

THE UNIVERSITY OF NEW SOUTH WALES

SCHOOL OF PHYSICS

MID-SESSION EXAMINATION

SEPTEMBER 2010

PHYS2050

Electromagnetism

Time Allowed: 50 minutes

Total number of questions: 3

Candidates may bring their own calculators.

Answers must be written in ink. Except where they are expressly required, pencils may only be used for drawing, sketching or graphical work.

Do not use red ink.

Question 1 (12 marks)

Given are the following vector fields:

$$\vec{v}_1(r) = x \vec{e}_x + y \vec{e}_y$$

$$\vec{v}_2(r) = (6x, z \cos yz, y \cos yz)$$

$$\vec{v}_3(r) = (x(z-y), y(x-z), z(y-x))$$

$$\vec{v}_4(r) = (x^2y, \cos z^3, zy)$$

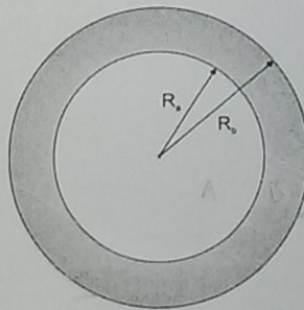
- (i) Explain in a few words: What is a conservative vector-field and what is a potential?
- (ii) What are the consequences if a vector field is conservative?
- (iii) Calculate the divergence and the curl of the above given vector fields. Which vector fields are conservative?
- (iv) If one of the above given vector fields is conservative, determine the corresponding potential.

Question 2 (18 marks)

Non-uniformly charged hollow sphere

A non-uniformly charged hollow sphere has an inner radius of R_a and an outer radius of R_b . The charge density inside of the hollow sphere is:

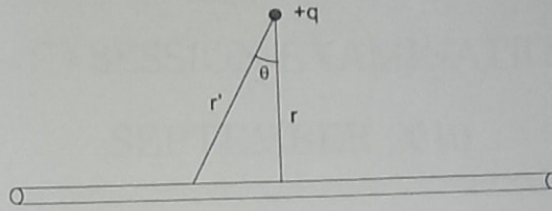
$$\rho(r) = \begin{cases} \frac{\alpha}{r^2} & \text{if } R_a \leq r \leq R_b \\ 0 & \text{otherwise} \end{cases}$$



- (i) Determine the total charge Q of the hollow sphere as a function of the constant α and the inner and outer radii. Determine the constant α as a function of Q .
- (ii) Calculate the electric field for the three areas: $0 \leq r < R_a$, $R_a \leq r \leq R_b$, and $r > R_b$.
- (iii) Calculate the electric potential for the three areas: $0 \leq r < R_a$, $R_a \leq r \leq R_b$, and $r > R_b$. (Note that the potential must be continuous at the interface)!
- (iv) Calculate the electric field and the electric potential at R_a and R_b and plot the electric field and the electric potential as a function of r .
- (v) Give an expression for the energy density $w(r)$ for the three areas, where:
$$W(r) = \int w(r') d^3r'$$

Question 3 (10 marks)

Infinite wire



An infinite wire is uniformly charged and carries a total charge of λ :

- (i) Calculate the electric potential of the wire at a distance r .
- (ii) Determine the electric field caused by the uniformly charged wire.
- (iii) Determine the force which acts on the charge $+q$ at the distance R .