TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2078 Chaitra

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

Subject: - Electrical Machines I (*EE 551*)

- ✓ 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 hysteresis loop of a magnetic material used in electrical machine. Prove that the area of the loop is proportional to the energy loss per cycle per unit volume. [8]
   b) A 8 kVA. 400/120 V, 50Hz single phase transformer on test gives the following results: [8]

O.C. test:	120V	4A	75W	(carried on LV side)
S.C. test:	9.5V	20A	110W	(carried on HV side)

   Calculate the equivalent circle parameters referred to HV side.
2. a) A 2 MVA, Delta-star, 33/6.6 kV, three phase transformer has primary and secondary resistance of 8 Ohm and 0.08 ohm per phase. The percentage impedance is 7 percent. Calculate the voltage regulation at full load at 0.75 pf lagging. [8]
   b) Explain the operating principle of a single phase transformer and derive the emf equation. [8]
3. a) What is back emf in dc motor? Explain the roles of back emf in dc motor. [8]
   b) A 4 pole shunt generators with a lap would has armature resistance of 0.1 ohm and field circuit resistance of 50 ohm. The generator supply power to six filament lamps of rated 200 V 600 Watt each. The brush contact drop is 1 V per brush. If generator terminal voltage is 220 V after lamps are connected then find armature current and generated emf. [8]
4. a) A 230 V dc series motor draws a line current of 100 A from mains while running at 1000 rpm. Its armature resistance is 0.15 Ohms and field resistance is 0.1 Ohms. When the motor draws current of 25 A, calculate the speed. [10]
   b) A dc shunt motor is operating at a constant speed supplied with rated voltage. Due to an accident, the field terminal of the motor gets disconnected. What will happen on the motor performance? Discuss on the implications. [6]
5. a) Derive the condition for maximum torque of an induction motor. Draw the Torque-slip characteristics of induction motor for different supply voltage. [8]
   b) A 40 kW, 3-phase slip ring induction motor of negligible stator impedance at a speed of 0.96 times synchronous speed at rated torque. The slip at maximum torque is 4 times the full-load value. If the rotor resistance of the motor is increased by 5-times, determine. [8]
      i) The speed, power output and rotor copper loss at rated torque.
      ii) The speed corresponding to the maximum torque.

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2078 Baisakh

TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2078 Baishakh

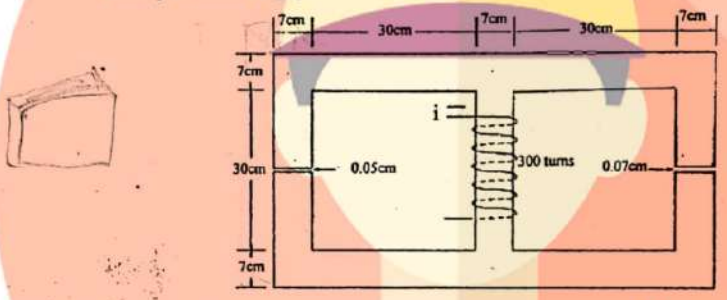
Exam.	Back		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	II /II	Time	3 hrs.

Subject: - Electrical Machines I *(EE 551)*

- ✓ 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 hysteresis phenomenon with ac excitation. [8]

   b) A ferromagnetic core with a relative permeability of 4000 is shown below. The dimensional area as shown and depth of core is 7cm. The air gap is 0.05cm on left and 0.07cm on right side. The effective area of gap is 5% larger due to fringing effect. If current in coil is 10A, calculate flux in left, right and middle part along with flux density in each air gap. [8]



2. a) A 100KVA, 2200/220V transformer when tested gave the following results:
   OC test: 400W 10A 220V
   SC test: 808W 30A 90V
   Compute all the parameters of the equivalent circuit referred to HV sides of the transformer. Draw the equivalent circuits also. [8]

   b) A 50 KVA, 4400/220V transformer with an equivalent impedance of (0.01+j0.02)ohm is to operate in parallel with a 25KVA, 4400/220V transformer with an equivalent impedance (0.02+j0.04) ohm. The two transformers are connected in parallel and made to carry a load of 60KVA.

   (i) Find the individual transformer currents
   (ii) What percent of the rated capacity is used in each transformer? [8]

3. a) Explain the voltage build up process in de shunt generator and define the meaning of critical resistance and critical speed. [8]

   b) A dc compound generator has to supply a current of 120A to the load at 120V. The shunt field, series field and armature winding resistances are 30ohm, 0.05 ohm and 0.1ohm respectively. Calculate the emf generated by the armature in the following two cases: [8]

   (i) long shunt connection
   (ii) Short shunt connection

4. a) Explain the operating principle of a DC motor and clarify the functions of commutator segments and carbon brushes in dc motor. [8]

b) A 220V dc shunt motor has armature winding resistance of 0.08 ohm and field winding resistance of 110 ohms. It runs at a speed of 1400rpm at half load. If a resistance of 30 ohms is connected in series with the field winding and load torque is increased by 10%, calculate the new speed of the motor. [8]

5. a) Explain the isolated mode and grid connected mode of three phase induction generator. [8]

b) A 400V, 4-pole, 50Hz, 3 phase, slip ring induction motor has a delta connected stator winding and a star connected rotor winding. At standstill the voltage between the two slip rings is 190V. The stator impedance is (0.5+j2.5) ohm. The rotor resistance and reactance at standstill are 0.06 ohm and 0.3 ohm respectively and it develops a maximum torque of 150N-m. Calculate: [8]

(i) Slip at which motor develops the maximum torque.
(ii) Torque, power output at full load, given that full load slip is 0.04.

