

National Exams December 2002

98-BS-4 Electric Circuits and Power

**3 hours duration**

**Notes:**

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit, with the answer paper, a clear statement of any assumptions made.
2. Candidates may use one of two calculators: a Casio FX-991 or a Sharp EL-540.
3. This is a closed book exam.
- 4 a. Candidates must answer Q1 and Q2, and three of Q3 - Q7 in Part 1 Basics of the exam.
  - b. Candidates must answer two out of the four questions of Part 2 Power.
  - c. Candidates must answer two out of the four questions of Part 3 Electronics.
5. Marks for each question are as indicated in square brackets associated with each part of each question

## 98-BS-4 Electric Circuits and Power

- For all of the numerical answers which you calculate, it is required that you clearly specify the units for all answers.

### PART 1 BASICS

The National Syllabus for this course shows the main topics and their weight in percent for the Basics section.

1.	Electrical quantities	3%
2.	Circuit principles and network theorems	10%
3.	Signal waveforms and transient response	7%
4.	Steady state AC circuits	16%
5.	Magnetic fields and circuits	10%

- Total value of 46%, appearing as 32 Marks in the following Questions.

- Please answer Q1, Q2 and 3 of Q3, Q4, Q5, Q6, Q7 (for a Total of 32 marks).

Q1. A Christmas tree light set is required that will operate from a 6 volt battery on a tree in a city park. The heavy-duty battery can provide 9 amps for the four-hour period of operation each night. Design a parallel set of lights, that is find the maximum number of lights that can be placed in the set, when the resistance of each bulb is 12 ohms.

[Total of 4 marks]

Q2. Suppose we have a circular potentiometer whose total resistance is 5,000 ohms. It is supplied by a 12 volt source. We wish to supply an electronic circuit, whose input resistance is 20,000 ohms, with 5 volts using the circular potentiometer in the voltage divider mode. Specify the setting for the circular potentiometer.

[Total of 4 marks]

Q3.

- a. Using Mesh Equation, find the values of the voltages  $v_1$  and  $v_2$ .  
[6 marks]
- b. Then find the current flowing from left to right in the 2 ohm resistor  
[2 marks].
- [Total of 8 marks]

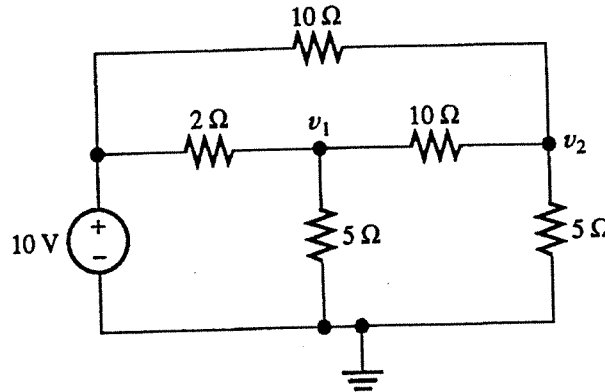


Figure for Question 3.

- Q4. The periodic current waveform  $i(t)$  shown is flowing in the series R-L branch indicated. Calculate and plot the variation of  $v_{AB}$  with time from 0 to 12 msec.  
[Total of 8 marks].

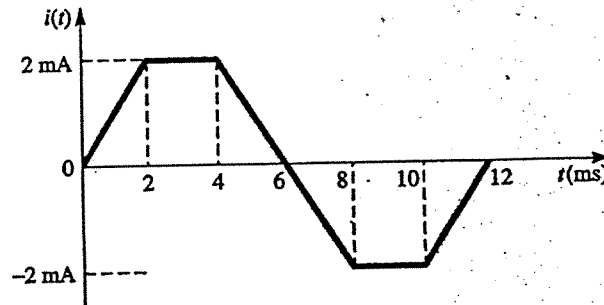
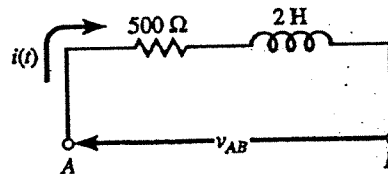


Figure for Question 4



Q5. An AC electrical load of 2500 watts has a power factor of 0.8 lagging, and is supplied at a voltage of 200 volts. The source frequency is 1000 Hz. Graph, that is plot, the  $v(t)$  and  $i(t)$  of the load on the same axis.  
 [Total of 8 marks]

