Form No. T611

Philadelphia University
Faculty of Engineering

Student Name:
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Dept. of Electrical Engineering
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Course No: (610213)	Time Allowed: 2 Hours
Lecturer: Dr. Mohammad Abu-Naser	No. of Pages: 7

Question 1: *(40Mark)*

Objectives: This question is related to multiple choices

1) The force between two charges separated by a distance r varies as
   a) r^2
   b) r
   c) 1/ r
   d) $1/r^2$
2) The relative permittivity of air is
   a) 0
   b) 1
   c) 8.85×10^{-12}
   d) none of the above
3) The absolute permittivity of air is
   a) 0
   b) 1
   c) 8.85×10^{-12}
   d) none of the above
4) Electric field lines enter or leave a conducting surface at an angle
   a) of 90°
   b) of 30°
   c) of 60°
   d) of 0°
5) A unit charge moves on an equipotential surface from point A to point B. Then,
   a) $V_A = V_B$
   b) $V_A > V_B$
   c) $V_A < V_B$
   d) none of the above
6) The absolute permeability of air is
   a) 10^6 H/m
   b) $4\pi \times 10^{-3}$ H/m
   c) $4\pi \times 10^{-7}$ H/m
   d) None of the above
7) Magnetic flux passes more easily through
   a) air
   b) wood
   c) vacuum
   d) iron
8) By increasing the number of turns 3 times in a toroid, the magnetic flux
   a) will remain unchanged
   b) will become three times
   c) will reduce to one-third
   d) none of the above

9) A current is passed through a straight wire. The magnetic field established around it has magnetic lines

a) circular
b) straight
c) oval
d) none of the above

10) A conductor of length 1 m carrying current of 1 A is placed parallel to a magnetic field of 1 T. The magnetic force acting on the conductor is

a) zero
b) 1 N
c) 0.5 N
d) 2.5 N

11) A conductor of length 1 m carrying current of 1 A is placed perpendicular to a magnetic field of 1 T. The magnetic force acting on the conductor is

a) zero
b) 1 N
c) 0.5 N
d) 2.5 N

12) The basic requirement for inducing emf in a coil is that ....

a) flux should link the coil
b) there should be change in flux linking the coil
c) coil should form a closed loop
d) none of the above

13) The emf induced in a coil of N turns is given by ....

a) $d\varphi/dt$
b) $dt/d\varphi$
c) $-N\, d\varphi/dt$
d) $-N\, dt/d\varphi$

14) Which of the following statements is true

a) The divergence is performed on a vector and the result is scalar
b) The divergence is performed on a vector and the result is vector
c) The divergence is performed on a scalar and the result is scalar
d) The divergence is performed on a scalar and the result is vector

15) Which of the following statements is true

a) The gradient is performed on a vector and the result is scalar
b) The gradient is performed on a vector and the result is vector
c) The gradient is performed on a scalar and the result is scalar
d) The gradient is performed on a scalar and the result is vector

16) Two long, straight, parallel conductors separated by a finite distance carrying currents in opposite directions. The magnetic force between them is:

a) Attraction
b) Repulsion
c) Rotational
d) None

17) A vector $\vec{A} = 3\hat{x} + 4\hat{y}$. The corresponding unit vector $\hat{A}$ is:

a) $0.6\hat{x} + 0.8\hat{y}$
b) $\hat{x} + \hat{y} + \hat{z}$
c) $0.12\hat{x} + 0.16\hat{y}$
d) $0.6\hat{x} + 0.8\hat{y} + \hat{z}$

18) $\vec{A} = 3\hat{x} + 2\hat{y} + \hat{z}$ and $\vec{B} = 2\hat{x} + 5\hat{y} + 3\hat{z}$, the dot product $\vec{A} \cdot \vec{B}$ is:

a) 0
b) $6\hat{x} + 10\hat{y} + 3\hat{z}$
c) 19
d) $\sqrt{19}$

19) $\vec{A} = \hat{x} + 2\hat{y}$ and $\vec{B} = 3\hat{x} + 2\hat{y}$, the cross product $\vec{A} \times \vec{B}$ is:

a) $-4\hat{z}$
b) 0
c) $3\hat{x} + 4\hat{y}$
d) $8\hat{z}$

20) Two charges $Q_1 = 10$ mC and $Q_2 = 50$ mC enclosed by surface S. The net flux that crosses S is:

a) $50\hat{x}$ mC
b) 0
c) 50 mC
d) 60 mC

Notes:

Rectangular Coordinates

$$\nabla A = \frac{\partial A}{\partial x}\hat{x} + \frac{\partial A}{\partial y}\hat{y} + \frac{\partial A}{\partial z}\hat{z}$$

$$\nabla \cdot \vec{A} = \frac{\partial A_x}{\partial x} + \frac{\partial A_y}{\partial y} + \frac{\partial A_z}{\partial z}$$

Cylindrical Coordinates

$$\nabla A = \frac{\partial A}{\partial r}\hat{r} + \frac{1}{r}\frac{\partial A}{\partial \phi}\hat{\phi} + \frac{\partial A}{\partial z}\hat{z}$$

$$\nabla \cdot \vec{A} = \frac{1}{r}\frac{\partial}{\partial r}(rA_r) + \frac{1}{r}\frac{\partial A_\phi}{\partial \phi} + \frac{\partial A_z}{\partial z}$$

Question 2: ***(15Mark)***

Objectives: This question is related to electrostatic relationships

For the following electric flux density $\vec{D} = 8xy\hat{x} + 4x^2\hat{y}$ C/m^2, determine:

a) The charge density

$$\rho_v = \nabla \cdot \vec{D} = \frac{\partial D_x}{\partial x} + \frac{\partial D_y}{\partial y} + \frac{\partial D_z}{\partial z}$$

$$= 8y + 0$$

$$= 8y \ \text{C/m}^3$$

b) The total charge stored in the region 0<x<1, 0<y<1, 0<z<1

$$Q = \iiint \rho_v \, dv$$

$$= \int_{x=0}^{1} \int_{y=0}^{1} \int_{z=0}^{1} 8y \, dx \, dy \, dz$$

$$= x \Big|_0^1 \, z \Big|_0^1 \, \frac{8y^2}{2} \Big|_0^1$$

$$= 1 \times 1 \times 4(1^2 - 0^2)$$

$$= 4 \ \text{C}$$

Question 3: ***(15Mark)***

Objectives: This question is related to electrostatic relationships

For the following electric potential $V = x^2 + 2y^2 + 4z^2$ V, determine:

a) The electric field

$$\vec{E} = -\nabla V = -\frac{\partial V}{\partial x}\hat{x} - \frac{\partial V}{\partial y}\hat{y} - \frac{\partial V}{\partial z}\hat{z}$$

$$= -2x\hat{x} - 4y\hat{y} - 8z\hat{z} \text{ V/m}$$

b) The energy within the region 0<x<1, 0<y<1, 0<z<1

$$W = \frac{1}{2}\varepsilon_0 \iiint |E|^2 dv$$

$$= \frac{1}{2}\varepsilon_0 \int_{x=0}^{1}\int_{y=0}^{1}\int_{z=0}^{1} (4x^2 + 16y^2 + 64z^2)\, dx\, dy\, dz$$

$$= \frac{1}{2}\varepsilon_0 \left[\frac{4x^3}{3}\Big|_0^1 y\Big|_0^1 z\Big|_0^1 + \frac{16y^3}{3}\Big|_0^1 x\Big|_0^1 z\Big|_0^1 + \frac{64z^3}{3}\Big|_0^1 x\Big|_0^1 y\Big|_0^1 \right]$$

$$= \frac{1}{2}\varepsilon_0 \left[\frac{4}{3} + \frac{16}{3} + \frac{64}{3} \right]$$

