TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2083 Baishakh

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

Subject: - Electrical Machine Design *(EE 603)*

- ✓ *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) Classify the insulating materials on the basis of their thermal stability. [5]
   b) What are the fundamental requirements of high conducting materials? Classify and explain the electrical conducting materials in brief. [5]
2. a) Derive the expression of temperature gradient in conductors placed in slot if slot insulation is comparatively thick. [6]
   b) An induction machine has a temperature rise of 25°C and 40°C after 1 hour and 2 hour respectively while operating at full load of 7.5 kW. The constant losses are 80% of full load copper loss. Determine how long the motor can be operated at twice the rated output without overheating. [6]
3. a) Classify the transformer on the basis of construction, application, number of phase and colling method. [4]
   b) For a 500 kVA, 50Hz, 6600/400, single phase core type, oil immersed, natural cooled power transformer, the design parameters are: [20]

   Constant for output voltage per turn (K) = 0.8,
   Resistivity of copper 0.021 Ω-mm^2/m,
   Maximum flux density in core (Bm) = 1.5 Wb/m^2,
   Current density = 2.75 A/mm^2,
   Core type = Cruciform,
   Window space factor (kW) = 0.27,
   Stacking factor (K_i) = 0.9,
   Ratio of height to width of windows (H_w/W_w) = 2.5,
   Ratio of yoke height to width (H_y/D_y) = 1,
   Axial depth of LV winding = 402 mm,
   Axial depth of Hv winding = 377.5 mm,
   Inside diameter of LV winding = 310 mm,
   Outside diameter of LV winding = 348 mm,
   Inside diameter of HV winding = 360 mm,
   Outside diameter of HV winding = 418 mm,

   Calculate;
   (i) Dimension of core, window and yoke.
   (ii) Overall dimension of frame
   (iii) Perunit resistance and leakage reactance.
   (iv) Perunit regulation at 0.8 pf lagging
   Taking iron loss = 1460 W, copper loss = 3865 W at full load, height of tank =1.6 m, length of tank = 1.05 m, width of tank = 0.62 m, find the temperature rise. If the mean rise of oil is not to rise 35°C, find the necessary number of tubes and show its arrangement.

4. a) Write about the factors to be considered while estimating the length of air gap in induction machines. [6]

b) A 15 kW, 440 V, 50 H_z, 1480 rpm, 3-phase induction motor is built with an inner diameter of stator 25 cm and length 16 cm. The specific loading is 23000 amp-conductors per meter. Estimate the following parameter for a 11 kW, 460 V, 6 pole, 50 H_2 delta connected induction motor, assuming same specific loadings as the previous motor with 84% efficiency and power factor 85% for each machine. Assume, current density 4 A/mm^2, stator slot pitch is 15 to 25 mm, ratio of slot depth to width is 3 and flux density in stator core is 1.2 Wb/m^2. [12]

Calculate;

(i) Main dimension

(ii) No of stator slot

(iii) No of stator conductor and area of stator slot

(iv) Dimension of each stator slot

(v) Minimum width of stator teeth

5. a) Explain the factors to be considered while selecting the number of poles in a DC machine. [8]

b) Calculate the main dimensions of the machine for a 7.5 kW, 4 pole, 1000 rpm and 220 V DC shunt generator. Given that full load efficiency is 0.83, maximum gap flux density is 0.9 Wb/m^2, specific electrical loading is 30,000 ampere conductor/meter and field form factor is 0.7. Assume that the maximum efficiency occurs at full load and the field current is 2.5% of rated load current. The pole face is square. [8]

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TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2082 Bhadra

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

Subject: - Electric Machine Design *(EE 603)*

- ✓ *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) Discuss in brief about insulating material with their classification. What are the fundamentals requirements of a good insulating material, electrical properties of insulating materials? [5]

   b) Give the advantages of cold rolled grain oriented steel laminations over hot rolledsteel laminations in transformer. [5]

2. a) What are heating time constant and cooling time constant? Explain with necessary mathematical expressions and graph. [6]

   b) A 400 kVA transformer has its maximum efficiency at 80% of full load and when this transformer is working in an ambient temperature of 40°C on full load, its oil temperature is observed to be 60°C after 1 hour and 72°C after 2 hours. Calculate its heating time constant and final steady temperature rise of the transformer. If the rate of heat dissipation is improved by 20% with the help of external fan, find the new kVA rating for same steady temperature rise. [6]

3. a) For a 500 kVA, 50Hz, 6600/400, single phase core type, oil immersed, natural cooled power transformer, the design parameters are: [20]
   Constant for output voltage per turn (K) = 0.8,
   Resistivity of copper = 0.021 $\Omega mm^2/m$,
   Maximum flux density in core (B_m) = 1.5 Wb/m^2,
   Current density = 2.75 A/mm^2,
   Core type = Cruciform,
   Window space factor (kW) = 0.27,
   Stacking factor (K_i) = 0.9,
   Ratio of height to width of windows (H_w/W_w) = 2.5,
   Ratio of yoke height to width (H_y/D_y) = 1,
   Axial depth of LV winding = 402 mm,
   Axial depth of HV winding = 377.5 mm,
   Inside diameter of LV winding = 310 mm,
   Outside diameter of LV winding = 348 mm,
   Inside diameter of HV winding = 360 mm,
   Outside diameter of HV winding = 418 mm.
   Calculate;
   i) Dimension of core, window & yoke.
   ii) Overall dimension of frame
   iii) Per unit resistance & leakage reactance.
   iv) Per unit regulation at 0.8 pf lagging

   Taking iron loss = 1460 W, copper loss = 3865 W at full load, height of tank = 1.6 m, length of tank = 1.05 m, width of tank = 0.62 m, find the temperature rise. If the mean rise of oil is not to rise 35°C, find the necessary number of tubes and show its arrangement.