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TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2077 Chaitra

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

Subject: - Electrical Machines I *(EE 551)*

- ✓ 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) An iron ring has mean length of 80cm and cross sectional area of 16 sq. cm. has a radial air gap of 2mm. The core is wound with a coil of 1000 turns. If a current of 6amp is passed through the coil, calculate the magnetic flux and magnetic flux density in the core. Given that the relative permeability of the core is 2000. [8]

   b) 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. [8]

2. a) What do you mean by an ideal transformer? Explain the operating principle of an ideal single phase transformer and derive the emf equation. [8]

   b) A 20kVA, 220V/2200V, 50Hz single phase transformer has the following parameters: R_0=500 ohm, X_0=160ohm, R_{01}=0.04ohm and X_{01}=0.1ohm.

   (i) Calculate the iron loss of the transformer.
   (ii) calculate the primary current at which the efficiency for the transformer will be maximum and also calculate the maximum efficiency. [8]

3. a) Explain the voltage build-up process of a dc shunt generator and define meaning of critical resistance and critical speed. [8]

   b) A dc short compound generator supplies a current of 50A to the load at 200V. The shunt field, series field and armature winding resistances are 100 ohm, 0.05 ohm and 0.08 ohm respectively. Calculate the emf generated by the armature and efficiency of the generator. Given that the no-load loss of the generator is 300 watts. [8]

4. a) What do you mean by back emf in dc motor? Explain the importance roles of back emf in DC motor. [8]

   b) A 220V dc shunt motor has armature winding resistane of 0.08 ohm and field winding resistance of 100 ohms. Calculate the starting current draws by the motor with Normal input voltage switched on. If the starting current is to be reduced by 80%, calculate the value of starting resistance to be connected in series with armature circuit with input voltage reduced by 10%. [8]

5. a) Explain the T-S characteristic curve of a three phase induction motor and explain the effect of increasing the rotor circuit resistance on T-S characteristics curve. [8]

   b) A 380V, 4-pole, 50Hz, 3 phase, slip ring induction motor has a star connected stator winding and a star connected rotor winding. At sandstill the voltage between the two slip rings in 180V. The stator impedance is 0.5+j2.5ohm. The rotor resistance and reactance at standstill are 0.06ohm and 0.3ohm respectively and it develops a starting of 60Nm. Calculate:

   (i) Slip at which the motor develops the maximum torque.
   (ii) Torque, power output at full load, given that full load slip is 0.05. [8]

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2076 Bhadra

TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2076 Bhadra

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

Subject: - Electrical Machine-I *(EE 551)*

- ✓ 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 is meant by statically and dynamically induced emf? On what factors do these depend? Give practical example of each. [8]

   b) A wrought iron bar of 30 cm long and 2 cm in diameter is bent into circular shape. It is wound 600 turns of winding. Calculate the current required to produce a flux of 0.05 mwb in the core in the following two cases: a) with no air gap b) with an air gap of 4mm. Given that $\mu_r = 4000$. [8]

2. a) A 20 kVA, 250/2500 V transformer when tested gave the following results: [8]
   O.C. test (L.V. side): 105 W,1.4 A, 250 V.
   S.C. test (H.V. side): 320 W, 8 A, 120 V.
   Compute all the parameters of the equivalent circuit as referred to the L.V. side and also draw the resultant circuit as referred to H.V. side.

   b) Explain how the efficiency of a transformer varies with load. Derive the condition for maximum efficiency. [8]

3. a) Explain the voltage build up process in dc generator. Also, explain the meaning of critical speed and critical resistance. [6+2]

   b) A dc short shunt compound generator delivers 6kw to the load at 250V. The armature winding, series field winding and shunt field winding have resistance of 0.1 Ω, 0.2 Ω and 250 Ω respectively. Calculate the emf generated by armature. [8]

4. a) Explain working principle of D.C. motor. Derive torque equation of a D. C motor. [8]

   b) A 250V d.c shunt motor has armature winding resistance of 0.2 ohm and field winding resistance of 125 ohm. It draws a current of 32 Amp. and runs at a speed of 1500 r.p.m. If a resistance of 75 ohm is connected in series with the field and the load torque on the shaft is increased by 20%, what will be the new speed of the motor? [8]

5. a) Explain T-S characteristic of three phase induction machine. [8]

   b) A 400V, 4 pole, 50 Hz, 3 phase slip ring Induction Motor has a star connected stator winding and a star connected rotor winding. At standstill, the voltage between the two slip rings is 200V. The stator impedance is 0.8+j3 ohm. The rotor resistance and standstill reactance are 0.08 ohm and 0.25 ohm respectively. The motor produces a torque of 10 Nm at starting. Calculate: [4+4]

   (i) Maximum torque that can be developed by the motor.
   (ii) Calculate the torque developed by the rotor at 1430 rpm.

