36 A TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2075 Baisakh

Exam.	Back		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

Subject: - Electrical Machine I *(EE551)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) Describe different types of losses on the transformer. Derive the expression for the maximum efficiency also. [5+3]

   b) A 50 KVA, 4400/220V transformer has $R_1 = 3.45\Omega$, $R_2 = 0.009\Omega$, $X_1 = 5.2\Omega$ and $X_2 = 0.015\Omega$. Calculate
   (i) equivalent resistance, reactance and impedance as referred to both primary and secondary sides
   (ii) total copper loss using individual resistance of the two windings and using equivalent resistances as referred to each side. [4+4]

2. a) Explain the different three phase transformer connections with neat sketch. Write their application also. [5+3]

   b) A mild steel ring of 30 cm mean circumference has a cross-sectional area of 6 cm^2 and has a winding of 500 turns on it. The ring is cut through at a point so as to provide an air gap of 1mm in the magnetic circuit. It is found that a current of 4A in the winding, produces a flux density of 1T in the air gap. Find (i) the relative permeability of the mild steel and (ii) inductance of the winding. [8]

3. a) Describe the method of excitation and types of D.C. Generator. [8]

   b) A 4 pole d.c shunt generator with a field resistance of 100 Ω and an armature resistance of 1Ω has 378 wave connected conductors in its armature. The flux per pole is 0.02 wb. If a total resistance of 10Ω is connected across the armature terminals and the generator is driven at 1000rpm. Calculate the power absorbed by the load. [8]

4. a) What is the necessity of a starter in a d.c. motor. Describe the working of 3-point starter. [2+6]

   b) A 200V d.c. series motor runs at 800 rpm when taking a line current of 15A. The armature and field resistances are 0.6Ω and 0.4Ω respectively. Find the speed at which it will run when connected in series with a 5Ω resistance and taking the same current at the same voltage. [8]

5. a) Define synchronous speed of three phase induction motor. Why does the rotor of a three phase induction motor rotate in the same direction as the rotating magnetic field? Why rotor can never reach the speed of stator field. [2+3+3]

   b) An 8 pole, 50 Hz, three phase induction motor develops a starting torque of 50 Kg-m. The rotor has an impedance of (0.8+j4) ohm per phase. At what speed the motor will develop maximum torque and calculate the magnitude of maximum torque. [8]

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36 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2074 Bhadra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

Subject: - Electrical Machine I *(EE551)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ ***All** questions carry equal marks.*
- ✓ *Assume suitable data if necessary.*

1. a) A magnetic core consists of circular ring with outer diameter 5.5 cm and inner diameter 3.5 cm. The relative permeability of the iron is 2000. A radial airgap of 2 mm is cut in this core. Calculate the direct current that will be required in a coil of 1000 turns uniformly distributed around the core to produce a magnetic flux of 0.3 mWb in the airgap. Assume the magnetic leakage is negligible.

   b) Draw the equivalent circuit of a transformer with their parameters as it is in primary side and secondary side. How all parameters can be transferred to primary side - explain with mathematical derivation.

2. a) Open circuit and Short circuit test on 5kVA, 220/400V, 50Hz, single phase transformer gave the following results.
   Short circuit test (on H.V. side): 40V, 11.4A, 200 watts
   Determine the efficiency and the voltage regulation of the transformer at full load at 0.9pf lagging

   b) State the conditions for proper operation of two transformers in parallel giving reasons for imposition of each of these conditions.

3. a) Explain the voltage build-up process of dc shunt Generator and define the meaning of critical resistance and critical speed.

   b) A dc shunt generator gives full load output of 30 kW at a terminal voltage of 200 V. The armature and shunt field resistances are 0.05 ohm and 50 ohm respectively. The iron and friction losses are 1000 W. Calculate: (i) generated emf; (ii) copper losses; (iii) efficiency

4. a) A 500V dc series motor runs at 500 rpm and takes 60A. The resistance of the field and the armature are 0.3Ω and 0.2Ω respectively. Calculate the value of the resistance to be shunted with the series field in order that speed be increased to 600rpm, if the load torque is assumed to be constant. Saturation may be neglected.

   b) Explain the operation of 3-point dc motor starter with neat diagram.

5. a) Derive the relationship for torque developed by a 3-phase induction motor. Draw a typical torque-slip characteristic and deduce the condition for maximum torque.

   b) The rotor resistance and reactance of a 4-pole, 50 Hz, 3-phase slip ring induction motor are 0.4 and 4 ohm/phase respectively at stand still. Calculate the speed at maximum torque and the ratio (max torque) / (Starting torque). What value should the resistance per phase have so that the starting torque is half of maximum torque?

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36 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2073 Bhadra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

Subject: - Electrical Machine I *(EE551)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) Define Magnetic Circuit and hence list out the similarities between Magnetic and Electric Circuits. Deduce ohms law for magnetic circuit. [8]

   b) A transformer is rated at 100kVA. At full load its copper loss is 1200 W and its iron loss is 960 W. Calculate: [8]

      i) Efficiency at full load, unity power factor

      ii) Efficiency at half load, 0.8 power factor

2. a) Explain no-load and loaded operation of single phase transformer. Prove that the magnetic flux in the core at no load and load conditions remains same. [8]

   b) The data obtained from the test of a 10 KVA, 250 V/1000V single phase transformer are given below: [8]

      No-load test (ON L.V side): 250 V, 0.8 A, 80 watt

      Short circuit test (ON H.V side): 80 V, 10 A, 120 watt

      Calculate the equivalent circuit parameters refer to primary side and draw the equivalent circuit.

