ECE 320 & ECE 329

ENERGY SYSTEMS I

BACKGROUND STUDY IN ENERGY SYSTEMS

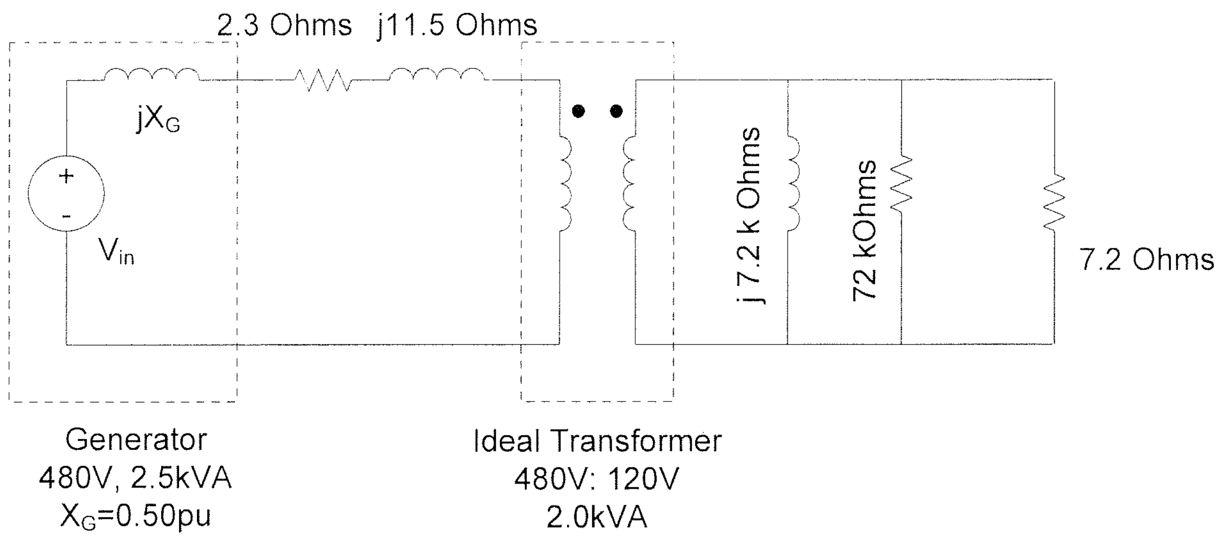
SESSION no. 17

ECE 320 / ECE 329 NAME ______________________________

Quiz 5 22 February 2012

Per Unit

1. (6 points) For the transformer circuit shown below:
   a. Specify the base for each region of the circuit.
   b. Convert all the impedances to per unit on the base that you specify.
   c. Draw the per unit circuit that your analysis creates.



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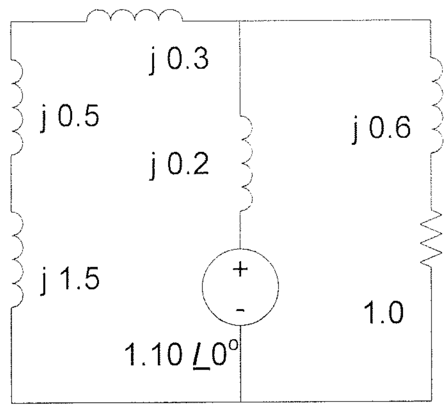
ECE 320 / ECE 329
Quiz 5
Per Unit

NAME ______________________

22 February 2012

2. (4 points) For the per unit circuit shown below, find the real power dissipated in the resistor.



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ECE 320 / ECE 329 NAME ____________________

Quiz 5 22 February 2012

Per Unit

1. (6 points) For the transformer circuit shown below:
   a. Specify the base for each region of the circuit.
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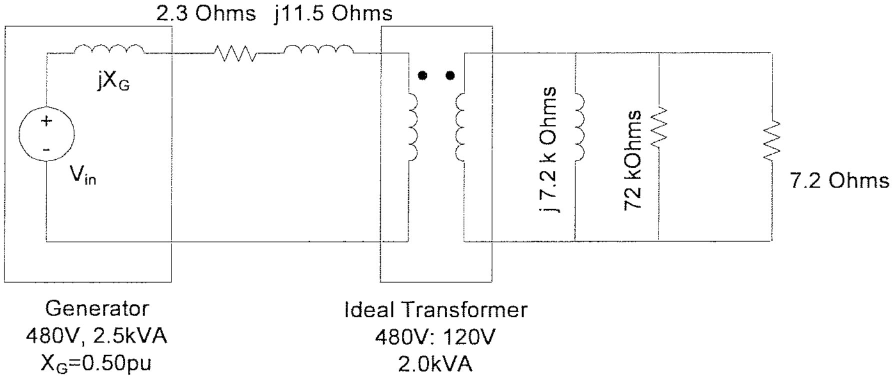


