ECE 330 HW 8

IMPORTANT: Please treat HW 8 as a homework assignment and please upload your solution by 8th April, 10 am to Gradescope. We expect and trust that you will continue of show your academic integrity. It is okay to discuss with fellow students, but you have to submit your own solution. Please continue to use Piazza to ask questions but do not post solutions/answers on Piazza. Stay Safe!

Problem 1
In the following questions, EFE stands for "energy from the electrical system into coupling field" and EFM stands for "energy from the mechanical system into coupling field."

In an electromechanical system, the flux linkage is given by:

$$\lambda(i, x) = \frac{0.04i}{x - 0.01}$$

where x defines the geometry of the mechanical subsystem, and i denotes the current into the system. It is operated on the closed cycle "a-b-c-d-a" as indicated in the table below. Over this cycle, x is held constant along the paths "a-b" and "c-d," and i is held constant along the paths "b-c" and "d-a."

	a	b	c	d	a
i (A)	0	i_b	i_b	0	0
λ (Wbt)	0	8	λ_c	0	0
x (m)	0.03	0.03	0.02	0.02	0.03

(a) Is the system electrically linear? Please justify your reasoning.
(b) Compute i_b and λ_c.
(c) Compute the energy stored in the coupling field, W_m, at a, b, c, and d.
(d) Sketch the complete cycle ($a \to b \to c \to d \to a$) on the $\lambda - x$ plane and the $\lambda - i$ plane.
(e) Compute the EFE and the EFM for each of the four trajectories: $a \to b$, $b \to c$, $c \to d$, and $d \to a$.
(f) Is the system operating as motor or a generator over this cycle? Please justify your reasoning.

Problem 2
An electromechanical system has the following relationship:

$$\lambda = \frac{0.04}{x + 0.01} i$$

Consider the following to be point a: $x = 0.01$ m, $i = 2$ A, $\lambda = 4$ Wb-tns.

(a) Find the energy, W_m, at point a.

(b) Find the EFE and EFM as the system is moved along constant x from point a to point b with $i = 4$ A.
(c) Find the energy, W_m, at point b.
(d) Find the EFE and EFM as system is moved along constant current from point b to point c which has $x = 0.03$m.
(e) Find the energy, W_m, at point c.
(f) Find the EFE and EFM as the system is moved along constant flux from point c to point a.
(g) For this cycle, is this a motor or a generator? Please justify your reasoning.

Problem 3
Repeat Problem 2 with the following non-linear relation:

$$\lambda = \frac{0.04}{x + 0.01} i^2$$

Consider the following to be point a: $x = 0.08$ m, $i = 1.5$ A, $\lambda = 1$ Wb-tns.

(a) Find the energy, W_m, at point a.
(b) Find the EFE and EFM as the system is moved along constant x from point a to point b with $i = 3$ A.
(c) Find the energy, W_m, at point b.
(d) Find the EFE and EFM as system is moved along constant flux from point b to point c which has $x = 0.0125$m.
(e) Find the energy, W_m, at point c.
(f) Find the EFE and EFM as the system is moved along constant current from point c to point a.
(g) For this cycle, is this a motor or a generator? Please justify your reasoning.

Problem 4
A single-phase rotating machine has one set of windings on the stator with current I_s and one set of windings on the rotor with current I_r. The flux linkages of the stator and the rotor windings are given by:

$$\lambda_s = L_s i_s + M \cos(\theta) i_r$$
$$\lambda_r = M \cos(\theta) i_s + L_r i_r$$

In operating this electromechanical system, the currents i_s and i_r are kept constant at I_s and I_r, respectively, while the rotor is rotated from $\theta = 0$ to $\theta = 90°$. Along this path, compute the energy transferred from the mechanical subsystem into the coupling field (i.e. the EFM).