4. a) Write about the factors to be considered while estimating the length of air gap in induction machines. [6]

b) A 15 kW, 440 V, 50 H_z, 1480 rpm, 3-phase induction motor is built with an inner diameter of stator 25 cm and length 16 cm. The specific loading is 23000 amp-conductors per meter. Estimate the following parameter for a 11 kW, 460 V, 6 pole, 50 H_2 delta connected induction motor, assuming same specific loadings as the previous motor with 84% efficiency and power factor 85% for each machine. [12]
Assume, current density 4 A/mm^2, stator slot pitch is 15 to 25 mm, ratio of slot depth to width is 3 and flux density in stator core is 1.2 Wb/m^2.
Calculate;

(i) Main dimension

(ii) No of stator slot

(iii) No of stator conductor and area of stator slot

(iv) Dimension of each stator slot

(v) Minimum width of stator teeth

5. a) Explain the factors to be considered while selecting the number of poles in a DC machine. [8]

b) Calculate the main dimensions of the machine for a 7.5 kW, 4 pole, 1000 rpm and 220 V DC shunt generator. Given that full load efficiency is 0.83, maximum gap flux density is 0.9 Wb/m^2, specific electrical loading is 30,000 ampere conductor/meter and field form factor is 0.7. Assume that the maximum efficiency occurs at full load and the field current is 2.5% of rated load current. The pole face is square. [8]

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TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2082 Baishakh

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

Subject: - Electric Machine Design *(EE 603)*

- ✓ 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 ageing of core and how it can be minimized? [4]
   b) What are the fundamental requirements of a good insulating materials? List out the merits and demerits of addition of silicon with iron with suitable diagram. [6]
2. a) Derive the expression of temperature gradient in conductors placed in slot if slot insulation is very thick. [4]
   b) A 20 h.p., 400V, 3 phase, 50 Hz, induction motor has a final steady state temperature rise of $40^\circ C$ when running at its rated output. Calculate its one hour rating for the same temperature rise, if the heating time constant is 180 min. The ratio of conductor losses to constant losses can be assumed as 1.25 and the total losses of the machine at full load is 1800 W. [8]
3. a) Give suitable reasons for the following. [8]
   (i) Distribution transformer are designed to have maximum efficiency at loads much smaller than full loads.
   (ii) LV winding is kept near to core and HV winding is kept outside the LV winding.
   b) Design a 100 kVA, 2,200/480 V, 50Hz, single phase, core type oil immersed natural cooled transformer. [16]
   The required data for design are given below:
   Voltage per turn = 7.5,
   Maximum flux density in the core = 1.2 Wb/m^2
   Core Type = Cruciform,
   Current density = 2.5 A/mm^2,
   Window space factor = 0.28,
   Stacking factor = 0.9,
   Ratio of window height to width = 2
   And, width of duct between LV and core, LV winding, HV winding and duct between HV and LV are 5 mm, 25 mm, 30 mm, 10 mm respectively. Assuming all other required parameters, calculate:
   (i) Overall dimension of core.
   (ii) Overall dimension of frame.
   (iii) Per unit resistance and leakage reactance drop.
   (iv) Per unit regulation at 0.8 poner factor.
4. a) Derive the output equation for three phase induction motor. [6]
   b) A 15 kW, 440 V, 50 Hz, 1480 rpm., 3-phase induction motor is built with an inner diameter of stator 25 cm and length 16 cm. The specific loading is 23000 ampere conductors per meter. Estimate the following parameter for a 11 kW, 460 V, 6 pole, 50 Hz delta connected induction motor, assuming same specific loadings as the previous motor with 84 % efficiency and power factor 85% for each machine. Assume, current density 4 A/mm^2, stator slot pitch is 15 to 25 mm, ratio of slot depth to width is 3 and flux density in stator core is 1.2 Wb/m^2.Winding factor = 0.955. Slot space factor = 0.4. [12]

Calculate:

(i) Main dimension.
(ii) No. of stator slot.
(iii) No. of stator conductor and area of stator slot.
(iv) Dimension of each stator slot.
(v) Minimum width of stator teeth.

5. a) Explain the factors to be considered while selecting the ampere conductor per meter in a dc machine. [8]

   b) Calculate the diameter (D) and length (L) of armature for a 10 kW, 4 pole, 900 rpm, 220 V shunt motor. Given full load efficiency = 0.80, maximum gap flux density = 0.85 Wb/m^2, specific electrical loading = 30,000 ampere conductor/meter, field form factor (K_f) = 0.7. Assume that maximum efficiency occurs at full load and the field current is 3% of rated current. The pole face is square. [8]

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TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2081 Bhadra

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

Subject: - Electric Machine Design *(EE 603)*

- ✓ 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 the fundamental requirements of high conducting material? Classify and explain the electrical conducting material in brief. [6]

   b) What are the fundamental requirements of a good insulating materials? List out the merits and demerits of addition of silicon with iron with suitable diagram. [4]

2. a) What are heating time constant and cooling time constant? Explain with necessary mathematical expressions and graphs. [6]

   b) The temperature rise of a transformer is 25°C after one hour and 37.5°C after two hours of starting from cold conditions. Calculate the Final steady state temperature rise and the heating time constant. If its temperature falls from the final steady value to 40°C in 2.5 hour when disconnected, calculate its cooling time constant .The ambient temperature is 30°C. [6]

3. a) Derive an output equation for the three phase core type transformer. [6]

   b) The design parameter for 150 kVA, 50 Hz, 11000/440 V, 3-phase, delta/star, core type, oil immersed natural cooled distribution transformer are given below. [7+7+4]

