UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE
Department of Electronic and Electrical Engineering

MAIN EXAMINATION 2015

Title of the Paper:
Electromagnetic Fields I

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

Instructions:
1. To answer, pick any to sum a total of 100% from 10 questions in the following pages.
2. The answer must be written in the space provided in the question book. Use the answer book as a scratch pad. Consider valid the only answer under the assigned the space.
3. This paper has 10 pages, including this page.

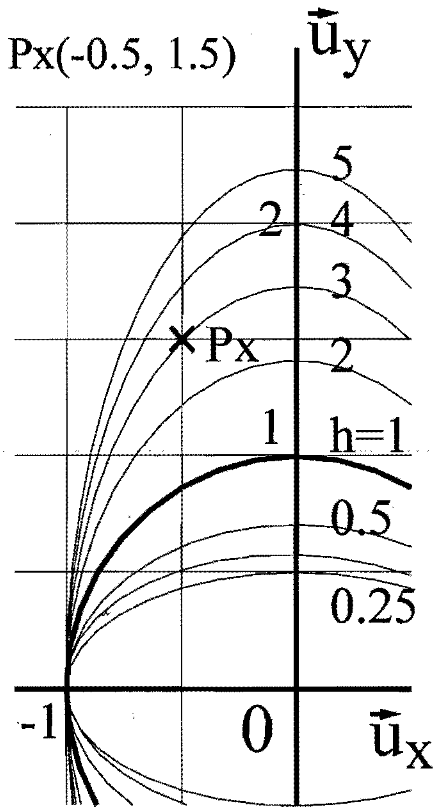
DO NOT OPEN THE PAPER
UNTIL PERMISSION HAS BEEN GIVEN BY THE INVIGILATOR.

Q1: **(10 pts)** Given a scalar function $f(x, y, z) = x^2 \cdot y + z$, find (i) $\int f \cdot d\vec{l}$ and (ii) $\int f \cdot dl$ along a straight line from (1,0,0) to (0,1,0). (5 pts each)

Q2: **(20 pts)** List any five pairs of dual equation in electromagnetic fields. (4 pts for each pair)

term	Electric Fields	Magnetic Fields

Q3: **(10 pts)** Given a scalar function, $h(x,y) = y^2/(1-x^2)$, the height of a inverted cone shown in Fig. Q3-1, (i) calculate graphically the gradient magnitude and direction of the height at the location $P_x(-0.5, 1.5)$; (ii) calculate the same but analytically. Check if the two answers are close. (5 pts each, in the 5 pts, 3 pts for the direction part)



h(x,y)=y²/(1-x²)
h-axis out of the paper
contour (constant height, "h")

Fig. Q3-1

Q4: (10 pts) Given a field pattern "A" shown in Fig. Q4-1, (i). by inspection determine and mark the area which has curl≠0 or div≠0 or both≠0 of the pattern. (ii). Then analytically calculate the non-zero curl or divergence to prove. Take closed surface anywhere in the pattern but the location must be specified. The fields are in xy-plane only, no contribution in z-axis top and bottom. The closed surface may be cubically or circinately bounded. (5 pts each)

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

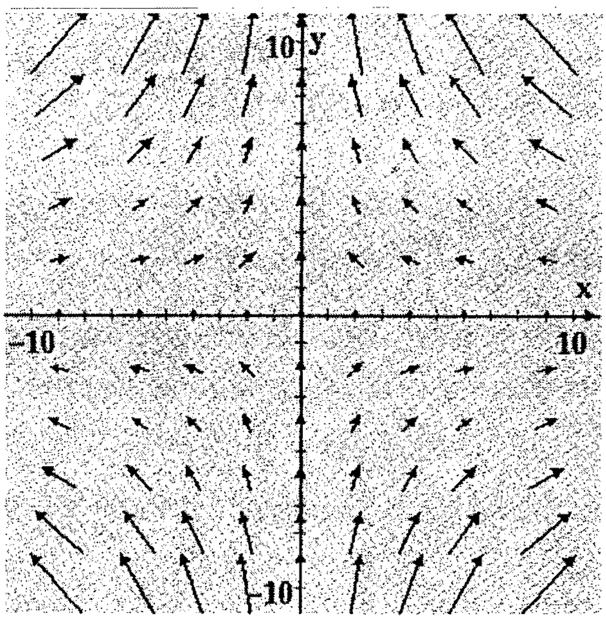


Fig. Q4-1

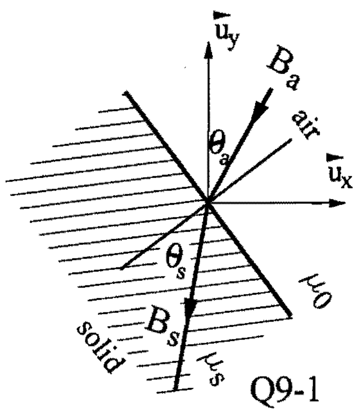
Q5: **(20 pts)** Two perfect conducting metal squares have the same side width "a", and separation "d" with insulation material ε/μ_o filled in between. (i) Find the total magnetic energy stored in this space, if it energized by a total source current I_{tt} Amp from the one side of the square to the other side and the other disk flowed in opposite direction. (ii) Find the total electric energy stored in this space, if it energized by a total source charge Q_{tt} Coul. Answer in dual form or half the grade points. Consider no fringing effect. (10 pts each)

Q6: **(10 pts)** A point charge with a charge +Q Coul is located at d Mtr above an infinitive perfect conducting plane in xy-plane. Find the charge density on the plane. Use the image method. Is there any dual method in static magnetic fields and give the reason behind? (hint: In Cartesian, $\vec{u}_R = (\sin\theta \cdot \cos\phi,, \sin\theta \cdot \sin\phi,, \cos\theta))$ (6 pts for the first question, 4 pts for the second).

Q7: **(20 pts)** A coaxial cable has a inner radius r_i and outer radius r_o with insulation material ε/μ_o. Consider no end fringing effects. (i) Calculate the cable per unit inductance and capacitance. (ii) the Characteristic impedance z_o. (8 pts for each answer in (i) and 4 pts for (ii))

Q8: **(10 pts)** Prove (i) which equation or law in electric fields will degenerate into Kirchhoff's Voltage Law, specifying the necessary conditions; (ii) which will degenerate into Kirchhoff's Current Law likewise. (5 pts each)

Q9: (20 pts) (i) Shown in Fig. Q9-1, a space divided into two parts, one part is in the air and the other in a solid with relative permittivity ε_r=8 (μ_r=8). The boundary plane is through the Cartesian origin and its unit normal vector is (0.8, 0.6). If an E-field, (-2. -3) is coming from the air through the boundary into the solid. Find the E-field in the solid. (ii) Construct the dual question in the magnetic field. (10 pts each)



Q9-1

Q10: (20pts) A current coil of the size shown in Fig. Q10-1, carries a current I. Determine the vector potential of this coil at the point on its axis and z meters away from the coil plane. (10 pts for correct formulation)

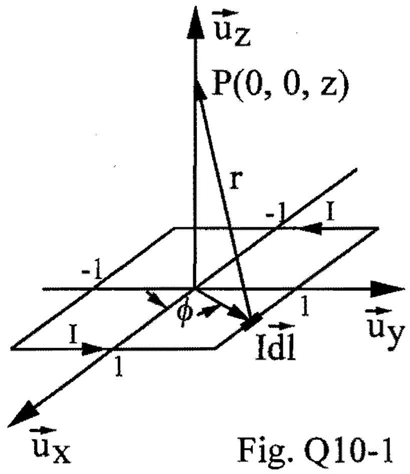


Fig. Q10-1