Test #1 **SKEE4633** **1 hour 15 minutes** **Oktober 2019**

Q1. In an electromagnetic relay system, the flux linkage λ and current i relationship is given by:

$$i = 6x^2\lambda^2 + 8(2x - 7)^2\sqrt{\lambda}$$

Evaluate the electromechanical force, f_m when $\lambda = 2$ Volt-second and $x = 2$ m.

[6 marks]

Q2. The magnetic circuit shown in **Figure Q2** is made of high permeability steel so that its reluctance can be negligible. Assume that the moveable part can only move horizontally. The dimensions are shown in the Figure. Given $p = 40$ cm, $N = 1000$ turns, and $i = 5$ A.

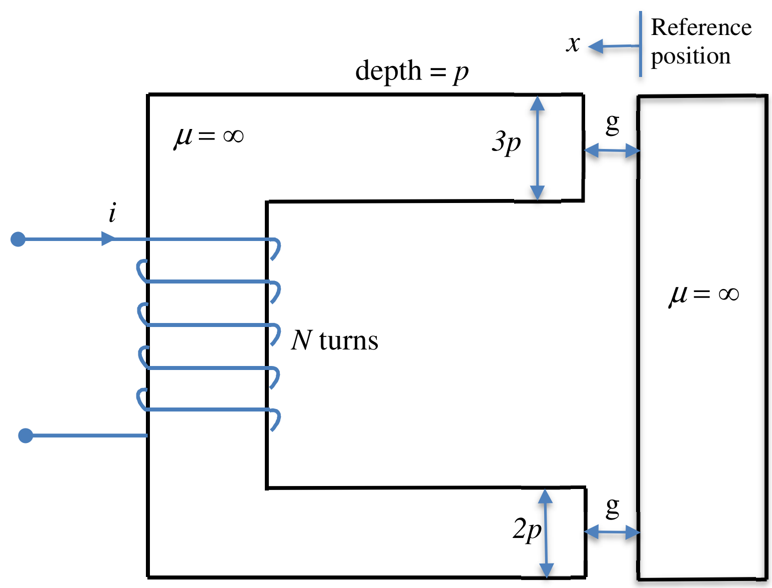

Figure Q2

(a) Obtain an expression for the total reluctance, $\Re$, and the inductance of the coil, L, as a function of air-gap length, g, and magnetic circuit parameters (N, p, and μ_o— see **Figure Q2**). **[3 marks]**

(b) For $g = 4$ cm, find the value of the inductance, flux linkage, and energy in the air gaps. **[3 marks]**

(c) Obtain an expression for the electromechanical force, f_m, acting on the moveable part as a function of the winding current i, the air gap length, g, and magnetic circuit parameters (N, p and μ_o— see **Figure Q2**). Calculate the electromechanical force, f_m at g = 4 cm. **[3 marks]**

Q3. An eight-pole DC machine has 64 coils with 20 turns per coil. It has 40 mWb flux per pole and run at 2000 revolution per minute (rpm). The armature is lap-wound.

(a) Find the induced voltage in the armature, E_a. Also, find the induced voltage for each turn. **[2 marks]**

(b) Find the developed torque on the armature, T, when the conductor current is 50 A. Also, find the developed torque for each turn. **[2 marks]**

(c) Find the maximum power can be produced by the generator. The conductors are available which are rated at 25 V and 2.5 A. **[2 marks]**

Q4. A 10.8 kW, 108 V, 1200 rpm dc generator has armature resistance $R_a = 0.1\ \Omega$, shunt field winding resistance, $R_{fw} = 80\ \Omega$. The rated field current is 1.15 A. The magnetization characteristic at 1200 rpm is shown in **Figure Q4** on page 4. The no-load terminal voltage is adjusted to 108 V and run at 1200 rpm.

1. The machine is operated as a separately excited DC generator:
   - (i) Determine the terminal voltage, V_t, at the full-load. Assume the armature reaction effect at the full-load $I_{f(AR)} = 0.1$ A.
   - (ii) Determine the field current required to make the terminal voltage V_t = 108 V at full-load condition. Assume the armature reaction effect at the full-load $I_{f(AR)} = 0.1$ A.

[3 marks]

2. The machine is operated as a self-excited shunt DC generator:
   - (i) Determine the maximum value of the armature current that the generator can supply and the corresponding values of the terminal voltage, V_t and the generated voltage, E_a. Neglect armature reaction effects.
   - (ii) Determine the terminal voltage, V_t, at the full-load. Assume the armature reaction effect at the full-load $I_{f(AR)}$ = 0.1 A.