3. a) Explain voltage build up process in a dc shunt generator and define its critical resistance and critical speed. [4+2+2]

   b) A dc long shunt compound dc generator has armature winding resistance of 0.4 ohm, series field winding resistance of 0.5 ohm and shunt-field winding resistance of 100 ohms. The generator delivers a current of 40 A to the load at 200 volt. Calculate the emf generated by the armature. [8]

4. a) A 240V dc shunt motor has armature resistance of 0.4 Ω and field winding resistance of 120 Ω. It runs at 1500 rpm and draws a current of 5A with certain load on its shaft. A resistance of 0.1Ω is connected in series with armature winding and the load on the shaft is reduced by 20%, calculate the new speed of the motor. [8]

   b) Why a dc motor draws high current at starting? Explain the operation of a dc motor starter with neat circuit diagram. [8]

5. a) Explain how an induction motor can be used as induction generator. Explain the procedure to determine the value of excitation capacitor required for voltage build up in the generator. [8]

   b) A 4-pole, 50Hz 3-ϕ slip ring induction motor has star connected stator and rotor windings. The rotor winding has resistance 0.8Ω and reactance of 4Ω per phase at standstill. The emf induced between slip rings at standstill is 400 V. The Stator to rotor turn ratio is 4. The motor runs at 1490 rpm at no-load and 1300 rpm at full-load. Calculate: [8]

      i) Starting current
      ii) No-load current
      iii) Full load current

43 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2071 Bhadra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEX, BCT, BME, BIE	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

Subject: - Electrical Machine *(EE554)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) What are different types of losses in transformer? Derive the expression of efficiency of transformer. [8]
   b) An iron ring of mean diameter 100cm and cross sectional area 10cm^2 is wound with 1000 turns and has μ_r = 2000. Compute (i) reluctance (ii) flux produced when the current through the coil is 1A (iii) Flux in the ring if a saw cut of 1mm length is made, the current through the coil remaining the same. [8]
2. a) A 25 KVA, single phase, 11 KV / 400V transformer has impedance of primary and secondary 0.4 + j2Ω and 0.02 + j1Ω respectively. Determine the load terminal voltage and primary current at half load. [8]
   b) Describe the construction and working principle of a dc generator with neat diagram. Also derive the emf equation of a dc generator. [8]
3. a) Describe different methods of controlling the speed of shunt DC motor. [8]
   b) Explain with necessary vector diagram how rotating magnetic field is produced in a three phase induction motor. Also explain how this rotating magnetic field helps the motor to rotate. [8]
4. a) Explain torque slip characteristics of 3-phase induction motor. Why the induction motor operates only in linear portion of torque-slip characteristics. [8]
   b) A 3.3 KV, 3-phase star connected synchronous motor has impedance of 0.2 + j2.2Ω/phase of the armature winding. The motor is operated at 0.5 pf leading with line current of 100 A. Determine the back emf per phase and also draw phasor diagram. [8]
5. Give reasons for the following statements. [4×4]
   a) Single phase induction motors are not self starting
   b) Servo motor has longer length and smaller diameter compared to other normal motor
   c) DC series motor can also be operated from ac supply
   d) Hysteresis and eddy current losses depends on the frequency of supply system

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43 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2072 Ashwin

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEX, BCT, BME, BIE	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

Subject: - Electrical Machine *(EE554)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ ***All** questions carry equal marks.*
- ✓ *Assume suitable data if necessary.*

1. a) Explain the operating principle of an ideal transformer and derive the emf equation.
   b) A ring of 30 cm mean diameter is made up of round iron rod 2.5 cm in diameter. A saw cut of 1 mm is made on the ring. It is uniformly wound with 500 turns of wire. Calculate the current required by the exciting coil to produce a total flux of 4m Wb. Assume a relative permeability of iron at this flux density as 800.
2. a) Explain the operation principle of dc generator. What are main functions of carbon brush in dc generator?
   b) A 20 kVA, 250V/2500V, 50Hz single phase transformer gave the following test results:

   No-load test (on L.V. side): 250V, 1.4A, 105 watts

   Short circuit test (on H.V.side): 120V, 8 A, 320 watts

   Calculate the equivalent circuit parameters referred to primary side and draw the equivalent circuit.
3. a) Sketch and explain the torque slip characteristics of a 3-phase induction motor indicating the starting torque, maximum torque and the operating region. How does rotor resistance affect the torque slip characteristics?
   b) A 200V DC shunt motor drives a centrifugal pump where constant torque is required. The motor draws a current of 50 A when running at 1000rpm. What value of resistance must be inserted in the armature circuit to reduce the speed to 800rpm at constant torque? Given that armature winding resistance, R_a = 0.1 Ω and field winding resistance, R_f= 100 Ω
4. a) With the help of phasor diagrams, explain the effect of excitation in a 3-phase synchronous motor.
   b) A 4-pole, 50 Hz, 3 phase induction motor develops a starting torque of 50 N-m. The rotor winding has an impedance of (0.8+j2) Ω per phase at stand still. At what speed the motor will develop maximum torque and calculate magnitude of the maximum torque.
5. a) What do you understand by double field revolving theory? Explain it with the help of a neat diagram.
   b) A 500 KVA, 50 Hz, 6600V/400V, 1- phase transformer have primary and secondary winding resistances are 0.4 Ω and 0.001 Ω respectively. If the iron loss is 3.0 KW, Calculate the efficiency at (a) full load (b) half full load.

