THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND COMMUNICATIONS ENGINEERING

SECOND SEMESTER EXAMINATION (2022)

EE324 – ELECTRICAL MACHINES AND DRIVES

BEEP3

TIME ALLOWED: 3 HOURS

INFORMATION FOR STUDENTS:

- You have TEN (10) minutes to read the paper. You must NOT begin writing during this time.
- All answers must be written in the ANSWER BOOK supplied. COMPLETE THE DETAILS REQUIRED ON THE FRONT COVER OF YOUR ANSWER BOOK. DO THIS NOW.
- Drawing instruments and calculators are permitted.
- Answer ALL FIVE (5) questions. Total of 100 marks.
- All questions carry equal marks.
- If you are found cheating in the examination, the penalties specified by the University shall apply.
- Switch OFF all mobile phones.

QUESTION ONE **[3+6+2+9 = 20 marks]**

A. State three (3) methods of braking and/or reversing DC motors

B. Name and explain two (2) speed control methods in DC motors .

C. State the two (2) torque measurement techniques in DC motors.

D. DC generators are named after the type of excitation. Under self-excitation, there are three (3) main excitation methods used.

   I. Define **series** and **shunt generators** in terms of how the windings are connected.
   II. State a distinction between each in terms of their **terminal voltage** and **load current**.

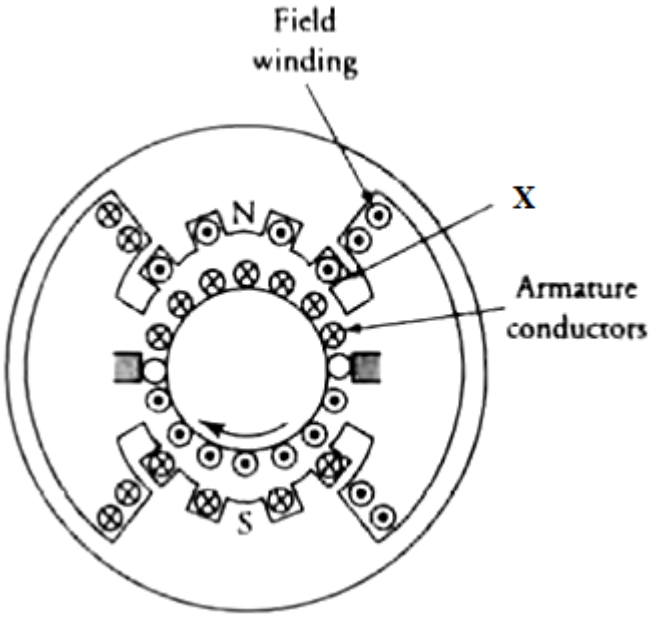
QUESTION TWO **[8+12 = 20 marks]**

A. An ideal transformer has a 150-turn primary and 900-turn secondary. The primary is connected to a 240-V, 50-Hz source. The secondary winding supplies a load of 3 A at a lagging power factor (pf) of 0.8.
   Determine;
   a) the a-ratio
   b) the current in the primary
   c) the power supplied to the load
   d) the flux in the core.

B. A 100-kVA, 13.2/2.2-kV, 50-Hz, step-down transformer has a core-loss equivalent resistance of 8 kΩ and a magnetization reactance of 7 kΩ. The equivalent winding impedance as referred to the primary side is 3 + jl2 Ω.
   If the transformer delivers the rated load at a power factor of 0.707 lagging, determine its voltage regulation and efficiency.

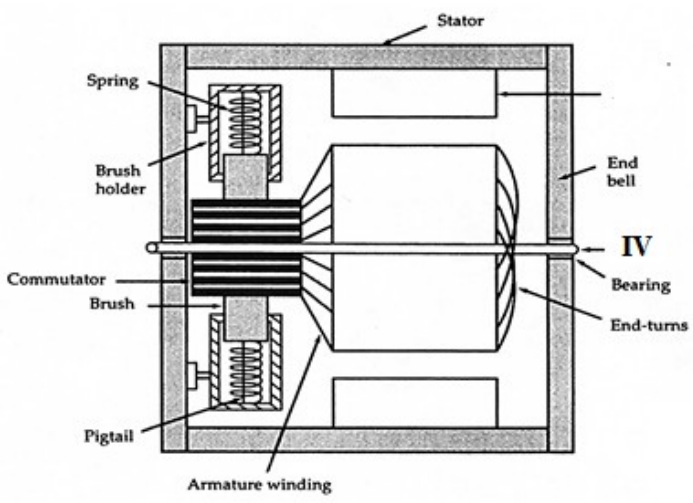
QUESTION THREE **[3+17 = 20 marks]**

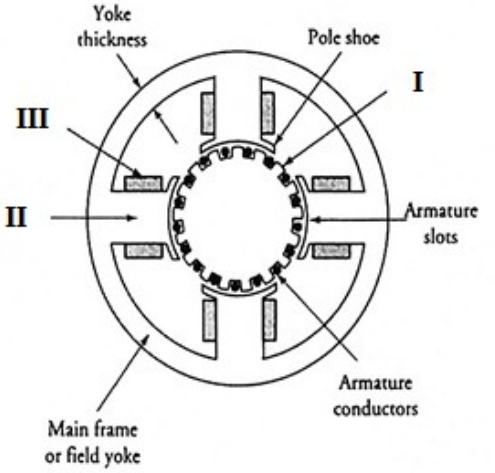
A. The following is a diagram showing the cross-section of a DC generator.



