EE 201.3 (Section 03)

(Instructor: Denard Lynch)

Final Examination

Thursday, December 18, 2003

9:00 AM

Time Allowed: 3 Hours

Materials allowed: One 8½" X 11" sheet of notes, Calculators

Instructions:

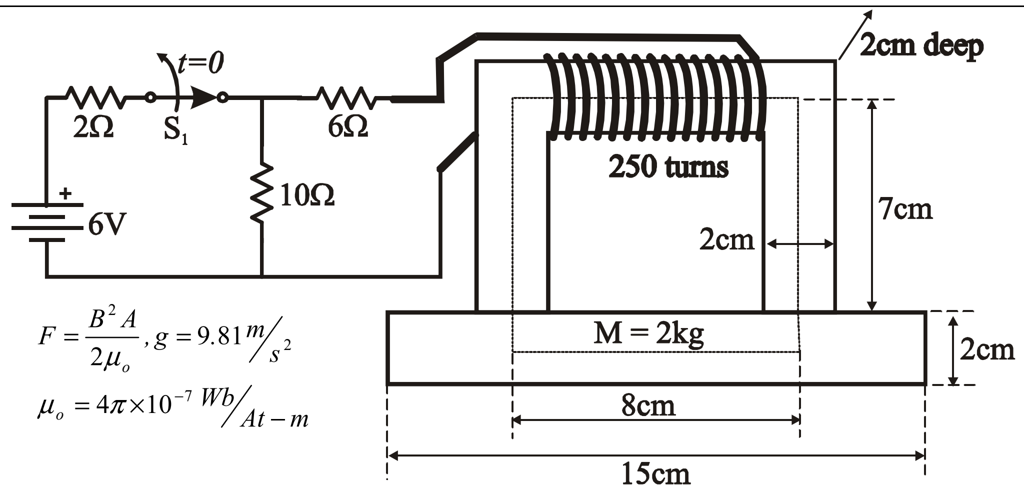
- **Answer all questions in the space provided (use page backs for rough work if necessary)**
- **State your assumptions; show all relevant work. Box, circle or otherwise highlight your answers. Please try to write neatly.**
- **Put your name and student number on the cover page; put *only* your student number on all remaining pages.**
- **Weighting for each question is indicated in the left margin (Total marks:50)**

2	3	4	5	6	7	Total
/9	/7	/7	/10	/6	/11	/50

Name:____

Student Number:__________________________________

For Questions 1.1 through 1.6, refer to the diagram of the electromagnet and associated circuit shown below:



$$F = \frac{B^2 A}{2\mu_o}, g = 9.81\, m/s^2$$

$$\mu_o = 4\pi \times 10^{-7}\, Wb/At-m$$

The switch, S_1 has been closed for a long time (>>5τ) so that a steady-state current is flowing in the winding of 250 turns, and the electromagnet is holding up a 2kg bar as shown. All ferromagnetic components are also 2cm deep so that all relevant cross-sections are 2cm X 2cm. Assume the ferromagnetic material is the same throughout and has a μ_r of 1850.

1.1 Determine the reluctance, $\Re$ of the total path the flux Φ must traverse.

[1]

1.2 What flux density, B, is required at the contact points to *just* support the 2kg bar?

[2]

⇒ For the remaining questions, assume that the total reluctance, $\Re$ of the flux path is 350,000 A-t/Wb. (Note: this *may* not be related in any way to the answer to 1.1 above.)

1.3 How much current would be required in the coil to produce a flux density, B of 0.35T in the core?

[2]

1.4 Assuming that μ is constant over the range of interest and the reluctance is as given above (350,000At/Wb), what is the inductance, L of the coil?

