Phys 321 – E & M II – Test 2 – October 15, 2001

1. Consider an infinite parallel-plate capacitor, with the lower plate (at $z = 0$) and carrying the charge density $+\sigma$, and the upper plate (at $z = d$) carrying the charge density $-\sigma$.

a) Determine the 3 × 3 matrix that represents the stress tensor in the region between the plates.

b) Determine the force per unit area on the bottom plate.

Recall: $T_{ij} = \varepsilon_0 (E_i E_j - \frac{1}{2}\delta_{ij} E^2) + \frac{1}{\mu_0}(B_i B_j - \frac{1}{2}\delta_{ij} B^2)$

$$\vec{F} = \oint_S \overleftrightarrow{T} \cdot d\vec{a} - \varepsilon_0 \mu_0 \frac{d}{dt}\int_V \vec{S}\, d\tau$$

2. Write down the (real) electric and magnetic fields for a monochromatic plane wave of amplitude E_0, frequency ω, and phase angle zero that is traveling in the direction from the origin to the point (1,2,!2), with polarization parallel to the *yz* plane.

3. Suppose you wanted to float a small square thin sheet of aluminum by using a high-powered laser beam. The laser is arranged so its beam is pointing vertically upwards. The cross-sectional area of the laser beam is 5×10^{-5} m^2. The piece of aluminum is large enough to reflect the whole laser beam and it weighs 4×10^{-3} N. What must the intensity of the laser beam be in order to float the aluminum sheet?

Recall: The momentum density in a vacuum is given by $\vec{\wp} = \frac{1}{c^2}\vec{S}$.

4. A long coaxial cable caries current *I*. The current flows down the surface of the inner cylinder, radius *a*, and back along the outer cylinder, radius *b*. The inner and outer conductors are held at a potential difference *V*.

a) Use Ampere's Law to determine the magnetic field in the region between the conducting cylinders.

b) Use Gauss's Law to determine the electric field in the region between the conducting cylinders. Show that $\vec{E} = \frac{V}{\ell n(\frac{b}{a})}\frac{\hat{s}}{s}$.

c) Calculate the power (energy per unit time) transported down the coaxial cable.