[3 marks]

List of Potentially Useful Formula

$\mu_o = 4\pi \times 10^{-7}$ H/m	$W_f = \int_0^{\lambda} i d\lambda$	$f_m = -\left.\frac{\partial W_f(\lambda, x)}{\partial x}\right\|_{\lambda=\text{constant}}$
$B = \frac{\phi}{A} = \mu H$	$W_f^{'} = \int_0^{i} \lambda di$	$f_m = \left.\frac{\partial W_f^{'}(i, x)}{\partial x}\right\|_{i=\text{constant}}$
$R = \frac{l}{\mu A}$	$W_f = V_{ag}\int_0^{B} HdB = \frac{B^2}{2\mu_o}V_{ag}$	$K_a = \frac{Np}{\pi a}$ a = p for lap a = 2 for wave
$Hl = Ni$ $\phi R = Ni$	$W_f^{'} = V_{ag}\int_0^{H} BdH = \frac{\mu_o H^2}{2}V_{ag}$	$E_a = K_a \phi \omega_m$ $T = K_a \phi I_a$
$L \equiv \frac{\lambda}{i} = \frac{N\phi}{i} = \frac{N^2}{R}$	$W_f = \frac{1}{2}i^2 L(x)$	$I_a = I_f + I_t$ $V_t = R_f I_f$
$\lambda \equiv N\phi = Li$	$f_m = \frac{i^2}{2}\frac{d}{dx}L(x) = \frac{\lambda^2}{2L(x)^2}\frac{d}{dx}L(x)$	$V_t = E_a - R_a I_a - R_{sr} I_t$
$P = T\omega_m = E_a I_a$	$V_t = E_a - R_a I_a$	$\frac{d}{dx}UV = V\frac{d}{dx}U + U\frac{d}{dx}V$
$I_{f(eff)} = I_f - I_{f(AR)} + \frac{N_{sr}}{N_f}I_t$	$I_{f(eff)} = I_f - I_{f(AR)} - \frac{N_{sr}}{N_f}I_t$	$\frac{d}{dx}\frac{U}{V} = \frac{V\frac{d}{dx}U - U\frac{d}{dx}V}{V^2}$

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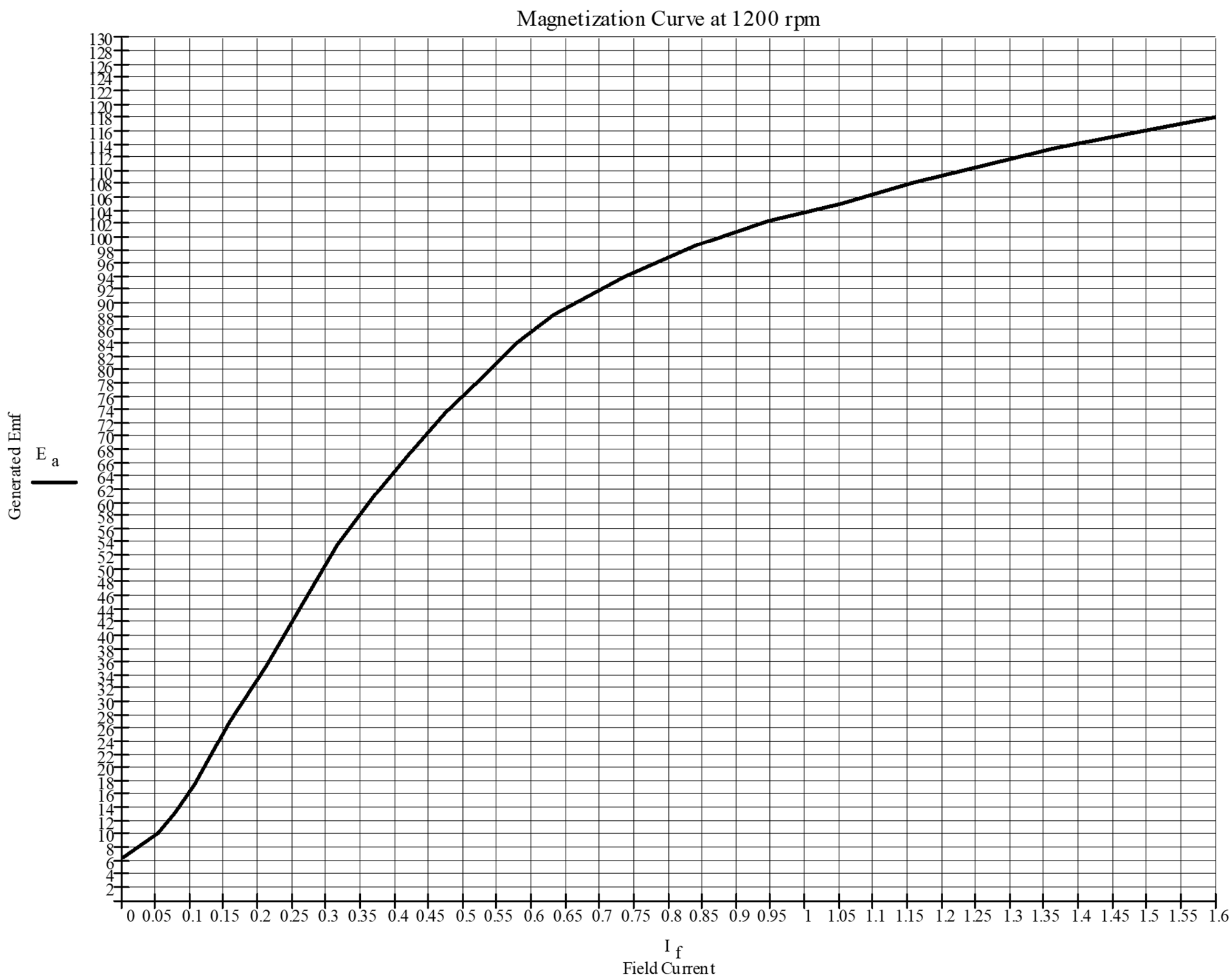

Figure Q4