[1]

1.5 What is the steady-state current through the coil prior to the switch being opened?

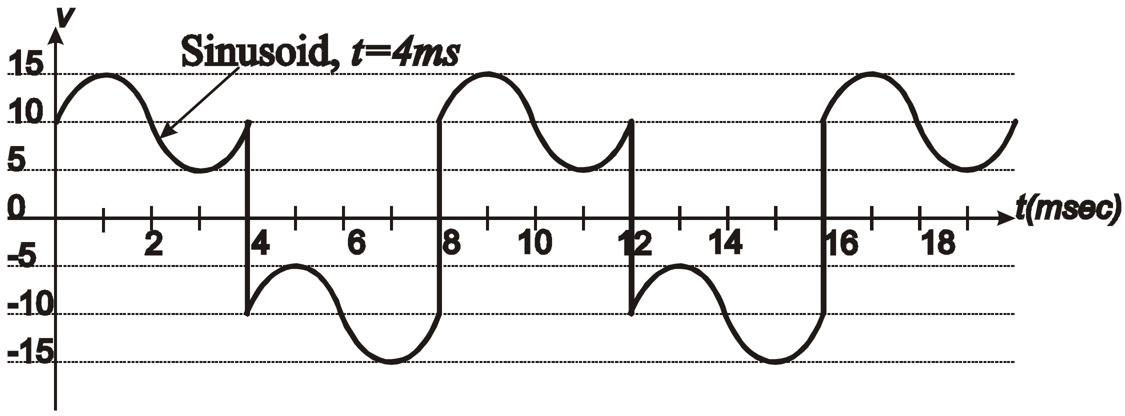
[1]

1.6 If we assume that a current of 0.25A will *just* hold up the bar, *and* that the inductance of the coil is 250mH, determine the time after the switch S_1 is opened until the bar starts to fall.

[2]

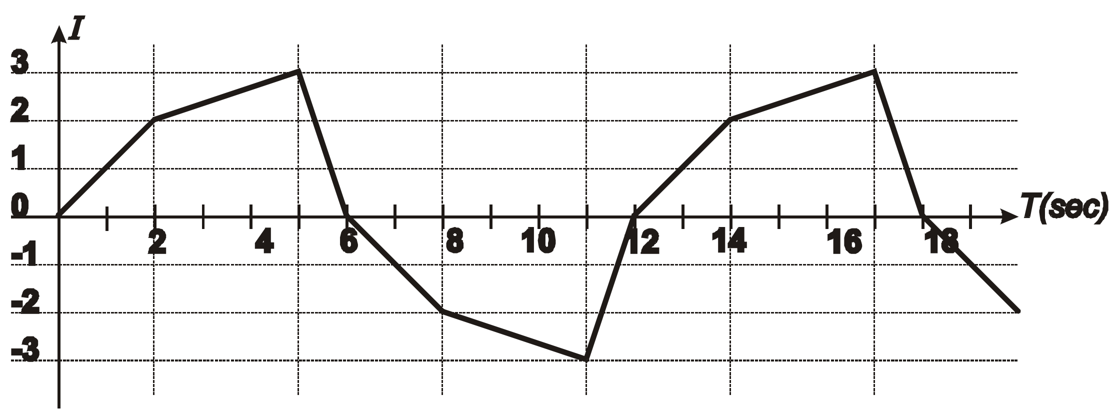
[2]

2.1 Find the *average* and *effective* (RMS) values of the following waveform. (Hint: you do not need to use calculus to solve this problem – use known values for common waveforms.)

