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 <u>All</u> questions.*
- ✓ *The figures in the margin indicate <u>Full Marks</u>.*
- ✓ *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
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 **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *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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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]

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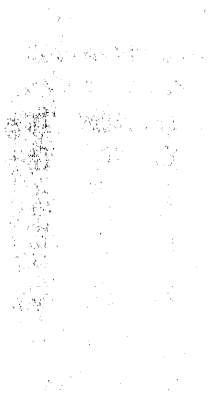

16 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2074 Chaitra

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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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.*

1. 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 $\leq$ 40m/s, frequency of flux reversal $\leq$ 50Hz, current per brush $\leq$ 400A, and armature mmf per pole $\leq$ 7500A. The mmf required for air gap is 50% of armature mmf and gap contraction factor is 1.15. [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 density in gap = 0.40 wb/m^2, Ampere conductors per meter= 15000 and ratio of per pitch =0.66 [8]

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26 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2072 Chaitra

Exam.	Regular		
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. Discuss in brief about insulating material with their classification. What are the fundamental requirements of a good insulating material, electrical properties of insulating material? [8]

2. A generator has open slots each containing 3 strips of copper in the arrangement of three strips along the depth of the slot. The length of the slot portion of the conductor is 0.5 m, each strip has a cross section of $8\times10mm^2$ and current density in the strip is $4A/mm^2$. The electrical and thermal resistivities of the copper are $0.021\times10^{-6}\Omega$-m and 0.0025Ω-m respectively. The insulation between the strips and the slot walls is taken as 4mm thick and has a thermal resistivity of 3Ω-m. Calculate the temperature difference for the following cases: [8]

   i) Between the centre of the embedded portion of the strip and the overhang
   ii) Between the conductor and the slot walls

3. Design a 125KVA, 50 Hz, 6600/400V, 1-phase, core type oil immersed natural cooled distribution transformer. [18]

   Given that:
   Maximum flux density in the core = 1.35 Wb/m^2
   Current density = $2.75A/mm^2$
   Core type = cruciform two stepped.
   Window space factor = 0.30
   Stacking factor = 0.9
   Ratio of window height to width 2.5
   Take hot rolled steel sheet and area of yoke is 20 % greather than area of core
   Axial depth of L.V. winding = 268 mm
   Axial depth of L.V. winding = 276mm
   Inside diameter of LV winding = 255 mm
   Radial depth of LV winding = 14 mm
   Radial depth of HV winding = 18 mm
   Width of insulation between LV and HV = 11mm
   Outside diameter of LV winding = 293 mm
   Inside diameter of HV diameter = 314 mm
   Outside diameter of HV winding = 351 mm

   Calculate:
   i) Dimension of the core, window and yoke
   ii) Overall dimension of the frame
   iii) Leakage reactance of the transformer

   Appropriate values for additional data required may be assumed if necessary.

4. What are the factors for the selection of specific electric loading in induction motor? [4]

5. Calculate (i) diameter (ii) length (iii) number of turns per phase (iv) full load current and cross section of conductors and (v) total I^2R loss of stator of 3 phase, 120kW, 2200 volts, 50 Hz, 750 rpm (synchronous speed), star connected slip ring induction motor from the following particulars: [12]

   B_{av}=0.48 tesla, ac=26000ampere conductor per metre, efficiency=92%, power factor= 0.88, L=1.25τ, K_W=0.955, current density=5A/mm^2, mean length of stator conductors= 75cm, ρ= 0.021 ohm per metre and mm^2 section.

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

7. A design is required for a 30 KW, 4 pole, 900 rpm dc shun generator, the full load terminal voltage being 240 V. Assume that the full load armature voltage is 3% of the terminal voltage. [8]

   Calculate the main dimension of the machine. Given that:

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

8. What is the importance of temperature as a factor in the life of insulating materials? [4]

9. For a transformer show that the emf per turn E_t is given by $E_1 = K\sqrt{KVA}$ where KVA = rating of transformer. [4]

10. Derive the expressions for output equation of three phase transformer. [6]

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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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26 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2071 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) What is ageing? How it can be minimized? Enlist the merits and demerits of addition of silicon with iron. [5]

   b) Discuss soft magnetic material in brief. Give their application from its commercial aspects. [5]

