Show all your work and indicate your reasoning in order to receive most credit.

1. (a) A sailboat is manufactured so that the mast leans at an angle θ with respect to the deck. An observer standing on a dock sees the boat go by at speed v (See Fig. 12.14 in the textbook). What angle does this observer say the mast makes?

   (b) A spotlight is mounted on a boat so that its beam makes an angle θ with the deck (See Fig. 12.20 in the textbook). If this boat is then set in motion at speed v, what angle does an observer on the dock say the beam makes with the deck?

   (c) Compare answers in parts (a) and (b), and explain the difference if any.

2. A parallel-plate capacitor, at rest in reference frame S_0 and tilted at a 45° angle to the x axis, carries charge densities $\pm\sigma$ on the two plates (See Fig. 12.41 in the textbook). System S is moving to the right at speed v relative to S_0.

   (a) Find $\vec{E}_0$, the field in S_0.

   (b) Find $\vec{E}$, the field in S.

   (c) What angle do the plates make with the x axis? (Hint: use the result of Problem 1(a) above.)

   (d) Is the field perpendicular to the plates in S?

3. As you know, the magnetic north pole of the earth does not coincide with the geographic north pole – in fact, it's off by about 11°. Relative to the fixed axis of rotation, therefore, the magnetic dipole moment vector of the earth is changing with time, and the earth must be giving off magnetic dipole radiation.

   (a) Find the formula for the total power radiated, in terms of the following parameters: Ψ, the angle between the geographic and magnetic north poles, M, the magnitude of the earth's magnetic dipole moment), and Ω, the angular velocity of rotation of the earth.

   Hint: the power radiated by a magnetic dipole $\mathbf{m}(t)$ is

$$P = \frac{\mu_0 \ddot{m}^2}{6\pi c^3}$$

(b) Using the fact that the earth's magnetic field is about half a gauss at the equator, estimate the magnetic dipole moment M of the earth. For the purpose of soving this problem consider the earth to be a perfect sphere of radius $R = 6.4 \times 10^6$ m.

(c) Find the power radiated.

(d) Pulsars are thought to be rotating neutron stars, with a typical radius of 10 km, a rotational period of 10^{-3} s, and a surface magnetic field of 10^8 T. What sort of radiated power would you expect from such a star?