UNIVERSITY OF DUBLIN

TRINITY COLLEGE

FACULTY OF ENGINEERING & SYSTEM SCIENCES

School of Engineering

Department of Computer Science

BA (Mod) Computer Science **Trinity Term 2000**

Junior Freshman Supplemental Examination

1BA5 - Electrotechnology I

Friday, 26th May, 2000 Luce Hall 14.00 - 17.00

Mr. A. Donnelly

Attempt questions A **and** B and **FOUR** other questions.
All questions carry equal marks.
Mark your answers to question A on the examination paper and hand it up with your answer book

(NOTE: the marks written beside each question are intended as a rough guide as to how questions will be marked.
Concentrate your efforts accordingly !)

A. In each of the multiple choice questions which follow, select the answer which best reflects the (whole) truth, and mark your answer in the box provided.
Write your candidate identifier on this paper and hand it up with your solution.
You gain 1 mark for each correct answer.
You lose $\frac{1}{4}$ of a mark for each incorrect answer.
No marks are awarded (or deducted) for unanswered multiple choice questions.

A.1. Resistivity increases with temperature in copper and decreases with temperature in silicon because

(a) copper is a conductor and silicon is a semi-conductor []

(b) electrons become less mobile in copper at high temperatures and more mobile in silicon []

(c) electrons become more numerous in silicon at high temperatures and less numerous in copper at high temperatures []

(d) electrons become less mobile in copper at high temperatures and there are relatively few more available, whereas in silicon there are much more available at high temperatures. []

(e) none of the above []

A.2. A resistor marked Red Red Orange Gold reads 19 kΩ ± 1kΩ when measured with an ohmmeter. The deviation from the marked/stated value is

(a) - 18.2 % to -9.1 % []

(b) ± 5.3 % []

(c) ± 5 % []

(d) - 13.9 % to -4.3 % []

(e) impossible to tell []

A.3. A 330 Ω ± 0.5% resistor would have the following colour bands

(a) orange orange brown []

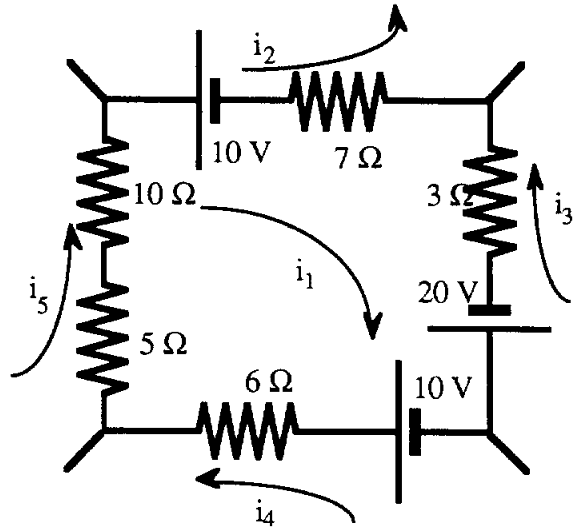
(b) orange orange brown gold []

(c) orange orange red gold []

(d) none at all []

(e) orange orange red []

A.4. The KVL equation for loop 1 is:



(a) $20 + 31i_1 - 7i_2 + 3i_3 + 6i_4 + 15i_5 = 0$ []

(b) $0 = 31i_1 - 3i_2 + 17i_3 + 6i_4 + 15i_5$ []

(c) $20 = 31i_1 + 7i_2 - 3i_3 + 6i_4 + 15i_5$ []

(d) $20 = 31i_1 - 7i_2 - 3i_3 - 6i_4 + 15i_5$ []

(e) $-20 = 31i_1 - 7i_2 + 3i_3 - 6i_4 - 15i_5 = 0$ []

A.5. A 3Ω and a 4Ω resistor are connected in parallel, all in series with a 5Ω which is all in parallel with a 10Ω resistor. The total equivalent resistance is

(a) 4Ω []

(b) just over 4Ω []

(c) 3Ω []

(d) just under 5Ω []

(e) none of the above []

