UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE
Department of Electrical and Electronic Engineering

July 2014
SUPPLEMENTARY EXAMINATION

Title of the Paper:
Electromagnetic Fields I

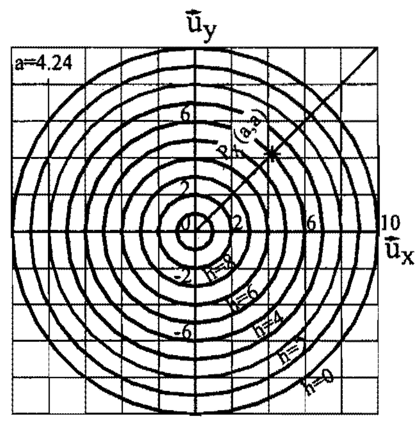
Course Number: **EE341**
Time Allowed: **Three Hours.**

Instructions:
1. To answer, pick any to sum a total of 100% from 12 questions in the following pages.
2. The answer is better neatly written in the space provided in the question book. Use the answer book as a scratch pad.
3. This paper has 8 pages, including this page.

DO NOT OPEN THE PAPER
UNTIL PERMISSION HAS BEEN GIVEN BY THE INVIGILATOR.

Q1, 10 pts: Given a scalar function $f(x,y)=1$, find (i) $\int f \cdot d\vec{l}$ and (ii) $\int f \cdot dl$ along a semi-circle from (10,0) to (-10,0) on top two quadrants in xy-plane, center at (0,0), radius=10. (5 pts for each (i) and (ii))

Q2, 15 pts: A given scalar function is $(10-h(x,y))^2=(x^2+y^2)$, where $h(x,y)$ is the height of a cone, the peak of which is 10 shown in Fig. Q2-1, (i) calculate graphically the maximum change (gradient) of the height at the location near $P_x(4,4)$ and the direction of the change; (ii) calculate the same but analytically. Check if the two answers are close. (5 pts for (i) and 10 pts for (ii).)



$(10\text{-}h(x,y))^2=(x^2+y^2)$
h-axis out of the paper
contour (constant height, "h") of a cone.
Fig. Q2-1

Q3, 15 pts: Given the field pattern shown in Fig. Q3-1, (i) by inspection determine and mark the area which has curl≠0 or div≠0 or both≠0 of the pattern. Then (ii) analytically calculate the non-zero curl or divergence to prove. Take closed surface anywhere in the pattern but must be specified. The fields are in xy-plane only, no contribution in z-axis top and bottom. The closed surface may be bounded by a square or a circle. (5 pts for (i), 10 pts for (ii))

$\mathbf{A} = \hat{\mathbf{x}}\, xy^2 + \hat{\mathbf{y}}\, x^2 y$, for $-10 \le x, y \le 10$

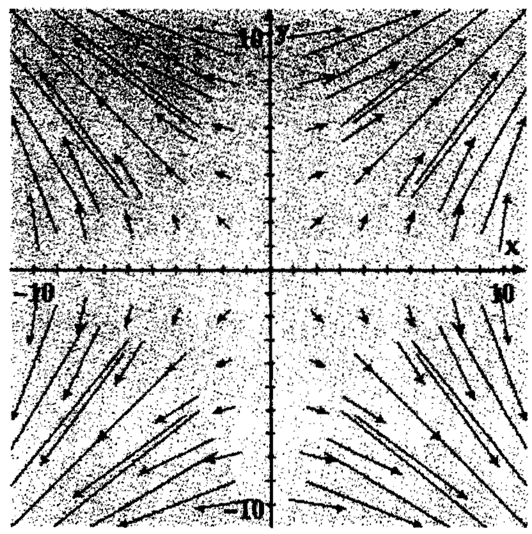


Fig. Q3-1

Q4, 10 pts: Fill in the dual equation. (2 pts for each blank)

Electric Fields	Magnetic Fields
$V = \frac{1}{4\pi\varepsilon}\int_v \frac{q_v \cdot dv}{r}$	
	$\oint_c \vec{H} \circ d\vec{l} = I$
$\vec{\nabla} \times \vec{E} = 0$	
$V_c = \frac{1}{C}\int_0^t i_c \cdot dt$	
Time constant $= R \cdot C$	

Q5, 15 pts: A point charge with a charge +q Coul. is located *d* Mtr above an infinitive perfect conducting xz-plane, shown in Fig. Q5-1. (i) Find the charge density on the x-axis. Use the image method. (ii) Is there any dual method in static magnetic fields and give the reason behind? (10 pts for (i), 5 pts for (ii)).

