Mid Term: Feb 2019. PH 1201 IN: cba132ZN

Time : 1 hour

INSTRUCTIONS

This question paper contains two parts A and B. Part A contains 6 multiple choice questions(MCQs), each carrying 4 mark, all compulsory. Part B has two questions, carrying total of 26 marks. Part B has to be answered in regular answer sheet.

INSTRUCTIONS for Part A (MCQs)

Circled only one of the four choices (a, b, c, d) for each question in the MCQ question paper itself. Answers should be circled using a PEN only.

A correct answer will fetch 4 mark, a wrong answer -1 marks and no answer 0 marks.

All rough calculation for the MCQ should be done on the answer sheet. Clearly mention "PART A" on top of the answer sheet on which the rough calculation is done. These calculations will not be marked.

NO WRITING OR MARKING ON THE MCQ QUESTION PAPER IS PERMITTED AT ANY STAGE OF THE EXAMINATION. ANY WRITING OR MARKING ON THE MCQ QUESTION PAPER WILL BE **PENALIZED**. For every question that is marked in any fashion in the MCQ question paper , 1 marks will be deducted from the overall score, up to a maximum deduction of 3 marks.

Please tie the three sheets together with a tag (MCQ question paper, the white answer sheet for rough work corresponding to part A, the white answer sheet corresponding to part B; in this order) and hand the bunch over to the invigilators when you leave.

Part A

1. The value of closed line integral given by $\oint_c((2xy)dx + (x)^2dy)$, where "$c$" is the boundary of the region defined by the two curves $y = x$ and $y = x^2$ in the $x \geq 0$, $y \geq 0$ plane is given by (4 marks)

a. 5

b. 7

c. None of the above

d. Zero

2. Which of the following correspond to the correct form of the radial component of $\overrightarrow{\nabla}$ operator in spherical polar coordinate (4 marks)

a. $\frac{\partial}{\partial r}\hat{r}$

b. $sin\theta\frac{\partial}{\partial r}\hat{r}$

c. $\frac{1}{r}\frac{\partial}{\partial r}\hat{r}$

d. None of the above

3. Which of the following correspond to the correct form of the line element in cylindrical coordinates (4 marks)

a. $ds^2 = (d\rho)^2 + \rho^2(d\phi)^2 + sin^2\phi(dz)^2$

b. $ds^2 = (d\rho)^2 + (d\phi)^2 + (dz)^2$

c. $ds^2 = (d\rho)^2 + \rho^2(d\phi)^2 + (dz)^2$

d. None of the above

4. The value of $\overrightarrow{\nabla}^2(\frac{1}{r})$ is given by (4 marks)

a. Zero

b. $\delta(r)$

c. $-4\pi\delta(r - r')$

d. None of the above

5. The electric field due to a uniformly charged spherical shell of charge density σ and radius "R" at a distance "d" $(d < R)$ from its center is given by

a. $\frac{\sigma}{\epsilon_0}$

b. Zero

c. $\frac{1}{4\pi\epsilon_0}\frac{1}{R^2}\hat{r}$

d. None of the above

6. The unit tangent to the curve $x = t^2 + 1, y = 4t - 3$ and $z = 2t^2 - 6t$ at $t = 2$ is given by (4 marks)

a. $2/3\hat{i} + 2/3\hat{j} + 2/3\hat{k}$

b. $2/3\hat{i} + 2/3\hat{j} + 1/3\hat{k}$

c. $1/3\hat{i} + 2/3\hat{j} + 1/3\hat{k}$

d. None of the above

Part B

1. Given an electric field configuration

$$\mathbf{E} = \alpha\frac{e^{-Kr}}{r}\hat{r}$$

where α ,K are constants,

a. Obtain an expression for the local charge density using Gauss's law. (4 marks)

b. By performing a volume integration over the full space obtain the expression for the total charge corresponding to the above distribution.(4 marks)

c. What is the net flux of the electric field passing through the surface of the sphere with radius R with it's centre laying at $r = 0$?(4 marks)

2. a. What is the value of the electric field inside the meat of the spherical conductor of radius R whose centre is place at the origin $(x = 0, y = 0, z = 0)$ and is subjected to an uniform electric field $\mathbf{E}$ pointing in the $\hat{z}$ direction ? (1 mark)

b. What is the induced charge density inside the meat of the conductor ? (1 mark)

c. Assuming that the centre of the sphere is at the origin ($x = 0, y = 0, z = 0$) and the applied electric field is pointing along $+z$ direction, predict the sign of the charge induced at the point ($x = 0, y = 0, z = -R$) on the surface of the sphere. (4 marks)

d. What is the potential difference between the two points ($x = 0, y = 0, z = -R$) and ($x = 0, y = R, z = 0$) which are lying on the surface of the sphere ? (4 marks)

e. What is the direction of the net electric field expressed in terms of unit vectors ($\hat{x}, \hat{y}, \hat{z}$)at the point ($x = 0, y = 0, z = R$) on the surface of the sphere ? (4 marks)

Additional Information

Spherical polar coordinate system

$$\begin{aligned} x &= r sin\theta cos\phi \\ y &= r sin\theta sin\phi \\ z &= r cos\theta \end{aligned}$$

Cylindrical coordinate system

$$\begin{aligned} x &= r cos\theta \\ y &= r sin\theta \\ z &= z \end{aligned}$$

Gauss Law in differential form:

$$\nabla.\mathrm{E} = \frac{\rho}{\epsilon_0}$$