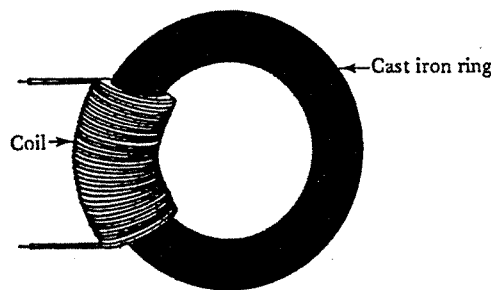
Q6. A 240 volt, 60 Hz source is connected to two parallel loads

1. Load 1 - A 15 kW load with an 86.6% power factor lagging.
2. Load 2 - A 15 kVA load with a power factor angle of  $30^\circ$  leading.

- A. Determine the reactive power of the source in kVA. [2 marks].
- B. Determine the apparent power of the source [2 marks].
- C. Determine the source current which would be measured by an ammeter [2 marks].
- D. Determine the power factor of the source [2 marks].

[Total of 8 marks]

Q7. A cast iron ring has a 2500 turn coil as shown on the diagram. The coil is supplied by a 120 volt source. The cross sectional area of the ring is  $4 \text{ cm}^2$ , and the length of the magnetic path is 20 cm. The core has a relative permeability of 100,000.  $\mu_0 = 4 \pi \times 10^{-7} \text{ H/m}$



- a Add a second winding which will supply 24 volts to a resistive load connected across it. [3 marks]
  - b If a resistive load of 2 ohms is connected across the second coil, find the input volt-amps to the 2500 turn coil shown. [3 marks]
  - c What resistance does the 120 volt source see? [2 marks]
- [Total of 8 marks]
- .....

## PART 2 POWER

The National Syllabus for this course shows the main topics and their weight in percent for the Power section.

6.	Transformers	10%
7.	DC machines	10%
8.	AC machines	10%

- Total value of 30%, appearing as 20 Marks in the following Questions.

Please answer 2 of 4 questions from this Power area (for a Total of 20 marks)

Q8. Three single phase transformers each rated 250 kVA, 7200/600 volts have been purchased by an industrial plant. The available voltage on the three-phase transmission line coming to the plant is 12,470 volts (line-to-line). Rated three-phase load is taken by the industrial plant at 600 volts.

- Find the current in the primary windings of the three-phase transformer [3 mark].
- Find the current in the secondary windings of the transformer [3 mark].
- Calculate the kVA rating of the three-phase transformer [2 marks].
- If the load on the transformer is at 0.85 power factor lagging, what is the maximum allowable kW value for this load. [2 marks].

[Total of 10 marks]

Q9. A 120 volt dc motor drives a conveyor. The armature resistance is 0.24 ohms, the field resistance is 120 ohms, and the rotational losses are 160 watts. On full load, the line current is 16.5 amps and the motor runs at 680 RPM.

- What is the power available to produce torque? [4 marks]
- What is the output power? [2 marks]
- What is the output torque? [4 marks]

[Total of 10 marks]

Q10. A 750 kVA, 2400 volt, 60 Hz, Y-connected synchronous generator has a no-load voltage of 2880 volts (line to line). The generator is operated at rated voltage, rated kVA, and a lagging power factor of 0.866.

(i) Calculate the synchronous reactance of the generator (neglect resistance) [5 marks].

(ii) Calculate the torque angle [5 marks]

[Total of 10 marks]

Q11. A 3-phase, 600 volt, 60-Hz, 20-hp induction motor provides rated torque to a crusher load at a slip of 5%.

Determine:

(a) The speed of the rotor with respect to the stator (in RPM) [2 marks]

(b) The speed of the stator field with respect to the rotor field (in RPM) [3 marks]

(c) The torque provided by the motor [5 marks]

[Total of 10 marks]

### PART 3 ELECTRONICS

The National Syllabus for this course shows the main topics and their weight in percent for the Electronics section.

9. Semiconductor diodes and rectifiers 8%

10. Simple transistor amplifiers and switches 8%

11. Introduction to digital logic and devices 8%

• Total value of 24%, appearing as 16 Marks in the following Questions.

Please answer 2 of 4 questions from this Electronics area (for a Total of 16 marks).