Select a base of 480V : 120V, 2.0kVA

$$Z_{baseR} := \frac{(120\cdot V)^2}{2000\cdot V\cdot A} = 7.2\,\Omega \qquad Z_{baseL} := \frac{(480\cdot V)^2}{2000\cdot V\cdot A} = 115.2\,\Omega$$

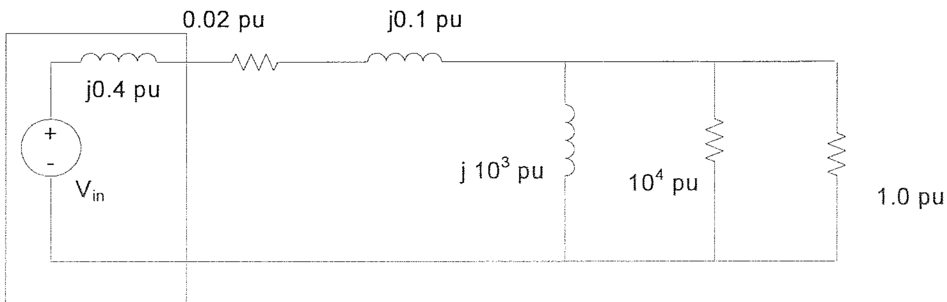
$$R_{Lpu} := \frac{7.2\cdot\Omega}{Z_{baseR}} = 1 \qquad X_p := \frac{11.5\cdot\Omega}{Z_{baseL}} = 0.1$$

$$R_{Cpu} := \frac{72\cdot k\Omega}{Z_{baseR}} = 1\times10^4 \qquad R_p := \frac{2.3\cdot\Omega}{Z_{baseL}} = 0.02$$

$$X_{Mpu} := \frac{7.2\cdot k\Omega}{Z_{baseR}} = 1\times10^3$$

Convert the generator to per unit on the system base.

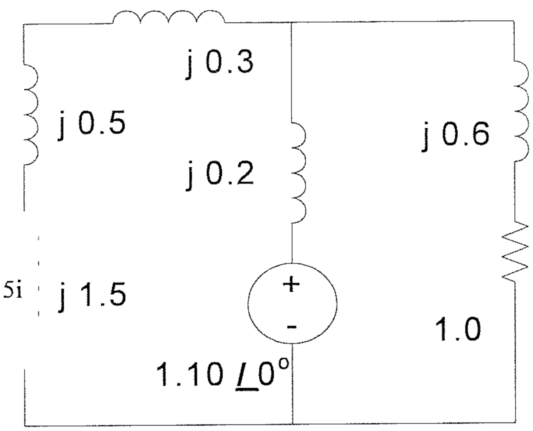
$$Z_{baseG} := \frac{(480\cdot V)^2}{2500\cdot V\cdot A} = 92.16\,\Omega \qquad X_G := \frac{0.50\cdot Z_{baseG}}{Z_{baseL}} = 0.4$$



2. (4 points) For the per unit circuit shown below, find the real power dissipated in the resistor.

$j := \sqrt{-1}$

A node method



$$\frac{V_x - 1.1}{j \cdot 0.2} + \frac{V_x}{j \cdot 2.3} + \frac{V_x}{1.0 + j \cdot 0.6} = 0$$

$$V_x := \frac{\dfrac{1.1}{j \cdot 0.2}}{\dfrac{1}{j \cdot 0.2} + \dfrac{1}{j \cdot 2.3} + \dfrac{1}{(1.0 + j \cdot 0.6)}} = 0.922 - 0.115i$$

Find the resistor current.

$$I_r := \frac{V_x}{1.0 + j \cdot 0.6} = 0.627 - 0.491i$$

Find the resistor power.

$$P_r := \frac{\left(\left|I_r\right|\right)^2}{1.0} = 0.634$$

Alternative method: use loop equations.