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2076 Baisakh

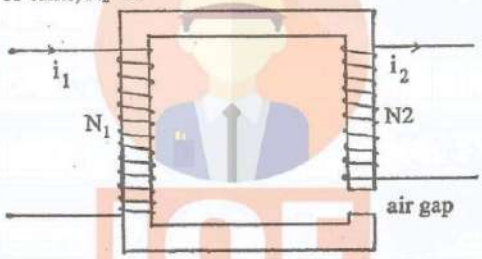
TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2076 Baisakh

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

Subject: - Electrical Machine I *(EE 551)*

- ✓ 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 magnetic circuit with a single air gap is shown fig below. The core dimensions are: Cross-sectional area $A_c=1.8\times10^{-3}m^2$, Mean core length $l_c=0.6m$, Gap length $g=2.3\times10^{-3}m$, $N_1=83$ turns, $N_2=20$



Assume that the core relative permeability of 2000.

i) Calculate the reluctance of the core and that of the gap R_g. For a current of $i_1=1.5A$, and $i_2=1.25$ A calculate

ii) The total flux ϕ, in the air gap. [8]

b) Define voltage regulation of a transformer. Deduce the expression for the voltage regulation when it is connected with lagging load. [2+6]

2. a) Describe the various losses in a transformer. When the efficiency of a transformer will be maximum? Derive it mathematically. [8]

b) The O.C. and S.C. test data are given below for a single phase, 5kVA, 200V/400V, and 50Hz transformer. [8]
O.C. test from LV side: 200V 1.25A 150W
S.C. test from HV side: 20V 12.5A 175W
Calculate the equivalent circuit parameters referred to primary side and draw the equivalent circuit.

3. a) Explain the voltage build-up process dc generator and define the meaning of critical resistance. [8]

b) A 220V dc shunt motor draws a current of 25A and runs at 1200rpm with certain load on it's shaft. The armature winding resistance and field winding resistances are 0.1Ω and 110Ω respectively. If a resistance of 50Ω is connected in series with the field winding and load torque on the shaft is reduced by 10%, calculate the new speed. [8]

4. a) Why series motor is use for high torque applications? Draw and explain the electrical and mechanical characteristics of compound motor? [6]

   b) A short shunt compound dc generator supplies a load current of 150A at 230V. The generator has following winding resistances
   Armature resistance=0.15 ohm
   Series field resistance=0.1 ohm
   Shunt field resistance = 100 ohm
   Calculate (a) emf generated if the carbon brush drop is 2v per brush. And also (b) calculate the ratio of voltage generated. If the same generator is connecting as long shunt generator to the original short shunt compound generator. [10]

5. a) Explain how a 3-phase induction motor can be used as generator in grid-connected mode. [8]

   b) A 3 phase, 400V, 50Hz, 2 pole induction motor has rotor circuit resistance of 2Ω and rotor circuit resistance of 8Ω at stand still. It develops a starting torque of 10N-m. At which speed, the motor develop maximum torque and calculate the value of maximum torque. [8]

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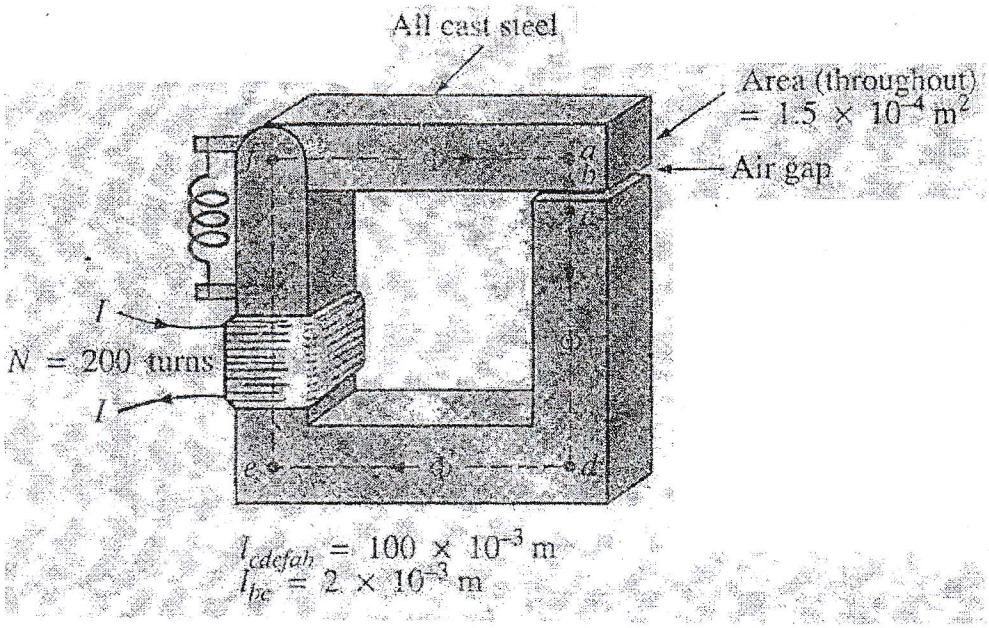
16 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2075 Bhadra