I. Name the component labelled X
II. State the function of X

B. The following figures are of a typical DC generator





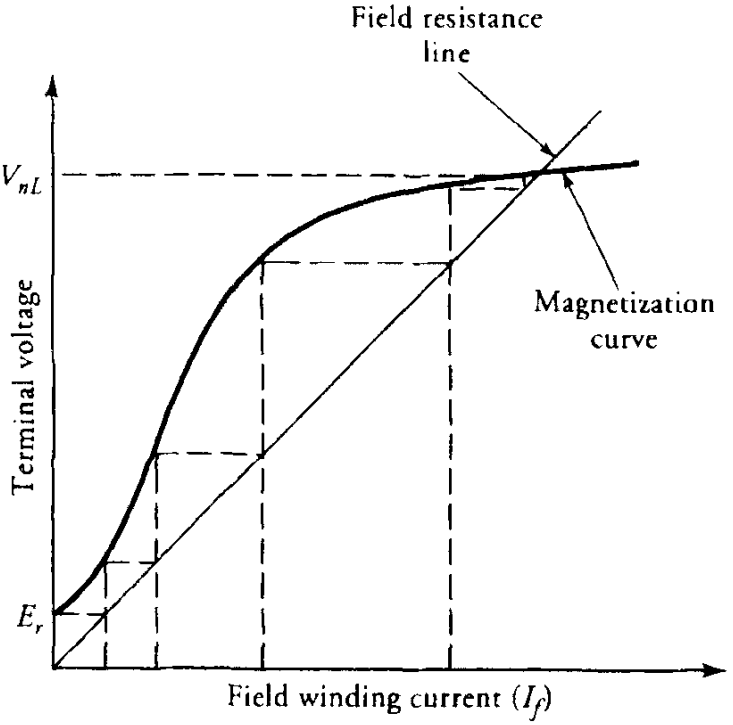
I. Name the parts labelled in roman numerals
II. State the functions of the following
    a) Commutator
    b) Spring
III. What material is the **brush** made of and why?

IV. In an experimental setup, there appears to be a distortion in the main field windings, thereby reducing the emf induced in the armature coils.
   a) State one likely cause of the above
   b) State two (2) ways in which the effect in (a)) can be reduced or minimized

QUESTION FOUR [12+8 = 20 marks]

A. The armature of a 6-pole, lap-wound dc generator has 28 slots with ten conductors in each slot. The flux per pole is 0.05 Wb and the armature speed is 1200 rpm.
   Calculate;
   I. the frequency of the induced emf in each armature conductor,
   II. the induced emf in the armature,
   III. the induced emf per coil,
   IV. the induced emf per turn, and
   V. the induced emf per conductor.