   Constant for output voltage per turn = 0.45
   Maximum flux density in the core = 1.35 Wb/m^2
   Current density in conductor = 2.5 A/mm^2
   Take 5% more current density in HV winding
   Core type = three stepped
   Window space factor = 0.25
   Stacking factor = 0.9
   Ratio of window height to width = 2.3
   Take hot rolled steel and area of yoke is 20% greater than gross area of core
   Width of LV winding = 20 mm
   Width of HV winding = 25 mm
   Width of duct between HV and LV winding = 15 mm
   Mean height of coil = 231.25 mm
   Resistivity of copper = 0.021 Ω-mm^2/m
   Height of tank = 1150 mm
   Width of tank = 425 mm
   Length of tank = 1050 mm
   Total losses = 2850 W

   Assuming all other required parameters, calculate:
   (i) Overall dimension of frame.
   (ii) Per unit voltage regulation at 0.85 pf.
   (iii) Calculate the minimum number of tubes of diameter 50 mm with average length of 1.05 m required for maintaining the mean temperature within the permissible limit. The mean temperature of the oil not exceed 35°C. The rate of heat dissipation from plain wall is 6.5 and 6 W/m^2-°C for convection and radiation respectively. The provision of tubes improves the rate of heat dissipation by 35%.

4. a) What are the factors influencing air gap length determination in induction motor? [6]

b) A 15 KW, 440V, 3-phase, 50 Hz, 1480 rpm, three phase induction motor is built with an inner diameter of stator 25 cm and length 16 cm. The specific loading is 23,000 ampere conductors per meter. Estimate the following parameter for a 11 KW, 460V, 6 pole, 50 Hz delta connected induction motor, assuming same specific loadings as the previous motor with efficiency 84% and power factor 85% for each machine. Assume; [12]

Current density = 4 A/mm^2
Winding factor = 0.955
Stator slot pitch = 15 to 25 mm
Slot space factor = 0.4
Ratio of slot depth to width = 3
Flux density in stator core= 1.2 wb/m^2

Calculate:

(i) Main dimensions of the machine.
(ii) No. of stator slots.
(iii) No. of stator conductor and area of stator slot.
(iv) Area and dimension of each stator slot.

5. a) Explain the factors to be considered while selecting the number of poles in dc machine. [8]

b) Find the main dimension of a 200 kW, 250 V, 6 pole,1000 rpm dc shunt generator. The maximum value of flux density in the gap is 0.87 Wb/m^2 and ampere conductors per meter of armature periphery are 31,000. The ratio of pole arc to pitch is 0.67 and the efficiency is 91 percent. Assume the ratio of length of core to pole pitch is 0.75. [8]

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TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2080 Bhadra

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

Subject: - Electric Machine Design *(EE 603)*

- ✓ 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 the different classes of insulator used in Electric Machine? Classify them based on their thermal stability and materials used. [5]

   b) Explain the advantages of cold rolled grain oriented steel laminations over hot rolled steel laminations in transformer. [5]

2. a) Derive the expression for internal temperature (hot spot) of the core. [6]

   b) The temperature rise of a transformer is 25°C after one hour and 37.5 °C after two hours of starting from cold conditions. Calculate its final steady temperature rise and the heating time constant. If temperature falls from final steady value to 40°C in 2.5 hours when disconnected, calculate its cooling time constant constant. The ambient temperature is 30°C. [8]

3. a) Differentiate between core type and shell type transformer on the basis of construction, mechanical design, leakage reactance and cooling. [6]

   b) The design parameter for 1000 kVA, 50 Hz, 66/11 kV, 3-phase, delta/delta, core type, oil immersed natural cooled power transformer are given below. [18]

   Constant for output voltage per turn = 0.6

   Maximum flux density in the core = 1.45 Wb/m^2

   Current density in conductor = 2.75 A/mm^2

   Core type = cruciform two stepped

   Window space factor = 0.13

   Stacking factor = 0.9

   Ratio of window height to width = 2.75

   Take hot rolled steel and area of yoke is 20% greater than gross aca of core

   Width of LV winding = 40 mm

   Width of HV winding = 50 mm

   Width of duct between HV and LV winding = 20 mm

   Resistivity of copper = 0.021Ω-mm^2/m

4. a) Explain the factors that should be considered while estimating the length of air gap in induction machine. [6]

b) For a 2.2 kw, 440 V, 3 phase, 50 Hz, 1430 rpm squirrel cage induction motor having efficiency of 0.8 and power factor 0.85 designed for its best power factor. [12]

Given, Bar = 0.44 wb/m^2, ac = 21000 A/m, slot space factor = 0.4, ratio of slot depth to width = 4, stator slot pitch = 12 to 15 mm, $\delta_s = 4A/mm^2$. Calculate

(i) Main dimension.

(ii) T_s (Turns per phase of stator conductor).

(iii) a_s (area of stater conductors).

(iv) no.of stater slots.

(v) Area and dimension of each stator slot.

(vi) Minimun width of stater teeth.

(vii) Find stater loading.

