EE201.3

Section 03

Mid-term Examination

October 23, 2001

Time allowed: 2 hours

Permitted: one 8.5” X 11” formula sheet, calculators

Instructions:

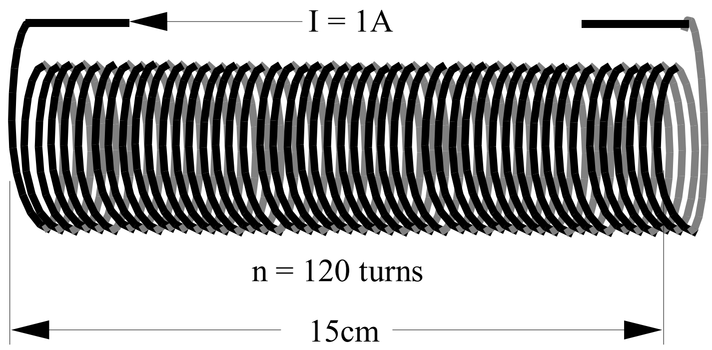
Do all questions
Weighting is indicated in the left margin
Show relevant work; use reverse side of pages if necessary
Circle or otherwise highlight your answers
Indicate your Student Number at the bottom of each page

Name: ______________________________

Student Number: ______________________

Question 1:

The tightly wound, air-core coil shown in the figure is excited by a current of 1A which produces a flux of 0.113μWb inside the coil.



[2] i) Calculate the inductance of the coil.

[2] ii) Estimate the diameter of the coil.

[1] iii) Will the inductance increase or decrease if an iron core is placed inside the coil?

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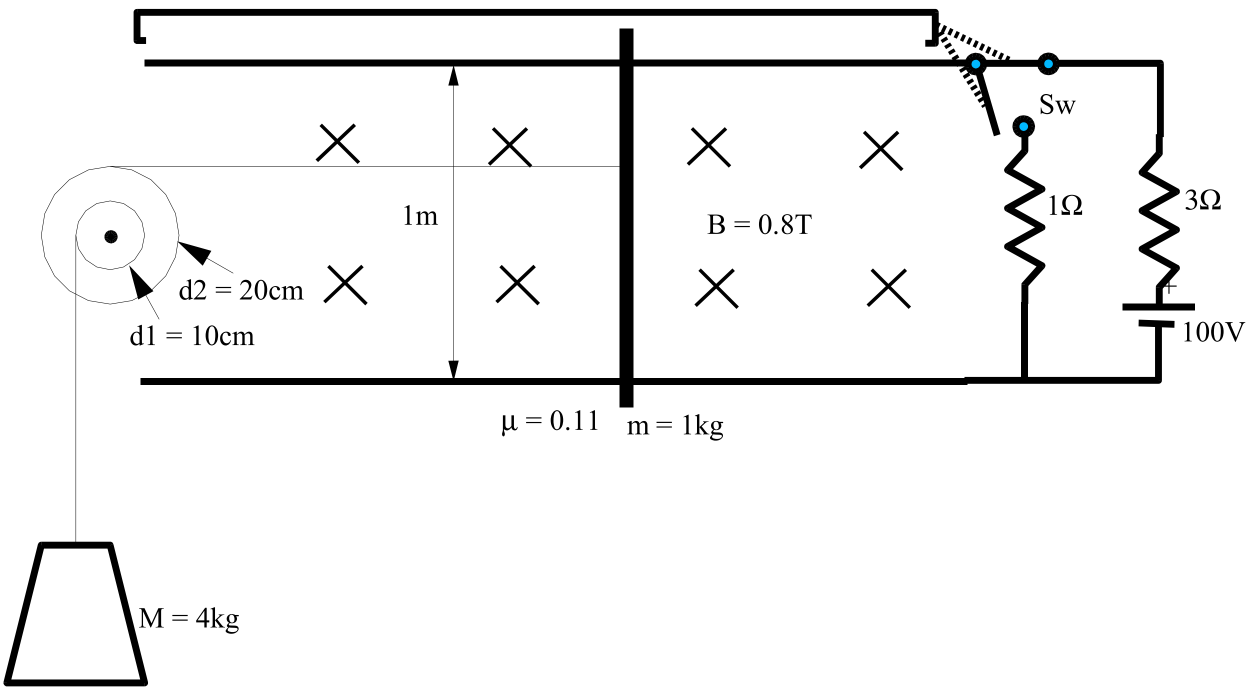
Question 2:

A bar (with no internal resistance) rests on two rails 1meter apart. A cable attached to the bar is wound around a cylinder with a diameter of 20cm. A weight with mass = 4kg is attached to another cable which is wound around another cylinder with a diameter of 10cm which is fixed to the same axel. A 100V battery and resistors are available to be connected to the rails through a switch arrangement. Assume the weight and friction from the cables as well as wind resistance etc. are negligible. Assume the bar is at rest before the switch is closed to connect the 100V battery to the rails through the 3Ω resistor. (Refer to the figure below.)



a) Immediately after the switch is closed (i.e. $t=0^+$), determine:

[1] i) the magnitude and direction of the current through the bar

[1] ii) the motional EMF of the bar, E_m

[1] iii) the magnetic force on the bar, F_{mag}

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[1] iv) indicate if the bar will move and in which direction.

b) Assume the rails are long enough for the system to reach "steady state" and determine:

[1] i) the magnitude and direction of the current through the bar

[1] ii) the motional EMF of the bar, E_m

[1] iii) the magnitude and direction of the velocity of the bar

[1] iv) whether the bar is acting as a motor or a generator.

c) When the bar reaches the end of the rails, it activates the switching arrangement such that the battery is *disconnected* from the system and a 1Ω resistor is now connected across the rails. Again assume the rails are long enough for the system to reach steady state and determine:

[1] i) the magnitude and direction of the current through the bar

[1] ii) the magnitude and direction (up or down) of the velocity of the weight, M

[1] iii) whether the bar is acting as a motor or a generator.

