THE UNIVERSITY OF ZAMBIA SCHOOL OF ENGINEERING

Department of Electrical & Electronic Engineering

MEC 3102

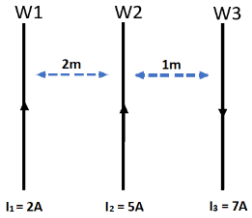
Assignment 1: Electromechanical devices (Due on 25/08/23)

TUTORIAL AND ASSIGNMENT QUESTIONS

INSTRUCTIONS:

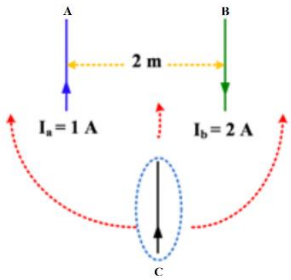
i. Answer and submit only the highlighted question

1. What are Magnetic fields and give its application? [5]
2. State the following:
   (a) Ampere's Law [2]
   (b) Lorentz force [2]
   (c) Faraday's Laws [4]
   (d) Lenz's Law [2]
3. A long, rigid wire lying along the y-axis carries a 5.0 A current flowing in the positive y-direction. What is the magnetic force per unit on the wire? Consider the directions too.
   (a) A constant magnetic field of magnitude 0.3T is directed along the positive x-axis. [2.5]
   (b) A constant magnetic field of magnitude 0.3T is directed 30 degrees from the x-axis towards the +y-axis. [2.5]
4. Three straight conductors are arranged as shown below:



   Determine the magnetic force acting on the second wire for 2.5m length. [5]

5. Two conductors A and B is 2 meters apart with the currents respectively 1 A and 2 A. where should conductor C be placed so that the magnetic force acting on it is zero.



6. The axle of a certain motor car is 1.5 m long. Calculate the e.m.f. generated in it when the car is travelling at 140 km/h. Assume the vertical component of the earth's magnetic field to be 40 μT.
7. Two coils, A and B, are wound on the same ferromagnetic core. There are 300 turns on A and 2800 turns on B. A current of 4 A through coil A produces a flux of 800 μWb in the core. If this current is reversed in 20 ms, calculate the average e.m.f. induced in coils A and B.
8. Define the following terms:
   (a) Permeability [2]
   (b) Coercive force [2]
   (c) Reluctance [2]
   (d) Permeance [2]
   (e) Magnetomotive force [2]

9. A coil of 200 turns is wound uniformly over a wooden ring having a mean circumference of 600 mm and a uniform cross-sectional area of 500 mm^2. If the current through the coil is 4 A, calculate:

(a) the magnetic field strength,

(b) the flux density, and

(c) the total flux

10. Fig. 3 shows an iron circuit with a small air gap cut in it. A 6000-turn coil carries a current I = 20 mA which sets up a flux within the iron and across the air gap. If the iron cross section is 0.8×10^{-4} m^2, the mean length of flux path in iron is 0.15 m, μ_r = 800 in iron and air gap length is 0.75 mm, calculate the air gap flux density. It may be assumed that the flux lines flow straight across the air gap, i.e. air gap cross section is also 0.8×10^{-4} mm^2.

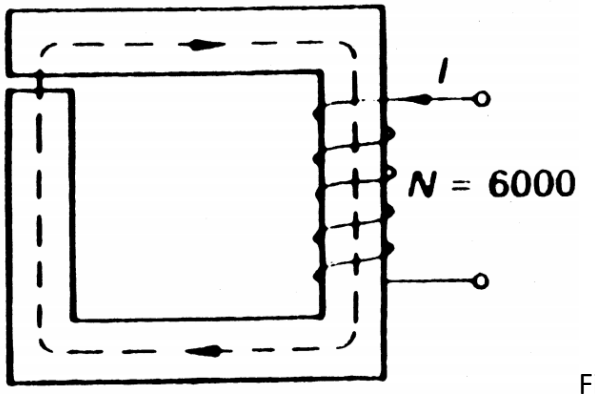


Fig.3

11. In the magnetic circuit detailed in Figure 4 with all dimensions in mm, calculate the required current to be passed in the coil having 200 turns in order to establish a flux of 1.28 mWb in the air gap and air gap length of 0.1 m. Neglect fringing effect and leakage flux. The B-H curve of the material is given in Figure 5. Permeability of air may be taken as, $\mu 0 = 4\pi \times 10\text{-}7$ H/m.