Note : For best power factor, use [$\tau = \sqrt{0.18L}$]

5. a) Explain, various factors should be consider while selecting the value of specific electrical and magnetic loading in dc machine. [8]

b) A design is required for a 30 kW, 4 pole, 900 rpm dc shunt generator, the full load terminal voltage being 220V. Assume that the full load armature voltage is 3% of the terminal voltage. Calculate the main dimensions of the machine if the maximum gap density is 0.85 wb/m^2, specific electrical loading of 20,000 ampere conductor/meter and field resistance is 120Ω. The ratio of pole arc to pole pitch is 0.7. [6]

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TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2079 Bhadra

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

Subject: - Electric Machine Design *(EE 603)*

- ✓ 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 the fundamental requirements of a good insulating material? Explain the application of insulating materials in machines in brief. [5]

   b) What is ageing of core of electrical machine? What are the advantages and disadvantages of adding silicon with iron? [5]

2. a) Derive the expression of temperature gradient in conductors placed in slot if

   (i) Slot insulation is thick
   (ii) Overhang is considerably not [2+2]

   b) A 350 kVA transformer has its maximum efficiency at 85% of full load. During a short full load heat run the temperature rise after one hour and two hours is observed to be 24°C and 34°C respectively. Find thermal time constant and final steady temperature rise of the transformer. If by use of fan, cooling is improved so that heat dissipation per unit area per degree rise in temperature is increased by 15%, find the new kVA rating possible

   (i) for same, final temperature rise as before
   (ii) if the allowable temperature rise taken as 50°C. [10]

3. a) Derive the output equation of a single phase transformer. [6]

   b) The design parameter for 150 kVA, 50 Hz, 6600/400 V, 3-phase, delta/star, core type, oil immersed natural cooled distribution transformer are given below. [18]
   Max. flux density in core = 1.35 Wb/m^2
   Current density in conductor = 2.75 A/mm^2
   Constant for output voltage per turn = 0.45
   Core type = cruciform two stepped
   Window space factor = 0.27
   Stacking factor = 0.9
   Ratio of window height to width = 2.5
   Take hot rolled steel and area of yoke is 20% greater than gross area of core
   Width of LV, HV winding and duct between them are 20 mm, 25 mm and 15 mm respectively

   Assuming all other required parameters, calculate:

   (i) Dimension of the core, window and yoke
   (ii) Overall dimension of the frame
   (iii) Per unit resistance and leakage reactance drop
   (iv) Per unit voltage regulation at 0.85 pf

4. a) What are the factors to be considered while determining the ampere conductor per meter of an induction machine? [4]

   b) Determine the main dimension, turn per phase number of slots and slot area of a 200 kw, 400 V, 4-pole, 50 Hz slip ring induction motor. Assume B_{av} = 0.5 wb/m^2, ac = 3000 AC/m, η = 0.9, p.f. = 0.9, current density = 3.5 A/mm^2. The slot space factor is 0.4 and ratio of core length to pole pitch is 1.2. The machine is delta connected. [12]

5. a) Explain the factors to be considered while selecting the number of poles in a dc machine. [8]

   b) Calculate the diameter (D) and length (L) of armature for a 7.5 KW, 4 pole, 1000 rpm, 220 V shunt motor. Given full load efficiency = 0.83; maximum gap flux density = 0.9 Wb/m^2; specific electric loading = 30000 AC/m; field form factor = 0.7; Field current is 2.5% of rated current. The pole face is square. [8]

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TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2078 Bhadra

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

Subject: - Electric Machine Design *(EE 603)*

- ✓ 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) Classify the insulating materials on the basis of their thermal stability. [5]
   b) What are the advantages and disadvantages of adding silicon with iron? [5]
2. a) Explain the temperature gradient in an iron core with necessary figure and expression. [6]
   b) A transformer has a temperature rise of 30°C after 2 hrs and 40°C after 3 hrs on quarter load. What is the final steady temperature rise at full load? If the transformer is on 30% overload, how long will it take to attain the same temperature rise provided that maximum efficiency occurs at 70% of full load? [6]
3. a) The design parameter for 100kVA, 4000/433V, 50 Hz, 3-phase, Δ/Y core type oil immersed natural cooled distribution transformer are given below. [20]

Max. flux density in core	= 1.3 Wb/m^2
Current density in conductor	= 2.5 A/mm^2
Constant for output voltage per turn	= 0.45
Core type	= cruciform
Window space factor	= 0.25
Stacking factor	= 0.9
Ratio of window height to width	= 2.5
Width of LV winding	= 20 mm
Width of HV winding	= 25 mm
Width of duct between HV and LV	= 15 mm

Take hot rolled steel and area of yoke is 20% greater than area of core

Calculate:

(i) Dimension of the core, window and yoke
(ii) Overall dimension of the frame
(iii)Per unit voltage regulation at 0.8 pf

   b) Why is the low voltage winding of transformer is placed near to the core in core type transformer? [4]
4. a) What are the factors that must be considered while selecting the length of air gap of induction motor? [8]
   b) Determine the main dimensions, turns per phase, number of slots, conductor size and slot area of 200 kw, 3ϕ, 400 V, 50 Hz, 1420 rpm slip ring induction motor. Assume Bav = 0.5 Wb/m^2, ac = 30000 ampere conductors per meter, efficiency = 0.9, p.f = 0.9, current density = 3.5 A/mm^2. The slot space factor is 0.4 and the ratio of core length to pole pitch is 1.2. The machine is star connected. [10]
5. a) What are the disadvantages of higher specific electric and magnetic loading in design of DC machine? [6]
   b) Calculate the main dimensions and the numbers of poles of a 37kw, 230V, 1400 rpm dc shunt motor so that a square pole face is obtained. The average gap density is 0.5 Wb/m^2 and ampere conductor per meter are 22000. Take full load efficiency of 90% and the ratio of pole arc to pole pitch is 0.7. [10]

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TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2078 Kartik

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

Subject: - Electric Machine Design *(EE 603)*

- ✓ 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 are the fundamental requirements of high conducting material? Classify and explain the electrical conducting material in brief. [5]

   b) Give the advantages of cold rolled grain oriented steel laminations over hot rolled steel laminations in transformer. [5]

