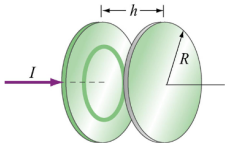
# Exercise sheet #14

**Problem 1.** A longitudinal **E** field inside a wire causes a current $\mathbf{J} = \sigma\mathbf{E}$. Since the curl of **E** is zero, this same longitudinal **E** component must also exist right outside the surface of the wire. Show that the Poynting vector flux through a cylinder right outside the wire is equal to $IV$, where $I$ the current and $V$ is the electric potential (resistance heating).

**Problem 2.** The intensity of sunlight, at the earth, is roughly 1 kilowatt $/\mathrm{m}^2$. How large is the magnetic field strength? Assume that the EM radiation from the sun is a plane sinusoidal wave.

**Problem 3.** A parallel-plate capacitor with circular plates of radius $R$ and separated by a distance $h$ is charged through a straight wire carrying current $I$, as shown in the figure below:

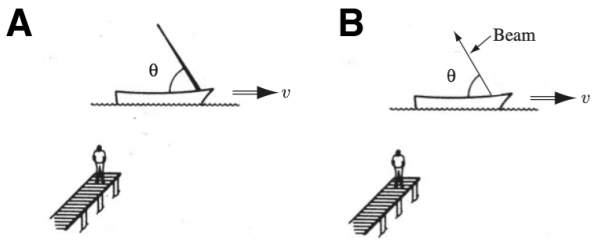



(a) Show that as the capacitor is being charged, the Poynting vector $\vec{\mathbf{S}}$ points radially inward toward the center of the capacitor.

(b) By integrating $\vec{\mathbf{S}}$ over the cylindrical boundary, show that the rate at which energy enters the capacitor is equal to the rate at which electrostatic energy is being stored in the electric field.

**Problem 4.** (a) A sailboat is manufactured so that the mast leans at an angle $\bar{\theta}$ with respect to the deck. An observer standing on a dock sees the boat go by at speed $v$ (Fig. below A). What angle does this observer say the mast makes?

(b) A spotlight is mounted on a boat so that its beam makes an angle $\bar{\theta}$ with the deck (Fig. below B). If this boat is then set in motion at speed $v$, what angle $\theta$ does an individual photon trajectory make with the deck, according to an observer on the dock? What angle does the beam (illuminated, say, by a light fog) make? Compare with part A.




**Problem 5.** A capacitor consists of two parallel rectangular plates with a vertical separation of 2 cm . The east-west dimension of the plates is 20 cm , the north-south dimension is 10 cm . The capacitor has been charged by connecting it temporarily to a battery of 300 V . What is the electric field strength between the plates? How many excess electrons are on the negative plate? Now give the following quantities as they would be measured in a frame of reference that is moving eastward, relative to the laboratory in which the plates are at rest, with speed $0.6c$ : the three dimensions of the capacitor; the number of excess electrons on the negative plate; the electric field strength between the plates. Answer the same questions for a frame of reference that is moving upward with speed $0.6c$.