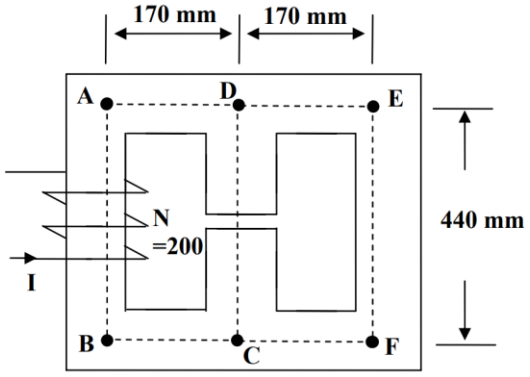


Fig.4

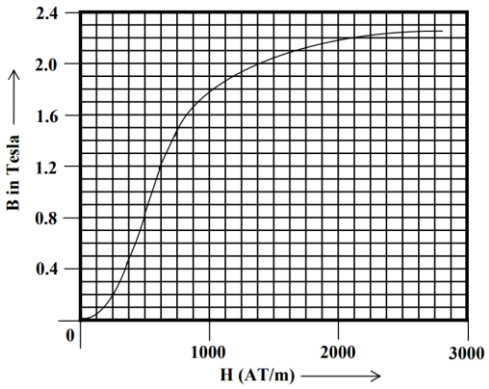
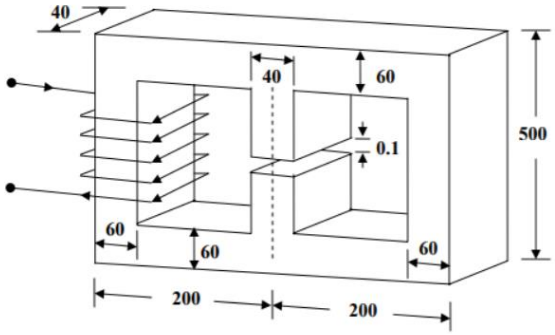


Fig.5



12. Explain the function of the commutator in a d.c. machine. A six-pole d.c. generator has a lap-connected armature with 480 conductors. The resistance of the armature circuit is 0.02 Ω. With an output current of 500 A from the armature, the terminal voltage is 230 V when the machine is driven at 900 r/min. Calculate the useful flux per pole and derive the expression employed.

13. A shunt generator supplies a 50-kW load at 400 V through cables of resistance 0.2 Ω. If the field winding resistance is 50 Ω and the armature resistance is 0.05 Ω, determine
    (a) The terminal voltage,
    (b) The e.m.f. generated in the armature.

14. A short-shunt compound generator supplies 50 A at 300 V. If the field resistance is 30 Ω, the series resistance 0.03 Ω and the armature resistance 0.05 Ω, determine the e.m.f. generated.

15. A DC motor is operating at 1200 rev/min. It draws 100 Amps from the line at a terminal voltage of 230 volts. The armature resistance between the terminals is 0.072.
    (a) Find the torque being developed by this motor.
    (b) Find the speed and armature current of this motor when the torque is 300 N-m, for the same excitation.

16. If a six-pole induction motor supplied from a three-phase 50 Hz supply has a rotor frequency of 2.3 Hz, calculate:
    (a) The percentage slip;
    (b) The speed of the rotor in revolutions per minute.

17. Describe, in general terms, the principle of operation of a three-phase induction motor. The stator winding of a three-phase, eight-pole, 50 Hz induction motor has 720 conductors, accommodated in 72 slots. Calculate the flux per pole of the rotating field in the airgap of the motor, needed to generate 230 V in each phase of the stator winding.

$$E = 4.44K_dK_p\emptyset fT$$

18. A 3-phase, 6 pole induction motor is rated 400Hz, 150V, 10hp, 3% slip at rated power output. The windage and friction loss is 200W at rated speed. With the motor operating at rated voltage, frequency, slip, and output power. Determine:
    a) Rotor speed.
    b) Frequency of the rotor current.
    c) Power crossing the air gap.
    d) Rotor copper loss.
    e) e) Output torque.