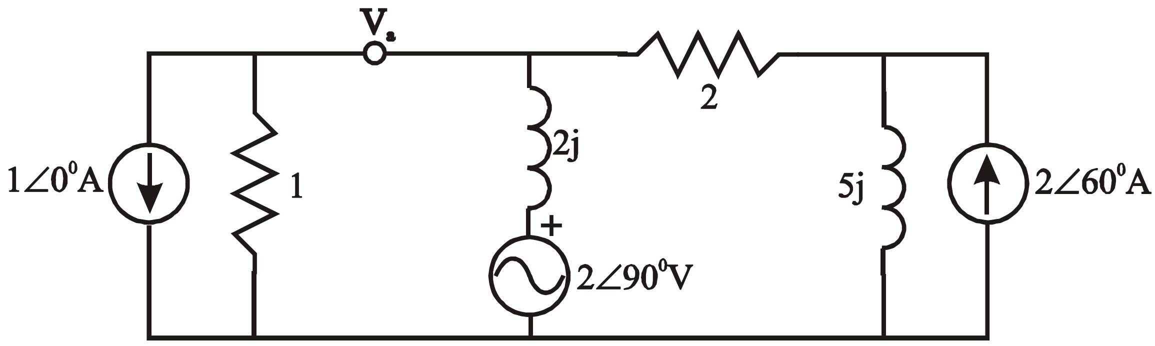


[5]

2.2 Use calculus to find the effective (RMS) value for waveform shown below:



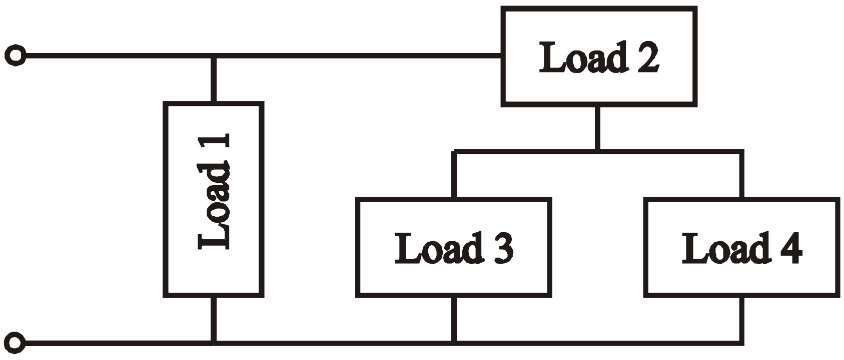
3.1 For the circuit shown below, find the voltage at the node labeled V_a.
[6]



3.2 Find the Power Factor, F_P, seen by the source for a combined load which uses an *apparent power*, S of 3800VA and a *reactive power*, Q of 1800$VAR_{Capacitive}$.
[1]

4.1 Find the total real power, *P*, reactive power, *Q*, and apparent power, *S*, for the combination of all the loads shown in the figure below. Draw and label the <u>*Power Triangle*</u> showing *P*, *Q*, and *S* in the complex plane.

[5]



The individual load characteristics are as follows:

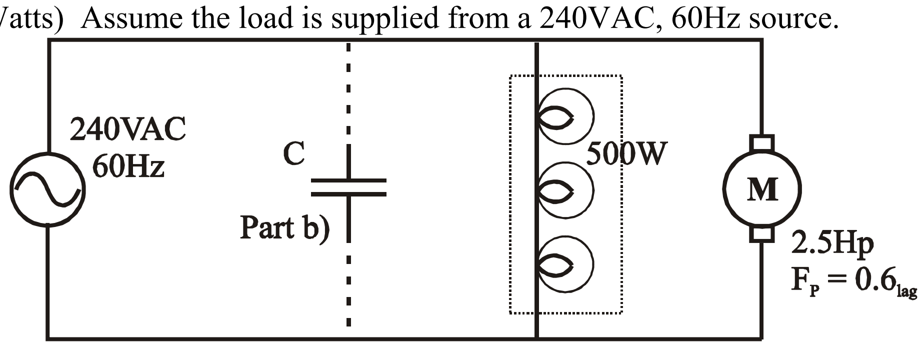
Load 1: P = 600W, Q = 400VAR_{IND}

Load 2: apparent power, S of 1060VA, $F_P = 0.73_{leading}$

Load 3: 800VAR_{IND}, $Z = 10\angle 36.9^0\Omega$

Load 4: P = 700W, S = 990VA (inductive load)

4.2 A small load, pictured below, consists of 500Watts of incandescent lighting (i.e. F_P = Unity), and a fully loaded 2.5Hp motor which is 100% efficient and has a Power Factor, F_P of $0.6_{lagging}$. (Note: 1Hp = 746Watts) Assume the load is supplied from a 240VAC, 60Hz source.

