ELECTROMAGNETISM

Level 2 Physics problems – Foundations of physics 2

Question 3 Cycle 2 Version 1

Professor D P Hampshire – 2nd Year Physics Lecture Course

These problems are formatively self-assessed. Students who showed the chutzpah to volunteer for the peer-marking pilot scheme will also mark one of their peer's scripts.

Reading Material (Please note that questions may not be exclusively associated with these chapters): Chapters 3 and 4: Introduction to Electrodynamics, D J Griffiths. Not necessary for homework but for 'fun' read Feynman Lectures in Physics Chapters 4-7. Fabulous insight. Also, Feynman Lectures in Physics Chapters 16 and 17.

1. Write down Faraday's law - define all terms used. [1 mark]

2. A current loop area S in the x-y plane is placed in a uniform time varying magnetic field $B_z(t) = B(0)\cos(\omega t)$.

a) Find the e.m.f. induced in the coil when it is fixed in the x-y plane. [1 mark]

b) Show that if the coil rotates at an angular frequency ω about the x-axis and that at $t = 0$ the maximum magnetic flux is enclosed in the loop, there is a voltage of frequency 2ω generated across the loop. [1 mark]

3. A high speed jet aircraft with a wingspan of 2 m flies upwards at an angle of 60 degrees to the horizontal at a speed of 500 ms^{-1} through a vertical magnetic field of 10 μT. What is the potential difference between the wing tips? [1 mark]

4. A simple loop of length 30 cm wraps once around the middle turns of a long coil. The coil has 2500 turns, is of length 1 m and radius 1 cm, and carries a current of 10 A. What is the magnetic flux through the single loop? [1 mark]

5. A conducting rod of mass m and resistance R is free to slide without friction along two parallel rails of negligible resistance separated by a distance l and connected with negligible resistance at one end. The rails are attached to a long inclined plane that makes an angle θ with the horizontal. There is a magnetic field B directed upward.

a) Show that there is a retarding force directed up the incline given by, [3 marks]

$$F = \frac{B^2 l^2 v \cos^2\theta}{R}$$

b) Suppose that the rod starts from rest, show that the terminal speed of the rod is, [2 marks]

$$v_t = \frac{mgR\sin\theta}{B^2 l^2 \cos^2\theta}$$