Electrodynamics II: Assignment 9.
Due March 13 at 11:00 am under the instructor's door C503 or scanned & sent via email.
(don't submit it to the instructor's mailbox or bring it to class).

1. Show or argue there's no propagating TE_{00} mode (or TM_{00} mode, for that matter) in a rectangular waveguide. Notice Jackson equations 8.35 and 8.43 imply propagation for the non-existent E_{00} mode would have the free-space dispersion relation, so equations 8.26a-b cannot be directly applied. Indeed, the lack of TE_{00} or TM_{00} modes is true for a guide of any uniform cross section.

2. Consider a long coaxial transmission line of inner- and outer-radius r_i and r_o. There's vacuum between the two conductors. A harmonic voltage $V(\omega)$ is applied at one end between the inner- and outer conductors and the line is so long there are no standing waves.
a. Find the free-space and guided-wave wavelength.
b. Using the Poynting formalism, find the power transmitted down the waveguide.
c. Compare the result of part (b) to the power transmitted down the line arrived at from circuit theory.
d. Find the "characteristic impedance" of the transmission line (the ratio of the voltage across the line to current down a conductor).
e. Look up the characteristics of the RG-6 coaxial cable (the type of cable plugged into your TV) and see if your result in (e) makes sense. (You'll need to account for the RG-6 dielectric being polyethylene, not vacuum).

3. Electromagnetic radiation in vacuum of angular frequency ω is normally-incident on a good conductor of conductivity σ. Show that the time-average radiation pressure arrived at from considering the magnetic force on the currents is the same as the result from the Poynting formalism $\langle P\rangle = 2\frac{\langle S_i\rangle}{c}$, where S_i is the incident Poynting flux.

There's a subtlety: the magnetic force exerted on slow electrons within the conductor, as is the case here, is proportional to $\mu_0 H$ not μH (see G.H.Wannier, Phys.Rev. vol 72, p 304, year 1947.).

4. Consider the simple waveguide we introduced in lecture: The single-plane perfect conductor. A plane wave in vacuum makes an angle-of-incidence θ_i with the conductor. In terms of the free-space wavelength λ_0, find the wavelength of the standing waves in the direction normal to the mirror and the wavelength of propagation parallel to the mirror.