GX548

OLLSCOIL NA hÉIREANN, GAILLIMH

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SPRING EXAMINATIONS, 1999

THIRD YEAR ELECTRONIC ENGINEERING
THIRD YEAR MECHANICAL ENGINEERING

ELECTRICAL POWER AND MACHINES

Professor L.E. Davis
Professor D.J. Wilcox
Professor W.G. Hurley

Duration of examination: *Three* Hours

Instructions: Answer *five* questions

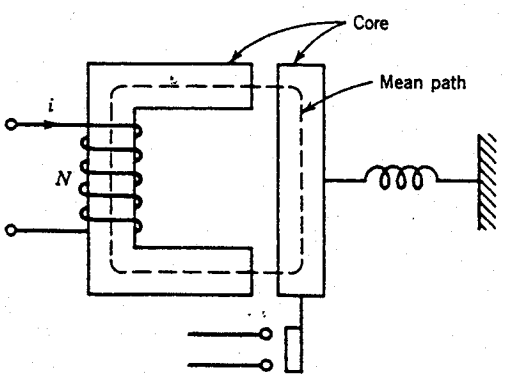
$\mu_o=4\pi x10^{-7}$ H/m 1 hp=746 W

1. Draw the B-H loop for a ferromagnetic material and label the residual flux density, the coercive force and the saturation flux density on the loop.

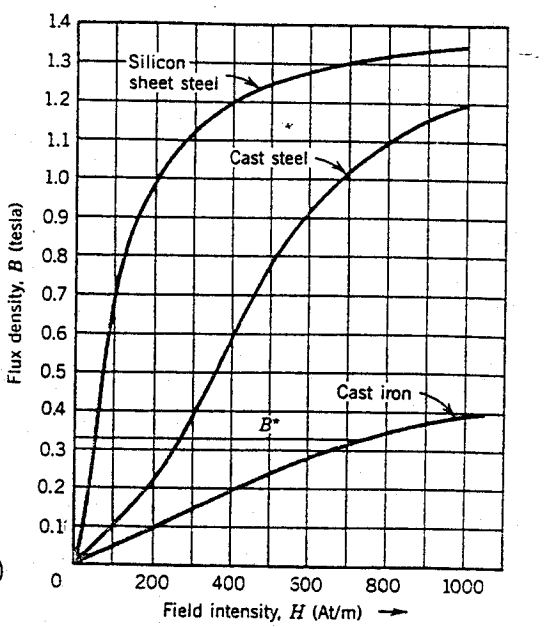
Fig. 1(a) represents the magnetic circuit of a relay. The coil has 500 turns and the mean core path length is 360mm. When the airgap lengths are 1.5 mm each a flux density of 0.8 T is required to actuate the relay. The core is cast steel and its B-H curve is shown in Fig. 1(b).

(a) Find the current in the coil at actuation.
(b) Calculate the relative permeability of the core material.
(c) If the airgap is zero, find the current in the coil for the same flux density in the core.

Neglect fringing.



(a)



(b)

Fig.1. (a) Relay (b) Magnetization curves.

2. Draw the equivalent circuit of a transformer and explain each element in it. A single phase 3kVA 480/240 V 50 Hz transformer has the following parameters:

High voltage side: $r_1 = 0.25\Omega$ $X_1 = 0.75\Omega$
Low voltage side: $r_2 = 0.05\Omega$ $X_2 = 0.18\Omega$

(a) Draw the equivalent circuit with quantities referred to the low voltage side.
(b) Determine the voltage regulation when the transformer is supplying full load at 240 V and 0.9 power factor lagging.
(c) If the load terminals are accidentally short-circuited determine the currents in the high voltage and low voltage windings.

Neglect core losses.