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) Find the value of I required to establish a magnetic flux of $\Phi = 0.75\times10^{-4}$ Wb in the series magnetic circuit as shown in figure below. Given, that the relative permeability for the steel is $\mu_r = 1424$. [8]



b) Explain the operating principle of transformer and prove that Net magnetic flux in the core remains same in No-load and loaded condition. [8]

2. a) Mention the conditions for parallel operation of transformer. "In parallel operation of transformer if we want to share load according to their capacity we have to match the per unit impedance of transformer according to their base" Justify this statement with mathematical expression. [2+6]

b) Following test data are obtained in a 220 v/440 v single phase transformer: [8]

O/C test: 220 v 1.3 Amp 160 watts

S/C test: 24 v 14 Amp 185 watts

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

3. a) Distinguish between self-excited and separately excited d.c generators. How are self-excited d.c. generators classified? Give their circuit diagrams and respective equations. [8]

   b) A dc shunt generator giving an out of 48.75 Kw at 250 V across the load. The armature winding resistance and field winding resistance are 0.02 Ω and 50 Ω respectively. No load power loss is 950 watt. Calculate the efficiency of the generator and B.H.P of the driving engine? [8]

4. a) A 220 V dc shunt motor draws a current of 20 A and runs at 1400 rpm with certain load on the shaft. The armature winding resistance and field winding resistance are 0.2 Ω and 220 Ω respectively. If a resistance of 0.1 Ω is added in series with armature and the load torque is increased by 10%, calculate the new speed. [8]

   b) Derive the relationship for torque developed by a 3-phase induction motor. Draw a typical torque-ship characteristic and deduce the condition for maximum torque. [8]

5. a) Explain the Torque-slip characteristics of a 3-phase induction motor and explain the effect of rotor circuit resistance on the characteristic. [8]

   b) A 3 phase, 400 V, 50 Hz, 4 pole induction motor has rotor circuit resistance 2 Ω and rotor circuit reactance of 8 Ω at stand still. It develops a starting torque of 5 N-m. The stator to rotor trun ratio in unity. Calculate the torque developed by the motor when it runs at 1400 rpm. [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 <u>All</u> questions.*
- ✓ *<u>All</u> 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 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
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

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36 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2073 Magh

Exam.	New Back (2066 & Later Batch)		
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) What do you understand by magnetic hysteresis? Proof that the area of hysteresis loop is proportional to the energy loss per unit volume. Differentiate between hard and soft magnetic materials. [8]

   b) A steel ring 12 cm mean radius and of circular cross section 1 cm in radius has an air gap of 2 mm length. It is would uniformly with 550 turns of wire carrying 3 A. Neglecting magnetic leakage. Calculate the magnetic flux density in the core. Given that relative permeability of the steel is 800. [8]

2. a) Discuss how to conduct open-circuit and short-circuit tests on a single phase transformer in the laboratory. Form the test results how the efficiency and voltage regulation of the transformer can be determined. [8]

   b) A single phase 500 KVA transformer working at unity power factor has an efficiency of 90% at half load and iron loss of 2000 watt. Determine efficiency at full load. [8]

3. a) Describe the function of commentator segments in DC Generator. Derive the expression of voltage generated in DC generator. [4+4]

   b) A dc short shunt compound generator has armature winding resistance of 0.5 ohm, series field winding resistance of 0.3 ohm and shunt field winding resistance of 200 ohms. It supplies a current of 50 Amp to the load at 200 V. Calculate the emf generated by the armature. [8]

4. a) What is back emf? How does back emf play an important roles in DC motor? [2+6]

   b) A 250 V dc shunt motor has the armature and field winding resistance of 1 Ω and 125 Ω respectively. When running light, it takes a currents of 5 A and the speed is 1500 rpm. When the load is added on the shaft, the motor draws a current of 25 Amp. Calculate the speed at this load. [8]

5. a) Describe the torque-speed characteristics of a 3-phase induction motor. Discuss the effect of variation of rotor resistance on the torque-speed characteristic. [8]

   b) A 4 pole, 50 Hz, 3 phase induction motor develops starting torque of 150 N-m. Calculate the torque developed by the motor when running at a speed of 1450 rpm. Given at that rotor resistance and reactance at stand still are 0.5Ω and 2Ω respectively and rotor EMF at stand still is 400 V per phase. [8]

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36 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2072 Ashwin

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) What is eddy current loss how it takes place in Ferro-magnetic material with ac excitation. How it can be minimized. [4+4]

   b) A 20 kVA, 220V/2200V, 50Hz single phase transformer gave the following test results: [8]

   No-load test (on L.V. side) : 220V, 1.4 A, 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 showing the values of parameters.