$$\begin{pmatrix} I_1 \\ I_r \end{pmatrix} := \begin{pmatrix} j \cdot 2.5 & -j \cdot 0.2 \\ -j \cdot 0.2 & 1.0 + j \cdot 0.8 \end{pmatrix}^{-1} \cdot \begin{pmatrix} 1.1 \\ -1.1 \end{pmatrix} = \begin{pmatrix} -0.05 - 0.401i \\ -0.627 + 0.491i \end{pmatrix}$$

$$P_r := \frac{\left(\left|I_r\right|\right)^2}{1.0} = 0.634$$

ECE 320 / ECE 329 NAME ____________________

Quiz 5 22 February 2012

Per Unit

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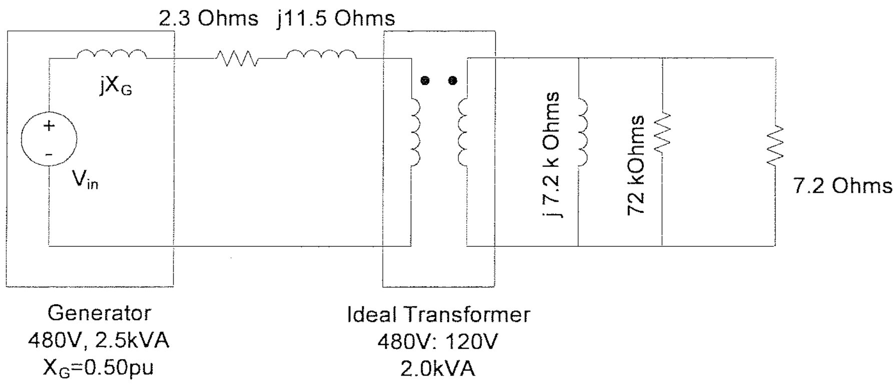

Select a base of 480V : 120V, 2.0kVA

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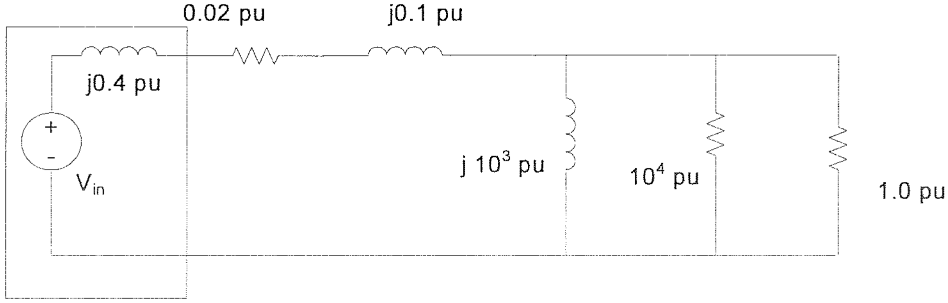


ECE 320 / 329 Syllabus

Lsn	Date	Topic	Assignment
		Single Phase AC Power	
1	11-Jan-12	Single Phase AC; Power Calculations	Circuits Text
2	13-Jan-12	Recitation: Single Phase AC; Power Calculations	Lesson 1
	16-Jan-12	Holiday	
3	18-Jan-12	Power in Single Phase AC Circuits	Circuits Text
4	20-Jan-12	Reactive and Complex Power	Circuits Text
5	23-Jan-12	Reactive and Complex Power Examples	Circuits Text
6	25-Jan-12	Recitation: Power in Single Phase AC Circuits	Lessons 1-5
		Transformers	
7	27-Jan-12	AC Power; Ideal Transformers	C:65-76, 109-115
8	30-Jan-12	Non-ideal transformers	C: 76-90
9	1-Feb-12	Non-ideal transformers	C: 90-94, 100-109
10	3-Feb-12	Non-ideal transformers	C: 76-94, 100-109
11	6-Feb-12	Recitation: Transformers	Lessons 7-10
12	8-Feb-12	Per Unit	C: 94-99
13	10-Feb-12	Transformers Review	C: 76-94, 100-115
		Per Unit	
14	13-Feb-12	Per Unit	C: 94-99
15	15-Feb-12	Per Unit	C: 94-99
16	17-Feb-12	Recitation: Per Unit	Lessons 11-12
	20-Feb-12	Holiday	
		DC Motors	
17	22-Feb-12	Introduction to DC Motors: Linear DC Motors	C: 32-46, 473-485
18	24-Feb-12	Exam #1: Power Fundamentals and Transformers	Lessons 1-13
19	27-Feb-12	Introduction to DC Motors: Linear DC Motors	C: 32-46, 473-485
20	29-Feb-12	DC Motors	C:514-527
21	2-Mar-12	Recitation: Linear DC Motors	Lessons 21-23
22	5-Mar-12	DC Motors	C: 514-527,533-562
23	7-Mar-12	DC Motors	C: 514-527,533-562
24	9-Mar-12	DC Motors	C: 514-527,533-562
		Spring Break	
25	19-Mar-12	DC Motors Example	C: 573-578, 592-594
26	21-Mar-12	Recitation: DC Motors	Lessons 24-28
		Circuit Analogs and Lumped Parameter Magnetics	
27	23-Mar-12	Electromechanical Analogs	Handout
28	26-Mar-12	Electromechanical Analogs	Handout
29	28-Mar-12	Exam #2: DC Motors	Lessons 17, 19-26
30	30-Mar-12	Electromechanical Analogs	Handout
31	2-Apr-12	Recitation: Electromechanical Analogs	Lessons 27, 28, 30
32	4-Apr-12	Electromechanical Analogs; Magnetic Circuits	C:1-8
33	6-Apr-12	Magnetic Circuits	C:1-8,28-32