3. Explain with the aid of a diagram why laminations are used to reduce eddy current losses in motors and transformers.

The magnetic structure of a 2 pole synchronous machine is shown in Fig 2. Draw the magnetic equivalent circuit for this structure. Assuming the rotor and stator iron have infinite permeability, find:

(a) the air gap flux
(b) the air gap flux density
(c) the rotor inductance

for I=10 A, N= 1000 turns, g = 10mm and A_g= 2500 cm^2.

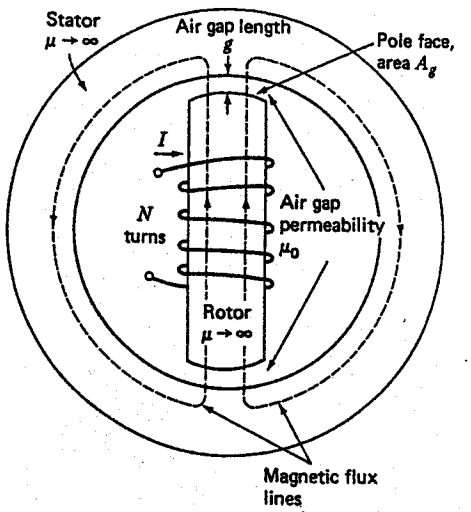


Fig. 2. Synchronous machine.

4. Explain, with the aid of sketches, the role of a commutator in a dc machine.
A 12 kW, 100 V, 1000 rpm dc shunt motor has an armature resistance R_a=0.1Ω.
The magnetization characteristic at 1000 rpm is shown in Figure 3. At no-load conditions, the motor runs at 1000 rpm and the armature takes 6A.

(a) Find the value of the resistance of the shunt field.
(b) Find the speed and electromagnetic torque when rated current flows in the armature.
(c) Find the starting torque, if the starting armature current is limited to 150% of its rated value.

Neglect armature reaction.

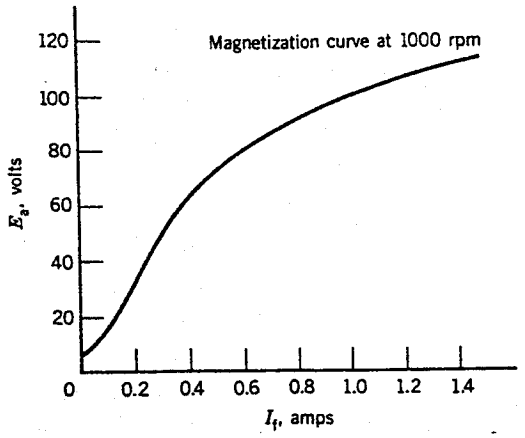


Fig. 3. Magnetization curve at 1000 rpm

5. Explain how power in the three-phase circuit may be measured by the two-wattmeter method. A 400 V, 50 hp three phase induction motor operates at 1/4 capacity and 80% efficiency, the power factor is 0.45 lagging. Calculate

(a) the two readings obtained by the two-wattmeter
(b) the line current

6. Describe the no-load test and the blocked-rotor test of an induction motor.

The following test results are obtained from a three phase, 60 hp, 2200 V, six pole, 50 Hz squirrel cage induction motor.

No load test:	1600 W at 2200 V, 50Hz, 4.5 A
Blocked-rotor test:	9000 W at 270 V, 15 Hz, 25 A

The stator resistance per phase: 2.8 Ω.

(a) Determine the no-load rotational losses
(b) Determine the motor parameters:

The rotor equivalent resistance
The stator leakage reactance
The rotor leakage reactance
The magnetising reactance

7. Define the following terms: Total Harmonic Distortion (THD) and distortion factor. Establish the relationship between these two quantities.

A series RLC circuit has the following parameters: R = 5 Ω, L= 100mH, C=0.28 μF. The amplitude of the fundamental of the emf supplying the circuit is 480 V at 50 Hz. A 19^{th} harmonic of the input voltage exists which is 2% of the fundamental. Calculate

(a) the amplitude of the harmonic current in the capacitor
(b) the amplitude of the harmonic voltage across the capacitor
(c) the power factor of the source