Course code and name:	B38EM Introduction to Electricity and Magnetism
Type of assessment:	**Individual**
Coursework Title:	**Take home Assignment 2**
Student Name:	
Student ID Number:	

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Introduction to Electricity and Magnetism B38EM
Assignment #2

$\varepsilon_0 = 8.85\text{x}10^{-12}\ \text{Fm}^{-1}$, $e = 1.6\text{x}10^{-19}\ \text{C}$, $\mu_0 = 4\pi\ 10^{-7}\ \text{N/A}^2$

1. Consider the system shown in **Figure Q1** where a metal bar of mass *m* slides frictionless on two parallel conducting rails separated by a distance *l*. A resistor *R* is connected across the rails. If a uniform magnetic field B, pointing into the page, fills the entire region, find the following:

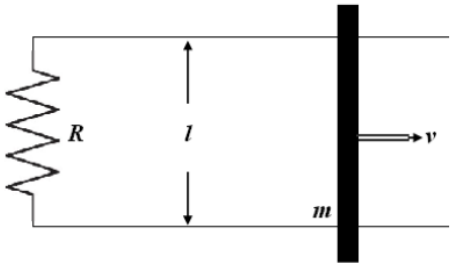

Figure Q1

(a) If the bar moves to the right at speed *v*, what is the current in the resistor? In which direction does it flow? *(3 marks)*

(b) Determine the magnetic force. What is the direction of the force? *(3 marks)*

(c) If the bar starts out with speed v_0 at t=0, and it is left to slide, what is its speed at a later *t*? *(4 marks)*

(d) If the initial kinetic energy of the bar was $\frac{1}{2}mv_0^2$. Check that the energy delivered to the resistor is exactly that. (Hint: First find the power delivered to the resistor) *(3 marks)*

2. The transformer shown in **Figure Q2** consists of a long wire coincident with the *z*-axis carrying a current $I = I_0 \cos \omega t$, coupling magnetic energy to a toroidal coil situated in the *x*–*y* plane and centred at the origin. The toroidal core uses iron material with relative permeability, μ_r, around which 100 turns of a tightly wound coil serves to induce a voltage V_{emf}, as shown in the figure.
   (a) Develop an expression for V_{emf} *(3 marks)*
   (b) Calculate V_{emf}, for the parameters in **Table Q2** *(2 marks)*

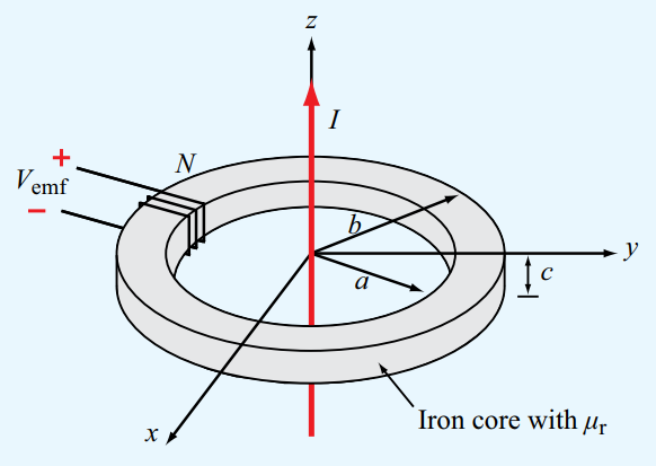

Figure Q2

Table Q2

Parameter	Value
Frequency, f	60 Hz
Relative permeability, μ_r	4000
a	5 cm
b	6 cm
c	2 cm
Current amplitude, I_0	50 A

3. In a Cartesian coordinate, a plane wave is polarized with its electric vector along *z*. The wave propagates along the *y*-axis. The electric field is given by $E_z(y,t) = E_0 e^{j(ky-\omega t)}$ Volts/metre. This wave is propagating in vacuum; its amplitude is E_0 = 7 V/m and its wavelength is λ = 0.3 meters.

a) What is the frequency of the wave? **(*2 marks*)**
b) How large is the magnetic field associated with this wave **(*2 marks*)** and in what direction is it oriented **(*2 marks*)**?
c) What is the average rate at which energy is transported by this wave (per square metres)? **(*2 marks*)**

4. A coaxial cable that connects a radar receiver to its antenna is 30-m-long and it is lossless. The cable has a characteristic impedance $Z_0 = 50\ \Omega$ and operates at 2 MHz. The cable is terminated at an unmatched antenna that has an impedance of $Z_L = 60 + j40\ \Omega$. If the phase velocity on this transmission line is $u = 0.6c$ (where c is the speed of light in vacuum), find:

d) The complex reflection coefficient Γ at the cable and antenna interface; **(*2 marks*)**

e) The voltage standing wave ratio; **(*2 marks*)**

f) The input impedance of this transmission line. **(*1 marks*)**