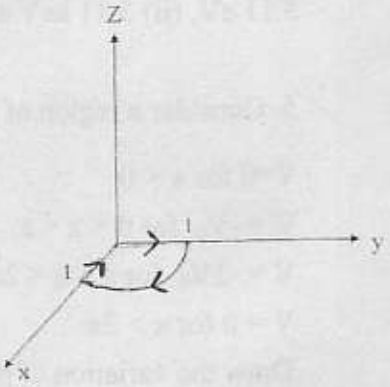
The LNM Institute of Information technology, Jaipur
First Midterm Examination Feb 2011
Sub: Physics II, Full Marks: 40, Time: 1h

[**ATTENTION**: Don't write anything on the question paper. If you are found guilty, your paper will be cancelled, even if you are not involved in any unfair activity]

1. What is the mathematical expression of the fundamental theorem for curls (Stokes' Theorem). [2]

Verify the theorem for a given vector field, $\vec{F}(\rho,\varphi,z) = \rho\hat{\rho} + \hat{\varphi} + \hat{z}$, for the closed path shown in the figure. [4]



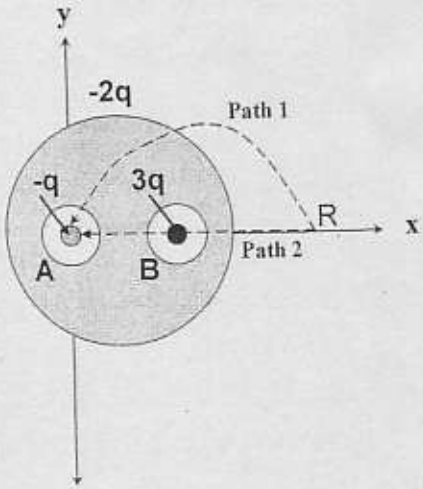
$$\vec{\nabla}\times\vec{F} = \left(\frac{1}{\rho}\frac{\partial F_z}{\partial\varphi} - \frac{\partial F\varphi}{\partial z}\right)\hat{\rho} + \left(\frac{\partial F_\rho}{\partial z} - \frac{\partial Fz}{\partial\rho}\right)\hat{\varphi} + \frac{1}{\rho}\left(\frac{\partial}{\partial\rho}(\rho F_\varphi) - \frac{\partial F\rho}{\partial\varphi}\right)\hat{z}$$

3. A long line charge of $\lambda = (10^2 \in_0) C/m$ is oriented along z-axis.

(a) Calculate the electric field vector at $(0.01m, \frac{\pi}{4} radian, 1m)$ by using Gauss's law. [3]

(b) What is the potential difference between the point a$(0.01m, \frac{\pi}{4} radian, 1m)$ and b$(0.021m, \frac{\pi}{2} radian, 2m)$. [4]

4. Charge of amount (-2q) is added to a solid conducting sphere of radius a on the outer surface, as shown in the figure. It has two cavities A & B of radius b, which contains metallic shell with charge (-q) and (+3q), respectively. The radius of the inner metallic shells is c.



(i) Calculate the surface charge density of the solid conducting sphere. [1]

(ii) Calculate the amount of work required to bring a (-1/q) charge from an external reference point R to the surface of the inner metallic shell in the cavity A. [4]

(iii) If the solid conducting sphere is grounded, do you expect any change in the above answers? [1]

(iv) Do you expect difference in work done if we follow path1 and path 2? [1]

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4. The energy transferred to the scattered electron in Compton effect is given by

$E_e = h\nu \frac{\alpha(1-\cos\theta)}{1+\alpha(1-\cos\theta)}$ where $\alpha = \frac{h\nu}{m_0 c^2}$ and the rest mass energy of the electron is 0.511 MeV.

Find the maximum energy transferred to the electron when the incident photon has energy (i) 5.11 eV, (ii) 5.11 keV and (iii) 5.11 MeV. Comment on the result. [7]

5. Consider a region of space with the potential as described by

$V=0$ for $x < 0$

$V = -V_0$ for $0 < x < a$

$V = -2V_0$ for $a < x < 2a$

$V = 0$ for $x > 2a$

Draw the variation of potential along the x-direction. [2]

A particle of mass m is confined in the region $0 < x < 2a$ and has an energy E, where, the magnitude of energy E is greater than V_0 but less than $2V_0$, $(V_0 < |E| < 2V_0)$. Write the Schrödinger equation(s) in the different regions for $0 < x < 2a$. [3] Write the most general solution for each of them. [4]

6. Consider a particle in a one dimensional box. The potential for such a box may be written as $V = 0$ for $0 < x < L$ and $V = \infty$ everywhere else. Find the expectation value of position if the particle is in the first excited state. [4]