PHL 110 Fields and waves. Minor I exam

04 August 2012, 09.30AM to 10.30AM

1. Concentric conducting spherical shells with radii a and b $(b > a)$ are maintained at a potential difference of V_0 such that $V(r = b) = 0$. Determine V and $\vec{E}$ in the region between the shells. Determine the total charge induced on the shells and the capacitance of the capacitor, if the region between the shells has a dielectric. (6)

2. A plane interface between a metal and a dielectric material has a free surface charge density σ_f. Write down the normal and tangential components of $\vec{E}$ and $\vec{D}$ on both sides of the interface. (5)

3. In a region of space, vector potential is given by $\vec{A} = \hat{z}\,\beta\,(x^2 + y^2)$, where β is a constant. Obtain (i) the magnetic field $\vec{B}$, (ii) the magnetic flux linked to a rectangular loop of width a and height b lying in $y = 0$ plane as shown in the figure.1, and (iii) the current density associated with this field. .....(6)

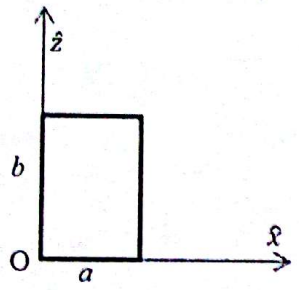

Figure.1

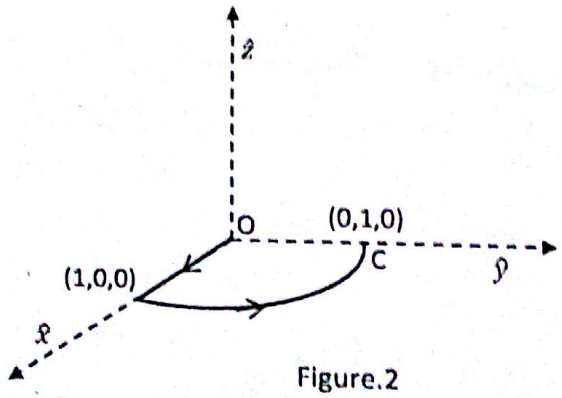

Figure.2

4. (a) An electron of charge q and mass m moves in crossed electric and magnetic fields, $\vec{E} = E_0\hat{x}$ and $\vec{B} = B_0\hat{y}$ with constant velocity $\vec{v}_0$. Estimate the value of this velocity. (2)

(b) Charge density in a region of space is $\rho(\vec{r}) = Cq[\delta^3(\vec{r}) - \delta^3(\vec{r} - 2\hat{x} - 2\hat{y})]$, where C is a constant. Obtain the electric flux linked to a sphere of radius $R = 2$ centered at (0,2,2). (2)

(c) Estimate the work done in moving an electron of charge $-e$ from $(R, 0, 0)$ to $(0, R, 0)$ along a circular arc of radius R in the presence of a dipole $\vec{p} = p_0\hat{x}$ fixed at the origin. (2)

(d) A vector field A is given by $\vec{A} = \pi sin\theta\,\hat{r} + cos\theta\,\hat{\theta} + 6r\hat{\varphi}$. Find $\int_O^C \vec{A}.\vec{dl}$ along the path from point O (0,0,0) to C (0,1,0) through (1,0,0) as shown in the figure.2. (2)