2. a) If the ambient temperature is θ_a, determine the maximum temperature of conductor placed in slot if the slot insulation is comparatively very thick. [6]

   b) A 400 kVA 1100/400V three phase transformer is working in an ambient temperature of 35°C on full load, its oil temperature is recorded as follows 59°C after 1.5 hour and 71°C after 3 hours. Its full load copper losses is 2 times the iron losses. Calculate its heating time constant, final steady temperature rise and 1 hour rating. [6]

3. a) For 500 kV, 3-phase, 50 Hz, 66/11 kV, delta/star, core type, oil immersed natural cooled power transformer is: [18]

   Maximum flux density in the core = 1.6 wb/m^2
   Constant for output voltage per turn = 0.6
   Core type = cruciform
   Current density in the conductor = 2.5 A/mm^2
   Window space factor = 0.22
   Stacking Factor = 0.9
   Ratio of window height to width = 2.75

   With of duct between LV and core, LV winding, HV winding and duct between HV and LV are 10 mm, 50 mm, 60 mm, 20 mm respectively. Assuming all other required parameters, calculate:

   (i) Overall dimension of core
   (ii) Overall dimension of frame
   (iii)Per unit resistance and leakage reactance drop
   (iv)Per unit voltage regulation

   b) Why are distribution transformers designed to have maximum efficiency at loads much lower than full load? Derive the expression for calculating the number of tubes to be prosvided in a transformer tank. [3+3]

4. a) Prove that the output of a three phase induction machine can be expressed in terms of its main dimension, specific loading and speed. [8]

b) Determine the main dimension, turns per phase, number of slots, conductor cross section and slot area of a 250HP, 3 phase, 50 Hz, 400V, 1410 rpm slip ring induction motor. Assume average flux density = 0.5 wb/m^2
Ampere conductor per meter = 30000
Efficiency = 0.9 and power factor = 0.9
Winding factor = 0.95
Current density = 3 A/mm^2
The slot space factor is 0.4 and the ratio core length to pole pitch is 1.2.
The machine is delta connected. [10]

5. a) A design is required for a 30 kW, 4 pole, 900 rpm dc shunt generator, the full load terminal voltage being 240 V. Assume that the full load armature voltage drop is 2.5% of terminal voltage. Calculate main dimension of machine. Given that: [8]

Maximum gap flux density = 0.85 Wb/m^2
Specific electric loading = 20000 ampere conductor per metre
Field resistance = 120Ω
Ratio of pole arc to pole pitch = 0.7
Field form factor = 0.7

b) What are the factors that are to be considered while selecting the ampere conductor per meter (AC) in DC machine? [8]

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TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2076 Chaitra

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

Subject: - Electric Machine Design *(EE 603)*

- ✓ 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 loss and eddy current loss. [4]

   b) Discuss in brief about insulating material with their classification. [4]

2. a) Explain the temperature gradients in the conductor placed in the slot with necessary figures and expressions. [6]

   b) A 20 h.p., 400V, 3-phase, 50 Hz, induction motor has a final steady temperature rise of 40°C when running at its rated output. Calculate its one hour rating for the same temperature rise, if the heating time constant is 180 minute. The ratio of conductor losses to constant losses may be assumed as 1.25 and the total losses of the machine at full load are 1800 W. [8]

3. a) Deduce a mathematical expression to obtain the leakage reactance of core type transformer. [6]

   b) Design a 100 KVA, 50 Hz, 11/132 kV, 3-phase, Δ/Y, core type oil immersed natural cooled distribution transformer. [16]

   Maximum flux density in core = 1.35 wb/m^2, Core type = 3 stepped
   Current density = 2.75 A/mm^2
   Window space factor = 0.4
   $H_w/W_w = 3$
   Take hot rolled steel sheet and area of yoke = 1.2 Area of core
   Axial depth of L. V. = 268 mm
   Axial depth of H. V. = 276 mm
   Radial depth of L. V. = 14 mm
   Radial depth of H. V. = 18 mm
   Width of insulation between L.V and H.V = 11 mm
   Outside diameter of L.V = 293 mm, Inside diameter of L.V = 255 mm
   Inside diameter of H.V = 314 mm, Outside diameter of H.V = 351 mm

   Calculate:

   (i) Dimension of core, window and yoke
   (ii) Overall dimension of frame
   (iii) Leakage reactance of transformer
   (iv) Voltage regulation at 0.8 pf lagging at full load.

4. a) Explain the consideration to be made while selecting the number of stator slot for a 3-phase induction motor. [6]

b) A 15 kW, 440 V, 50 Hz, 1480 r.p.m., 3-phase induction motor is built with an inner diameter of stator 25 cm and length 16 cm. The specific loading is 23000 ampere conductors per meter. Estimate the following parameter for a 11kW, 460V, 6 pole, 50 Hz delta connected induction motor, assuming same specific loadings as the previous motor with 84% efficiency and power factor 85% for each machine.

Assume, current density 4 A/mm^2, stator slot pitch is 15 to 25 mm, ratio of slot depth to width is 3 and flux density in stator core is 1.2 Wb/m^2.

