UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE

Department of Electrical and Electronic Engineering

July 2016
SUPPLEMENTARY EXAMINATION

Title of the Paper:

Electromagnetic Fields I

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

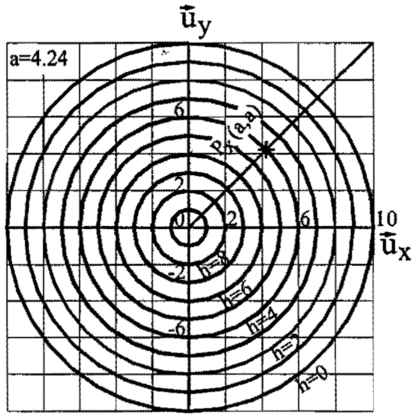
Instructions:

1. Answer all questions, no choice.
2. The answer is better neatly written in the space provided in the question book. Use the answer book as a scratch pad. Mark personal name and ID, and hand in all of them.
3. This paper has 7 pages, including this page.

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

Q1, 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.

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).)



$(10-h(x,y))^2=(x^2+y^2)$
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))

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

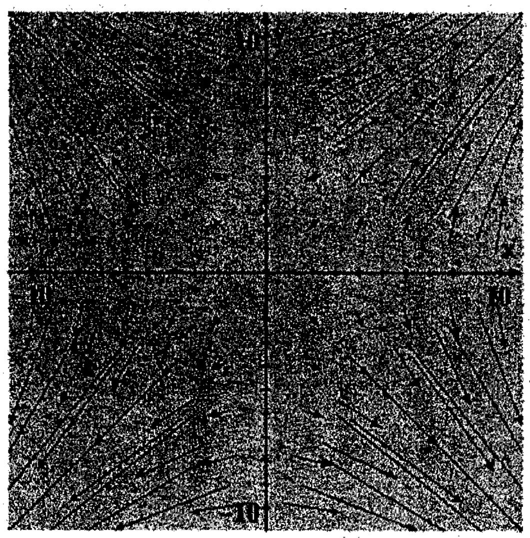


Fig. Q3-1

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, 10 pts: A magnetic circuit with all the pertinent dimensions in centimeter and cross sectional area $2x10^{-3}$ Mtr^2 is shown in Fig. Q5-1. 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)

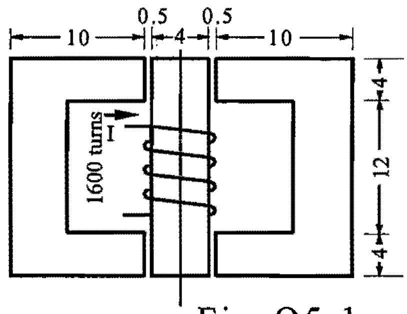


Fig. Q5-1

Q6, 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)

Q7, 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 triangle from (-10,0) to (0,10) to (10,0) on top two quadrants in xy-plane, center at (0,0). (5 pts for each (i) and (ii))

Q8, 10pts: A square coil of side *a*, shown in Fig. Q8-1 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.

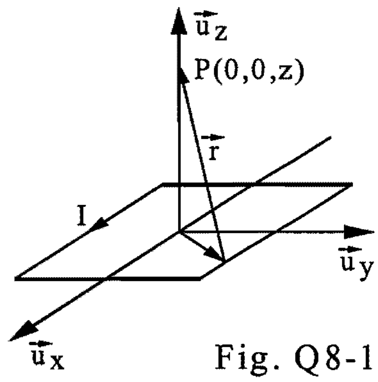


Fig. Q8-1

Q9, 10 pts: In the air, there is a slab of the dielectric material with the constants ε_r. Find the angle α_4 in terms of α_1. The geometry of the complex slab is shown in Fig. Q9-1. (hint:

$$\tan(a \pm b) = \frac{\tan(a) \pm \tan(b)}{1 \mp \tan(a) \cdot \tan(b)} \quad \frac{\tan\theta_2}{\tan\theta_1} = \frac{\varepsilon_2}{\varepsilon_1})$$

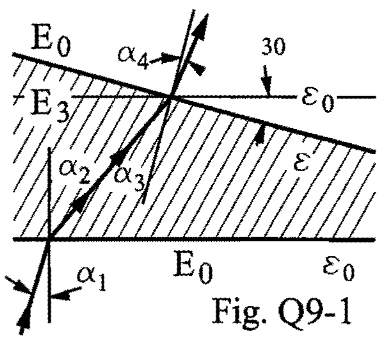


Fig. Q9-1