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43 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2071 Bhadra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEX, BCT, BME, BIE	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

Subject: - Electrical Machine *(EE554)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) What are different types of losses in transformer? Derive the expression of efficiency of transformer. [8]

   b) An iron ring of mean diameter 100cm and cross sectional area 10cm^2 is wound with 1000 turns and has μ_r = 2000. Compute (i) reluctance (ii) flux produced when the current through the coil is 1A (iii) Flux in the ring if a saw cut of 1mm length is made, the current through the coil remaining the same. [8]

2. a) A 25 KVA, single phase, 11 KV / 400V transformer has impedance of primary and secondary 0.4 + j2Ω and 0.02 + j1Ω respectively. Determine the load terminal voltage and primary current at half load. [8]

   b) Describe the construction and working principle of a dc generator with neat diagram. Also derive the emf equation of a dc generator. [8]

3. a) Describe different methods of controlling the speed of shunt DC motor. [8]

   b) Explain with necessary vector diagram how rotating magnetic field is produced in a three phase induction motor. Also explain how this rotating magnetic field helps the motor to rotate. [8]

4. a) Explain torque slip characteristics of 3-phase induction motor. Why the induction motor operates only in linear portion of torque-slip characteristics. [8]

   b) A 3.3 KV, 3-phase star connected synchronous motor has impedance of 0.2 + j2.2Ω/phase of the armature winding. The motor is operated at 0.5 pf leading with line current of 100 A. Determine the back emf per phase and also draw phasor diagram. [8]

5. Give reasons for the following statements. [4×4]

   a) Single phase induction motors are not self starting
   b) Servo motor has longer length and smaller diameter compared to other normal motor
   c) DC series motor can also be operated from ac supply
   d) Hysteresis and eddy current losses depends on the frequency of supply system

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26 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2071 Magh

Exam.	OLD Back (2065 & Earlier Batch)		
Level	BE	Full Marks	80
Programme	BEL, BEX, BCT	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

Subject: - Electrical Machine I *(EG577EE)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt any **Five** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1a) Why soft magnetic material is used to make transformer core or armature core of the electrical equipment? State and explain Faraday's laws of electromagnetic induction. Describe different processes of EMF induced in a coil. **[10]**

b) A 30 cm long circular iron is bent into circular ring and 600 turns of windings are wound on it. The diameter of the rod is 20mm and relative permeability of the iron is 4000. A time varying current I=5.Sin314t is passed through the winding. Calculate inductance and average value of the emf induced in the coil. **[6]**

2a) A 25 kVA, 250V/2500V, 50 Hz single phase transformer gave the following test results:
No load test (on L. V. side): 250V, 1.4A, 105 watts
Short circuit test (on H. V. side): 120V, 8A, 320 watts
Calculate the equivalent circuit parameters referred to primary side and draw the equivalent circuit. **[8]**

b) Explain the operation of transformer at different loading conditions (resistive, inductive, capacitive) showing their corresponding circuit diagram and phasor diagram. **[8]**

3.a) What is meant by transformer inrush current? Discuss the term **"doubling effect"** in transformer in detail. **[2+6]**

b)A 4–Pole dc shunt generator has wave wound armature. The armature and field winding resistances are 0.2Ω and 60Ω respectively. The brush contact drop contact drop is 1 volt per brush. The generator is delivering a power of 3 kW at 120V.
Calculate:
a) Total armature current coming out from the brush.
b) Current in each armature conductor.
c) Generator EMF (E). **[2+3+3]**

4 a) Discuss the types of armature winding in dc machine in brief. Draw the sketch for lap winding in which no. of slot = 12, no. of pole = 2 and no. of commutator segments =12. **[4+4]**

b) A 240V dc shunt motor has armature winding resistance of 0.4Ω and field winding resistance of 120Ω. It draws a current of 27A at half load and the corresponding speed is 600rpm.
i) If a resistance of 1Ω connected in series with the armature winding keeping the load torque constant to half load torque, calculate the new speed.
ii) If a resistance of 1Ω connected in series with the armature winding and the load torque is increased to full load torque, calculate the new speed. **[4+4]**

5 a) What are the types of dc generator, discuss each type in brief. Explain loading characteristics of compound dc generator. **[4+4]**

b) Explain two reaction model of salient pole synchronous machine. **[8]**

6 a) How does voltage build up occurs in an induction generator? Explain **[8]**

b) A 4-pole,50Hz, 3 phase induction motor with star connected rotor gives 500V between the slip rings at standstill. Calculate the magnitude and frequency of emf induced per phase in rotor circuit at a speed of 1460RPM. **[8]**

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41 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division

2071 Magh

Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BEX, BCT, BME, BIE	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

Subject: - Electrical Machine *(EE554)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt All questions.*
- ✓ *The figures in the margin indicate Full Marks.*
- ✓ *Assume suitable data if necessary.*

1. a) A rectangular iron core is shown in figure 1. It has a mean length of magnetic path of 100 cm, cross-section of (2 cm × 2 cm), relative permeability of 1400 and an air-gap of 5 mm cut in the core. The three coils carried by the core have number of turns, $N_a = 335$, $N_b = 600$ and $N_c = 600$; and the respective currents are 1.6 A, 4 A and 3 A. The directions of the currents are as shown in the figure. Find the flux in the air-gap. [6]

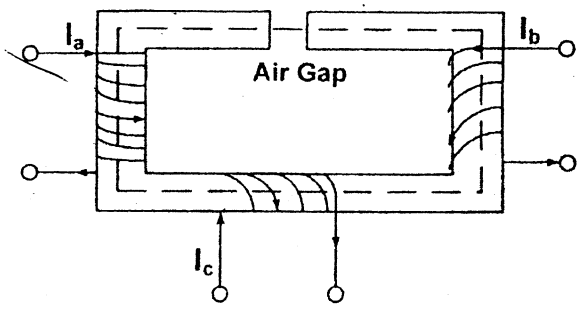

Figure 1

b) State Faraday's Laws of electromagnetic induction. Distinguish between statically induced emf and dynamically induced emf. [6]

2. a) Explain the working of an ideal transformer under (i) no-load and (ii) loaded conditions and derive expressions for voltage and current ratios relating to transformer turns ratio. [4+4]

b) The following test results were obtained for open circuit and short circuit tests on a 8 kVA, 400/120 V, 50 Hz transformer: [8]

Open-circuit Test (LV Side) : 120 V, 4 A, 75 W
Short-circuit Test (HV Side) : 9.5 V, 20 A, 110 W

Calculate the equivalent circuit parameters referred to high voltage side. Also calculate the efficiency at half full load and 0.8 power factor lagging load.