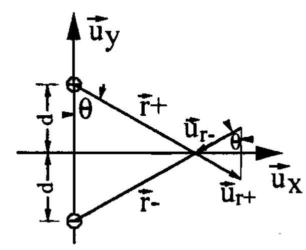


Fig. Q5-1

Q6, 15 pts: A long parallel plate cable has a width w and a separation d with insulation material ε/μ_o. Consider no end fringing effects. (i) Calculate the cable inductance and capacitance per unit length. (ii) the Characteristic impedance z_o. (5 pts for each answer)

Q7, 10 pts: A long parallel plate cable has a width w and a separation d with insulation material ε/μ_o. Consider no end fringing effects. (i) Find the total electric energy stored in the cable per meter, energized by a source charge q_l Coul/Mtr. (ii) Find the total magnetic energy stored in the cable per meter, energized by a total source current I_s. (5 pts for each)

Q8, 15 pts: An electric dipole antenna has a dipole moment 1/9 coul-mtr and its direction is oriented in the z-axis. Calculate (i) the electric field at 1 KM away with $\theta = 0°$ and (ii) the same with $\theta = 90°$. (iii) Comment on the direction of the two fields with respect to the dipole orientation. (5 pts for each.)(hint: $V = \frac{\vec{p} \circ \vec{u_r}}{4\pi\varepsilon \cdot r^3}$)

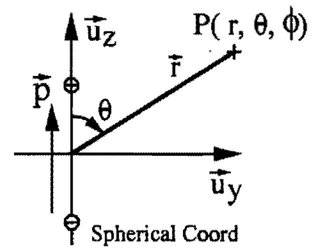


Fig. Q8-1

Q9, 10 pts: Two point charges carry equal and opposite charge +q/-q, are located each at *d* meters away from xy-plane on z-axis in the Cartesian coordinates. Find the zero potential surface.

Q10, 10 pts: A magnetic circuit with all the pertinent dimensions in centimeter and cross sectional area $2x10^{-3}$ Mtr^2 is shown in Fig. Q10-1. In the figure, the left and the right "C" are equal in size. Determine the current in the 1600-turn coil to establish a flux density of 0.75 T in each air gap. Given the iron u_r=1000. (hint: using analogy of Ohm's law in magnetic circuit)

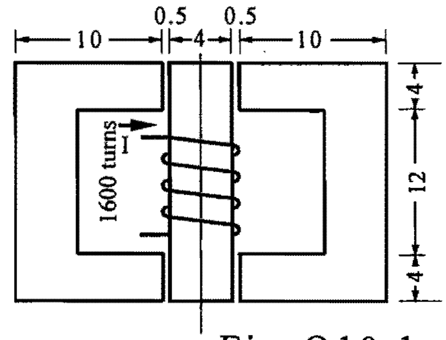


Fig. Q10-1

Q11, 10pts: A square coil of side a, shown in Fig. Q11-1 carries a current I. Determine the vector potential of this coil at the point on its axis $\vec{u}_z$ and z meters away from the coil plane.

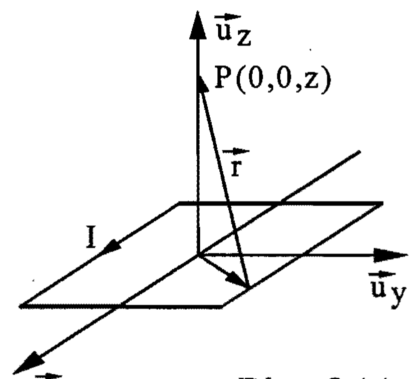


Fig. Q11-1

Q12, 10 pts: In the air, there is a slab of the dielectric material with the constants ε. Find the angle α_4 in terms of α_1. The geometry of the complex slab is shown in Fig. Q12-1.

(hint: $\tan(a \pm b) = \dfrac{\tan(a) \pm \tan(b)}{1 \mp \tan(a) \cdot \tan(b)}$)

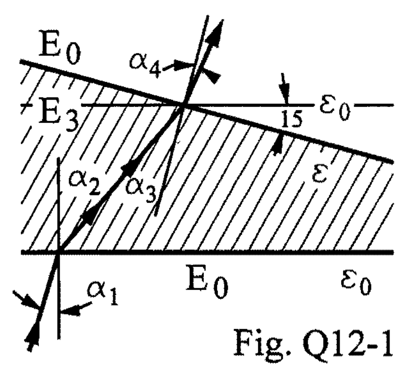


Fig. Q12-1