$$= \frac{1}{2} \times 8.85 \times 10^{-12} \times \frac{84}{3}$$

$$= 1.239 \times 10^{-10} \text{ J}$$

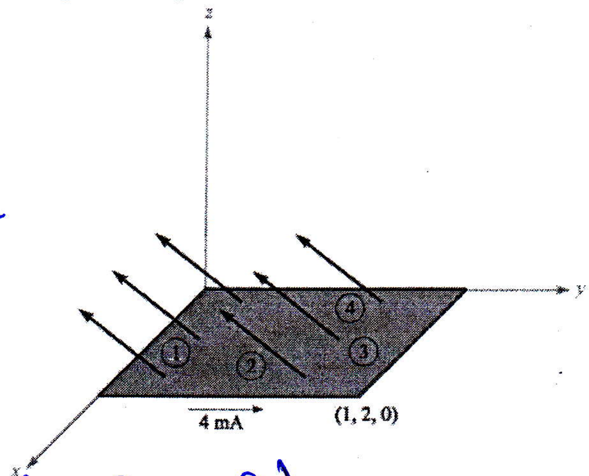
Question 4: ***(15Mark)***

Objectives: This question is related to magnetic torque and flux

Consider the rectangular loop of dimension 1m × 2m carrying a 4mA current shown in the following figure. The loop is in a uniform magnetic flux density

$\vec{B} = -0.6\hat{y} + 0.8\hat{z}$ T

a) Calculate the magnetic moment
b) Calculate the magnetic torque
c) Calculate the angle between the flux density and vector normal to the loop
d) when viewed from the positive x-axis, is the expected direction of rotation clockwise or counterclockwise?
e) Calculate the magnetic flux through the loop



a) $\vec{m} = IA\hat{n}$

$= 4\times10^{-3} \times .2\times1\,\hat{z}$

$= 8\times10^{-3}\,\hat{z}$

b) $\vec{T} = \vec{m}\times\vec{B}$

$= 8\times10^{-3}\,\hat{z} \times (-.6\hat{y} + .8\hat{z})$

$= 4.8\,\hat{x}$ mN.m

c) $\theta = \tan^{-1}\frac{.6}{.8} = 36.9^\circ$

d) The direction of rotation is counter clockwise when viewed from the positive x-axis.

e) $\phi = \iint \vec{B}\cdot d\vec{s}$

Since the flux is uniform

$\phi = \vec{B}\cdot\vec{A} = (-.6\hat{y} + .8\hat{z})\cdot 2\hat{z} = 1.6$ Wb

or

$\phi = |B||A|\cos\theta = 1\times2\times\cos 36.9^\circ$

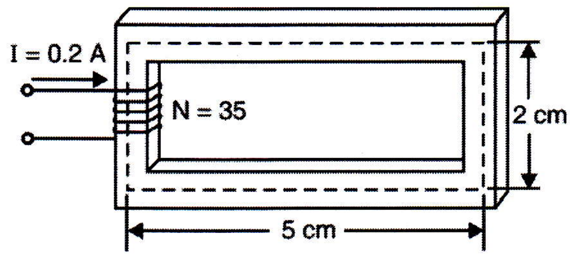
$= 1.6$ wb

Question 5: ***(15Mark)***

Objectives: This question is related to magnetic circuits

The relative permeability of the rectangular core shown in the following figure is 750. The core has a uniform cross sectional area of 15 mm^2. Calculate:

a) mmf
b) mean path length of the core
c) reluctance of the core
d) magnetic flux
e) magnetic flux density
f) inductance of coil
g) energy stored in the magnetic field



a) $mmf = NI = 35 \times .2 = 7$ A.turn

b) $L = (2\times5 + 2\times2)\times10^{-2} = 0.14$ m

c) $\mathcal{R} = \frac{L}{\mu_0 \mu_r A} = \frac{0.14}{4\pi\times10^{-7}\times750\times15\times10^{-6}} = 9.9\times10^{6}\ H^{-1}$

d) $\phi = \frac{mmf}{\mathcal{R}} = \frac{7}{9.9\times10^{6}} = 7.07\times10^{-7}$ Wb

e) $B = \frac{\phi}{A} = \frac{7.07\times10^{-7}}{15\times10^{-6}} = .0471$ T

f) $L = \frac{\lambda}{I} = \frac{N\phi}{I} = \frac{35\times7.07\times10^{-7}}{0.2}$

$= 0.1237$ mH

g) $W = \frac{1}{2}LI^2 = \frac{1}{2}\times.1237\times0.2^2$

$= 2.474\ \mu J$