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

   b) The rise in temperature of a transformer after one hour and two hours of starting from cold conditions are 25°C and 40°C respectively. Determine its final steady temperature rise and the heating time constant. If its temperature falls from the final steady value to 45°C in 90 minutes when disconnected from the operation, determine its cooling time constant. The ambient temperature is 30°C. [6]

3. a) Derive an expression for KVA output of a single phase transformer from design point of view. [8]

   b) For a 2.2 kW, 440V, 3 phase, 50 Hz, 1430 rpm squirrel cage induction motor using star delta starter and having efficiency of 0.8 and power factor 0.85 at full load the following data are given: [16]
   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) No. 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

4. a) What will be the effect if air gap length is too wide in induction machine? Explain different factors to be considered when selecting suitable air gap length. [8]

   b) Find the main dimension number of stater turns size of conductor of a 5HP, 400 V, 3 phase, 4 pole, 50 Hz squirrel cage induction motor star delta starting. Use the following data. Average flux density in the air gap = 0.4 wb/m^2. [10]
   Ampere conductor per meter of armature periphery = 22000
   Full load efficiency = 83%
   Full load p.f. = 0.84 (lagging)

5. a) Derive the output equation of DC machine. [8]

   b) Calculate the main dimensions and the number of poles of a 40 KW, 240 V, 1450 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 22000. Take full load efficiency of 92% and ratio of pole arc to pole pitch of 0.7. [8]

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26 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2072 Kartik

Exam.	New Back (2066 & Later Batch)		
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) What are the fundamental requirements of a good insulating material? Explain the application of insulating materials in machines in brief. [5]

   b) What are the requirements of magnetic material for making transformer core? [5]

2. a) "Ventilating ducks are kept across the lamination to reduce the temperature rise within the material in electrical equipment." Justify the statement. [6]

   b) A 250 volt, 1 kilowatt single element resistor is made from 0.2 mm thick nickel chromium strip. The temperature rise of the strip does not exceed 300°C. Calculate the length and width of the strip. Assume e = 0.9, Radiating efficiency = 0.75, Resistivity of nichrome = 1×10^{-6} Ω-m. [6]

3. a) What are the difference between power transformer and distribution transformer from design aspect? [4]

   b) Design a 150 KVA, 50 Hz, 6600/400V, 1-phase, core type oil immersed natural cooled distribution transformer. Given that: [20]

   Maximum flux density in core = 1.35 Wb/m^2
   Current density = 2.75 A/mm^2
   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 sheet and area of yoke is 20% greater than area of core
   Axial depth of L.V winding = 268 mm
   Axial depth of HV winding = 276 mm
   Inside diameter of LV winding = 255 mm
   Radial depth of LV winding = 14 mm
   Radial depth of HV winding = 18 mm
   Width of insulation between LV and HV = 11 mm
   Outside diameter of LV winding = 293 mm
   Inside diameter of HV winding = 314 mm
   Outside diameter of HV winding = 351 mm

   Calculate:

   i) Dimensions of the core, window and yoke
   ii) overall dimensions of the frame
   iii) Leakage reactance of the transformer
   iv) Draw overall dimension of the transformer

4. a) Discuss the factors to be considered for selection of magnetic loading in induction machine. [8]

   b) Determine the main dimensions, turns per phase, number of slots conductor size and slot area of a 250HP, 3-ϕ, 400V, 50Hz, 1430RPM slip ring induction motor. Assume, B_{av} = 0.5Wb/m^2, ac = 30000 ampere conductors per meter, efficiency = 0.9, Power factor = 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. **Appropriate values for additional data required may be assumed.** [10]

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

   b) A design is required for a 50KW, 4 pole, 6000RPM, dc shut generator. The full load terminal voltage is 220V. If the maximum gap density is 0.83Wb/m^2 and the armature ampere conductors per meter are 30000, Calculate suitable dimensions of armature core to give a square pole face. Assume that the full load armature voltage drop is 3% of the rated terminal voltage and that the field current is 1% of rated full load current, ratio of pole arc to pole pitch is 0.67. [8]

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26 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2070 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) Why CROS is known as superior magnetic material? [5]
   b) Classify the insulating materials on the basis of their thermal stability. [5]
2. a) Derive the expression for internal temperature (hot spot) of the core. [6]
   b) The temperature rise of a 150 kVA transformer is 25°C and 37.5°C after 1 and 2 hours respectively staring from cold condition. Calculate its heating time constant and final steady temperature rise. [6]