3. a) Explain the working principle of dc generator with neat diagram. [3+3]

b) A short shunt compound generator supplies a load current of 100 A at 250 V. The generator has the following winding resistances: shunt field 130 Ω, armature 0.1 Ω and the series field 0.1 Ω. Find the emf generated and the armature current, if the brush drop is 1 V per brush. [6]

4. a) What is back emf? How does back emf play an important role in DC motor? [2+4]

   b) A dc shunt motor runs at 600 RPM taking 60 A from a 230 V supply. Armature resistance is 0.2 Ω and field resistance is 115 Ω. Find the speed when the current through the armature is 30 A. [6]

5. a) Explain the torque-slip characteristics of an induction motor. Show the condition for which the maximum torque develops in the induction motor. [3+3]

   b) A 3-phase delta connected 440 volts, 50 Hz, 4-pole induction motor has a rotor stand-still emf per phase of 130 volts. If the motor is running at 1,440 RPM, calculate for this speed : (i) the slip, (ii) the frequency of rotor induced emf, (iii) the value of the rotor induced emf per phase, and (iv) stator to rotor turn ratio. [4]

6. a) What do you mean by V-curve and inverted V-curve for a synchronous motor? Explain with a neat diagram. [6]

   b) What are the advantages of rotating magnetic system and stationary armature system in ac machine? [4]

   c) Write short notes on the following: [2×4]

      i) Universal motor
      ii) AC servo motor

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26 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2071 Magh

Exam.	OLD Back (2065 & Earlier Batch)		
Level	BE	Full Marks	80
Programme	BEL, BEX, BCT	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

Subject: - Electrical Machine I *(EG577EE)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt any **Five** questions.*
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b)A 4–Pole dc shunt generator has wave wound armature. The armature and field winding resistances are 0.2 Ω and 60 Ω respectively. The brush contact drop contact drop is 1 volt per brush. The generator is delivering a power of 3 kW at 120V.
Calculate:
a) Total armature current coming out from the brush.
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4 a) Discuss the types of armature winding in dc machine in brief. Draw the sketch for lap winding in which no. of slot = 12, no. of pole = 2 and no. of commutator segments =12. **[4+4]**

b) A 240V dc shunt motor has armature winding resistance of 0.4 Ω and field winding resistance of 120 Ω. It draws a current of 27A at half load and the corresponding speed is 600rpm.
i) If a resistance of 1 Ω connected in series with the armature winding keeping the load torque constant to half load torque, calculate the new speed.
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41 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2071 Magh

Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BEX, BCT, BME, BIE	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

Subject: - Electrical Machine *(EE554)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
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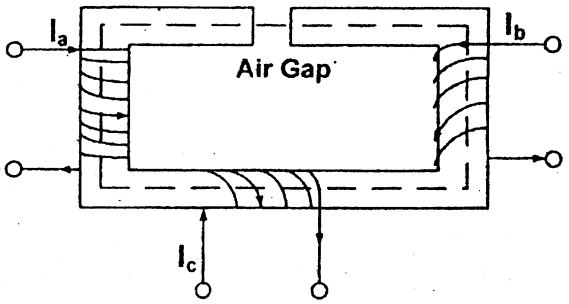

Figure 1

b) State Faraday's Laws of electromagnetic induction. Distinguish between statically induced emf and dynamically induced emf. [6]

2. a) Explain the working of an ideal transformer under (i) no-load and (ii) loaded conditions and derive expressions for voltage and current ratios relating to transformer turns ratio. [4+4]

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b) A short shunt compound generator supplies a load current of 100 A at 250 V. The generator has the following winding resistances: shunt field 130 Ω, armature 0.1 Ω and the series field 0.1 Ω. Find the emf generated and the armature current, if the brush drop is 1 V per brush. [6]

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   b) A dc shunt motor runs at 600 RPM taking 60 A from a 230 V supply. Armature resistance is 0.2 Ω and field resistance is 115 Ω. Find the speed when the current through the armature is 30 A. [6]

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   b) A 3-phase delta connected 440 volts, 50 Hz, 4-pole induction motor has a rotor stand-still emf per phase of 130 volts. If the motor is running at 1,440 RPM, calculate for this speed : (i) the slip, (ii) the frequency of rotor induced emf, (iii) the value of the rotor induced emf per phase, and (iv) stator to rotor turn ratio. [4]

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26 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2071 Magh

Exam.	OLD Back (2065 & Earlier Batch)		
Level	BE	Full Marks	80
Programme	BEL, BEX, BCT	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

Subject: - Electrical Machine I *(EG577EE)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt any **Five** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1a) Why soft magnetic material is used to make transformer core or armature core of the electrical equipment? State and explain Faraday's laws of electromagnetic induction. Describe different processes of EMF induced in a coil. **[10]**

b) A 30 cm long circular iron is bent into circular ring and 600 turns of windings are wound on it. The diameter of the rod is 20mm and relative permeability of the iron is 4000. A time varying current I=5.Sin314t is passed through the winding. Calculate inductance and average value of the emf induced in the coil. **[6]**

