ENGINEERING 2C03

DAY CLASS Dr. Wm. Garland

DURATION: 3 hours

McMASTER UNIVERSITY FINAL EXAMINATION April 20, 1999

Special Instructions:

1. Closed Book. All calculators and up to 6 single sided 8 ½" by 11" crib sheets are permitted.
2. Do all questions.
3. The value of each part is as indicated. TOTAL Value: 100 marks

THIS EXAMINATION PAPER INCLUDES 2 PAGES AND 10 QUESTIONS. YOU ARE RESPONSIBLE FOR ENSURING THAT YOUR COPY OF THE PAPER IS COMPLETE. BRING ANY DISCREPANCY TO THE ATTENTION OF YOUR INVIGILATOR.

1. [10 marks] A certain toaster has a heating element made of Nichrome resistance wire. When first connected to a 120V voltage source (and the wire is at a temperature of 20.0 °C), the initial current is 1.80 A but begins to decrease as the resistive element heats up. When the toaster has reached its final operating temperature, the current has dropped to 1.53 A. The temperature coefficient of resistivity, α, for Nichrome is 0.4×10^{-3} / °C.
   a. Find the power the toaster consumes when it is at its operating temperature.
   b. What is the final temperature of the heating element?

2. [10 marks] In figure 1, find
   a. the current in the 20 Ω resistor and
   b. the potential difference between points *a* and *b*.

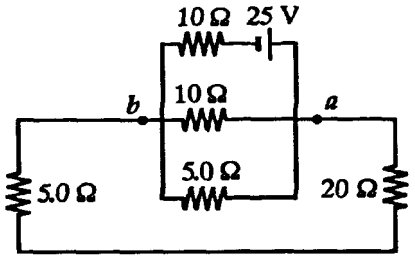

Figure 1

3. [10 marks] An inductor *(L* =400 mH), a capacitor (*C* =4.43 μF), and a resistor *(R* = 500 Ω) are connected in series. A 50.0 Hz ac generator produces a peak current of 250 mA in the circuit.
   a. Calculate the required peak voltage *Vmax* .
   b. Determine the angle by which the current leads or lags the applied voltage.

4. [10 marks] Determine the current (magnitude and direction) in each branch of figure 2.

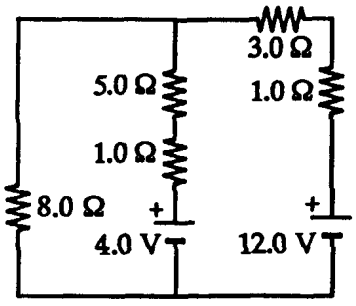

Figure 2

continued on page 2...

5. [5 marks] The concrete sections of a certain superhighway are designed to have a length of 25.0 m. The sections are poured and cured at 10 °C. What minimum spacing should the engineer leave between the sections to eliminate buckling stress if the concrete is to reach a temperature of 50 °C? The linear expansion coefficient, α, for concrete is 12×10^{-6} / °C.

6. [10 marks] Around a crater formed by an iron meteorite, 75.0 kg of rock has melted under the impact of the meteorite. The rock has a specific heat of 0.800 kcal/kg °C, a melting point of 500°C, and a latent heat of fusion of 48.0 kcal/kg. The original temperature of the ground was 0.0°C. If the meteorite hit the ground while moving at 600 m/s, what is the minimum mass of the meteorite? Assume no heat loss to the surrounding unmelted rock or the atmosphere during the impact. Disregard the heat capacity of the meteorite. Recall that 1 calorie = 4.186 J.

7. [10 marks] A Thermopane window of area 6.0 m^2 is constructed of two layers of glass, each 4.0 mm thick separated by an air space of 5.0 mm. If the inside is at 20°C and the outside is at -30 °C, what is the heat loss through the window? The thermal conductivity of air is 0.0234 W/m°C and that for glass is 0.80 W/m°C. Ignore the insulation value of the surrounding air.

8. [10 marks] A house loses thermal energy through the exterior walls and roof at a rate of 5000 J/s = 5.00 kW when the interior temperature is 22°C and the outside temperature is -5°C. Calculate the electric power required to maintain the interior temperature at 22°C for the following two cases:
   a. The electric power is used in electric resistance heaters (which convert all of the electricity supplied to thermal energy).
   b. The electric power is used to operate the compressor of a heat pump (which has a coefficient of performance equal to 60% of the Carnot cycle value).

9. [15 marks] The circuit in figure 3 has been connected for a long time.
   a. What is the voltage across the capacitor?
   b. If the battery is disconnected, how long does it take the capacitor to discharge to 1/10 of its initial voltage?

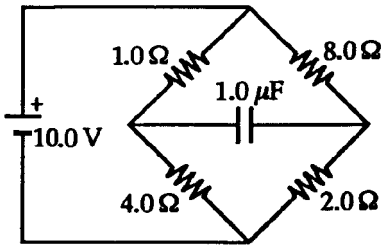

Figure 3

10. A particular engine has a power output of 5.0 kW and an efficiency of 25%. If the engine expels 8000 J of thermal energy in each cycle, find
    a. the heat absorbed in each cycle and
    b. the time for each cycle.

The End