   If the rate of heat dissipation is improved by 20% with help of external fan. Find the new kVA rating for same steady temperature rise. The maximum efficiency occurs at 80% of full load.
3. a) Why are distribution transformer designed to have maximum efficiency at loads much lower than full load? Derive the expression for calculating the number of tubes to be provided in a transformer tank. [4+4]
   b) 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 chosen: [6+6+4]

   Bm = 1.0 wb/m^2, δ = 2.3 A/mm^2, constant for volt per turn = 0.45, type of core-cruciform Kw = 0.18, Hw/Ww = 2.5, total loss at full load = 1.2 kW

Winding dimensions:

	Inside diameter (mm)	Outside diameter (mm)	Conductor Area (mm2)
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 50 mm 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%.

4. a) Why should the number of stator slots never be equal to number of rotor slot? Prove that the output of a three phase induction machine can be expressed in terms of its main dimension, specific loading and speed. [2+8]

   b) Find the main dimensions of a 15 kW, 3-phase, 400 V, 50 Hz, 2810 rpm, squirrel cage induction motor having full load efficiency and pf of 0.88 and 0.9 respectively. Given that Bav = 0.5 wb/m^2, ac = 25000 A/m and rotor peripheral speed = 20 m/s. [8]

5. a) For a dc machine design show that the minimum number of coil or commutator segments required is EP/15. [8]

   b) A 600 kW, 500 V, 900 rpm, dc shunt generator is designed to have a square pole face. The loadings are B_{av} = 0.6 wb/m2, ac = 35000 A/m, full load efficiency = 0.91, ratio of pole arc to pole pitch = 0.75. Calculate the main dimensions of the machine. [8]

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27 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2071 Shawan

Exam.	New Back (2066 & Later Batch)		
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) What is ageing? How was it removed? What were the advantages and disadvantages after removal of ageing problem? [5]

   b) Explain the advantages and disadvantages of addition of silicon in electric sheet materials. [5]

2. a) Obtain the expression of temperature gradient placed in slots assuming that the slot insulation is comparatively very thick as compared to that on the end connections. [6]

   b) Explain heating time constant and cooling time constant with neat sketch. [6]

3. a) Calculate (i) Overall dimension of core (ii) Overall dimension of frame (iii) per unit resistance and leakage reactance drop and (iv) Per unit voltage regulation at 0.85 power factor, For a 150KVA, 11000/420V, 50Hz, 3-phase, Δ/y core type, oil immersed natural cooled distribution transformer from the following data:

   Maximum flux density = 1.35 Wb/mm^2, constant for output voltage per turn = 0.45, current density in conductors = 2.5 A/mm^2, core type = cruciform, window space factor = 0.25, stacking factor = 0.9, ratio of height of window to width = 2.5, width of LV winding, HV winding and duct in between = 20mm, 25mm, 15mm respectively. [16]

   b) Find the condition for designing a transformer in minimum cost. [8]

4. a) Calculate the minimum width of stator teeth of induction motor. [4]

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

   c) Calculate (i) diameter (ii) length (iii) number of turns per phase (iv) full load current and cross section of conductors and (v) total I^2R loss of stator of 3 phase, 120 Kw, 2200V, 50Hz, 750 RPM (synchronous speed), star connected slip ring induction motor form the following particulars: [8]
   B_{av} = 0.48 Tesla, ac = 26000 ampere conductor per meter, efficiency = 92%, power factor = 0.88, L = 1.25τ , K_w = 0.955, current density = 5 A/mm^2, mean length of stator conductors = 75 cm, ρ = 0.021 ohm per meter length and per mm^2 cross-section area

5. a) What is field form factor of a dc machine? What are the factors to be considered while selecting the number of poles in a dc machine? Explain. [1+7]

   b) Find the main dimension, number of poles and length of air gap of a 1000Kw, 500V, 300rpm dc generator. Assume the specific magnetic loading B_{av} = 0.7 Wb/m^2, ampere conductor per meter = 40000, square pole face, ratio of pole arc to pole pitch is 0.7. Assume efficiency as 92% and gap contraction factor as 1.15. [8]

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BEL III/I

27 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2070 Ashad

Exam.	New Back (2066 & Later Batch)		
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) What do you mean by soft magnetic materials? Give their application according to their commercial use. [5]

   b) Where are the conductors of high resistance used? Classify them according to their purpose. [5]

