px−Et)/ℏ),

where p is the momentum, and E = p²/2m is the kinetic energy. Calculate the group velocity and the wave velocity. Which one corresponds to the classical speed of the particle? Note that the wave velocity is half the group velocity.

Exercise 4 (G 9.25)
Assuming negligible damping (γ_j = 0), calculate the group velocity (v_g = dω/dk) of the waves described by

k̅ = ω/c√ε_r ≈ ω/c [1 + Nq²/2mε₀ ∑ f_j / (ω_j² − ω² − iγ_jω)].

Show that v_g < c, even when v > c.
Exercise 5 (G 9.28)
Consider a rectangular wave guide with dimensions 2.28cm × 1.01cm. What TE modes will propagate in this wave guide, if the driving frequency is $1.70 \times 10^{10}$ Hz? Suppose you wanted to excite only one TE mode; what range of frequencies could you use? What are the corresponding wavelengths (in open space)?