A.6. The heat output from a 10 Ω resistor powered by a real DC source equivalent to an ideal 20 V voltage source in series with a 10 Ω internal resistance is:

(a) 40 W []

(b) 10 W []

(c) zero []

(d) just under 40 Joules []

(e) none of the above []

A.7. A circuit consisting of a real DC source (equivalent to a series internal resistance and an ideal voltage source) driving a single load resistance is at its most efficient when

(a) the internal cell resistance is zero []

(b) the load resistance is very large in relation to the internal cell resistance []

(c) the load is absorbing the maximum power from the source []

(d) load resistance and internal cell resistance are equal []

(e) none of the above

A.8. A circuit consisting of a real DC source (equivalent to a series internal resistance and an ideal voltage source) driving a single load resistance is at its most efficient when

(a) the internal cell resistance is zero []

(b) the load resistance is very large in relation to the internal cell resistance []

(c) the load is absorbing the maximum power from the source []

(d) load resistance and internal cell resistance are equal []

(e) none of the above []

A.9. A circuit consisting of a real DC source (equivalent to a series internal resistance and an ideal voltage source) driving a single load resistance is at its most efficient when

(a) the internal cell resistance is zero []

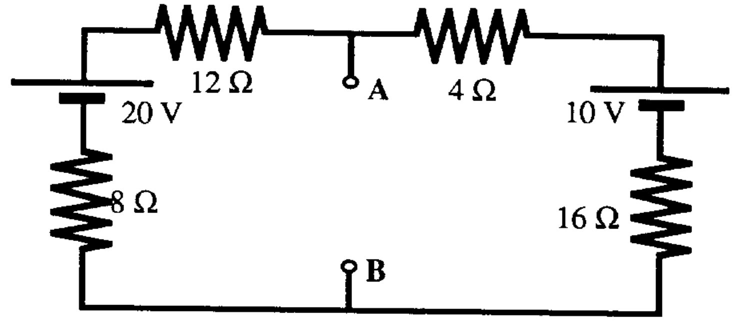
(b) the load resistance is very large in relation to the internal cell resistance []

(c) the load is absorbing the maximum power from the source []

(d) load resistance and internal cell resistance are equal []

(e) none of the above []

A.10. The Thévinin equivalent of the circuit opposite between A and B is given by (R_{TH},E_{TH}):



(a) 10 Ω, 25V ▯

(b) 10 Ω, 15V ▯

(c) 40 Ω, 15V ▯

(d) 40 Ω, 5V ▯

(e) none of the above ▯

A.11. Self inductance is:

(a) the ratio of induced back-emf to the rate of change of current ▯

(b) the ratio of the rate of change of induced back-emf to current ▯

(c) the ratio of the rate of change of induced back-emf to the rate of change of current ▯

(d) the ratio of the induced back-emf to current ▯

(e) none of the above ▯

A.12 RMS averages are often quoted in AC circuits because

(a) this figure reflects the average value of the waveform without being confused by the cancelling effect of the sign changes ▯

(b) the RMS value is more accurate ▯

(c) RMS values are more convenient ▯

(d) an AC current of 1 Amp has the same average power as a DC current of the same value ▯

(e) trick question ! there is no advantage to RMS values ▯

A.13. Fill in the blanks in the following statement:
"In a certain AC load, the current leads the voltage by 30°. The load is __X__ and could have a value __Y__", where

(a) X = capacitive, and Y = $100(\sqrt{3} + j)\ \Omega$ []

(b) X = resistive, and Y = $5\ \Omega$ []

(c) X = inductive, and Y = $17(1 + j\sqrt{3})\ \Omega$ []

(d) X = capacitive, and Y = $0.05(\sqrt{3} - j)\ \Omega$ []

(e) none of the above []

A.14. The impedance of a series combination of a 30 Ω resistor and a 53 μF capacitor and a 95 mH inductor at 50 Hz. is

(a) $30 - j30\ \Omega$ []

(b) $30 + j30\ \Omega$ []

(c) $24 + j12\ \Omega$ []

(d) $24 - j12\ \Omega$ []

(e) none of the above []

