UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE

Department of Electronic and Electrical Engineering

MAIN EXAMINATION 2011

Title of the Paper:

Electromagnetic Fields I

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

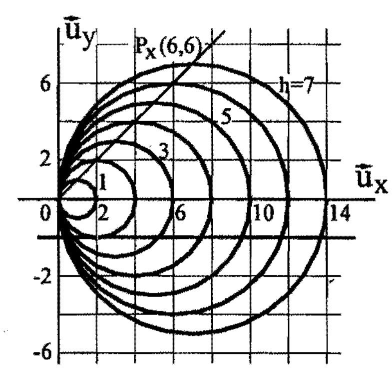
Instructions:

1. To answer, pick any to sum a total of 100% from 14 questions in the following pages.
2. Each question carriers 10 points.
3. The answer is better written in the space provided in the question book. Use the answer book as a scratch pad.
4. This paper has 9 pages, including this page.

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

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

Q2: Given a scalar function, $h(x,y) = (x^2 + y^2)/2x$, the height of a slanted cone shown in Fig. Q2-1, (i) calculate graphically the maximum change (gradient) of the height at the location $P_x(6,6)$ and the direction of the change; (ii) calculate the same but analytically. Check if the two answers are close. **10 pts** (5 pts for each (i) and (ii), 3 pts for the direction part)



h(x,y)=(x²+y²)/2x
h-axis out of the paper
contour (constant height, "h") of a slant cone.

Fig. Q2-1

Q3: Given two field patterns shown in Fig. Q3-1 and -2, by inspection determine and mark the area which has curl≠0 or div≠0 or both≠0 of the pattern. Then 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 cubically or cylindrically bounded. **10 pts** (5 pts for each pattern.)

(b) $\mathbf{A} = -\hat{\mathbf{x}} \sin 2y + \hat{\mathbf{y}} \cos 2x$, for $-\pi \le x, y \le \pi$

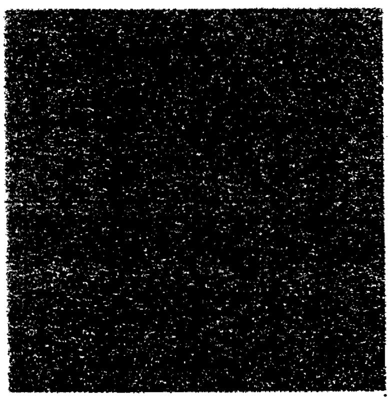


Fig. Q3-1

(d) $\mathbf{A} = -\hat{\mathbf{x}} \cos x + \hat{\mathbf{y}} \sin y$, for $-\pi \le x, y \le \pi$

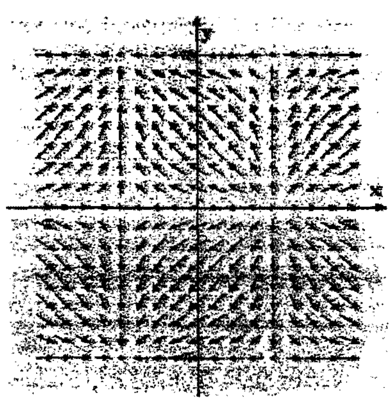


Fig. Q3-2

Q4: List any five pairs of dual equation in electromagnetic fields. **10 pts**
(2 pts for each pair)

term	Electric Fields	Magnetic Fields

Q5: 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) Find the total electric energy stored in this 1 meter long cable, energized by a source charge q_l Coul/Mtr. (ii) Find the total magnetic energy stored in this 1 meter long cable, energized by a source current Is. **10 pts** (5 pts for each)

Q6: An infinitely long line charge with a line density $+q_l$ Coul/Mtr is located d Mtr above an infinitive perfect conducting 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? **10 pts** (6 pts for the first question, 4 pts for the second).

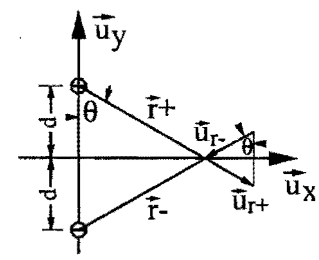


Fig. Q6-1

Q7: 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. **10 pts** (4 pts for each answer in (i) and 2 pts for (ii))

Q8: 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. **10 pts** (4 pts for (iii), 3 pts for each of (i) and (ii).)

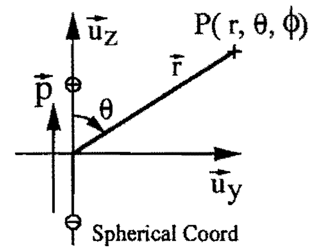


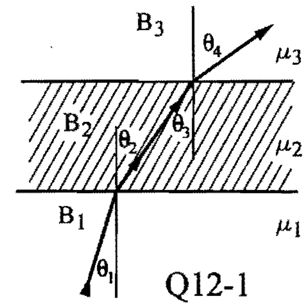
Fig. Q8-1

Q9: Two infinitely long line charges in the direction of z-axis, one carries a charge, +q coul/mtr located at the center of the cylindrical coordinates (possibly a Cartesian) and the other carries -0.2q coul/mtr at d meters away from z-axis. Find the zero potential surface. **10 pts**

Q10: 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. **10 pts** (5 pts for each)

Q11: Two parallel and infinitively long conductors are separated 2d mMtr apart. Set the conductors along z-axis lying on xz-plane and the coordinates center at middle point of the two conductors. The conductors carry a current of I Amps in opposite direction and so each is stored an opposite charge of q coul/mtr on the line. (i) Determine the B-field away from y-axis $(0, \infty)$; (ii) determine the E field likewise. Notice any special point about these two fields. **10 pts** (4 pts each, 2 pts for the notice)(hint: application of ready known formula is recommended)

Q12(i) Show that if no surface current densities exist at the parallel interfaces shown in Fig. Q12-1, the relationship between θ_4 and θ_1 is independent of μ_2. (ii) Show the same for independent of ε_2 for electric fields if no surface charge densities exist likewise. **10 pts** (5 pts for each)



Q12-1

Q13: A current coil of radius r_o 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. **10pts**

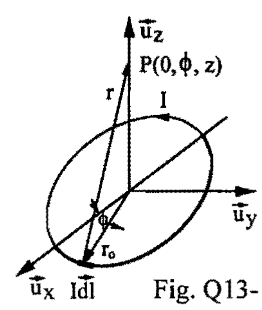


Fig. Q13-1

Q14: A series magnetic circuit with a uniform thickness of 6 cm is shown in Fig. Q14-1 with all dimensions in centimeters. If the current through the 500-turn coil is 1.0 A, (i) determine the current in the 600-turn coil in order to maintain flux of 1.0 mWb in the air gap. Assume the permeability of the magnetic material is $\mu_r = 500$. (ii) Compute the ratio of the mmf drop across the air gap to the applied mmf. **10 pts**
(8 pts for (i), 2 pts for (ii))

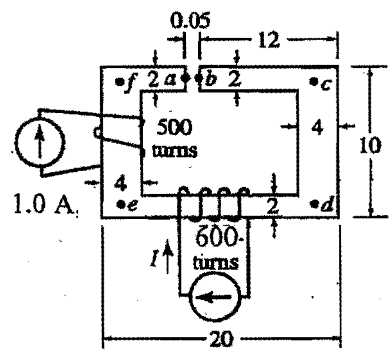


Fig. Q14-1