2a) A 25 kVA, 250V/2500V, 50 Hz single phase transformer gave the following test results:
No load test (on L. V. side): 250V, 1.4A, 105 watts
Short circuit test (on H. V. side): 120V, 8A, 320 watts
Calculate the equivalent circuit parameters referred to primary side and draw the equivalent circuit. **[8]**

b) Explain the operation of transformer at different loading conditions (resistive, inductive, capacitive) showing their corresponding circuit diagram and phasor diagram. **[8]**

3.a) What is meant by transformer inrush current? Discuss the term **"doubling effect"** in transformer in detail. **[2+6]**

b)A 4–Pole dc shunt generator has wave wound armature. The armature and field winding resistances are 0.2 Ω and 60 Ω respectively. The brush contact drop contact drop is 1 volt per brush. The generator is delivering a power of 3 kW at 120V.
Calculate:
a) Total armature current coming out from the brush.
b) Current in each armature conductor.
c) Generator EMF (E). **[2+3+3]**

4 a) Discuss the types of armature winding in dc machine in brief. Draw the sketch for lap winding in which no. of slot = 12, no. of pole = 2 and no. of commutator segments =12. **[4+4]**

b) A 240V dc shunt motor has armature winding resistance of 0.4 Ω and field winding resistance of 120 Ω. It draws a current of 27A at half load and the corresponding speed is 600rpm.
i) If a resistance of 1 Ω connected in series with the armature winding keeping the load torque constant to half load torque, calculate the new speed.
ii) If a resistance of 1 Ω connected in series with the armature winding and the load torque is increased to full load torque, calculate the new speed. **[4+4]**

5 a) What are the types of dc generator, discuss each type in brief. Explain loading characteristics of compound dc generator. **[4+4]**

b) Explain two reaction model of salient pole synchronous machine. **[8]**

6 a) How does voltage build up occurs in an induction generator? Explain **[8]**

b) A 4-pole,50Hz, 3 phase induction motor with star connected rotor gives 500V between the slip rings at standstill. Calculate the magnitude and frequency of emf induced per phase in rotor circuit at a speed of 1460RPM. **[8]**

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Shankar Poudel

33 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2070 Bhadra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEX, BCT, BME, BIE	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

Subject: - Electrical Machine *(EE554)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) The flux in transformer remains practically constant from no load to full load. Justify the statement. [4]

   b) Derive an expression for Cu saving in an auto-transformer. [4]

   c) A 230 V / 2300 V single-phase transformer is excited by 230 V ac voltage. The equivalent resistance and reactance referred to primary side are 0.1 Ω and 0.4 Ω respectively. Given that R_0 = 500 Ω and X_0 = 200 Ω. The load impedance is (400 + j600) Ω. Calculate: (i) Primary current and input power factor (ii) Secondary terminal voltage. [8]

2. a) Derive an emf equation for a dc generator. [4]

   b) DC shunt generator shall be started keeping its output terminal open. Justify the statement. [4]

   c) A 4 pole, 250 V long shunt dc compound generator supplies a load of 10 KW at the rated voltage. The armature, series and shunt field resistances are 0.1 Ω, 0.15 Ω and 250 Ω respectively. The armature is lap wound with 300 conductors. If the flux per pole is 50 mWb, calculate the speed of the generator. [8]

3. a) With the help of a neat sketch, explain the working principle of three terminal DC motor starter. [5]

   b) A dc series motor of resistance 1 Ω between terminals runs at 1,000 RPM at 250 V with a current of 20 A. Find the speed at which it will run when connected in series with a 6 Ω resistance and taking the same current at the same supply voltage. [5]

   c) A circular iron core has a cross-sectional area of 5 sq.cm. and mean length of 25 cm including an air gap of 4 mm. The core is wound with 500 turns of winding. Calculate the inductance of the coil. If a dc current of 10 Ampere passed through the coil, calculate magnetic flux in the core. Given that relative permeability of the core is 2000. [6]

4. a) What will be the condition for maximum torque and explain torque slip characteristics of 3-phase induction motor. [8]

   b) A 3-phase, 50 Hz induction motor has starting torque which is 1.25 times full load torque and a maximum torque which is 2.5 times the full load torque. Neglecting stator resistance and rotational losses and assuming constant rotor resistance. Find [8]

      i) slip at maximum torque
      ii) the slip at full load
      iii) the current at starting in per unit full load current

5. a) With the help of phasor diagrams, explain the effect of excitation in a 3-phase synchronous motor. [8]

   b) A 1200 KVA, 6600 V, 3-phase star connected stator of a synchronous generator has a armature resistance of 0.4 Ω/phase and synchronous reactance of 6 Ω/phase. The generator delivers full load current at pf of 0.8 lagging at normal rated voltage. Calculate the terminal voltage for the same excitation and load current at 0.8 pf leading. [8]

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33 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2070 Magh

Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BEX, BCT, BME, BIE	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

Subject: - Electrical Machine *(EE554)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) Explain the working of an ideal transformer under (i) no-load and (ii) loaded conditions and derive expressions for voltage and current ratios relating to transformer ratio. [8]

   b) The following test results were obtained on a 20 kVA, 2200/220 V, 50 Hz single phase transformer: [8]

   Open-circuit Test (LV Side): 220 V, 1.1 A, 125 W
   Short-circuit Test (HV Side): 52.7 V, 8.4 A, 287 W
   Calculate the equivalent circuit reffered to L.V side and draw the equivalent circuit.