ECE 320 / 329 Syllabus

Lsn		Topic	Assignment
		Power Electronics	
34	9-Apr-12	Fundamentals of Power Electronics	H: 185-196
35	11-Apr-12	Ideal Converters: Buck	H: 185-196
36	13-Apr-12	Ideal Converters: DC to DC	H: 196-214
37	16-Apr-12	Ideal Converters: DC to DC	H: 196-214
38	18-Apr-12	Recitation: Ideal DC to DC Converters	Lessons 34-37
39	20-Apr-12	Isolated switch mode power supplies	H: 236-255
40	23-Apr-12	Isolated switch mode power supplies	H: 236-255
41	25-Apr-12	Industrial & Commercial Distribution Systems	Demonstration
42	27-Apr-12	Exam #3: Analogs, Power Electronics	Lessons 27-28, 30-40
		Wiring and Power Quality	
43	30-Apr-12	Industrial & Commercial Distribution Systems	Lab Handout
44	2-May-12	Industrial & Commercial Distribution Systems	Lab Handout
45	4-May-12	Power Quality	Demonstration, C:218-222
		Final Examination	
46	7-May-12	Final Exam: Due 2:30pm Pacific Time	Lessons 1-45

Textbooks

Circuits Text: Find and use your own text from your circuits course. If you lost yours, any calculus-based circuits textbook is fine. The major on-line book retailers have a good selection.

C: Chapman, Electric Machinery Fundamentals, Fifth Ed, ISBN 978-0073529547
We use the Fifth Edition for this course. The Third and Fourth Editions are pretty similar but the homework problems have different numbers.   This is the most popular text available for learning electric machines.

H Daniel W. Hart, Introduction to Power Electronics, ISBN 978-0073380674 (2010 edition)
This is the best introductory power electronics textbook that I have found. No other explains the basics like Dr. Hart.

Outreach Students:

ECE 320 requires completion of all four exams.
ECE 329 requires completion of the Final Exam only.

ECE 320
Homework
Intro to DC Machines

Recitation: Wednesday 29 February 2010

1. Problem 1.9 on page 58 in the textbook.

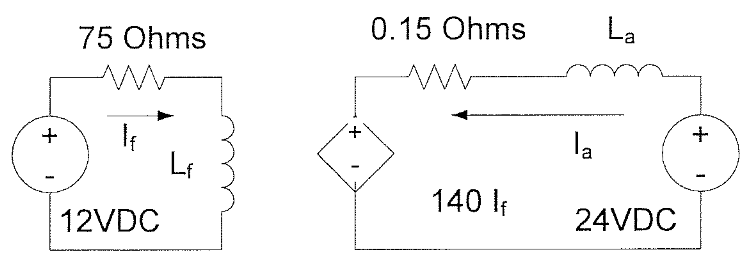
2. Problem 1.10 on page 58 in the textbook.

