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

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

$$i = 2\lambda^2 + 3\lambda(x-4)^2 + \sin x$$

Evaluate the electromechanical force, f_m when $\lambda = 2$ Vs and $x = 1$ m. [**5 marks**]

Q2. The magnetic circuit shown in **Figure Q2** is made of high permeability steel so that its reluctance can be negligible. The rotor is free to turn about a vertical axis. The dimensions are shown in the Figure.

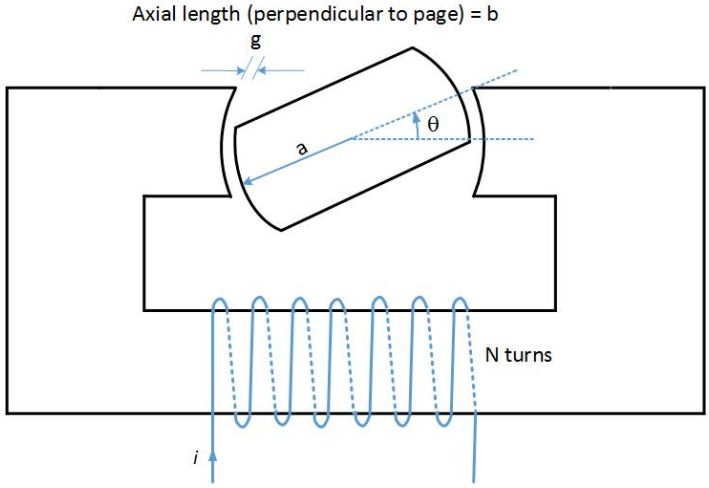

Figure Q2

(a) Obtain an expression for the effective cross sectional area normal to the flux, A_g, and the total volume of the air gap, V_g, as a function of the rotor angle, θ, and magnetic circuit dimensions (a, b, and g, see Figure Q2). [**3 marks**]

(b) Obtain an expression for the torque acting on the rotor as a function of the winding current i, the rotor angle, θ, and magnetic circuit dimensions (a, b, and g, see **Figure Q2**). **[3 marks]**

(c) Calculate the torque. Given a = 15 cm, g = 2 mm, b = 20 cm, N = 1000 turns, θ = 30°, and B = 1 T. **[3 marks]**

Q3. An eight-pole, 25-kW, 120-V DC generator has a lap-wound armature, which has 64 coils with 16 turns per coil. Its rated speed is 2400 revolution per minute (rpm).

(a) How much flux per pole is required to produce the rated voltage in this generator at no-load conditions? [**3 marks**]

(b) What is the current for each parallel path in the armature of this generator at the rated load? [**2 marks**]

(c) What is the induced torque in this machine at the rated load? [**2 marks**]

(e) If the resistance of this winding is 0.011 Ω is per turn, what is the armature resistance R_A of this machine? [**2 marks**]

Q4. An 8 kW, 80 V, 800 rpm dc shunt generator has armature resistance R_a = 0.1 Ω, shunt field winding resistance, R_{fw} = 70 Ω. The rated field current is 0.8 A. The magnetization characteristic at 800 rpm is shown in **Figure Q4**.

The machine is operated as a self-excited shunt dc generator at 800 rpm.

(a) Determine the maximum and minimum values of the no-load terminal voltage, if the field control resistance, R_{fc}, whose value can be changed from 0 to 165 Ω. [**2 marks**]

(b) R_{fc} is adjusted to provide a no load terminal voltage of 84 V. Determine the values of R_{fc}. [**2 marks]**

(c) Determine the critical field circuit resistance. [**2 marks]**

(d) The no-load terminal voltage is adjusted to 90 V. Determine the full load terminal voltage. Neglect armature reaction effects. [**2 marks]**

(e) Repeat (d), assuming that the effect of armature reaction at full load is equivalent to 0.075 A field amperes, that is, $I_{f(AR)}$ = 0.075 A. [**2 marks]**