2. a) Explain torque-armature current and speed-torque characteristics of DC shunt and DC series motor. [8]

   b) A 220V dc shunt motor draws a current of 40A at full load and runs with speed of 1400rpm. Calculate the value of resistance required to be inserted in the armture circuit so that speed drops to 1200rmp at constant load. Given that R_a=0.02ohm and R_f=100ohms. [8]

3. a) Explain why synchronous motor is not self starting? Explain the starting method using damper winding. [8]

   b) A 4-pole dc shunt generator has wave wound armature. The armature and field winding resistance are 0.2 ohm and 60 ohms respectively. The brush contact drop is 1V per brush. The generator is delivering a power of 3 kW at 120V. Calculate: [8]

      i) Total armature current coming out from the brush
      ii) Current in each armature conductor
      iii) Generated EMF (E)

4. a) Explain the torque-slip characteristics of 3 phase induction motor. Show the condition for which the maximum torque develops in the induction motor. Discuss the effect of variation of rotor resistance on this maximum torque. [8]

   b) A 8-pole, 50 Hz, 3 phase induction motor develops a starting torque of 50 N-. The rotor winding has an impedance of (0.8+j2) Ω per phase. At what speed the motor will develop maximum torque and calculate the magnitude of maximum torque. [8]

5. a) What do you understand by double field revolving theory? Explain it with the help of a neat diagram. [8]

   b) A ring of 30 cm mean diameter is made up of round iron rod 2.5 cm in diameter. At one end, a saw cut of 1 mm wide is made through it. It is uniformly wound with 500 turns of wire. Calculate the current required by the exciting coil to produce a total flux of 4 mWb. Take relative permeability of iron as 800. Neglect leakage and fringing. [8]

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33 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division.
2069 Bhadra

Exam.	Regular (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BEX, BCT, BME, BIE	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

Subject: - Electrical Machine ***(EE554)***

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ ***All** questions carry equal marks.*
- ✓ *Assume suitable data if necessary.*

1. a) Explain the no-load and loaded operation of an Ideal transformer. Prove that the net magnetic flux in the core remains constant at any load.

   b) A magnetic circuit consists of a circular iron core having mean length of 10cm and cross-sectional area of $100mm^2$. The air gap is 2mm and the core has 600 turns of winding. Calculate the magnitude of current to be passed through the winding to produce air gap flux of 1 Telsa. Given $\mu_r = 4000$.

2. a) Explain the working principle of a d.c. motor and derive the equation of Torque developed by the armature of the d.c. motor.

   b) A dc series motor with armature resistance of 0.06Ω, and field winding resistance of 0.04Ω is supplied by a 220V source. If the motor draws 25A when running at 1200rpm, calculate the current drawn by motor when running at 800 rpm.

3. a) Explain the Armature control method and field control method of speed control of DC shunt motor.

   b) A 4 pole dc shunt generator has armature and field winding resistance are of 0.2Ω and 60Ω respectively. The brush contact drop is 1V per brush. The generator is delivering a power of 3KW at 120V. Calculate:

      i) Total armature current coming out from the brush

      ii) Current in each armature conductor

      iii) Generated EMF(E)

4. a) Explain the armature reaction in a synchronous generator for resistive, inductive and capacitive loading with necessary diagram.

   b) A-3phase, slip-ring, induction motor with star-connected rotor has an induced e.m.f. of 120 volts between slip-rings at standstill with normal voltage applied to the stator. The rotor winding has resistance per phase of 0.3 Ohm and standstill leakage reactance per phase of 1.5 Ohm. Calculate the current/phase when running short-circuited with 4% slip.

5. a) Explain the nature magnetic field created by signal phase induction motor with the help of double field revolving theory and explain why single phase induction motor is self starting.

   b) Write about the working principle of a signal stack stepper motor with neat diagram.

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33 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2068 Magh

Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BEX, BCT, BME, BIE	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

Subject: - Electrical Machine

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt any **Five** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) Explain the working principle of a single phase induction motor. What is the effect of air gap in the magnetic circuit? [5+3]

   b) A cast steel ring has a circular cross section of 3cm in diameter and mean circumference of 80cm. A 1mm air-gap is cut in the ring which is wound with a coil of 600 turns. Estimate the current required to establish a flux of 0.75 mWb in the air-gap. [8]

   Magnetization data:

H (AT/m)	200	400	600	800	1000	1200	1400	1600
B(T)	0.1	0.32	0.6	0.9	1.08	1.18	1.27	1.32

2. a) Explain the transformer on load and no load with the phasor diagram of resistive and capacitive load. [8]

   b) Test data on a 1-Ø, 250/500V, 50Hz transformer are: [8]

   O.C. Test: 250V, 1A, 80W (carried on L.V. Side)
   S.C. Test: 20V, 12A, 100W (carried on H.V. side)

   Then draw the equivalent circuit referred to primary side and find out the output power to obtain maximum efficiency at 0.9 lag p.f.

3. a) A 500-KVA, 3-Ø, 50Hz transformer has a voltage ratio (line voltage) of 33/11KV and is delta/star connected. The resistances per phase are: High voltage 35Ω, low voltage 0.876Ω and the iron loss is 3050W. Calculate the value of efficiency at full-load and one-half of full-load respectively at 0.8 p.f. [8]

   b) Why the dc motor draws large current at starting? Justify it clearly and also describe the working of 3-point dc motor starter. [3+5]

4. a) A short shunt compound generator delivers a current of 80A to the load at 220V. The shunt field, series and armature winding resistances are 100Ω, 0.05Ω and 0.1Ω respectively. Calculate the emf generated by the armature. [8]

   b) Draw and explain torque-slip characteristics of 3-Ø induction motor, showing clearly the starting torque, maximum torque and normal operating region. [8]

5. a) A 208V, 60 Hz, 4 pole, 3-Ø induction motor has a full-speed of 1755 rpm. [8]

   Calculate: (i) asynchronous speed, (ii) the slip and (iii) rotor frequency.

   b) Write down the criteria for synchronizing two 3-Ø alternators with the detail explanation. [8]

6. Write short notes on: [4×4]

   a) Capacitor starting of 1-Ø induction motor
   b) Armature reaction in dc machine
   c) Eddy current loss
   d) Starting methods of synchronous motor

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33 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2068 Bhadra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEX, BCT, BME, BIE	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

Subject: - Electrical Machine

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt any **Five** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. State whether the following statements are true or false and justify them. [(1+3)×4]
   a) Secondary of CT should not be kept open while the primary winding is energized.
   b) DC series motor should always be started at no load.
   c) Rotor core loss is often neglected in 3 phase induction motor.
   d) Construction of auxiliary winding of 1 phase induction motor is different from that of the main winding.