Q12. We have a voltage input of  $v_i = 20 \sin 1000 t$ .

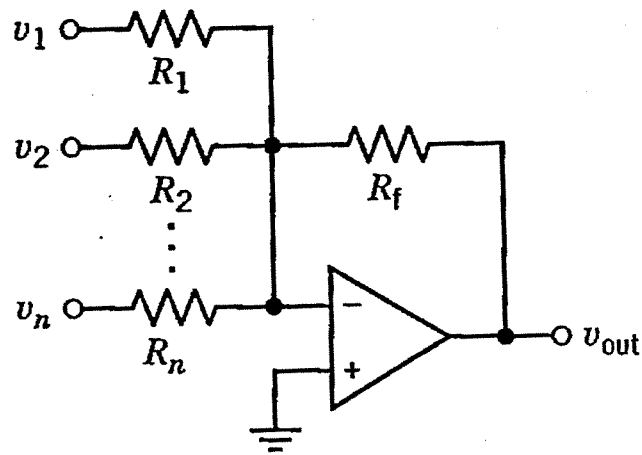
Ideal diodes, a resistor, and a d-c voltage source are available to you.

A. Design a clipping and rectifying circuit that will provide an output voltage which is never negative and which is clipped at a maximum value of 12 volts [6 marks].

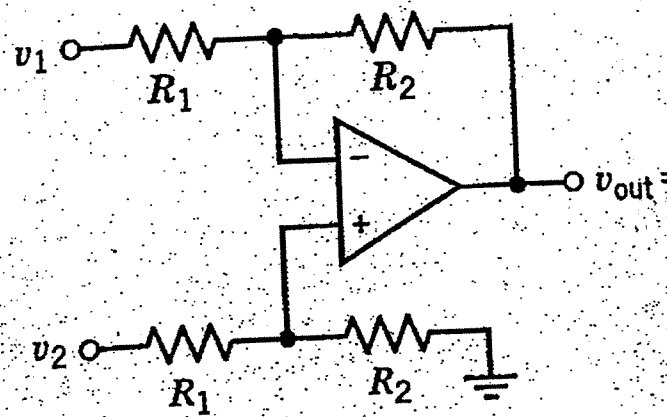
B. Sketch the output voltage [2 marks]

[Total of 8 marks]

Q13. Assume that the operational amplifiers of this question are ideal.  
 A. Write the expression for  $v_{out}$  for this circuit. [4 marks]



B. Write the expression for  $v_{out}$  for this circuit. [4 marks]



[Total of 8 marks]

Diagrams for Question 13

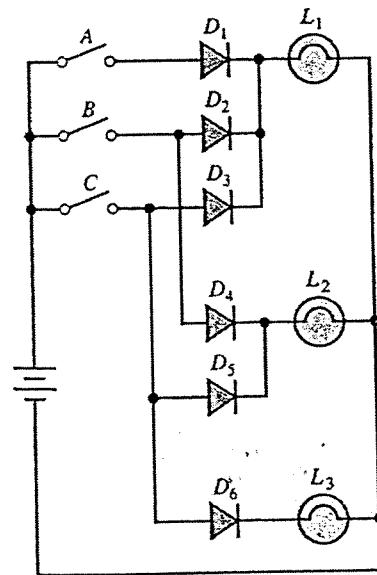
Q14. The voltage measurements of an npn BJT show that  $v_{BE} = 0.7$  volts and  $v_{CE} = 4$  volts, while its current measurements reveal that  $i_C = 1$  mA and  $i_B = 10$  microamps.

- In which region does the BJT operate. [2 marks]
  - Find the values of  $I_S$  (scale current),  $i_E$ ,  $\beta$ , and  $\alpha$  [6 marks]
- [Total of 8 marks]

Q15.

- Convert  $123_{10}$  from decimal to binary representation. [2 marks]
- Convert  $0.1102_2$  from binary to decimal representation [2 marks]
- The logic circuit has ideal diodes.

Figure for Question 15



Complete the following three statements: [4 marks]

Lamp  $L_1$  is illuminated when \_\_\_\_\_

Lamp  $L_2$  is illuminated when \_\_\_\_\_

Lamp  $L_3$  is illuminated when \_\_\_\_\_

[Total of 8 marks]

**END OF EXAM**