[ENG-29]

UNIVERSITY OF BOLTON

SCHOOL OF ENGINEERING

B.Eng. (Hons) AUTOMOTIVE PERFORMANCE ENGINEERING

SEMESTER 1 2021/22: OPEN BOOK EXAMINATION

ENGINEERING MATHEMATICS II

MODULE NUMBER: MSP5017

Date: Thursday 13th January 2022 **Time: 2pm – 4pm**

INSTRUCTIONS TO CANDIDATES:

Answer all SIX questions.

The maximum marks possible foreach part is shown in brackets.

The examination is open-book.

The examination covers Learning Outcome 1. (See Module Handbook).

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1. Consider the following equation:

$$sin(t) - cos(t) = 0$$

a) Show that the interval $[0,1]$ contains a root of this equation.

(4 marks)

b) Use the Newton Raphson Method to find this root correct to 5 decimal places.

(9 marks)

2. The following Ordinary Differential Equation represents the one eighth model for a car suspension system in the usual notation.

$$m\ddot{x} + c\dot{x} + kx = ky \qquad (1)$$

In what follows and that, assume that $m = 1, \quad c = 4 \quad , k = 29$ the car hits a step of height $y = 15$ at $t = 0$.

The General Solution to (1) comprises the sum of a Complementary Function and a Particular Integral:

a) Find the Complementary Function.

(8 marks)

b) Find the Particular Integral, and hence write down the General Solution

(4 marks)

Question 2 continues over the page…

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Question 2 continued

c) If the vertical displacement and velocity are zero at $t = 0$, write down the initial conditions, and use these to find the Particular Solution.

(10 marks)

d) As the system is underdamped, the first overshoot will be the largest. Show that this takes place between $t = 0.2$ and $t = 0.8$, and find the time at which this occurs correct to 5 decimal places. Hence find the size of the maximum overshoot correct to 2 decimal places.

(15 marks)

3. Use the method of Laplace transforms to solve the following differential equation:

$$\dot{x} + 2x = 4e^{2t} \qquad \text{with } x(0) = 0$$

(12 marks)

4. Find and classify the stationary points of the surface defined by:

$$z = 2x^3 + 2y^3 - 6x - 24y + 11$$

(13 marks)

5. A **closed** rectangular tank is to be made of sheet metal and is to have a volume 50m^3

Use partial differentiation to determine the dimensions and the total surface area of the tank so that the area of sheet metal is a minimum.

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(15 marks)

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6. Evaluate the following double integral:

$$\int_{y=0}^{3}\int_{x=0}^{2}(x^2y - y^2x)dxdy$$

(10 marks)

END OF QUESTIONS