2. a) What do you mean by an ideal transformer, explain the operating principle of an ideal transformer and derive the emf equation. [8]

   b) An 132KV/11kV Star/Detla, 3-phase transformer has balanced star connected 3-phase load of 4MW at p.f of 0.8 lagging per phase. The primary winding has resistance and leakage reactance of 10 Ω and 30 Ω respectively. The secondary winding has resistance and leakage reactance of 0.02 Ω and 0.06 Ω respectively. Given that the iron loss of transformer is 20 kW. Calculate: [8]

      i) Secondary phase and line currents

      ii) Primary line current

      iii) Efficiency of transformer

3. a) Explain the voltage building process in self excited dc generator. Also define critical resistance and critical speed. [4+2+2]

   b) A 25 KW short-shunt dc compound generator delivers rated power to the load at 250 V. The generator has shunt field, series field and armature resistance of 125Ω, 0.5Ω and 0.1Ω respectively. Calculate the emf generated in armature winding. Taking 2V as total brush drop. [8]

4. a) What is back emf in dc motor? Explain the roles of back emf in dc motor. [8]

   b) 250V dc shunt motor has armature-winding resistance of 0.4 ohm and field winding resistance of 125 ohms. It draws a current of 25 amp at half load and the corresponding speed is 1200 rpm. If a resistance of 50 ohm is connected in series with the field winding and load torque is increased by 20%. Calculate the new speed. [8]

5. a) Draw and explain the torque-slip (speed) characteristics of 3-phase induction motor, showing clearly the starting torque, maximum torque and normal operating region. [8]

   b) A 380V, 4-pole, 50Hz, 3 phase, slip ring induction motor has a star connecter stator winding and a star connected rotor winding. At standstill the voltage between the two slip rings is 180V. The stator impedance is 0.5+j2.5 ohm. The rotor resistance and reactance at standstill are 0.06 ohm and 0.3 ohm respectively. The stator to rotor turn ration ratio is 1:1. The motor consumes 500 watts at no-load. Calculate: [8]

      i) Speed at which the motor develops the maximum torque

      ii) Efficiency of the motor when it is running at 1350 rpm

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36 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2071 Bhadra

Exam.	Regular / 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 <u>All</u> questions.*
- ✓ *The figures in the margin indicate <u>Full Marks</u>.*
- ✓ *Assume suitable data if necessary.*

1. a) What do you mean by retaintivity and coercivity of a core? Prove that the energy spent in hysteresis loop is $W_h = \oint H.dB$. [2+6]

   b) While performing transformer test, copper loss is assumed to be negligible during no-load test and iron loss is assume to be negligible during short circuit test. Justify that these assumptions are correct with detail explanation. [8]

2. a) What do you mean by an ideal transformer? Explain the operating principle of an ideal single phase transformer and derive the emf equation. [8]

   b) A 25 KVA single phase 2200/220V transformer has primary winding resistance of 1 Ω, secondary winding resistance 0.01 Ω, primary leakage reactance of 1.5 Ω and secondary leakage reactance of 0.015 Ω. The iron loss of transformer is 206 W. Calculate the efficiency of the transformer at: (i) Half load (ii) 50% Overload. [8]

3. a) Explain the voltage build-up process of a dc shunt generator and define critical resistance and critical speed. [8]

   b) A series motor takes 20 A at 400 V to drive a fan at 200 RPM. Its armature resistance is 0.5 Ω and field resistance is also 0.5 Ω. If the torque required to drive the fan varies as the square of the speed, find the necessary applied voltage and current to drive the fan at 300 RPM. [8]

4. a) What do you mean by back emf in DC motor? Explain its role in DC motor. [4]

   b) A short shunt dc compound generator supplies a current of 50 A at 220 V. The shunt field, series field and armature winding resistances are 100 ohm, 0.05 ohm and 0.1 ohm respectively. Calculate the emf generated by the armature. [5]

   c) Explain the loaded operation of transformer? Draw the phasor diagram of a power transformer for inductive load. [4+3]

5. a) Explain the Torque-slip characteristics of an 3-phase induction motor and also explain the effect of Rotor Resistance in the characteristic. [8]

   b) The data obtained from the test of a 3-phase star connected, 400 V, 50 Hz induction motor are as follow: [8]

   No-Load Test: $V_l = 400$ V, $I_0 = 20$ A, $W_1 = 5000$ W and $W_2 = -3200$ W
   Blocked rotor test: $V_{SC} = 50$ V, $I_{SC} = 60$ A, $W_1 = 2300$ W and $W_2 = 750$ W

   Calculate the equivalent circuit parameters refer to stator side.

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33 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2071 Magh

Exam.	New Back (2066 & Later Batch)		
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) Explain the magnetization characteristic of an iron core with AC excitation. [8]

   b) An iron ring has a mean length of 1.25 m and cross-sectional area of 0.02 m^2. It has a radial air gap of 5 mm. Calculate the number of turns required to be wound on the core to produce a magnetic flux of 0.5 weber in the air gap with current of 2 amp in the coil. Assume that relative permeability of the core is 1000. [8]

2. a) Proof with suitable assumption that copper saving in auto transformer is significant when the transformation ratio is nearly equal to unity. [8]

   b) A 20 kVA, 250 V / 2500 V, 50 Hz single phase transformer has the following parameters: Ro = 600 ohm, Xo = 180 ohm, R_{01} = 0.05 ohm and X_{01} = 0.15 ohm. [8]

   i) Calculate the iron loss of the transformer.
   ii) Calculate the primary current at which the efficiency of the transformer will be maximum and also calculate the maximum efficiency.