B. The following diagram shows the voltage build-up phenomena.

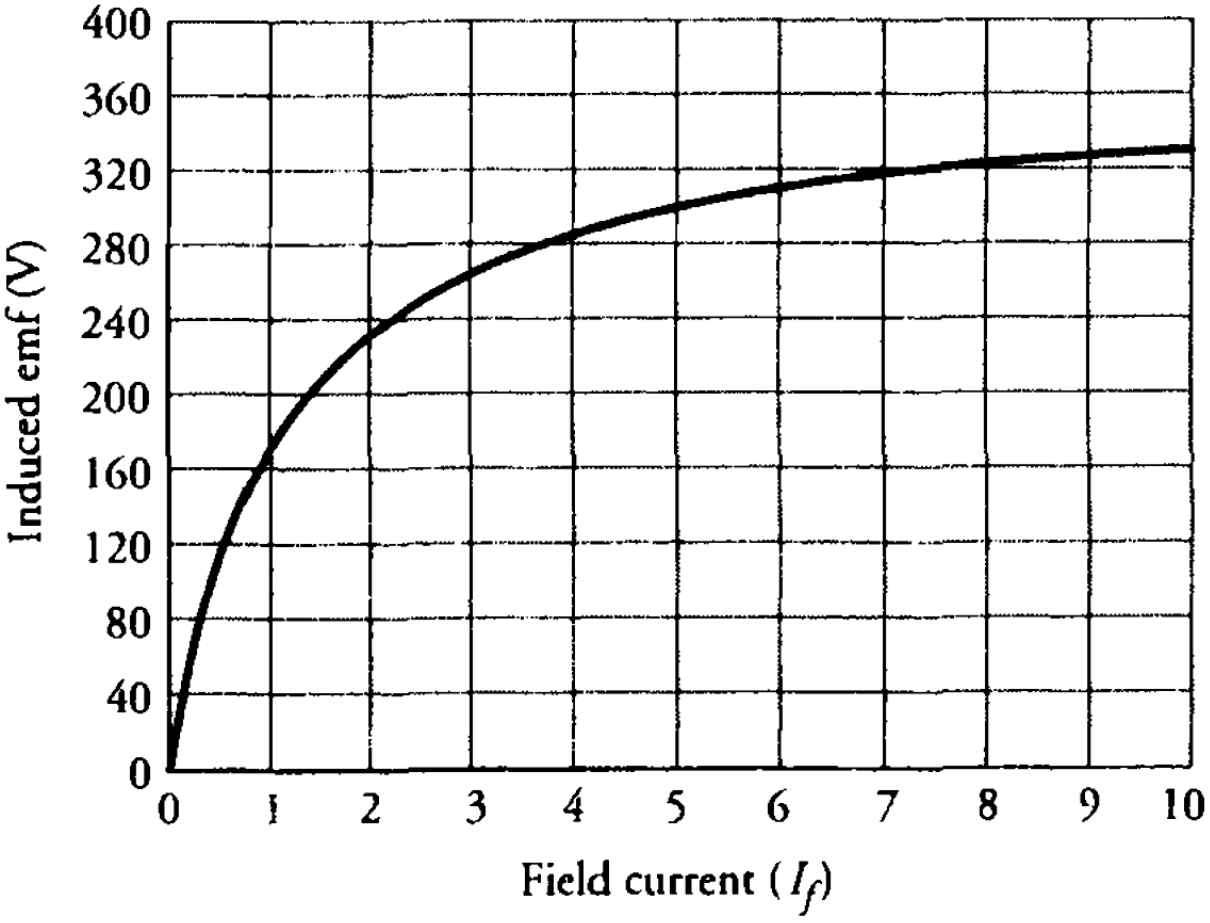


   I. Explain the phenomenon with the aid of the graph
   II. State the factor that reduces or brings down voltage build-up

III. How does voltage build-up stop?

QUESTION FIVE [14+6 = 20 marks]

A. A 240-kW, 240-V, 6-pole, 600-rpm, separately excited generator is delivering the rated load at the rated voltage. The generator has $R_a = 0.01\ \Omega$, $R_{fw} = 30\ \Omega$, $V_f = 120$ V, $N_f = 500$ turns per pole, and $P_r = 10$ kW. The demagnetizing mmf due to armature reaction is 25% of the armature current. Its magnetization curve is given in the figure below. [Only two (2) iterations required]

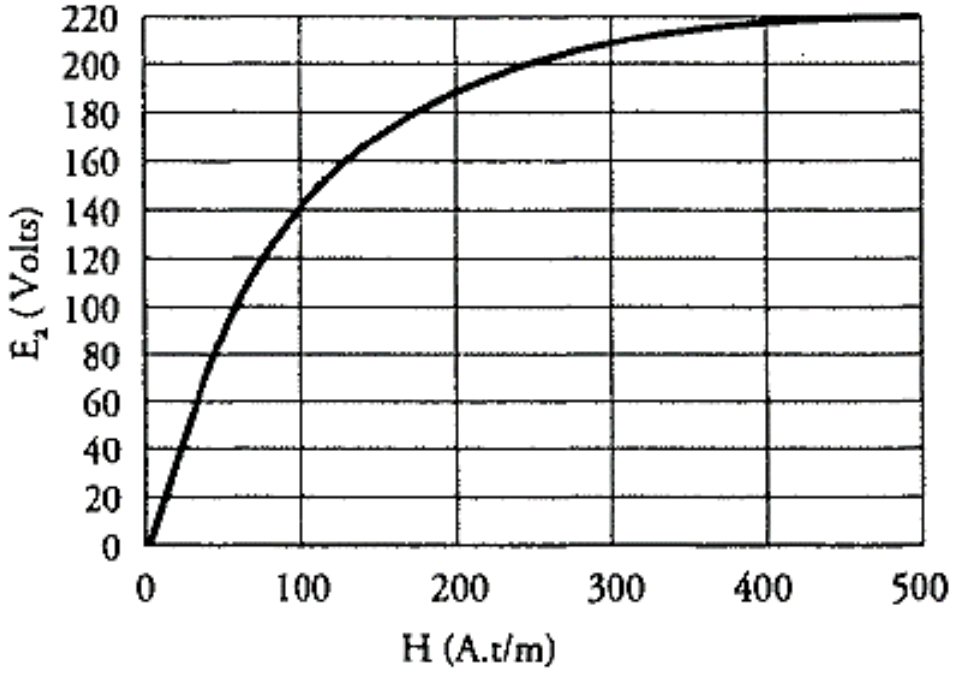


Determine;

I. the induced emf at full load,
II. the power developed,
III. the torque developed,
IV. the applied torque,
V. the efficiency,

VI. the external resistance in the field winding, and
VII. the voltage regulation.

B. The magnetization curve of a 10-hp, 220-V series motor is given in the figure below at 1200 rpm. The other parameters of the series motor are $R_a = 0.75\ \Omega$, $R_s = 0.25\ \Omega$ and $P_r = 1.04$ kW.



I. What is the armature current when the motor delivers its rated load at 1200 rpm?
II. What is the efficiency of the motor at full load?
III. What is the number of turns per pole?