EECE 261 – Quiz #2 – section 201

NAME: Solutions
STUDENT #:

Time allowed: 30 minutes | Materials allowed: pencil / pen / calculator

Part A: True or False / Multiple Choice (1 point each)

1) Electric Flux Density is linearly related to Electric Field Intensity in homogenous isotropic materials.
[X] True [ ] False

2) The total flux leaving a closed surface that encloses a charge is a function of the shape of the surface.
[ ] True [X] False

3) If I calculate the divergence of the Electric Flux Density at a point in space and the result is negative, it means that there is no charge situated at that point.
[ ] True [X] False

4) Changing the reference potential would affect measurements of the potential difference between two arbitrary points.
[ ] True [X] False

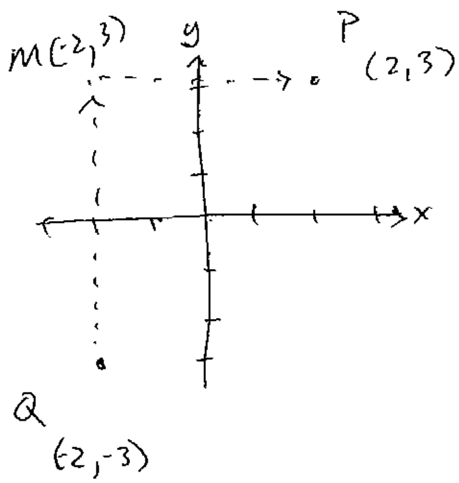
5) What surface would best be used in the determination of an expression for the Electric Field Intensity, **E**, due to an infinite line charge when using Gauss' law?
[ ] Sphere [ ] Cube [X] Cylinder [ ] Pyramid [ ] Doesn't matter

(Continued on overleaf...)

Part B –Calculation question (5 points)

6) Given the Electric Field Intensity $\mathbf{E} = x^2\hat{\mathbf{x}} + 2y\hat{\mathbf{y}}$ V/m, find the potential difference between the points P(2,3) and Q(-2,-3). Which point is at the higher potential?

This is a conservative field. Therefore the result is independent of path. Approach is to follow the coordinate system.



$$V = -\int_{\text{initial}}^{\text{final}} \bar{E} \cdot d\bar{L} \quad \text{Volts}.$$

$$= -\int_{y=-3}^{3} (x^2\hat{x} + 2y\hat{y})\Big|_{x=-2} \cdot dy\,\hat{y}$$

$$- \int_{x=-2}^{2} (x^2\hat{x} + 2y\hat{y})\Big|_{y=3} \cdot dx\,\hat{x}$$

Move from Q to P via M (-2, 3)

$$= -\int_{y=-3}^{3} 2y\,dy - \int_{x=-2}^{2} x^2\,dx$$

$$= -\left[y^2\right]_{-3}^{3} - \left[\frac{x^3}{3}\right]_{-2}^{2}$$

$$= 0 - \frac{16}{3} \text{ V}.$$

[Q is at the higher potential.]

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Part A: True or False / Multiple Choice (1 point each)

1) Electric Flux Density is linearly related to Electric Field Intensity in homogenous isotropic materials.
[X] True [ ] False

2) The total electric flux through a closed surface resulting from a point charge inside that surface is the same as the total electric flux due to a shell of charge (with the same total charge as the point charge) as long as the shell of charge is completely contained by the closed surface.
[X] True [ ] False

3) Divergence of a charge distribution is a measure of whether there are net positive or negative sources of charge in a region.
[ ] True [X] False

4) It is standard practice to consider the origin of any coordinate system as the zero reference for electric potential measurements.
[ ] True [X] False

5) What surface would best be used in the determination of the electric field intensity, **E**, due to an infinite sheet of charge when applying Gauss' law?
[ ] Sphere [X] Cylinder [ ] Pyramid [ ] Doesn't matter

(Continued on overleaf...)

Part B –Calculation question (5 points)

6) An Electric Field Intensity exists in free space and is defined by the function:

$$\boldsymbol{E} = 2x\mathbf{x} - 3\mathbf{y} + z^2\mathbf{z} \quad V/m$$

What is the total amount of charge in the cylindrical region bounded by $0 < \rho < 0.05$m and $0 < z < 0.1$m?

Approach:

$$\bar{D} = \varepsilon_o \bar{E}$$

$$\nabla \cdot \bar{D} = \rho_v$$

$$Q = \int_{vol} \rho_v \, dv$$

$$\bar{D} = \varepsilon_o \left[2x\hat{x} - 3\hat{y} + z^2 \hat{z} \right] \, C/m^2$$

$$\rho_v = \nabla \cdot \bar{D} = \varepsilon_o \left[2 + 2z \right] \, C/m^3$$

$$\left(\text{using } \nabla \cdot \bar{D} = \frac{\partial D_x}{\partial x} + \frac{\partial D_y}{\partial y} + \frac{\partial D_z}{\partial z} \right)$$

$$Q = \varepsilon_o \int_{z=0}^{0.1} \int_{\phi=0}^{2\pi} \int_{\rho=0}^{0.05} (2 + 2z) \, \rho \, d\rho \, d\phi \, dz$$

Sorry -- forgot the constant here -- please multiply the answer by epsilon_o. Otherwise the method is the same.

$$\varepsilon_o \left[\frac{\rho^2}{2} \right]_0^{0.05} \left[\phi \right]_0^{2\pi} \left[2z + z^2 \right]_0^{0.1}$$

$$= 0.00165 \, \varepsilon_o \; C.$$