3. a) Make a detail comparison between dc shunt generator and dc series generator with their circuit diagram, equations and characteristic curves. [8]

   b) A 250 V dc shunt motor has armature-winding resistance of 0.2 ohm and field winding resistance of 125 ohms. It draws a current of 25 amp at half load and the corresponding speed is 1400 rpm. If a resistance of 50 ohm connected in series with the field winding and load torque is increased by 20%. Calculate the new speed. [8]

4. a) Explain operating principle of dc motor. Prove that the armature torque of a dc motor is $T_a \propto \phi I_a$ where ϕ = flux per pole, I_a = armature current. [5+3]

   b) A dc shunt motor supplied by 220 Vdc draws a current of 25 A and runs at a speed of 1500 rpm. The armature and field winding resistance are 0.08 Ω and 110 Ω respectively. A resistance of 0.05 Ω is added in series with armature and load torque is increased by 20%, calculate the new speed. [8]

5. a) What do you mean by rotating magnetic field, synchronous speed and slip of a 3-ϕ induction motor? Derive the stand still torque equation $T_s = \frac{K_1 E_2^{\,2} R_2}{R_2^{\,2} + X_2^{\,2}}$ for 3-ϕ induction motor. [3+5]

   b) A 4 pole, 400 V, 3-phase, 50 Hz squirrel cage induction motor runs at 1450 RPM at 0.8 power factor lagging developing 11 KW. The stator losses are 1100 watt and mechanical losses are 400 Watt. Determine. [2+2+2+2]

   i) Rotor copper loss
   ii) Rotor Frequency
   iii) Line current
   iv) Efficiency

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26 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2070 Bhadra

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

Subject: - Electrical Machine I *(EG551)*

- ✓ 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 operating principle of an ideal transformer and derive the emf equation [8]

b) An iron ring has a mean length of 1.5m and cross-sectional area of 50c m^2. It has a radial air gap of 4mm. The ring is wound with 500 turns. What dc current would be needed in the coil to produce a flux of 100 mb in the air gap. Assume that $\mu r = 2000$. [8]

2 a) Explain the different power losses in the transformer and how the efficiency is calculated? Drive the condition at which the efficiency of transformer will be maximum. [8]

b) A 20 kVA, 250V/2500V, 50Hz single phase transformer gave the following test results:

No-load test (on L.V. side) : 250V, 1.4 A, 105 watts
Short circuit test (on H.V. side): 120V, 8 A, 320 watts

Calculate the equivalent circuit parameters referred to primary side as well as secondary side and draw the respective equivalent circuits [8]

3 a) Explain the functions of commutator segments in dc generator. [4]

b) Case-I: A short shunt cumulative compound dc generator supplies 10 kw at 220V. The shunt field, series field and armature resistance are 100, 0.3and 0.4 ohms respectively. Calculate the induced emf.

Case-2: If the same generator is re-connected in long shunt compound mode and same value of emf and armature current is generated, Calculate the terminal voltage across the load. [8]

4 a) Explain the roles of back emf in dc motor. [4]

b) 240V dc shunt motor has armature-winding resistance of 0.4 ohm and field winding resistance of 120 ohms. It draws a current of 30 amp at half load and the corresponding speed is 1400 rpm. If a resistance of 1.2 ohm is connected in series with the armature winding and load torque is decreased by 20%. Calculate the new speed. [8]

5 a) A 150 kW, 3000V, 50Hz, 4 pole star-connected induction motor has a star-connected slip ring rotor with a transformation ratio of 4 (stator to rotor). The rotor resistance is 0.1 ohm/phase and rotor inductance is 3.61 mH per phase. Neglecting the stator impedance, calculate:

a) Starting current on rated voltage with slip rings short circuited. [8]
b) Necessary external resistance to be connected in rotor side reduce starting current to 30A

b) Explain how an Induction motor can be used as generator. Explain why excitation capacitors are required in isolated mode of operation. Explain why excitation capacitor are not required in grid connected mode of operation? [8]

c) Explain the operating principle of 3 phase induction motor in detail. [8]

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26 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2070 Magh

Exam.	New Back (2066 & Later Batch)		
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) Explain the hysteresis loop of a magnetic material used in electrical machine. Prove that the area of the loop is proportional to the energy loss per cycle per unit volume. [8]

   b) The no-load current of a transformer if 10 A at a p.f. of 0.3 lagging when connected to a 400 V, 50 Hz power supply. If the primary winding has 500 turns. Calculate: (a) the magnetizing and working component of no-load current. (b) iron loss (c) maximum and rms value of flux in the core. [8]

2. 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. [8]

   b) An 11KV/380V delta/star 3-phase transformer has balanced star connected 3-phase load of 40 KW at p.f. of 0.8 lagging per phase. Calculate the primary line current. If the transformer has iron loss of 1.0 KW, calculate the approximate efficiency of the transformer. Given that primary winding resistance and leakage reactance are 25Ω per phase and 40Ω per phase respectively. Secondary winding resistance and leakage reactance are 0.01Ω per phase and 0.02Ω per phase respectively. [8]