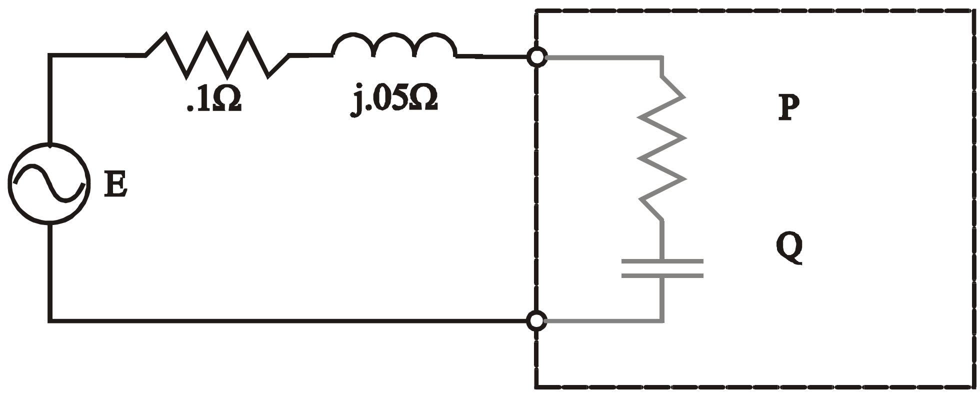


[2] **a)** What is the Power Factor for the combined lights and motor?

[2] **b)** Determine the *new* Power Factor if a 100µF capacitor is connected in parallel with the load.

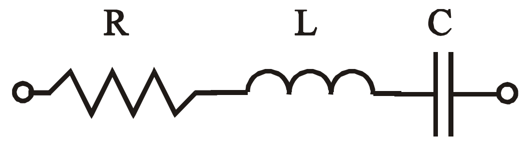
[1] **c)** What is the minimum VA rating for the 100µF capacitor in this situation?

[6] **5.1** Consider a source connected through a transmission line impedance to a load as shown below:



Determine the 2-element series equivalent circuit which will consume an amount of real power, P = 2.5W and reactive power, Q = 1.25VAR when the source, E is $1\angle 0$V. (Hint: You may need to use some algebra here!)

6.1 Consider a series resonant circuit as show in the diagram below (assume an ideal inductor):



a) Given R = 10Ω, L = 100mH and C = 0.068μF, find the resonant frequency, ω_s in Radian per second (R/s).

[1]

b) Given that C = 0.1μF, R = 220Ω and f_s = 1000Hz, find that Quality Factor, Q_s of the circuit at resonance.

[2]

c) Given R = 220, L = 100mH and C = 0.068μF, find the bandwidth of the circuit in Hz.

[2]

6.2 Design a series resonant circuit using a capacitor with a value of 0.022μF that will have half-power points (cut-off frequencies) of f_l = 3600Hz and f_2 of 4800Hz. (Assume an ideal inductor is available.)

a) What is the true (i.e. exact) centre frequency in Hz?

[1]

b) What value of inductor is needed to achieve this centre frequency?

[1]

c) If we assume that an *estimated* centre frequency of 4200 Hz is exact, What value of resistor is needed to achieve a bandwidth of 1200Hz?

[2]

6.3 Draw a phasor diagram showing v_R, v_L and v_C for a series resonant circuit with a total resistance, R of 220Ω and a Quality Factor at resonance, Q_s = 5 if the circuit is excited by a 10VAC source tuned to the resonant frequency.

[2]

6.4 If the average real power, P dissipated in the circuit described in 6.3 is measured to be 1W at resonance, what is the average reactive power, Q consumed by the circuit at resonance?

[1]