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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2015/2016

COURSE	:	VIBRATION
COURSE CODE	:	BDA 31103
PROGRAMME	:	3 BDD
DATE	:	JUNE 2016
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FIVE** (**5**) QUESTIONS **ONLY**

THIS QUESTION PAPER CONSISTS OF **SEVEN** (**7**) PAGES

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Q1 (a) A motorcycle moving over a rough can be modelled by considering:

- Mass of the motorcycle body, rider, seat, front wheel and rear wheel.
- Elasticity of rider, tires, suspensions and seat.
- Damping of the rider, seat, shock absorbers and tires.

Develop the mass-spring damper models of the system. Label all the components clearly.

(8 marks)

(b) Differentiate between passive and active isolation.

(4 marks)

(c) Experimental modal analysis deals with the determination of the natural frequencies, damping ratios and mode shapes through vibration testing. Select the necessary equipment to perform the modal analysis and justify your selection.

(8 marks)

Q2 A Mini Cooper S as shown in **Figure Q2** having a mass m = 1200 kg and a mass moment of inertia of I_0 – 400 kg.m^2, is supported on suspension system modelled as elastic springs. If the stiffness of the supports are given by k_1 = 3000 N/mm, and k_2 = 2000 N/mm, and the supports are located at l_1 = 1.0 m and l_2 = 1.5 m from the car centre of gravity.

(i) Derive the equation of motion for the car undergoing free vibration and write the equation of motion in matrix form.

(7 marks)

(ii) Evaluate the natural frequencies and the mode shape vectors of the vibrating car.

(9 marks)

(iii) Illustrate the vibration mode shape for each of the natural frequencies.

(4 marks)

Q3 A machine is modelled by the system shown in **Figure Q3**. The masses of the main elements are $m_1 = 5$ kg and $m_2 = 10$ kg, and the spring stiffness are as shown. Each roller has a mass $m_3 = 1$ kg, diameter = 10 cm, and mass moment of inertia J about its axis. Considering motion of the machine in the Longitudinal direction only and rollers roll without slipping, determine:

(i) The equation of motion of the machine by using Lagrange's equation. Write the equation of motion in matrix form.

(12 marks)

(ii) The natural frequencies of the machine.

(8 marks)

Q4 The equation of motion for a mass-spring system is as following:

$$m\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}\ddot{\vec{x}} + k\begin{bmatrix} 2 & -1 & 0 \\ -1 & 2 & -1 \\ 0 & -1 & 2 \end{bmatrix}\vec{x} = \vec{0}$$

By using the exact method, it is found that the fundamental natural frequency for the mass-spring system is $\omega = 0.45\sqrt{\frac{k}{m}}$ rad/s.

(i) Determine the fundamental natural frequency and the corresponding mode shape of the system by using Matrix Iteration method.

(13 marks)

(ii) Determine the fundamental natural frequency of the system by using Rayleigh's method.

(5 marks)

(iii) Which method produces more accurate natural frequency value? Justify your answer.

(2 marks)

Q5 A reciprocating engine is installed on the first floor of a building, which can be modeled as a rigid rectangular plate resting on four elastic columns. The equivalent mass of the engine and the floor is 900 kg. At the rated speed of the engine, which is 600 rpm, the operators experience large vibration of the floor. It has been decided to reduce these vibrations by suspending a spring-mass system from the bottom surface of the floor. Assume that the spring stiffness is $k_2 = 900$ kN/m.

(i) Find the weight of the mass to be attached to absorb the vibrations.

(4 marks)

(ii) What will be the natural frequencies of the system after the absorber is added.

(8 marks)

(iii) Find the values of k_2 and m_2 in order to have the natural frequencies of the system at least 30 percent away from the forcing frequency.

(8 marks)

Q6 (a) Previously, the intensity of acoustic was measured in pressure (Pa) unit. But, by taken the Bell system, the acoustician used decibel (dB) for indicating the pressure of sound. Give two (2) reasons why the dB is implemented for indicating the pressure of sound.

(8 marks)

(b) The information of sound in octave band (dB) is given in **Table Q6**.

- Noise level at a particular reception point from machine A.
- Noise level at a particular reception point from machine A.
- Noise level at same reception point from machine B.
- Attenuation produced by a particular type of noise enclosure.
- The octave band A-weighting values.

