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

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

$$i = 4x\lambda^2 + 5\lambda(4-2x)^2 + \frac{\lambda}{\sqrt{x}}$$

Evaluate the electromechanical force, f_m when $\lambda = 2$ Vs and $x = 1$ m. [**6 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.

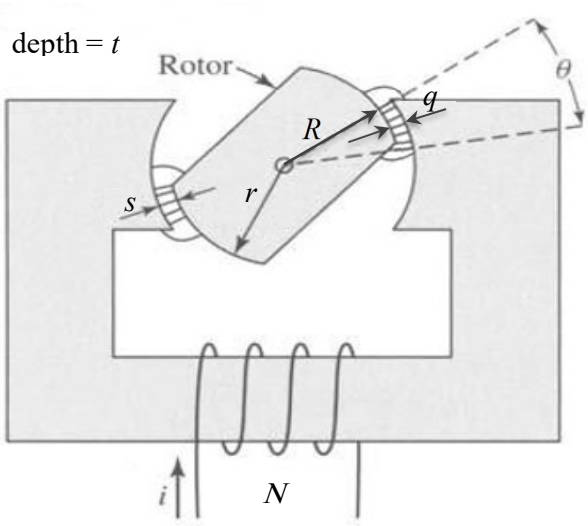

Figure Q2

(a) Obtain an expression for the total reluctance, R_g, and the inductance, L, of the magnetic system as a function of angular displacement, θ, permeability of the air gap, μ_o, and magnetic circuit dimensions (q, R, r, s, and t, 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 angular displacement, θ, and magnetic circuit dimensions (q, R, r, s, and t, see **Figure Q2**). **[3 marks]**

(c) Calculate the torque. Given $q = 3$ mm, $R = 5.8$ cm, $r = 5.9$ cm, $s = 2$ mm, $t = 5$ cm $N = 1000$ turns, $\theta = 30°$, and $i = 10$ A.
[3 marks]

Q3. An eight-pole DC generator has a wave-wound armature, which has 72 coils with 16 turns per coil. The flux per pole is 30 mWb. The DC machine rotates at 1400 revolution per minute (rpm). The resistance for each turn is 0.001 Ω. Calculate:

(a) The generated voltage and the voltage induced for each turn.
(b) The rated torque developed if the rated current through the turn is 20 A.
(c) The total armature resistance, R_a.

[7 marks]

Q4. A 14.4 kW, 120 V, 1200 rpm dc generator has armature resistance $R_a = 0.1$ Ω, shunt field winding resistance, $R_{fw} = 94$ Ω. The rated field current is 1.15 A. The magnetization characteristic at 1200 rpm is shown in **Figure Q4**.

1. The machine is operated as a separately excited DC generator at 1200 rpm with rated field current.
   (i) Determine the terminal voltage at the full-load. Neglect the armature reaction effect.
   (ii) Determine the terminal voltage at the full-load. Assume the armature reaction effect at the full-load $I_{f(AR)} = 0.15$ A.

2. The machine is operated as a self-excited shunt dc generator at 1200 rpm and the no-load terminal voltage is adjusted to 120 V.

   (iii) Determine the terminal voltage at the full-load. Neglect the armature reaction effect.
   (iv) Determine the terminal voltage at the full-load. Assume the armature reaction effect at the full-load $I_{f(AR)} = 0.15$ A.

[8 marks]

List of Potentially useful Formula:

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

Name:……

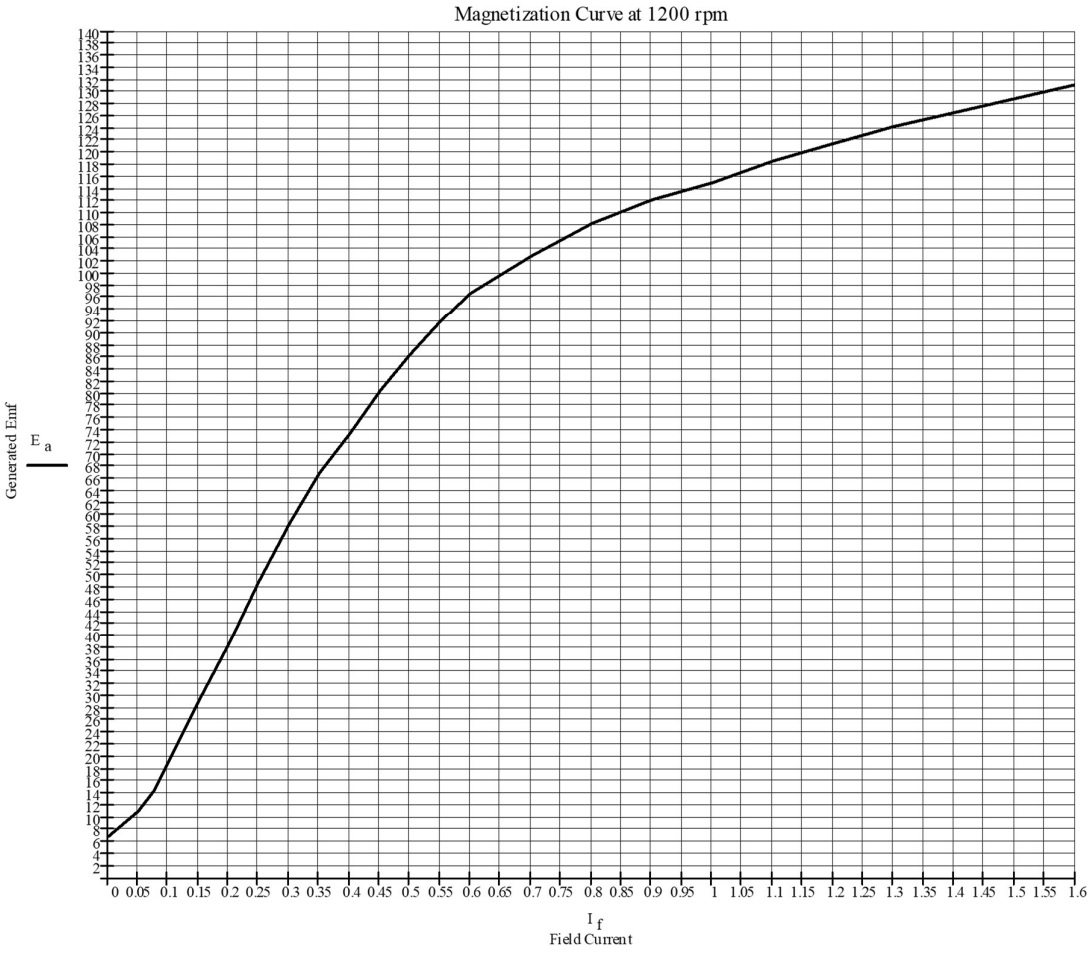

Figure Q4