3. a) Explain the voltage build-up process of a dc shunt generator. [4]

   b) A short shut compound de generator supplies 7.5kw at 230V. The shunt field, series field and armature resistance are 100, 0.3 and 0.4 ohms respectively. Calculate the induced emf and the load resistance. [8]

4. a) Prove that the torque developed by the armature of the dc motor is proportional to the product of flux per pole and armature current. [4]

   b) 240 V dc shunt motor has armature-winding resistance of 0.4 ohm and field winding resistance of 120 ohms. It draws a current of 27 amp at half load and the corresponding speed is 1200 rpm. If a resistance of 1 ohm connected in series with the armature winding and load torque is increased by 20%. Calculate the new speed. [8]

5. a) Explain the torque-slip characteristic of a three phase induction motor and explain the affect of rotor resistance on T-S characteristic. [8]

   b) A 400V, 4-pole, 50Hz, 3 phase, slip ring induction motor has a star connected stator winding and a star connected rotor winding. At standstill the voltage between the two slip rings is 190V. The stator impedance is 0.5+j2.5 ohm. The rotor resistance and reactance at standstill are 0.06 ohm and 0.3 ohm respectively. The stator to rotor turn ration is 1:1. The motor consumes 600 watts at no load. Calculate: [8]

      i) Speed at which the motor develops the maximum torque.
      ii) Efficiency of the motor when it is running at 1380 rpm.

   c) Explain how an induction motor can be used as generator. Explain its operation in isolated mode and grid connected mode. [8]

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26 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2069 Bhadra

Exam.	Regular (2066 & Later Batch)		
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) A 50cm long iron rod is bent into circular ring and 1000 turns of windings are wound on it. The diameter of the rod is 40mm and relative permeability of the iron is 5000. Calculate the inductance of the coil. If a time varying current is passed through the coil whose magnitude changes from 2 amp to 10 amp in 5 ms, calculate the average value of emf induced in the coil. [8]

   b) Describe no load test and short circuit test of a single phase transformer having following ratings: 10kVA, 6600V/220V. How the results obtained from the tests can be utilized to develop the equivalent circuit of the transformer refer to primary side? [8]

2. a) What are the different power losses that occur within the transformer? Derive the condition at which the efficiency of a transformer will be maximum. [8]

   b) A 50kVA, 200/2200, 50Hz single phase transformer has the following parameters: R_0 = 600Ohms, X_0 = 200 Ohm refer to primary side and R_{02} = 2 Ohms and X_{02} = 4 Ohm refer to secondary side. Calculate the efficiency of the transformer when supplying a power of 40kW to the load with 0.65 pf lagging at rated voltage. Is the transformer over-loaded or under-loaded? Calculate the percentage by which it is over-loaded or under-loaded. [8]

3. a) What do you mean by dc series motor? Why is this motor used to start heavy loads? [4]

   b) Derive emf equation of a dc generator. [4]

   c) A 250 dc shunt motor has armature winding resistance of 0.2 Ohm and field winding resistance of 125Ohms. It draws a current of 32 amp and runs at a speed of 1500 rpm. If a resistance of 75 Ohms connected in series with the field and the load torque on the shaft is increased by 20%, what will be the new speed of the motor? [8]

4. a) A shunt compound dc generator has the following parameters:

   Armature winding resistance (R_a) = 0.02 Ohms
   Series field winding resistance (R_{se}) = 0.04 Ohms
   Shunt field winding resistance (R_{sh}) = 100 Ohms
   Iron and friction loss = 250Watts
   The generator is delivering a 20kW to the load at 220V dc.

   Calculate emf generated by the armature and efficiency of the generator. [8]

b) Explain the no-load test and blocked rotor test of a three-phase induction motor? How the data obtained from these test can be used to calculate the equivalent circuit parameters of the motor? [8]

5. a) Explain the isolated and grid connected mode of operation of three phase induction generator. [8]

b) A 400V, 4-pole, 50Hz, 3 phase, slip ring induction motor has a star connected stator winding and a star connected rotor winding. At standstill the voltage between the two slip rings is 200V. The stator impendence is 0.8+j3 Ohm. The rotor resistance and reactance at standstill are 0.08 Ohm and 0.25 Ohm respectively. The motor produces a torque of 10-N-m at starting. Calculate: [8]

i) Maximum torque that can be developed by the motor
ii) Calculate the torque developed by the rotor at 1430rpm.

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26 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2069 Poush

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

Subject: - Electric 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 80 cm long iron rod has cross-sectional area of 200 sq.mm. It is bend into a circular ring with an air gap of 4 mm and the ring is wound with 500 turns of winding. What dc current would be needed in the coil to produce a flux of 250 mWb in the air gap. Assume that μr = 4000.

b) A 50 KVA, 2500V/250V, 50Hz single phase transformer draws a current of 0.3 Amp at no load and consumes 300Watts. When the primary winding is supplied by 100V with secondary winding short circuited, the primary draws a current of 20 Amp and consumes 500 watts. Calculate the equivalent circuit parameters of the transformer refer to secondary side. Also calculate the efficiency of the transformer at half load.