Calculate: [14]

(i) Main dimension
(ii) No. of Stator slot
(iii)No. of stator conductor and area of stator slot
(iv)Dimension of each stator slot.
(v) Minimum width of stator teeth

5. a) Explain the factors to be considered while selecting the number of poles in a dc machine. [8]

b) Calculate the diameter (D) and length (L) of armature for a 7.5 KW, 4 pole, 1000 rpm, 220V shunt motor. Given full load efficiency = 0.83; maximum gap flux Density = 0.9 Wb/m^2; specific electric loading = 30000AC/m; field form factor = 0.7; Field current is 2.5% of rated current. The pole face is square. [8]

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TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2076 Ashwin

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

Subject: - Electric Machine Design *(EE 603)*

- ✓ 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 electrical insulator? Write the various insulating materials used for different kinds of electrical machines? [5]

   b) What is ageing of core of electrical machine? How it can be minimized? [5]

2. a) What is hot spot? Derive the expression to find the hottest spot temperature in terms of surface temperature and thickness of plate. [8]

   b) The initial temperature of a machine is 40°C. Calculate the temperature of the machine after 1 hour if its final steady temperature rise is 80°C and the heating time constant is 2 hours. The ambient temperature is 30°C. [8]

3. a) For the design of a 25 KVA, 50 Hz, 11/0.433 KV, delta/star, 3-phase, core type, oil immersed, naturally cooled distribution transformer. The mean temperature of oil not to exceed 35 °C. The following parameters are choosen: B_m = 1.0 Wb/m^2, δ = 2.3 A/mm^2, constant for volt per turn=0.45, type of core-cruciform K_w=0.18, H_w/W_w =2.5, total loss at full load = 1.2 kw

   Winding dimensions:

	Insider diameter (mm)	Outsider diameter (mm)	Conductor Area (mm^2)
LV	138	156.2	14.9
HV	186.2	239	0.312

   Lc=253 mm, ρ=0.021 Ω-mm^2/m

   Take dimension: Ht=950 mm, Wt = 840 mm, Lt= 350 mm

   i) Calculate overall dimensions of frame.

   ii) Calculate per unit regulation at full load and 0.8 pf (lag).

   iii) Calculate the minimum number of tubes of diameter 50mm with average length of 1.35 m required for maintaining the mean temperature within the permissible limit. The rate of heat dissipation from plain wall is 6.5 and 6 for convection and radiation respectively. The provision of tube improves the rate of heat dissipation by 35%. [6+6+4]

   b) Derive the output equation of 3-phase transformer. Why are the windings of transformer made in circular form? [6]

4. a) Discuss the factors to be consider for the selection of stators slot in an induction machine. [6]

   b) Calculate: i) diameter ii) length iii) T_s iv) Full load current and a_s v) I^2R loss of stator of 3 phase, 120 KW, 2200 V, 50 Hz, 1480 rpm, star connected slip ring from the following particulars. B_{av}=0.8 Tesla, ac=26000, η=92%, p.f.=0.88, L=1.25τ, k_w=0.955, d=5A/mm^2, mean length of stator conductors = 75 cm, ρ=0.021Ω per meter and mm^2 section. [10]

5. a) Discuss the factors to be considered for the choice of number of poles in DC machine. [6]

   b) Calculate main dimensions of a 5 KW, 250V, 4 pole, 1500 rpm dc shunt generator having full load efficiency of 0.87 and designed to have a square pole face. Assume average flux density in gap= 0.42 Wb/m^2, ampere conductors per meter = 15,000 and ratio of per pitch = 0.66. [10]

TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2075 Chaitra

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

Subject: - Electric Machine Design *(EE 603)*

- ✓ 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) Differentiate Soft and Hard magnetic materials on the basis of B-H curve with sufficient examples. [5]

   b) Classify the materials of high resistivity on the basis of application. Briefly describe each of them with examples. [5]

2. a) Derive the expression for internal temperature (hot spot) of the core. [6]

   b) A transformer has a temperature rise of 40°C after 3 hrs and 50°C after 4 hours on quarter load. What is the final steady temperature rise at full load? If the transformer is working on 20% over load, how long will it take to attain the same temperature rise provided that maximum efficiency occurs at 65% of full load. [8]

3. a) Design a 125 KVA, 50 Hz, 6600/400V, 3-phase, Δ/Y, core type of oil immersed natural cooled distribution transformer. (Assume suitable data if necessary) [16]
   Maximum flux density in core = 1.35wb/m^2, core type=cruciform
   Current density=2.75 A/mm^2
   Window space factor=0.4
   H_w/W_w=2.5
   Take hot rolled steel sheet and area of yoke=1.2 area of core
   Axial depth of L.V. = 268 mm
   Axial depth of H.V. = 276 mm
   Radial depth of L.V. = 14 mm
   Radial depth of H.V. = 18 mm
   Width of insulation between L.V. and H.V. =11 mm
   Outside diameter of L.V. = 293 mm, Inside diameter of L.V. = 255 mm
   Inside diameter of H.V. = 314 mm, Outside diameter of H.V. = 351 mm
   Calculate:
   i) Dimension of core, window and yoke
   ii) Overall dimension of frame
   iii) Leakage reactance of transformer
   iv) Draw overall dimension of frame

   b) Why are windings of a transformer made into circular form? What is the advantage of using stepped cores in transformers? Derive the most economical dimension of a two-stepped core. [6]

4. a) Give reasons for the followings: [6]
   i) Stator slots should never be equal to the number of rotor slots

ii) The size of induction machine will be small if it is designed with higher speed for the same output.

b) For a 2.2 KW, 400V, 3 phase, 50 Hz 1420 rpm squirrel cage induction motor using star delta starter and having efficiency of 0.8 and power factor 0.825 at full load the following data are given. [12]

Specific Magnetic loading = 0.44 wb/m^2
Specific electric loading = 21000 A/m
Slot space factor = 0.4
Ratio of core length to pole pitch=1.5
Ratio of slot depth to width = 4
Stator slot pitch = 12 to 15 mm
Current density in conductor = 4 A/mm^2
Assuming all other required data, calculate

i) Main dimensions of the machine
ii) Size of stator turns per phase
iii) Size of stator conductor
iv) No. of stator slots
v) Area and dimensions of each stator slot.
vi) Minimum width of stator teeth.

