Examination Period 3: 2016/17

**Module Title**  
Electrical Principles

**Level**  
Four

**Time Allowed**  
Two hours

Instructions to students:

- Enter your student number **not** your name on all answer books.
- Answer **all** questions.
- All questions are equally weighted. Where a question has more than one part the division of marks is stated.
- The use of an electronic calculator of an approved type is permitted.
- Formula booklet will be provided.
- Students are **not** permitted to remove the examination paper from the examination room. For all purposes the examination paper remains the property of the University of Northampton.

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Answer all questions.

1. For the circuit shown in Figure Q1, calculate:
   a. The total resistance of the circuit. (5 marks)
   b. The current through each resistor. (5 marks)
   c. The voltage drop across the load resistor \( R_2 \) (3kΩ resistor). (5 marks)
   d. The power dissipated in the load resistor \( R_2 \) (3kΩ resistor). (5 marks)

   ![Figure Q1](image)

2. Considering the circuit shown in Figure Q2,
   a. Choose a suitable method to determine the currents flowing through all of the resistors. (15 marks)
   b. Calculate the value of the potential difference between a and b. (5 marks)

   ![Figure Q2](image)
3. a. **Figure Q3** shows a simple series resistor and capacitor circuit supplied by a 10V d.c. pulse. Using R=2k2Ω, C=0.47μF and assuming the capacitor is initially fully uncharged:

i. Calculate the voltage across the capacitor at 7.5ms  
(4 marks)

ii. Sketch one cycle of the output voltage ($v_{out}$) from 0 to 20ms.  
(10 marks)

![Figure Q3](image)

b. Use a 1μF capacitor to design a first order low-pass filter with a cut-off frequency of 2.5kHz. Draw a schematic of your design.  
(6 marks)

4. a. Calculate the frequency of an alternating waveform that has a period (periodic time) of 20 μs.  
(4 marks)

b. Find the peak to peak value of a sinusoidal voltage of 20 Volts r.m.s.  
(4 marks)

c. A series RCL circuit has the following complex driving function as its voltage source:

$$v = 3\sin \omega t + 10\sin(3\omega t + 0.55) + 6\sin(5\omega t + 1) \ \text{V}$$

where $\omega = 200 \text{ rad/s}$

i. Using the expression for the applied voltage, calculate the instantaneous voltage at a time of 10ms.  
(4 marks)

ii. Expressed in terms of degrees, what are the two phase-shifts represented in the voltage expression?  
(4 marks)

iii. Determine the fundamental frequency in (Hz).  
(4 marks)

**Note:** Your calculator should be on ‘radians’ mode for this entire question.
5. **a.** For each of the following, determine the impedance of the circuit element and state whether it is resistive, inductive or capacitive. Impedance should be presented in both rectangular and polar formats.

   i. \( V = 20[20°][V], I = 2.2[120°][A] \)  
   \( \) (5 marks)

   ii. \( V = 10[-60°][V], I = 3.2[-60°][mA] \)  
   \( \) (5 marks)

**b.** Find the impedance \( Z_T \) of the circuit shown in **Figure Q5** using \( R=220Ω, \) \( C= 1μF, \) and \( L=2mH. \) Assume the operating frequency is 1kHz.  
\( \) (10 marks)

**Figure Q5**

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End of Paper