Calculate;

(i) The overall noise levels for machines A and B, in both dB(A) and dB (linear).
(ii) The noise levels in each case after the machines have been enclosed.
(iii) The attenuation in dB(A) produced by the enclosure for the each machine.

From the calculation above, explain the difference between the dB(A) and dB(linear) values, and between the amount the attenuation provided in each case.

Table Q6

octave band	machine A	machine B	attenuation	A-weighting
63	105	68	4	-26
125	107	79	9	-16
250	99	82	15	-9
500	94	87	21	-3
1000	91	92	24	0
2000	87	96	30	1
4000	82	89	27	1
8000	79	81	26	-1

(12 marks)

-END OF QUESTIONS-

FINAL EXAMINATION

SEMESTER/SESSION : SEMESTER II / 2015/2016	PROGRAMME : 3 BDD
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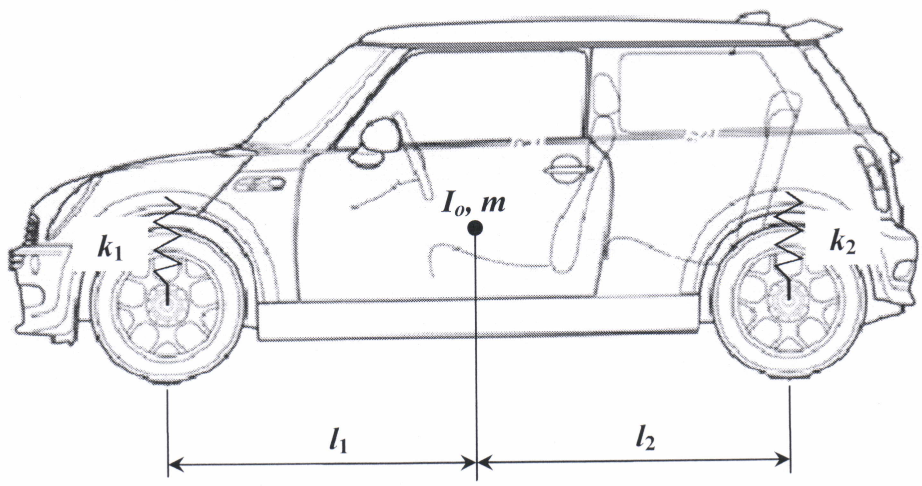

Figure Q2

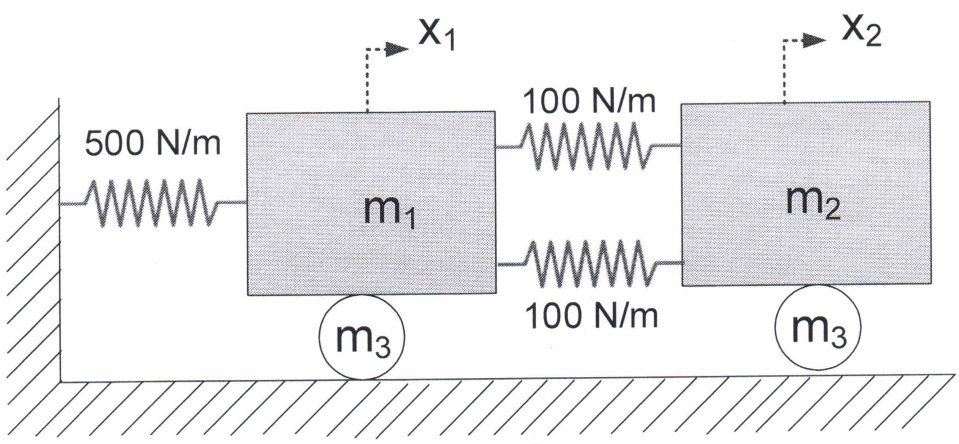

Figure Q3

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USEFUL FORMULAS:

Absorber formula

$$r_1^2, r_2^2 = \left(1 + \frac{\mu}{2}\right) \mp \sqrt{\left(1 + \frac{\mu}{2}\right)^2 - 1}$$

$$\mu = \frac{r_1^4 + 1}{r_1^2} - 2$$

Matrix Iteration formula

$$[K]^{-1}[M]\{X_{trial}\} = \frac{1}{\omega^2}\{X_{new}\}$$

Rayleigh formula

$$\omega^2 = \frac{\{X\}^T[K]\{X\}}{\{X\}^T[M]\{X\}}$$