OCD054

UNIVERSITY OF BOLTON

OFF CAMPUS DIVISION

MALAYSIA - KTG

BENG (HONS) MECHANICAL ENGINEERING

SEMESTER 2 EXAMINATION 2018/2019

ENGINEERING MODELLING AND ANALYSIS

MODULE NO. AME5004

Date: Tuesday 14th May 2019 **Time: 3 Hours**

INSTRUCTIONS TO CANDIDATES:

There are FOUR questions on this paper.

Answer ALL questions.

All questions carry equal marks.

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Q1 a) An LCR model circuit is one that includes a resistor, a capacitor and an inductor, connected in series with a voltage source, $e(t)$ as shown in **Fig.Q1 a)**

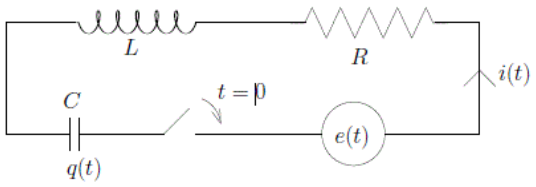

Fig.Q1 a) : An LCR model circuit

Before closing the switch at time $t = 0$ (s), the charge, q(C), on the capacitor and the resulting current, $i = \frac{dq}{dt}$ (A), in the circuit are zero. Applying Kirchhoff's second law to the circuit gives a second-order inhomogeneous differential equation for the charge on the capacitor,

$$L\frac{d^2q}{dt^2} + R\frac{dq}{dt} + \frac{1}{C}q = e(t)$$

In the circuit equation given above the parameters have the following values: R= 160 Ω, L= 1H, C = $10^{-4}F$and $e(t) = 20V$.

i) Use Laplace transformation to solve the second-order homogeneous differential equation for the charge on the capacitor q, in terms of t with the initial conditions $q(0) = 0$ and $q'(0) = 0$.

(8 marks)

Question 1 continued over the page.

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Question 1 cont'd…

ii) Determine an expression for the charge *q*, using inverse Laplace transform by partial fraction expansion method. (7 marks)

b) The impulse response of the analogue mechanical system is

$$H(s) = \frac{2+s}{(s+1)(s+3)}$$

i) Apply the inverse Laplace transform to obtain the continuous impulse input signal. (4 marks)

ii) From the second order differential characteristics equation obtained in part i), sketch the poles and zeros of the system. (6 marks)

Q2 a) Solving the following system of linear simultaneous equations using the method of Gaussian elimination:

$$\begin{aligned} 2I_1 - 4I_2 - 12I_3 &= 24 \\ 2I_1 + 4I_2 + 12I_3 &= -17 \\ 3I_1 - 12I_2 - 36I_3 &= 66 \end{aligned}$$

(12 marks)

b) Find by the double integration the volume of the following solids.

i) The solid lying under the graph of $z = \sin^2 x$ and over the region *R* bounded below by the *x*-axis and above by the central arch of the graph of $\cos x$ (4 marks)

Question 2 continued over the page

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Question 2 cont'd…

ii) The solid lying over the finite region R in the first quadrant between the graphs of x and x^2,and underneath the graph of $z = xy$ (4 marks)

iii) The finite solid lying underneath the graph of $x^2 - y^2$, above the xy –planes $x = 0$ and $x = 1$ (5 marks)

Q3 a) Obtain a numerical solution of the differential equation

$$\frac{dy}{dx} + 1 = -\frac{y}{x}$$

by using the Runge-Kutta method in the range of $x = 2.0(0.1)2.2$

given the initial condition $x = 2,\ y = 1$. (9 marks)

b) Solve a) by using Euler's method. (9 marks)

c) Determine the actual solution of the above differential equation. Then, compare the exact solution with analytical solution in a) and b). Justify your answers. (7 marks)

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Q4 a) A single pulse signal *v(t)* is represented as shown in **Fig.Q4 a)**

$$v(t)=\begin{cases}1, & -T/2 \le t \le T/2\\ 0, & \text{otherwise}\end{cases}$$

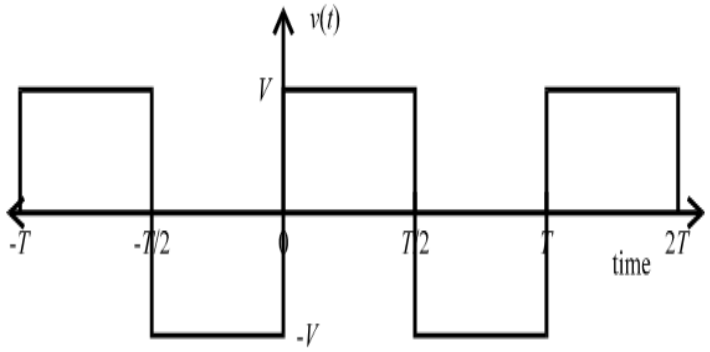

Fig.Q4 a)

i) Apply the Fourier transform on the pulse to obtain the spectrum of the signal. (9 marks)

ii) Sketch the frequency spectrum of the pulse signal. (4 marks)

b) A manufacturer of metal pistons finds that on the average 12% of his pistons are rejected because they are either oversize or undersize. What is the probability that a batch of 10 pistons will contain:

i) no more than two rejects (6 marks)

ii) at least 2 rejects. (6 marks)

END OF QUESTIONS