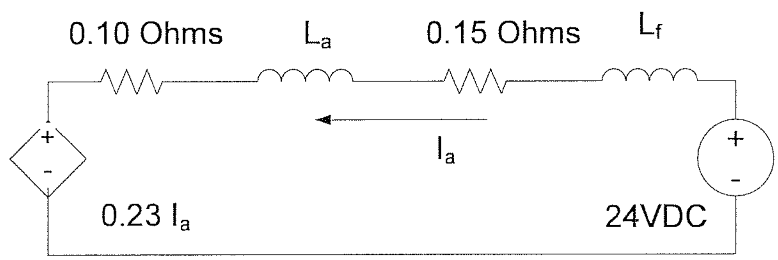
3. Problem 1.21 on page 63 of the textbook.

4. Identify the following parts of a DC machine. Your choice of method to identify them.

Armature	Field	Stator	Rotor
Leads	Terminals	Brushes	Field Poles
Field windings	Field magnets	Frame	End caps
Commutator	Armature winding	Teeth	Slots
Bearings	Shaft		

5. For the two circuits below, find the energy efficiency. The inputs are the independent sources; the outputs are the dependent sources.





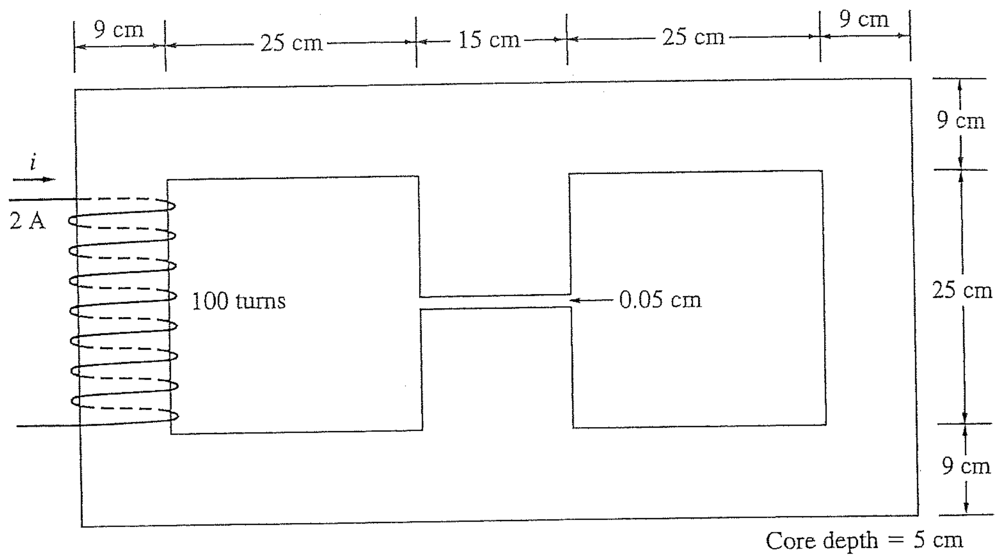


FIGURE P1–5
The core of Problem 1–8.

1–9. A wire is shown in Figure P1–6 that is carrying 2.0 A in the presence of a magnetic field. Calculate the magnitude and direction of the force induced on the wire.

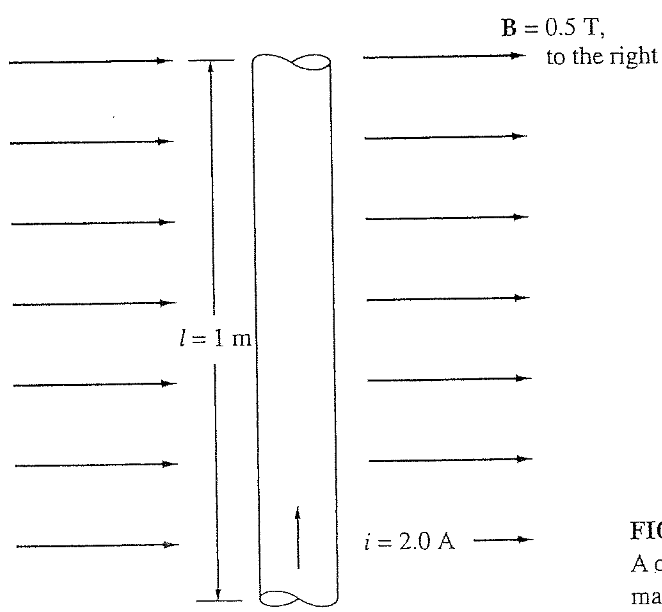


FIGURE P1–6
A current-carrying wire in a magnetic field (Problem 1–9).