2. a) Describe different types of losses on the transformer. Also derive the expression for the maximum efficiency of the transformer. [8]
   b) A 10 kVA, 200/400V, 50HZ, 1 phase, transformer gave the following test results: [8]

   OC test (HV open): 200V 1.3A 120W
   SC test (LV sort): 22V 30A 200W

   Determine shunt and series branch parameters referred to Low Voltage Side and hence draw equivalent circuit diagram also.

3. a) Explain working principle of DC generator in detail and hence derive the expression of emf equation also. [8]
   b) A 200V, dc shunt motor drives a centrifugal pump where torque is proportional to the square of speed. The motor draw a current of 50A when running at 1000 rpm. What value of resistance must be inserted in the armature circuit to reduce the speed to 800 rpm. Given: Armature resistance (R_a) = 0.1Ω and field winding resistance (R_f) = 100Ω. [8]

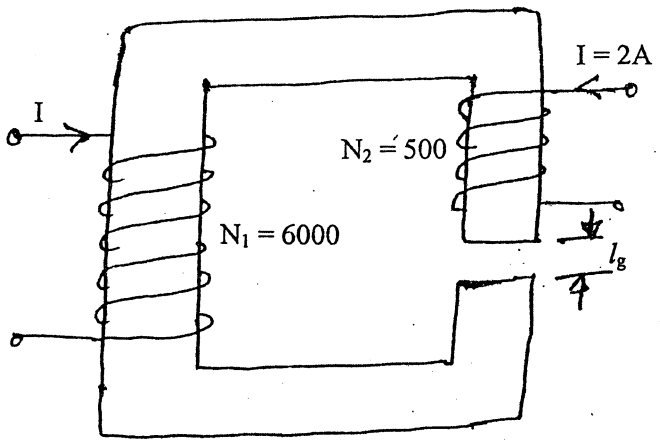
4. a) What do you mean by excitation control in synchronous motor? How synchronous motor can be operated in leading and lagging pf mode? [8]
   b) A 8-pole, 50Hz, 3-ph induction motor develops a starting torque of 50N-m. The rotor winding has an impedance of (0.8 + j4)Ω per phase. At what speed the motor will develop maximum torque and calculate the magnitude of maximum torque. [8]

5. a) Why single phase induction motor are not self starting? Explain any two starting methods for single phase induction motor. [8]

b) For the magnetic circuit shown below, calculate the value of current 'I' required to produce a magnetic flux density of 1.2 Tesla. [8]

Given:

X – sectional area of core = 16 sq.cm
Air gap length (l_g) = 0.06cm
Mean length of core (l_c) = 40cm
Relative permeability (μ_r) = 6000



6. a) Explain the operating principle of stepper motor and servo motor. [8]

b) Describe the Torque-slip characteristics of a three phase induction motor. Also explain the effect of rotor resistance on T-S characteristics. [8]

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26 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2067 Mangsir

Exam.	Regular / Back		
Level	BE	Full Marks	80
Programme	BEL, BEX, BCT	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

Subject: - Electrical Machine I

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt any **Five** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. Justify the following statements: [4×4]
   a) DC series motor should never be started on no-load.
   b) It is not possible to operate star delta transformer in parallel with star-star or delta-delta transformer.
   c) Induction motor cannot develop torque when rotor runs at synchronous speed.
   d) Salient pole alternators are suitable for low speed whereas cylindrical pole alternators for high speed.
2. a) What is meant by an instrument transformer? How they differ in principle of operation from that of power transformer? Explain with suitable diagram and mathematical expressions. [8]
   b) Two 1- phase transformers with equal number of turns have impendence of $(0.5 + j3)\Omega$ and $(0.6 + j10)\Omega$ with respect to the secondary. If they operate in parallel, determine how they will share total load of 100 kW at pf 0.8 lagging. [8]
3. a) Explain with reason, the suitability of DC series, DC shunt and DC compound motors. Identify suitable DC motor for the following application: [8]
      i) Electric traction ii) Vacuum cleaner
      iii) Paper making iv) Shearing and punching
   b) A long shunt compound generator has a shunt field winding of 1000 turns per pole, series field winding of 4 turns per pole and resistance of 0.05Ω. In order to obtain the rated voltage both at no load and full load for operation as shunt generator, it is necessary to increase filed current by 0.2A. The full load armature current of compound generator is 80A. Calculate the diverter resistance connected in parallel of series field to obtain flat compound operation. [8]
4. a) What are hystersis and eddy current losses? What are their significance in the operation of electric machine? Write down different methods to reduce them. [8]
   b) An iron ring of mean diameter 15cm and 10 sq-cm cross sectional area is wound with 200 turns of wire. There is an air gap of 2mm cut in the ring. For a flux density of 1 Wb/m^2 and relative permeability of 500, find the exciting current, the inductance and stored energy. [8]
5. a) How does an induction motor adjust its current with the changes in shaft load? Explain the effect of type of connection of stator winding of slip ring induction motor. [8]

b) A 3-ph induction motor has a ratio of maximum torque to full load torque as 2.5:1. Determine the ratio of actual starting torque to full load torque for star delta starting. Also calculate full load slip. [Given: rotor resistance per phase = 0.4Ω and rotor reactance per phase at stand still = 4Ω] [8]