Don't forget to submit Figure Q4 on page 3

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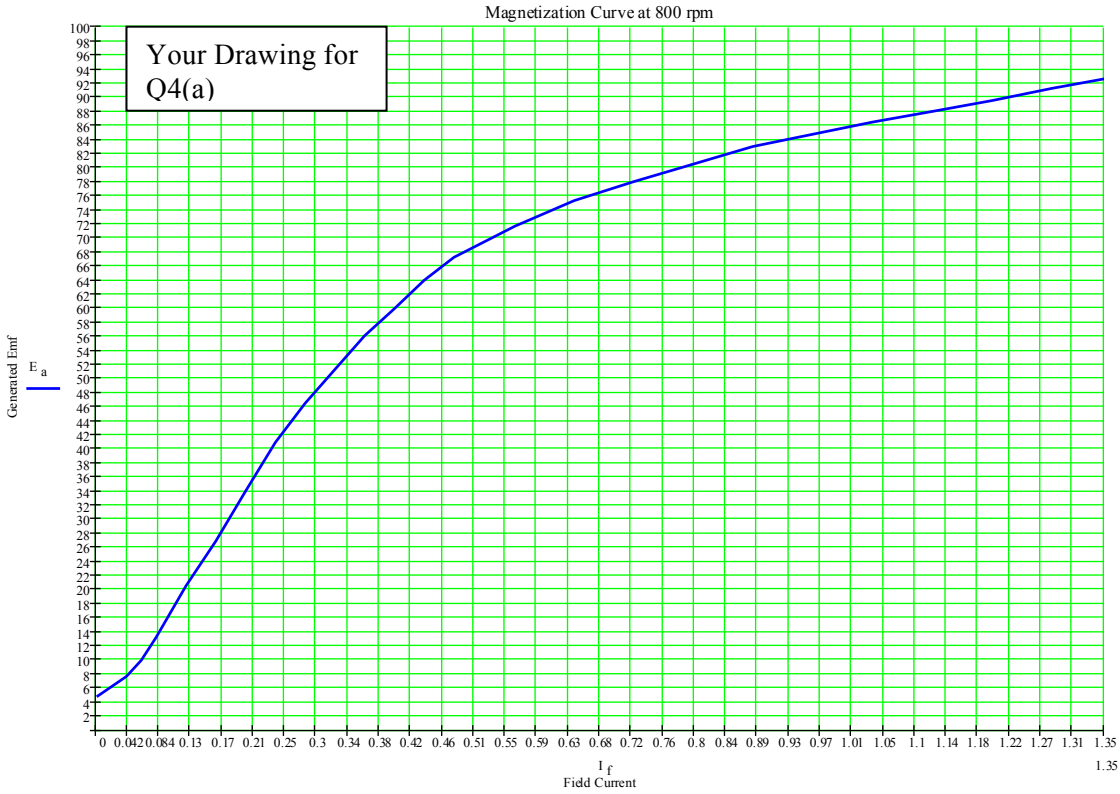