1–10. A wire is shown in Figure P1–7 that is moving in the presence of a magnetic field. With the information given in the figure, determine the magnitude and direction of the induced voltage in the wire.

1–11. Repeat Problem 1–10 for the wire in Figure P1–8.

1–12. The core shown in Figure P1–4 is made of a steel whose magnetization curve is shown in Figure P1–9. Repeat Problem 1–7, but this time do *not* assume a constant value of μ_r. How much flux is produced in the core by the currents specified? What is the relative permeability of this core under these conditions? Was the assumption

(c) Assume that the switch shown in the figure is now closed, and calculate the current **I**, the power factor, and the real, reactive, and apparent power being supplied by the source.
(d) How much real, reactive, and apparent power is being consumed by each load with the switch closed?
(e) What happened to the current flowing from the source when the switch closed? Why?

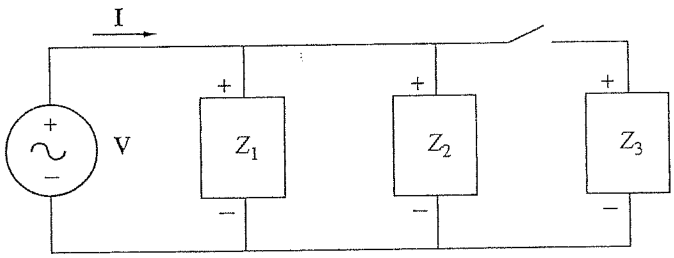


FIGURE P1–14
The circuit of Problem 1–19.

1–20. Demonstrate that Equation (1–59) can be derived from Equation (1–58) using simple trigonometric identities.

$$p(t) = v(t)i(t) = 2VI \cos \omega t \cos(\omega t - \theta) \tag{1–58}$$
$$p(t) = VI \cos \theta \, (1 + \cos 2\omega t) + VI \sin \theta \sin 2\omega t \tag{1–59}$$

Hint: The following identities will be useful:

$$\cos \alpha \cos \beta = \frac{1}{2}[\cos(\alpha - \beta) + \cos(\alpha + \beta)]$$
$$\cos(\alpha - \beta) = \cos \alpha \cos \beta + \sin \alpha \sin \beta$$

1–21. A linear machine shown in Figure P1–15 has a magnetic flux density of 0.5 T directed into the page, a resistance of 0.25 Ω, a bar length l = 1.0 m, and a battery voltage of 100 V.
(a) What is the initial force on the bar at starting? What is the initial current flow?
(b) What is the no-load steady-state speed of the bar?
(c) If the bar is loaded with a force of 25 N opposite to the direction of motion, what is the new steady-state speed? What is the efficiency of the machine under these circumstances?

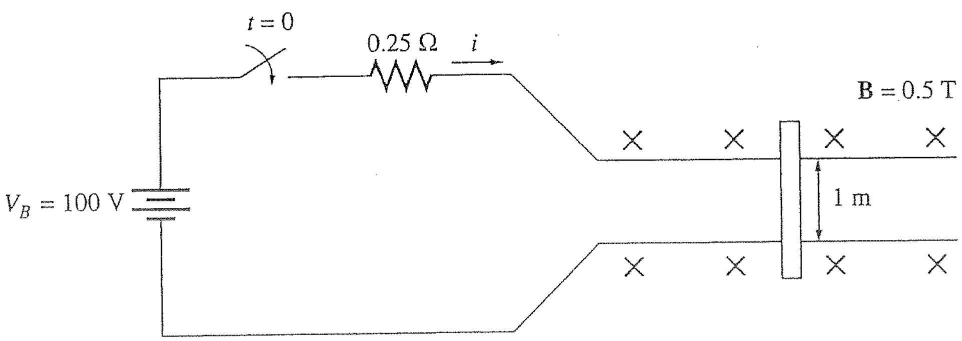


FIGURE P1–15
The linear machine in Problem 1–21.

University of Idaho

$\Theta = 0.524$

$\theta = 30 \cdot deg$

ECE 320

Energy Systems I

Lesson 17

Elementary DC Machines

Commutator

Brush

Rotor

Stator

Armature -> rotor   DC machine

Field -> Stator   DC Machine

Leads

Terminals

Field poles

Field windings

Field magnets

Armature winding

Slots

Teeth

Fan

Shaft

Bearings