INDIAN INSTITUTE OF INFORMATION TECHNOLOGY VADODARA
End Semester Examination (AY 2023-24, Winter Semester)
Course: EE100 Basic Electrical Engineering

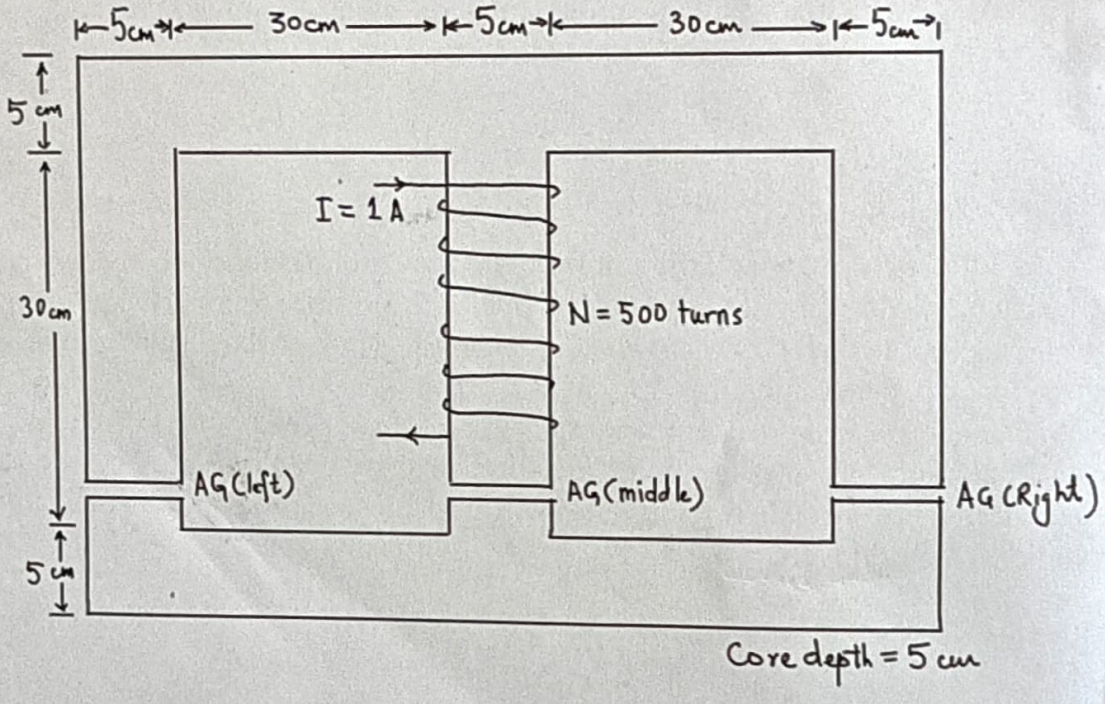
Full Marks: 120 **Date: 09/05/2024** **Time: 9:00 AM - 12:00 Noon**

Instructions:

1. *The exam is a closed book/resource.*
2. *Attempt **ALL** the questions.*
3. *Each question carries 20 marks.*
4. *Answer each question sequentially beginning on a new page.*
5. *Only a scientific calculator is permitted to be used.*

Ques. 1: In a typical magnetic circuit, define the following terms **(a)** Magnetomotive Force, **(b)** Magnetic Flux, and **(c)** Reluctance. How the three terms are related?

A ferromagnetic core with a relative permeability of 1500 is shown below. The depth of the core is 5 cm. The air gaps on the left, middle, and right sides of the core are 0.060 cm, 0.040 cm, and 0.020 cm, respectively. If there are 500 turns in the coil wrapped around the center leg of the core and if the current in the coil is 1.0 A, what is the flux in each of the left, center, and right legs of the ferromagnetic core? What is the magnetic flux density in each air gap?



Ques. 2: Draw a circuit diagram for the Y-Δ connection of a 13,800/480 V transformer bank consisting of three identical 100-kVA, 7967/480-V transformers.

Develop a relationship between the line voltage on the primary and the line voltage on the secondary side of the transformer bank.

Ques. 3: Draw the equivalent circuit model of **(a)** a separately excited DC motor, and **(b)** a shunt DC motor.

For a shunt DC motor, develop a relation between the motor's mechanical speed and induced torque assuming other relevant parameters. Subsequently, plot the torque-speed characteristics of the motor.

Ques. 4: Show that torque induced in a current-carrying loop in a uniform magnetic field is proportional to the strength of the loop's magnetic field, the strength of the uniform magnetic field, and the Sine of the angle between them.

Now, consider a simple rectangular loop ($l = 0.5\ m,\ b = 0.2\ m$) rotating at angular speed $\omega = 100\ rad/s$ in a uniform magnetic field $B = 0.5\ T$. Determine **(a)** the voltage induced in this rotating loop, **(b)** the current that would flow through the resistor 5 Ω connected as a load across the terminals of the loop, and **(c)** the magnitude and direction of the induced torque on the loop for the conditions in (b).

Ques. 5: A 440-V, 50-Hz, Y-connected, eight-pole synchronous generator has per-phase synchronous reactance of 1.0 Ω. Its full-load armature current is 50 A at 0.8 *pf* (lagging). It has an overall loss (mechanical plus electrical) of 2.0 kW. The field current in the machine is adjusted to provide a terminal voltage of 440 V at no load condition. Determine the following:

a) The synchronous speed of rotation in revolution per minute.
b) This generator's efficiency when operating at the rated current of 0.8 *pf* (lagging).
c) Shaft torque by the prime mover at full load.
d) Voltage regulation at 0.8 *pf* (lagging).

Ques. 6: Answer the following briefly:

a) How is the Induction Machine different from the Synchronous machine in construction?
b) Draw a schematic diagram of both the machines and describe their working principle.
c) For the induction machine, define *slip speed* and *slip*. How do the resulting rotor voltage and rotor frequency depend on the *slip*?
d) A three-phase, 60-Hz, induction motor runs at a no-load speed of 890 r/min and a full-load speed of 840 r/min. How many poles are there in the machine? Calculate the *slip* and the electrical frequency of the rotor at no-load and full-load conditions. What is the speed regulation (in %) of this motor?