[1] iv) Draw a free body diagram for the bar.

d) From the data determined in part b) at steady state (battery and resistor connected):

[1] i) calculate the total *electric* power supplied to this system

[1] ii) indicate the source (i.e. where it comes from)

[1] iii) identify where it is consumed (including the quantity).

e) From the data determined in part c) at steady state (only resistor connected):

[1] i) calculate the total *mechanical* power supplied to this system

[1] ii) indicate the source (i.e. where it comes from)

[1] iii) identify where it is consumed (including the quantity).

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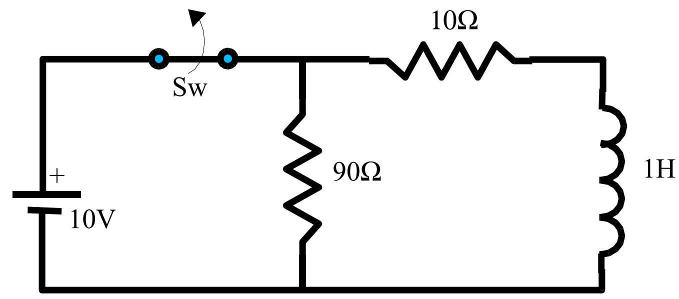
Question 3:

Consider the circuit shown in the accompanying figure. Assume the switch has been closed long enough for the system to reach steady state. Determine:



[1] i) the steady state current through the inductor

[1] ii) the steady state voltage across the inductor

[3] iii) the peak voltage that will appear across the switch contacts immediately after the switch is opened (i.e. at $t=0^+$).

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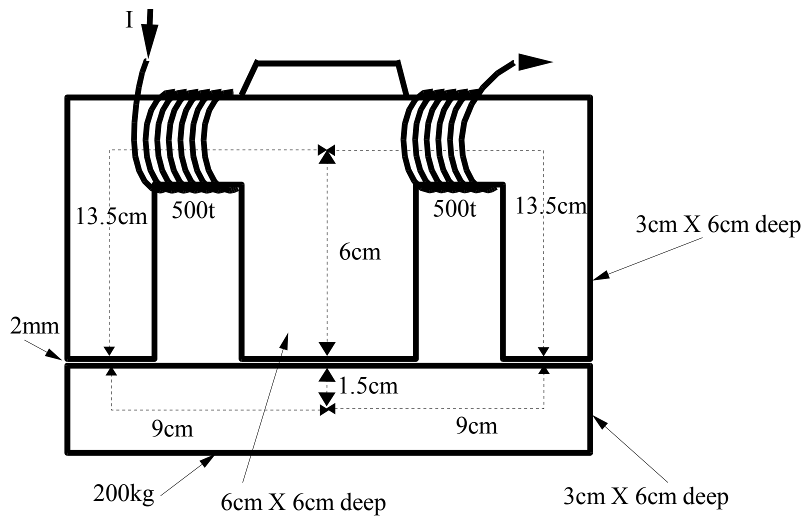
Question 4:



An electromagnet is use to remove hot ingots which have a mass of 200kg from a steel mill's conveyor (Note: temperature well below Currie temperature!). When attaching the electromagnet it can be brought to within 2mm of the ingots (i.e. assume a uniform air gap of 2mm). The magnet material and the ingot are both solid sheet steel. Some selected B-H data for sheet steel is shown below in Table 1. Neglect fringing at the air gaps (i.e. the air gap area is the same as the adjacent core area). Refer to the figure for other relevant data.

Some B-H data:

B (T)	0 - .2	.2 - .4	.4 - .5	.5 - .6	.6 - .7	.7 - .8	.8 - .9	.9 – 1.0	1.0 – 1.1
H (At/m)	90	100	110	120	130	140	150	175	250

Use the following table to help with your calculations:

Leg	**Φ**	**A**	**B**	**H**	**l**	**Hl**

[2] a) Determine the flux density required to start to lift the ingots.

[2] b) Draw an "electric equivalent" for this magnetic circuit.

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[2] c) What is the total flux flowing in the centre leg?

[2] d) What total NI (magnetomotive force) is required to produce this amount of flux?

[2] e) What current must flow through the windings to produce this flux?

[2] f) Once the ingot is attached (gap = 0mm), will the total flux in the centre leg increase of decrease?

[1] g) Once the ingot is attached (gap = 0mm), will the steady state current in the coil increase of decrease?

[2] f) If the current is supplied from a 100V ideal battery (i.e. no internal resistance), and the coils have a total resistance of 1Ω, how long will it take after the coil is energized to reach the level of current required to start to lift the ingots?