5. a) Explain various factors should be consider while selecting the value of specific electrical and magnetic loading in dc machine. [8]

b) Calculate the diameter and length of armature for a 7.5KW, 4 pole 1000rpm, and 220V shunt motor. Given: full load efficiency = 0.83; maximum gap flux density=0.9Wb/m^2: specific electrical loading= 30000 ampere conductor per meter; filed form factor is 0.7. Assume that the maximum efficiency occurs at full load and the field current is 2.5% of rated current. The pole face is square. [8]

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16 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2075 Ashwin

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

Subject: - Electric Machine Design *(EE603)*

- ✓ 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.*

a) Differentiate between transformer grade and dynamo grade steel. [4]

b) What are the advantages and disadvantages of adding silicon with iron? [4]

2. a) An induction motor is heated to a temperature of 60°C and is shut down. Calculate the temperature at a time 20 minutes after the shut down if the cooling time constant is 60 minutes. The ambient temperature is 30°C. [8]

b) Derive the expression for internal temperature (hot spot) of the core. [8]

3. a) Differentiate between power and distribution transformer. [4]

b) For a 500kVA, 50Hz, 6600/400V, single phase core type, oil immersed, natural cooled power transformer, the design parameters are:

Constant for output voltage per turn = 0.8
Resistivity of copper = 0.021 Ω-mm^2/m
Maximum flux density in the core = 1.5 Wb/m^2
Current density = 2.75A/mm^2
Core type = Cruciform
Window space factor = 0.27
Stacking factor = 0.9
Ratio of window height to width = 2.5
Ratio of yoke height to width = 1
Axial depth of LV winding = 402mm
Axial depth of HV winding = 377.5mm
Inside diameter of LV winding = 310mm
Outer diameter of LV winding = 348mm
Inside diameter of HV winding = 360mm
Outside diameter of HV winding = 418mm

Calculate:

i) Dimension of the core, window and yoke
ii) Overall dimension of the frame
iii) Per unit regulation at 0.8 pf lagging
iv) Taking iron loss = 1460W, copper loss = 3865W at full load, height of tank = 1.6m, length of tank = 1.05m, width of tank = 0.62m, find the temperature rise. If the mean temperature rise of oil is not to rise 35°C, find the necessary number of tubes and also show its arrangement. [20]

4. a) Derive the output equation for three phase induction motor. [5]

   b) What are the factors affecting the choice of specific electrical loading in induction machine? [5]

   c) A 90kW, 500V, three phase, 8 pole slip ring induction motor having 0.9 efficiency and power factor of 0.86 has 63 stator slots with 6 conductors per slot. If the slip ring voltage on open circuit is to be about 400V, find the number of rotor slots, rotor turns per phase, number of conductors per slot and appropriate full load rotor current per phase. Both stator and rotor are star connected. [6]

5. a) What are the factors affecting the choice of number of poles in DC machine? [4]

   b) Derive the output equation for the design of dc machine. [4]

   c) Determine the main dimensions, number of poles and length of air gap of a 600kW, 500V, 900rpm generator. Assume average gap density as 0.6 Wb/m^2 and ampere conductors per meter as 35,000 A/m. The ratio of pole arc to pole pitch is 0.75 and the efficiency is 91%.
   The following are the design constraints: peripheral speed ≤ 40m/s, frequency of flux reversal ≤ 50Hz, current per brush ≤ 400A, and armature mmf per pole ≤ 7500A. The mmf required for air gap is 50% of armature mmf and gap contraction factor is 1.15. [8]

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16 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2074 Chaitra

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

Subject: - Electric Machine Design *(EE603)*

- ✓ 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) Differentiate between hot rolled and cold rolled grain-oriented steel. [4]

   b) What are the different classes of insulation used in electrical machine? Mention their maximum working temperature and the types of material used in such classes. [4]

2. a) Derive the temperature rise-time curve of the machine under heating condition and also define heating time constant. [8]

   b) A 400 kVA transformer has its maximum efficiency at 80% of full load. During a short full load heat run, the temperature rise after one hour and two hours is observed to be 24°C and 34°C respectively. Find the thermal time constant and final steady temperature rise of the transformer. If, by use of a fan, the cooling is improved so that the rate of heat dissipation per unit area per degree rise in temperature is increased by 15%, find the new kVA rating possible

   (i) For the same final temperature rise as before
   (ii) If allowable temperature rise is taken as 50°C [8]

3. a) Differentiate between core and shell type transformer. [6]

   b) For a 4000 KVA, 3 phase, 50 Hz, 66 KV/11KV, 3 phase, 50 Hz, delta/delta, core type, oil immersed natural cooled power transformer are:

   Max flux density in core = 1.6 Wb/m^2
   Constant for output voltage per turn = 0.6
   Resistivity of Copper = 0.021 $\Omega mm^2/m$
   Core type = Cruciform
   Current density in conductors = 2.5 A/mm^2
   Window space factor = 0.22
   Stacking factor = 0.9
   Ratio of window height to width = 2.75
   Take hot rolled steel and area of yoke is 20% greater than area of core
   Width of duct between LV and core = 10mm
   Width of LV winding = 50mm
   Width of HV winding = 50 mm
   Width of duct between LV and HV = 20 mm

   Assuming all the other required parameters, calculate:

   (i) Overall core dimension
   (ii) Overall dimension of frame
   (iii)Per unit resistance and leakage reactance drop
   (iv)Per unit voltage regulation at 8.0 pf [18]

