1. A charge q (1 C) is placed at the center of a spherical shell of inner radius a = 3 cm consisting of a dielectric (dielectric constant 2.0) and a conducting layer with thickness 1 cm each, as shown in Fig. 1. Find
   (a) (10 %) the electric fields everywhere,
   (b) (4 %) the electrostatic pressure on the outer surface of the conducting layer,
   (c) (6 %) polarization in the dielectric and the equivalent volume and surface charge densities.
   (d) (10 %) a 2nd charge Q = 1 C is brought from infinity to a position 10 cm from the center of the sphere, find the "work" done.

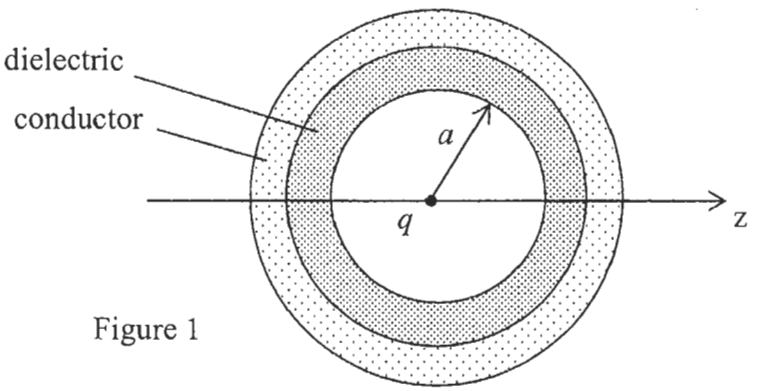

Figure 1

2. A cylindrical coaxial cable consists of an outer and an inner conductor of radii 4 cm and 2 cm, respectively. A dielectric material of dielectric constant 2.0 and thickness 1 cm fills the space between the two conductors, as shown if Fig. 2.
   (a) (15 %) Find the distribution of electrostatic potential if a voltage of 10 V is applied on the inner conductor while the outer one being grounded (V = 0 V).
   (Hint: divide the space into two regions, write down the governing differential equation and the boundary conditions at the interface.)
   (b) (7 %) Find the capacitance per unit length of this coaxial cable.
   (c) (8 %) If one replaces the dielectric by a magnetic material of relative permeability 2.0, find the inductance per unit length.

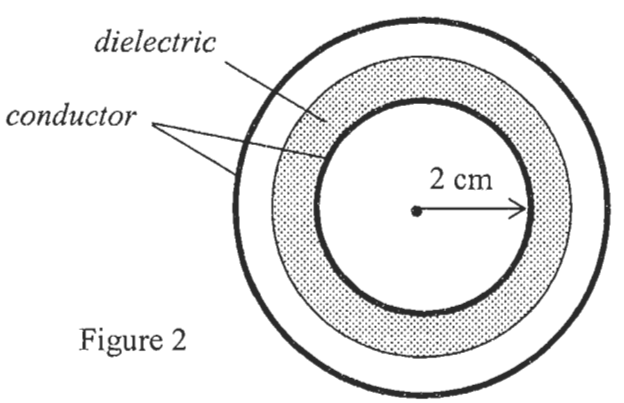

Figure 2

3. Explain the physical meaning of the following terms: (note: you need to explain in words not just with equations.)
   (a) (6 %) *retarded potentials* (relating potentials due to charges or currents) and *retarded time*.
   (b) (6 %) *phase velocity* and *group velocity* for a simple wave, such as electromagnetic wave.
   (c) (8 %) For electromagnetic wave propagating in a *medium*, explain the physical mechanisms responsible for the *dispersion* (you may want to explain the dispersion phenomenon first) and *absorption* of waves.

4. (a) (10 %) Briefly explain why the sky is blue at noon (of course, in a sunny day) and why the sky turns to orange/red during sunset.
   (b) (10 %) A spherical balloon is uniformly charged with 1 C of charge and the radius is oscillating at a frequency of 1 GHz, given by $R(t) = 1 + 0.5\cos\omega t$ cm. Find the electromagnetic fields at a distance 10 cm from the center of the balloon.