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 remain same.

b) A 120 KVA, 6000/400V, Y/Y 3-phase, 50 HZ transformer has an iron loss of 1600 W. The maximum efficiency occurs at ¾ full load. Find the efficiency occurs at 3/4 full load. Find the efficiencies of the transformer at: (i) Full-load and 0.8 power factor (ii) Half-load and unity power factor.

3 a) Explain the operating principle of a dc motor and prove that the torque developed by the armature of the dc motor is given by:

$$T_a = \frac{1}{2\pi} Z \varphi I_a \left(\frac{P}{A}\right)$$

Where Z = No of armature conductors

φ = Magnetic flux per pole, I_a = armature current

P = No of poles, A = No of parallel path in armature winding

b) A dc compound generator has to supply a current of 120A at 120V. The shunt field, series field and armature winding resistances are 30Ω, 0.05Ω and 0.1Ω respectively. Calculate the emf generated by the armature in the following two cases: (i) Long shunt connection (ii) Short shunt connection.

4 a) A 250V dc shunt motor has armature winding resistance of 0.2 ohm and field winding resistance of 125 ohms. It draws a current of 30 amp and runs at a speed of 1500 rpm. Calculate the value of resistance to be connected in series with armature in order to reduce the speed to 1250 keeping the load torque constant.

b) Derive the torque equation-($T_R = \frac{K.S.E_2^2.R_2}{R_2^2 + S^2.X_2^2}$) for three-phase induction motor draw and explain the torque – slip characteristic.

5 a) Explain the voltage build-up process of isolated three phase induction generator.

b) The power input to a 500V, 50Hz, 6-pole, 3-phase induction motor running at 975 rpm is 40KW. The stator losses are 1 KW and the friction and windage losses total 2 KW. Calculate: (i) The slip (ii) The rotor copper loss (iii) Shaft power and (iv) The efficiency.

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26 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2068 Bhadra

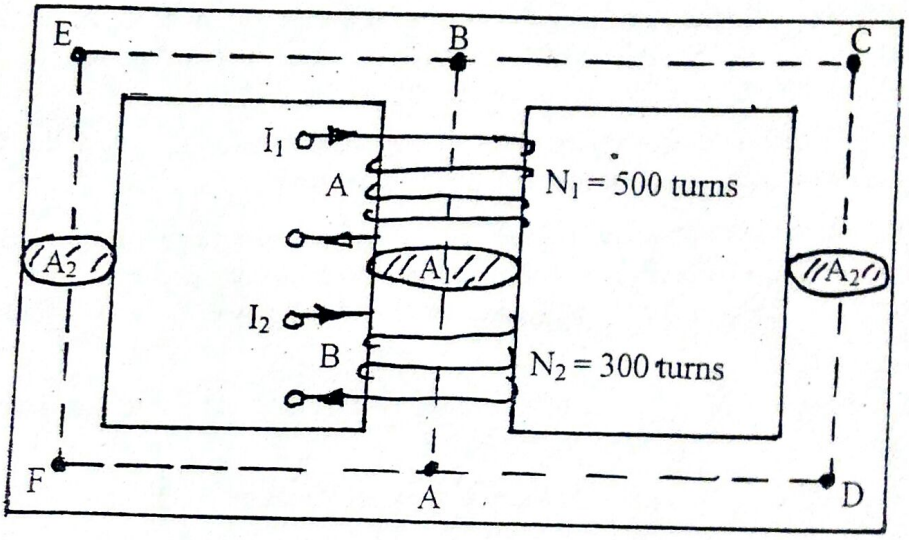
Exam.		Regular	
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

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 operating principle of transformer and derive the equation for emf induced in its secondary winding. [8]

   b) For magnetic circuit shown in figure below, calculate the current to be passed through coil A so that magnetic flux in the control core is 2mWb. Given that the relative permeability of core = 1000. [8]



Given that:

$I_2 = 5\text{Amp}$, $A_1 = 4\text{cm}^2$, $A_2 = 2\text{cm}^2$
$AB = CD = EF = 15\text{cm}$
$BC = AD = BE = AF = 15\text{cm}$

2. a) Explain no-load operation of a real transformer. What do you mean by Amp-turn balance in loaded transformer? Prove that the magnetic flux in the core remains constant irrespective of load on transformer. [8]

   b) A 5KVA, 50Hz, 1100V/110V single phase transformer has equivalent resistance of 0.04 Ohm and equivalent reactance of 0.24Ohms referred to secondary side. When it delivers a current of 40A to the load at 110V, its efficiency is maximum. Calculate the efficiency of the transformer when it is delivering 2 kw to the load at 0.85 power factor lagging. [8]

3. a) A 100KVA, 11KV/400V Delta /star 3-phase transformer has following parameters: [8]

   $R_1 = 25\Omega$, $X_1 = 50\Omega$, $R_2 = 0.04\Omega$, $X_2 = 0.4\Omega$
   Iron loss = 1000 Watts

   A 3-phase balanced load draws per phase current of 100Amp at 0.85 power factor lagging.

   Calculate primary line current and efficiency of the transformer.