

P506

Problem Set 3

(Due: September 25, 2008)

1) Jackson, problem 1.7.

Two long, cylindrical conductors of radii a_1 and a_2 are parallel and separated by a distance d , which is large compared with either radius. Show that the capacitance per unit length is given approximately by

$$C \approx \pi\epsilon_0 \left(\ln \frac{d}{a} \right)^{-1}$$

where a is the geometrical mean of the two radii.

Approximately what gauge wire (state diameter in millimeters) would be necessary to make a two-wire transmission line with a capacitance of 1.2×10^{-11} F/m if the separation of the wires was 0.5 cm? 1.5 cm? 5.0 cm?

2) Jackson, problem 2.1.

A point charge q is brought to a position a distance d away from an infinite plane conductor held at zero potential. Using the method of images, find:

- (a) the surface-charge density induced on the plane, and plot it;
- (b) the force between the plane and the charge by using Coulomb's law for the force between the charge and its image;
- (c) the total force acting on the plane by integrating $\sigma^2/2\epsilon_0$ over the whole plane;
- (d) the work necessary to remove the charge q from its position to infinity;
- (e) the potential energy between the charge q and its image [compare the answer to part d and discuss];
- (f) Find the answer to part d in electron volts for an electron originally one angstrom from the surface.

3) Jackson, problem 2.9.

An insulated, spherical, conducting shell of radius a is in a uniform electric field E_0 . If the sphere is cut into two hemispheres by a plane perpendicular to the field, find the force required to prevent the hemispheres from separating

- (a) if the shell is uncharged;
- (b) if the total charge on the shell is Q .