1. An electrical dipole (+q and –q) exists in a static field, $\bar{p} = q\bar{d}$ is the dipole moment and $\bar{d}$ is the directed distance from the negative charge to the negative charge. (a) Use $\bar{p}$ to derive the potential V in the spherical coordinate (5%), derive the electrical field in the spherical coordinate (5%), (c) derive the formula to describe the E-field streamlines (10%).
2. A thin electrical line is used to fabricate a regular polygon with N equal sides and current I passing through. Prove the magnetic flux density $\bar{B}$,

$$\bar{B} = \frac{\mu_0 NI}{2b\pi} \tan\frac{\pi}{N}\bar{a}_n$$

where b is the radius of a circumscribed circle surrounding the polygon whose apexes are on the circle, $\bar{a}_n$ is an unit vector perpendicular to the polygonal plane. (20%)

3. A uniform linearly polarized plane wave propagates at the z direction under the sea with the magnetic field intensity $\bar{E} = 20\cos(10^8\pi t)\bar{a}_x(V/m)$. The parameters of sea water are $\varepsilon_r = 72, \mu_r = 1, \sigma = 4(S/m)$. (a) Find attenuation constant, phase constant, intrinsic impedance, phase velocity, wavelength and skin depth (12%), (b) find the distance from z=0 where the amplitude of $\vec{E}$ is 2% (8%), (c)find $\bar{E}(z,t)$ and $\bar{H}(z,t)$ at z=0.6 (m) (10%).
4. A loss transmission line with its length =2 (m) and characteristic impedance $100(\Omega)$. (a) Calculate attenuation constant α and phase constant β if the input impedance is $60 + j300(\Omega)$ in the short circuit condition, (b) calculate the input impedance when the transmission line is connected with load $Z_L = 90 - j60(\Omega)$. Use the provided Smith chart to calculate the results (20%).
5. Two long parallel electrical lines have the same radius a and the distance l between these two lines, find the capacitance per unit length (10%).

(To be continued for Smith Chart)