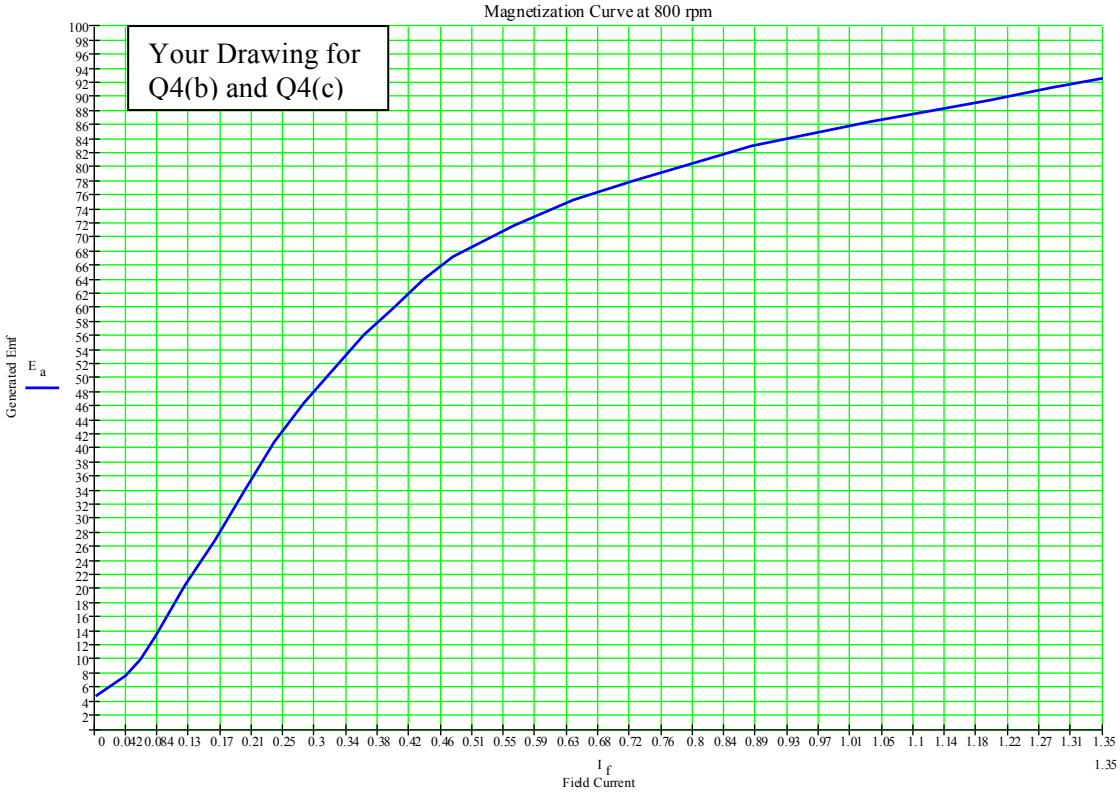

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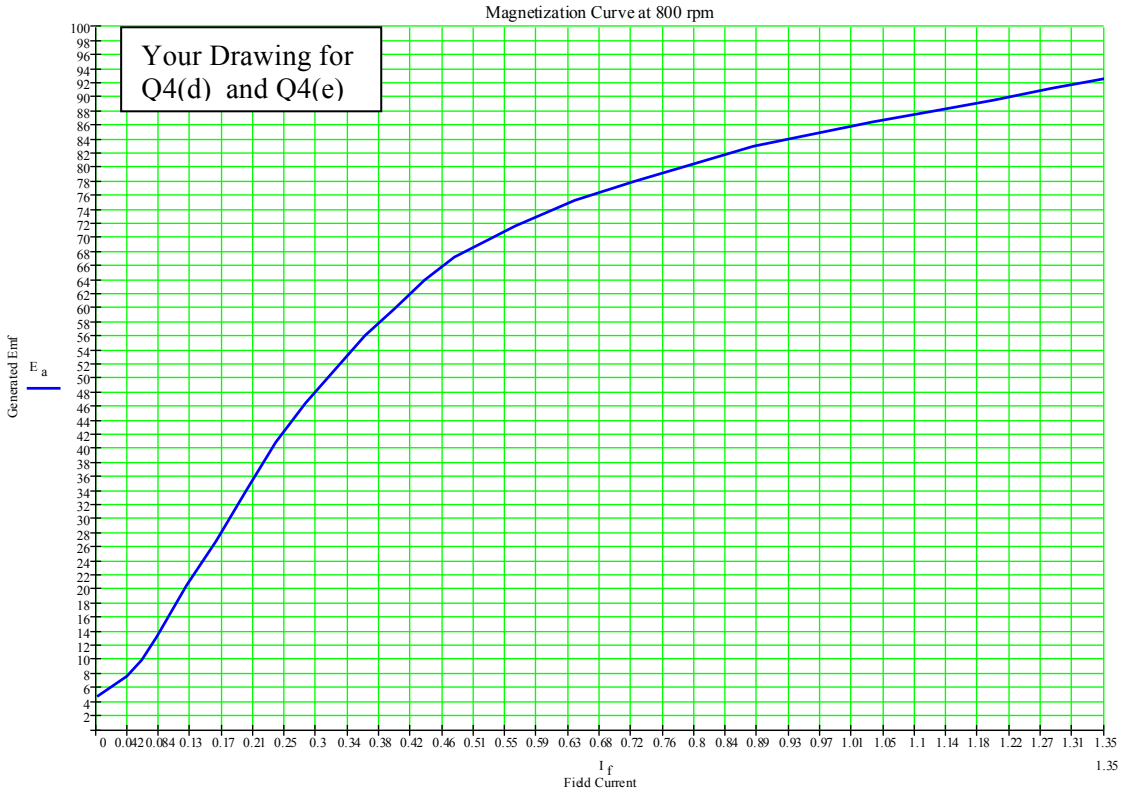

List of Potentially useful Formula:

$\mu_o = 4\pi \times 10^{-7}$	$W_f = \int_0^{\lambda} id\lambda$	$f_m = -\left.\frac{\partial W_f(\lambda, x)}{\partial x}\right\|_{\lambda=\text{constant}}$
$B = \frac{\phi}{A} = \mu H$	$W_f' = \int_0^{i} \lambda di$	$f_m = \left.\frac{\partial W_f'(i, x)}{\partial x}\right\|_{i=\text{constant}}$
$R = \frac{l}{\mu A}$	$w_f = \int_0^{B} HdB$	$K_a = \frac{Np}{\pi a}$
$Hl = Ni$ $\phi R = Ni$	$w_f' = \int_0^{H} BdH$	$E_a = K_a \phi \omega_m$
$L \equiv \frac{\lambda}{i} = \frac{N\phi}{i} = \frac{N^2}{R}$	$W_f = \frac{1}{2} i^2 L(x)$	$T = K_a \phi I_a$
$\lambda \equiv N\phi = Li$	$f_m = \frac{i^2}{2} \frac{d}{dx} L(x)$	$V_t = R_f I_f$
$P = T\omega_m = E_a I_a$		$V_t = E_a - R_a I_a$