A.15. Power factor is

(a) a measure of the efficiency of the load []

(b) a measure of the efficiency of the load-source combination []

(c) a measure of how much of the transmitted power is actually used in the load []

(d) a measure of how much of the transmitted power is actually wasted in the load []

(e) the proportion of peak power transmitted which is actually dissipated on average in the load []

A.16. A simple low-pass filter circuit might consist of

(a) input voltage across a series combination of capacitor and inductor, and output voltage taken across the capacitor. []

(b) input voltage across a series combination of capacitor and inductor, and output voltage taken across the inductor. []

(c) input voltage across a parallel combination of capacitor and inductor, and output voltage taken across the capacitor. []

(d) input voltage across a parallel combination of capacitor and inductor, and output voltage taken across the inductor. []

(e) none of the above []

A.17. Gauss' Law states that the integral over an entire surface of the dot product of the Electrostatic Field Intensity **E** with the local area vector **dA**, equals the charge below the surface divided by $\varepsilon_0\varepsilon_r$

(a) **E** and **dA** must be perpendicular. []

(b) **E** and **dA** must be parallel []

(c) the surface should be <u>closed</u> and the charge <u>enclosed</u>. []

(d) (a) and (c) above []

(e) (b) and (c) above []

A.18. "Electrostatic Potential at a point in an electric field is the work done in bringing a unit charge from infinity to the point in question". This definition

(a) is correct. []

(b) omits an essential reference to the zero of potential. []

(c) the unit charge must be positive. []

(d) (b) and (c) above. []

(e) none of the above alternatives. []

A.19. A small current flows through a reverse-biased semi-conductor PN junction because:

(a) no diode is perfect at cutting down current to zero. []

(b) the number of electrons cannot be reduced to zero. []

(c) the number of holes cannot be reduced to zero. []

(d) electrons and holes are often produced in pairs. []

(e) electrons and holes are often produced in pairs throughout the junction, even in the depletion region. []

A.20. In a full-wave rectified power supply containing two diodes and a centre-tapped transformer with a 12-0-12 V peak secondary output, the non-conducting diode must be capable of withstanding a reverse voltage of

(a) 12 V []

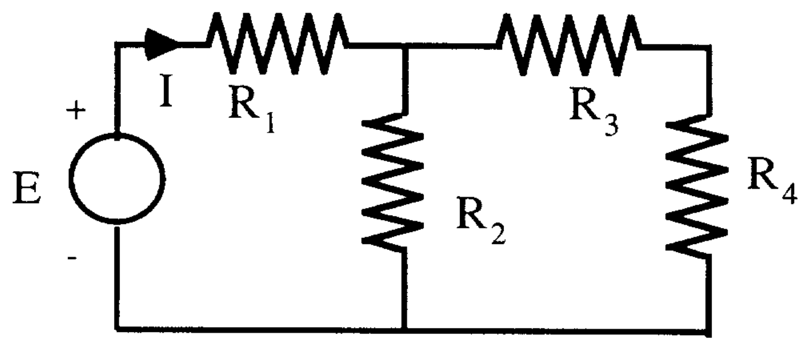
(b) 6 V []

(c) 24 V []

(d) alternately 12 v and 24 V []

(e) none of the above []

B. Describe briefly how the overall current, I, in the circuit below would be measured. Describe any precautions that should be taken (and the reasons for them) when the values of all components are measured. (6 marks)



State the rules for the propagation of errors in an arithmetic expression. Illustrate them by calculating the overall resistance of the above circuit (as seen by the supply, E), given the following actual measurements: (6 marks)

$E = (5 \pm 0.2)$ V	$R_1 = (102 \pm 2)\ \Omega$	$R_2 = (115 \pm 4)\ \Omega$
	$R_3 = (480 \pm 10)\ \Omega$	$R_4 = (155 \pm 3)\ \Omega$