4. a) Determine the main dimension, turns per phase, number of slots and slot area of a 250HP, 400V, 4-pole, 50Hz slip ring induction motor. Assume, Bav = 0.5Wb/m^2, ac = 3000 Ampere conductor/m, efficiency (η) = 0.9, pf = 0.9, current density = 3.5A/mm^2. The slot space factor is 0.4 and ratio of core length to pole pitch is 1.2. The machine is delta connected. [8]

   b) Derive the expressions for output equation of three phase induction machine. Explain the separation of D and L. [8]

5. a) For a dc machine, derive the expression for calculating the minimum number of commutator segments. Note the number of commutator segment = number of coils in armature. [8]

   b) Calculate the diameter and length of armature of 7.5 kW, 4 pole, 1800 rpm, and 220V shunt motor. Given: full load efficiency = 0.83, maximum gap flux density = 0.9 Wb/m^2, specific electric loading = 30,000 ampere conductor per meter, field form factor = 0.7. Assume that the maximum efficiency occurs at full load and the field current is 2.5% of rated current. The pole is square face and consider all the possible losses in the machine. [8]

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26 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2074 Ashwin

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

Subject: - Electrical Machine Design *(EE603)*

- ✓ 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) Compare the characteristics of conducting and insulating materials used in DC machine. [5]
   b) What is meant by "ageing" in magnetic material? Enlist the merits and demerits of addition of Silicon with Iron. [5]
   c) Differentiate between core type and shell type transformer on the basis of construction, Mechanical design, Leakage reactance and Cooling. [6]
2. a) Derive the expression for calculation of internal temperature of a homogenous material of thickness 't' length 'l' and width 'w'. Other necessary data's can be assumed. [8]
   b) A 250 volt 1 kilowatt single elemental resistor is made from 0.2mm thick nickel chromium strip. The temperature raised of the strip is not exceed 300°C. Calculate the length and width of the strip. Assume e = 0.9 , Radiating efficiency = 0.75. Resistivity of nichrome = $1\times10^{-6}\Omega$-m. [8]
3. a) Derive an expression for KVA output of a single phase transformer from design point of view. [6]
   b) Design a 25kVA, 11000/433 V, 50 Hz, 3 phase, delta/star core type distribution transformer. [14]

   The required data for design are given below:
   Maximum flux density in core= 1 Wb/m^2
   Current density in conductor= 2.3 A/mm^2
   Constant for output volt per turn, K=0.45
   Core type= cruciform
   Window space factor, Kw= 8/(30+kV)
   Staking factor =0.9
   Ratio of window height to width= 2.5
   Take area of yoke 20% more than area of limb.
   Width of LV winding=9.1 mm
   Width of HV winding=26.22 mm
   Total losses at full load =901 W

   Calculate:
   i) Dimensions of core, window and yoke
   ii) Overall dimensions of the frame
   iii) Per unit resistance and leakage reactance drop
   iv) Per unit voltage regulation at 0.8 pf
   v) Full load efficiency at 0.8 pf
4. a) Discuss the factors to be considered for the selection of stator slots in an induction machine. [6]
   b) Determine the main dimensions of a 15kW, 3 phase, 400 V, 50 Hz, 2810 rpm squirrel cage induction motor having efficiency of 0.88 and a full load power factor of 0.9. Assume specific magnetic loading = 0.5 Wb/m^2 and specific electric loading = 25000 A/m. Take rotor peripheral speed as approximately 20 m/s at synchronous speed. [8]
5. a) Explain the factors to be considered when selecting the number of armature slots in dc machine. [6]
   b) Calculate the main dimensions of a 5 kW, 250 V, 4 pole, 1500 rpm dc shunt generator having full load efficiency of 0.87 and designed to have a square pole face. Assume average flux

27 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2073 Shrawan

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

Subject: - Electrical Machine Design *(EE603)*

- ✓ 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. What are the fundamental requirements of high conducting materials? Classify and explain the electrical conducting materials in brief. [8]
2. Differentiate between soft magnetic material and hard magnetic material. [4]
3. Differentiate between natural and artificial convections in brief. Also derive an expression for the temperature rise-time curve for an electrical machine. [12]
4. Determine the main dimensions of the core, the number of turns and the cross sections of the conductors for a 5kVA, 11000/400 V, 50Hz, single phase core type distribution transformer. The net conductor area in the window is 0.6 times the net cross section of iron in the core. Assume a square cross-section for core, a flux density 1 Wb/m^2, a current density 1.4 A/mm^2, and window space factor 0.2. The height of window is 3 times its width. [12]
5. How is the flux density in the design of transformer is chosen? [4]
6. Derive the expressions for per unit resistance drop of a core type transformer. [8]
7. The following design data are provided for an induction motor. [12]

   Diameter of stator bore (D) =16cm, Length of stator core (L)= 8.5cm,Average flux density (Bav) = 0.44 wb/m^2,Power factor = 0.85,Efficiency = 86%,Frequency = 50 Hz ,Current density = $5A/mm^2$,Stator slots = 36,Rotor Slots = 30, Length of rotor bar = 15cm,Mean diameter of end ring = 12 cm, Resistivity of bar conductor = 0.020 Ohm-metre, Power out of 3-phase,4-pole, 400V,delta connected = 10kW,
   Calculate No-load maximum flux, Length of air gap, No. of turns per phase, Rotor bar current and area, End ring current and area, Losses in bars and end rings.
8. Derive the expressions for output equation of three phase induction machine. [8]
9. Calculate the main dimensions and the number of poles of a 37kW, 230V, 1400 RPM dc shunt motor so that a square pole face is obtained. The average gap density is 0.5 Wb/m^2 and ampere conductors per meter are 22,000. Take full load efficiency of 90% and the ratio of pole arc to pole pitch of 0.7. [8]
10. What are the factors for the selection of no. of poles in DC machine? [4]

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