IQRA National University, Peshawar
Department of Electrical Engineering

Summers

Course Code: EEE342		**Course Title:**	Electrical Machines
Prerequisite: Circuit Analysis		**Instructor:**	Engr. Sanaullah Ahmad
Module:	**Program:** BEE	**Total Marks:** 30	**Time Allowed:**

Note: 1) Attempt all questions.
2) Calculators borrowing/exchange is prohibited.

(b) A square ferromagnetic core has a mean path length of 55cm and a cross-sectional area of 150cm^2. A 200 turn coil of wire is wrapped around one leg of the core. The core is made of a material having magnetization intensity (H) 115 A. turns/m. Find: Marks 10

a. How much current is required to produce 0.012 Wb of flux in the core?
b. What is the core's relative permeability at that current level? ($4\pi\times10$-7H/m)
c. What is its reluctance?

CLO 2

Q2 (a) Derive Voltage and Impedance relationship with turn ratio for an ideal transformer? Marks 10

CLO 1

Q3 (a) Define power factor? Differentiate between Real, Apparent and reactive powers? Marks 10

CLO 1

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Mid Term

Core length = 55cm

cross area = 150 cm^2

N = 200 turns

H = 115 amp/m

(a): current = ?

$$B = \frac{\phi}{A}$$

$$B = \frac{0.012}{0.015m}$$

$$\boxed{B = 0.8T}$$

$$B = \mu H$$

$$\mu = \frac{B}{H}$$

$$= \frac{0.8}{115}$$

$$\boxed{\mu = 0.06 \, H/m}$$

Now for I

$$B = \frac{\mu I}{L}$$

$$I = \frac{BL}{\mu}$$

$$= \frac{0.8 \times 0.0055}{0.6 \, H/m}$$

$$\boxed{I = 0.0733 \text{ Ampere}}$$

(b): **Relative Permeability:**

$$\mu = \frac{B}{H}$$

$$\mu = \frac{0.8}{115} = 0.06 \text{ H/m}$$

$$\mu_r = \frac{\mu}{\mu_0} \qquad \mu_0 = 4\pi \times 10^{-7} \text{ H/m}$$

$$= \frac{0.06 \text{ H/}\cancel{m}}{4\pi \times 10^{-7} \text{ H/}\cancel{m}}$$

$$\boxed{\mu_r = 5540}$$

(C): Reluctance:

$$\mathcal{F} = H \cdot L$$

$$= 115 \times 0.0055$$

$$\boxed{\mathcal{F} = 63.25 \text{ A.Turns}}$$

$$\mathcal{F} = R\phi$$

$$R = \frac{\mathcal{F}}{\phi}$$

$$= \frac{63.25}{0.012}$$

$$\boxed{R = 5270 \ \frac{\text{A.turns}}{\text{Weber}}}$$

Question 2

Part (a)

Voltage:

$$\frac{N_p}{N_s} = \frac{V_p}{V_s}$$

$$e_p = -N_p \frac{d\phi}{dt}$$

$$V = V_m \sin \omega t$$
$$\phi = \phi_m \sin \omega t$$

$$e_p = -N_p \frac{d}{dt}(\phi_m \sin \omega t)$$

$$e_p = -N_p \omega \cos \omega t \, \phi_m$$
$$= -2\pi f N_p \cos \omega t \, \phi_m$$
$$= 2\pi f N_p \sin(90 - \omega t) \phi_m$$

$\because \omega = 2\pi f$

$\because \cos \omega t = \sin \omega t \, 90$

$\because \sin(90 - \omega t) \to 90$

$\because \sin = 1$

$$e_p = 2\pi f N_p 1 \phi_m (Max)$$

for rms, $\frac{V_m}{\sqrt{2}} = V_{rms}$

$$e_{prms} = \frac{2\pi f N_p 1 \phi_m}{\sqrt{2}}$$

$$\boxed{e_{prms} = 4.44 f N_p \phi_m}$$

$$\boxed{e_{srms} = 4.44 f N_s \phi_m}$$

$$\frac{e_{prms}}{e_{srms}} = \frac{\cancel{4.44} \cancel{f} N_p \cancel{\phi_m}}{\cancel{4.44} \cancel{f} N_s \cancel{\phi_m}}$$

$$\boxed{\frac{e_{prms}}{e_{srms}} = \frac{N_p}{N_s}}$$

$$\boxed{\frac{V_p}{V_s} = \frac{N_p}{N_s}}$$

Impedence:

$$Z = R + jX$$

$$X_C = \frac{1}{j\omega C}$$

$$X_L = j\omega L$$

$$V = IZ$$

$$Z_p = \frac{V_p}{I_p}$$ (Primary Impedence)

$$Z_s = \frac{V_s}{I_s}$$ (secondary Impedence)

$$\alpha = \frac{N_p}{N_s} = \frac{V_p}{V_s}$$

$$\boxed{\alpha = \frac{V_p}{V_s}}$$

$$\alpha V_s = V_p$$

$$\boxed{\alpha = \frac{I_s}{I_p}}$$

$$\frac{1}{\alpha} = \frac{I_p}{I_s}$$

$$I_p = \frac{I_s}{\alpha}$$

$$\Rightarrow Z_p = \frac{V_p}{I_p}$$

$$Z_p = \frac{\alpha V_s}{\frac{I_s}{\alpha}}$$

$$Z_p = \alpha^2 \frac{V_s}{I_s}$$

$$Z_p = \alpha^2 Z_s$$

$$\frac{Z_p}{Z_s} = \left(\frac{N_p}{N_s}\right)^2$$

$$\boxed{\sqrt{\frac{Z_p}{Z_s}} = \frac{N_p}{N_s}}$$

Question 3

Part (a)

Power factor:

Power factor is the ratio of the actual electrical power dissipated by an AC circuit to the product of the RMS values of current and voltage. The difference between the two is caused by reactance in the circuit and represents power that does no useful work.

- Power factor is the ratio of real and apperant power.

Cos θ = Power factor

$$\cos\theta = \frac{\text{Real power (KW)}}{\text{Apperant power (KVA)}}$$

Real Power:

The actual amount of power being used, or dissipated, in a circuit is called real power. It is measured in watts.

Denototed by = P

$$P = I^2 R$$

$$P = \frac{E^2}{R}$$

Apparent Power:

The combination of reactive power and real power is called apparent power. It is the product of circuit's voltage and current, without reference to phase angle. Measured in Volt-Amps.

$$S = I^2 Z, \quad S = IE$$

Reactive Power:

Reactive loads such as inductors and capacitors dissipate zero power, yet the fact that they drop voltage and draw current gives the deceptive impression that they actually do dissipate power.

Denoted by = Q

Measured in Volt-Amps-Reactive (VAR)

$$Q = I^2 X$$

$$Q = \frac{E^2}{X}$$