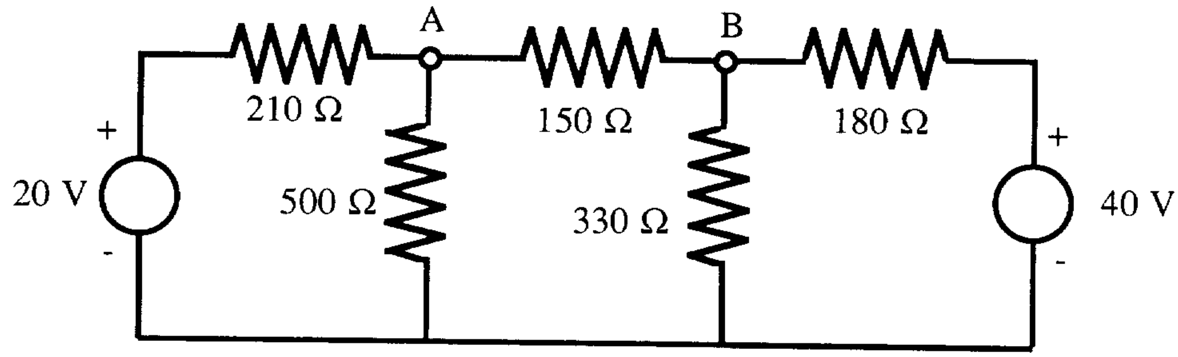
P.T.O.

The actual current flowing is found to be 6.9 mA (contrary to expectations). A wiring error is found that when corrected, causes the expected current to flow. What is this wiring error? Justify your answer with a circuit diagram and a calculation of the expected current and of the observed 6.9 mA (from your circuit containing the fault).

(8 marks)

C. Using the Theorem of Superposition, calculate the current flowing between A and B in the 150 Ω resistor in the circuit below.

(14 marks)

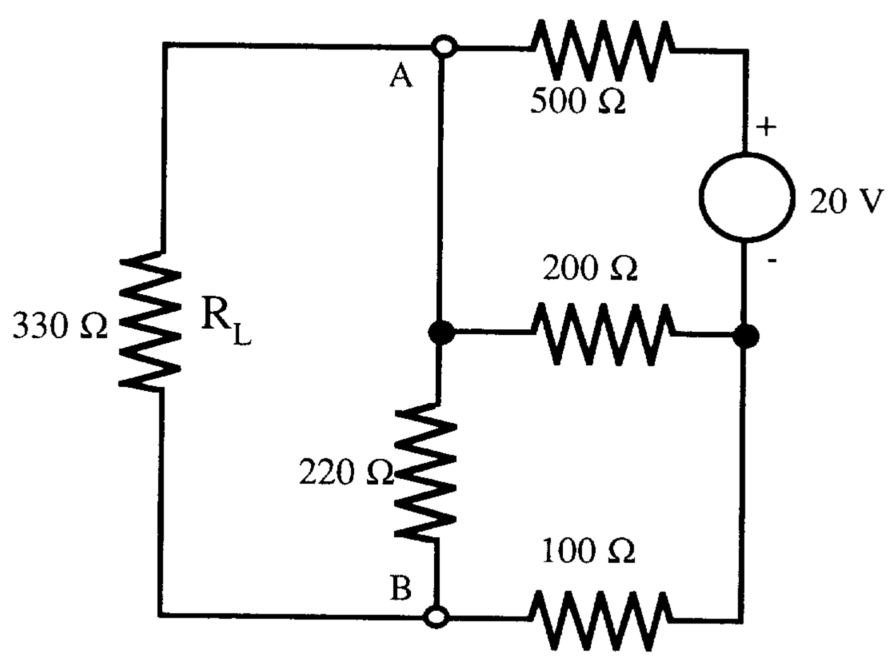


If the 20 V source were replaced with a 50 V source, what total current would flow? Explain your reasoning.

(6 marks).

D. Redraw the circuit below so that parallel and series combinations are clearer and obvious from the circuit diagram. Indicate nodes A and B on the new circuit diagram.