2. a) A transformer has a temperature rise of 20°C after one hour and 32°C after two hours on full load. What is the final steady state temperature rise at full load? If the transformer is working on 50% over load, how long will it take to attain the same temperature rise? Take the copper losses on full load equal to twice the iron loss. [6]

   b) What are heating time constant and cooling time constant? Explain. [6]

3. a) Starting from suitable assumption made develop a mathematical expression to obtain the leakage reactance of core type transformer. [8]

   b) For a 4000 KVA, 3 phase, 50 HZ, 66 KV/11 KV, 3 phase, 50 HZ, Δ/Δ , core type, oil immersed natural cooled power transformer are: [16]

   Max flux density in core = 1.6 wb/m^2
   Constant for output voltage per turn = 0.6
   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

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

   i) Over all core dimensions
   ii) Over all dimension of frame
   iii) Per unit resistance and leakage reactance drop
   iv) Per unit voltage regulation at 0.8 pf

4. a) Give reasons for the followings: [3×2]

   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 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 = 21,000 A/m
   Winding factor = 0.955
   Slot space factor = 0.4
   Ratio of core length to pole pitch = 1.5
   Ratio of slot depth to width = 2
   Stator slot pitch = 12 to 15 mm
   Current density in conductor = 4 A/mm^2
   Flux density in stator core = 1.2 Wb/m^2

   Assuming all other required parameters, calculate:

   i) Main dimension of the machine
   ii) No. of stator conductor and area of stator slot
   iii) No. of stator slots
   iv) Area and dimension of each stator slot
   v) Minimum width of stator teeth

5. a) Derive output equation of a dc machine. [8]

   b) Calculate 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 density in gap = 0.42 Wb/m^2, ampere conductors per meter = 15,000 and ratio of per pitch = 0.66 [8]

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27 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2069 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) Give the advantages of cold rolled grain oriented steel laminations over hot rolled steel laminations in transformers. [5]

   b) Classify the materials of high resistivity according to their purpose of use and also their field of application. [5]

2. a) "Ventilating ducts are kept across the lamination to reduce the temperature rise within the material in electrical equipment". Justify the statement. [4]

   b) During heat run test of a 150 KVA transformer, the temperature rise after one and two hours are 25°C and 37.5°C respectively. Calculate its heating time constant and final steady temperature rise. If the cooling is improved by external fan, the rate of heat dissipation is increased by 20%, find its new KVA. Take that the maximum efficiency occurs at 80% of full load and unity power factor. [8]

3. a) Derive an expression for KVA output of a single phase transformer from design point of view. [8]

   b) Given the information [16]
   Maximum flax density in core = 1.36 wb/m^2
   Current density in conductors = 2.4 A/mm^2
   Constant for output voltage per turn = 0.4
   Core type = cruciform
   Window space factor = 0.3
   Stacking factor = 0.9
   Ratio of window height to width = 2.5
   Width of LV, HV winding and duct between them = 20 mm, 25 mm, 15 mm respectively

   For a 100 KVA, 11000/400V, 50 Hz, Δ/Y core type oil immersed natural cooled distribution transformer. Assuming all other parameters wherever necessary calculate:

   a) Dimension of core, window and yoke
   b) Over all dimension of the frame
   c) Per unit resistance and leakage reactance drop
   d) Per unit regulation at 0.8 pf

4. a) What are the various factors to be considered for the rotor design in squirrel cage induction motor? Explain in detail. [8]

   b) Find the main dimensions, number of stator turns, size of conductor and number of stator of a 5 HP, 400 V, 3 phase, 50 HZ, 1500 synchronous rpm squirrel cage induction motor. Star delta starting is used. Use the following data: [10]

   Average flux density in the air gap = 0.4 wb/m^2
   Ampere conductor per meter of armature periphery = 22000
   Full load efficiency = 83%
   Full load p.f. = 0.84 lagging
   Appropriate values for additional data required may be assumed.

5. a) Show that minimum number of coils or commutator segments required for dc machine is EP/15 where E is the voltage of the machine and P is the number of pole of the machine. [8]

b) Calculate the diameter and length of armature for a 7.5 KW, 4 pole, 1000 rpm, 220 V shunt motor. Given that: [8]

Full load efficiency = 0.83
Max gap density = 0.9 Wb/m^2
Specific loading = 30000 A/m
Field form factor = 0.7

Assume that the maximum efficiency occurs at full load and field current is 2.5% of rated current. The pole face is square.

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