6. a) Explain two reaction theory of salient pole synchronous machines. Describe a method of determining direct and quadrature axis synchronous reactance of 3 phase synchronous machine. [8]

b) A 6.6 kV star connected, 3 phase synchronous motor works at constant voltage and constant excitation. It's synchronous reactance is 20Ω/phase, when the input is 100Kw and power factor is 0.8 leading. Find the power factor when the input is increased to 1500kW. [8]

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26 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2066 Magh

Exam.	Regular/Back		
Level	BE	Full Marks	80
Programme	BEL, BEX, BCT	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

Subject: - Electrical Machines I

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt any **Five** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) Identify various types of losses in a transformer. Derive the condition for maximum efficiency of the transformer. [8]

   b) A circular iron core with mean length of 100cm and cross-sectional area of 50mm^2 has 500 turns winding on the core. Calculate the flux density in the core if 10A current flows in the coil. Take $\mu_r = 2000$ for the iron core and neglect saturation. [8]

2. a) Describe the open circuit test and short circuit test for a single phase transformer. [8]

   b) A 4.2KV/120V, 50 Hz, 1-phase transformer has following series parameters: $R_1 = 1.4\Omega$, $X_1 = 3.5\Omega$, $R_2 = 0.04\Omega$, $X_2 = 0.1\Omega$. If the transformer draws 500A current on the secondary at rated terminal voltage, calculate voltage regulation at unity power factor. [8]

3. a) Explain the operating principle of a dc generator. Derive the expression of induced emf across generator terminals. [8]

   b) A dc series motor with armature resistance of 0.06Ω, and field winding resistance of 0.04Ω is supplied by a 220V source. If the motor draws 25A when running at 1200 rpm, calculate the current drawn by motor when running at 800 rpm. [8]

4. a) Justify why the dc motor draws large current at starting. Describe the working of a 3-point dc motor starter. [8]

   b) A 500 KVA, 50 Hz, 11KV/400V, 3-ph transformer has delta/star connection. Calculate the current drawn by the transformer from primary side when it delivers full load at rated terminal voltage at 0.8 lagging p.f. Assume ideal transformer operation. [8]

5. a) Describe the torque speed characteristics of an induction motor. Discuss the effect of rotor resistance and applied voltage on T-N characteristics of such motors. [8]

   b) A 3-phase, 440V, 50Hz, 6-pole induction motor draws 50KW at 0.85 lagging p.f. from the source when connected to rated supply. If rotor rotates at 950 rpm, calculate (i) rotor loss and (ii) overall efficiency of the motor. The friction loss and stator loss are 2 KW and 1.5 KW respectively at this running condition. [8]

6. a) Derive the expression for electrical power of salient pole synchronous machine. Show the power angle characteristics for such machines. [8]

   b) A 3-phase star connected, 5 MVA, 11 KV synchronous generator has armature resistance of 0.12Ω and synchronous reactance of 2Ω per phase. Calculate voltage regulation if the generator delivers full load at rated terminal voltage at 0.9 lagging p.f. Also find out generator power factor at which the voltage regulation is zero. [8]

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26 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2065 Chaitra

Exam.	Regular/Back		
Level	BE	Full Marks	80
Programme	BEL, BEX, BCT	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

Subject: - Electrical Machine I

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt any Five questions.*
- ✓ *The figures in the margin indicate Full Marks.*
- ✓ *Assume suitable data if necessary.*

1. a) Explain the magnetic hysteresis and show that energy spent per cycle per unit volume equal to the area of hysteresis loop? [4+4]

   b) The core of an electromagnet is made of an iron rod 1cm diameter, bent into a circle of mean diameter 10cm, a radial air gap of 1mm being left between the ends of the rod. Calculate the direct current needed in coil of 2000 turns uniformly spaced around the core to produce a magnetic flux of 0.2m wb in the air gap. Assume that the relative permeability of the iron is 150. [8]

2. a) Explain how the efficiency of a transformer varies with load and derive the condition for maximum efficiency. [4+4]

   b) A 1 phase 250/500 V, 50 Hz transformer gave the following test results

   Open circuit test : 250V, 1A, 80W on H.V. Side
   Short-circuit test : 20V, 12A, 100W on L.V. Side

   Calculate the equivalent circuit parameter and draw the equivalent circuit referred to low voltage side and high voltage side.

3. a) Explain the phenomenon of "building up" of voltage in a dc shunt generator and there by state the conditions to be fulfilled for self excitation Also explain the terms critical resistance and critical speed? [8]

   b) A dc shunt generator gives full load output of 30 KW at a terminal voltage of 200V. The armature and shunt field resistances are 0.05Ω and 50Ω respectively. The iron and friction losses are 100W. Calculate (i) generated emf (ii) copper losses (iii) efficiency. [8]

4. a) Explain why the dc series motor can not be started without some mechanical load? Also discuss the armature control and field control method for speed control of dc shunt motor. [2+3+3]

   b) A 220V, series motor is running at a speed of 800 rpm and draw 100A. Calculate at what speed the motor will run developing half the torque. Total resistance of the armature and field is 0.1Ω. Assume that the magnetic circuit is unsaturated. [8]

5. a) Explain why the rotor core loss in a three phase induction motor is negligible. [4]

   b) Explain the effect of rotor resistance on the torque slip characteristics of induction motor? [4]

   c) Explain the rotor rheostate method of speed control of slipring induction motor with neat circuit diagram and T-S characteristic. [8]

6. a) Explain the process of synchronizing two 3 phase alternator with dark lamp method. [8]

   b) Explain the starting methods of synchronous motor? [8]

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