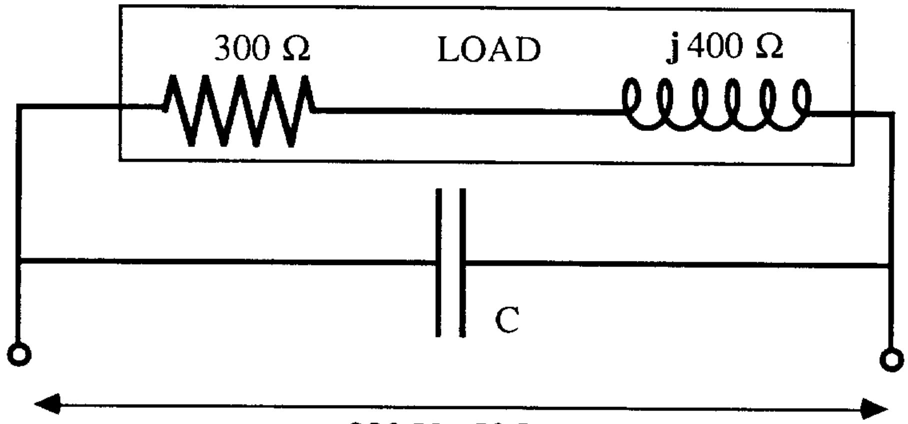
(4 marks)



Calculate the Thévinin Equivalent parameters of the circuit obtained when the 330 Ω load resistor between A and B is removed. Hence, or otherwise, calculate the current

flowing through the 330 Ω resistor in the original circuit.
What load resistor would draw maximum power from the circuit? (16 marks)

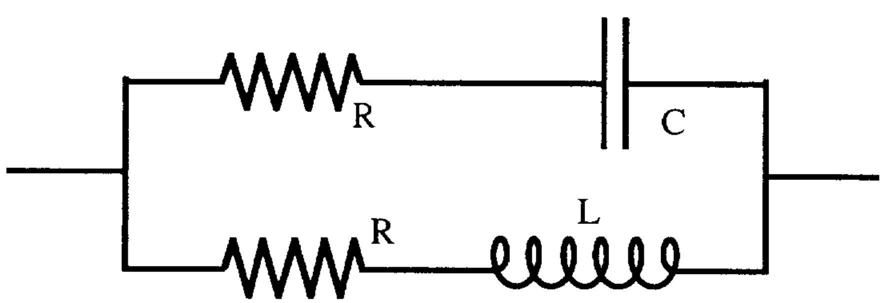
E. Define the terms, True Power, Reactive Power and Apparent Power with reference to AC circuits, giving formulae for each. (3 marks)



Calculate the power factor of the above (300 + j400) Ω load and the value of the power factor correction capacitor necessary to bring the overall power factor to 0.9 leading. (14 marks)

Fully specify the transformer required to supply the above load (including C) from a 3 kV supply. (3 marks)

F. Explain how the circuit below can be used to improve the performance of Hi-Fi loudspeakers. Indicate the position in the circuit of woofer and tweeter. (6 marks)



Demonstrate mathematically how the network may be made to appear purely resistive at all frequencies. Why is this property useful? Hence design such a circuit for 8 Ω loudspeakers using a 300 mH inductor. (14 marks)

G. Define the terms Electric Field, Electric Field Intensity, Potential and Capacitance. (4 marks)

State Gauss's Law and use it to calculate the electric field intensity a perpendicular distance, a, away from an infinite plane of charge that is uniformly distributed with density δ Coulombs/m^2. Hence calculate the potential between two parallel plates of area, A, distance, d, apart which have been oppositely charged to +Q and -Q. (8 marks)

Hence deduce the capacitance of the configuration. Calculate the overall capacitance of two parallel plate capacitances C_1 and C_2 that have the same plate separation, d, but differing plate areas d_1 and d_2. Express your answer in terms of C_1 and C_2. (8 marks)

H. Explain how a semi-conductor diode works. Your account should define the terms P-type material, N-type material, depletion region and majority / minority carriers. (8 marks)

Draw the circuit diagram and briefly describe the operation of a bridge-rectified power supply. Design such a circuit to supply 30 V at 500 mA DC from the 220 V, 50 Hz AC mains supply. Fully specify all components. What component(s) are required in the circuit (and where) to keep the ripple factor below 3% ? (12 marks)