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Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER 1
SESSION 2015/2016

COURSE	:	VIBRATION
COURSE CODE	:	BNJ 30103
PROGRAMME	:	3BNH/3BNK/3BNL/3BNG/3BNM
TEST DATE	:	DECEMBER 2015 / JANUARY 2016
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FIVE** (**5**) QUESTIONS **ONLY**

THIS QUESTION PAPER CONSISTS OF **NINE** (**9**) PAGES

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Q1 (a) A study of the response of a human body subjected to vibration is important in many applications. In a standing posture, the masses of head, upper torso, hips and legs and the elasticity and damping of neck, spinal column, abdomen and legs influence the response characteristics. Develop the approximation for modeling the human body. Label all the parts clearly.

(5 marks)

(b) Vibration absorber is a mechanical device used to reduce or eliminate unwanted vibration.

(i) Describe the differences between vibration isolator and vibration absorber.

(4 marks)

(ii) Justify the advantages to include a damper in the vibration absorber.

(3 marks)

(c) In some practical situations, it might be difficult to study a vibration system analytically. In such cases, experimental methods are used to measure the vibration response of the system to a known input.

(i) List the importance of vibration measurement.

(3 marks)

(ii) Illustrate and describe the basic features of a vibration measurement scheme.

(5 marks)

Q2 (a) The beam AB of mass m kg in **FIGURE Q2** is supported by springs of stiffness k_1 and k_2 at ends A and B. The beam center of gravity is at C of distance L_1 and L_2 from the end A and B. The beam is initially displaced at the center C with x and rotates with an angle θ as shown. The reaction of spring's forces at ends A and B are as in **FIGURE Q2**. I_o is the mass moment inertia of the beam at the center C.

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

(8 marks)

(i) Show that from the matrix of the equation of motions, this system is of static coupling and dynamic un-couplings.

(2 marks)

(b) Given the determinant of the above system is as below;

$$\begin{bmatrix} k_1 + k_2 - m\omega^2 & k_2L_2 - k_1L_1 \\ k_2L_2 - k_1L_1 & k_1L_1^2 + k_2L_2^2 - I_o\omega^2 \end{bmatrix} = 0$$

Where:

$m = 1800$ kg, $L_1 = 1.6$ m, $L_2 = 2.0$ m, $k_1 = 42$ kN/m. $k_2 = 48$ kN/m and radius of gyration, $r_c = 1.4$ m.

Determine;

(i) The natural frequency of the system.

(4 marks)

(ii) The amplitude ratios and mode shapes.

(6 marks)

Q3 Consider the 3-DOF system as shown in **FIGURE Q3.**

(a) Derive the equation of motion for the system by using Lagrange method. Write the final answer in matrix form.

(5 marks)

(b) Find all the natural frequencies of the system.

(6 marks)

(c) Determine and sketch all the mode shapes of the system.

(9 marks)

Q4 A shaft of negligible weight is 4 m in length is simply supported at both ends and carries three rotors of 50 kg each at equal distance over the length of the shaft as shown in **FIGURE Q4**. The shaft is made of steel with modulus of elasticity, E = 200 GPa and moment of inertia, $I_o = 30.7 \times 10^{-8}$ m^4.

(a) Compare the fundamental natural frequency values for the shaft system calculated by using Dunkerly's and Rayleigh's methods.

(18 marks)

(b) State the method which produces more accurate natural frequency value. Justify your answer.

(2 marks)

Q5 A sensitive electronic system, of mass 30 kg, is supported by a spring system on the floor of a building. The system is found to have a static deflection of 5 mm under self-weight.

(a) If the floor is subjected to a harmonic motion with frequency 7 Hz and amplitude 2 mm, determine the level of vibration (in term of displacement) felt by the sensitive electronic system.

(8 marks)

(b) Describe the phenomenon that occurred to the electronic system and give the reason why?

(2 marks)

(c) If the system is later to be installed the vibration isolation with addition damper 2000 Ns/m, analyse the vibration level (in term of displacement) and displacement transmissibility of the system.

(8 marks)

(d) Please suggest how the system can be redesigned to reduce the transmissibility to lesser than 1.

(2 marks)

Q6 (a) Define the sound pressure level, sound power level and worker's noise exposure.

(6 marks)

(b) If a piece of equipment has a sound pressure of 2 Pa, calculate the sound pressure level.

(2 marks)

(c) Calculate sound power level associated with a typical face-to-face conversation, which may have a sound power of 0.00001 W.

(2 marks)

(d) The sound pressure level of a machine is measured in octave band in the presence of a background noise, which is also measure with the machine turn off. The results of the measurement are shown in **TABLE Q6(a)**. Calculate:

(i) The sound pressure level generate by machine without background noise.

(3 marks)

(ii) The sound sound pressure level generate by machine without background noise in A-weighting. Use **TABLE Q6(b)** for A-weighting.

(2 marks)

(iii) The overall sound pressure level generate by machine in A-weighting. Use **TABLE Q6(b)** for A-weighting.

(3 marks)

TABLE Q6(a)

OCTAVE BAND Hz	Machine on (dB)	Machine off (dB)
125	92	88
250	88	82
500	85	77
1000	78	66
2000	76	63
4000	75	55
8000	70	53

TABLE Q6(b)

OCTAVE BAND Hz	A-weighting
125	-26.2
250	-16.1
500	-8.6
1000	0
2000	1.2
4000	1
8000	1.1

-END OF QUESTIONS-

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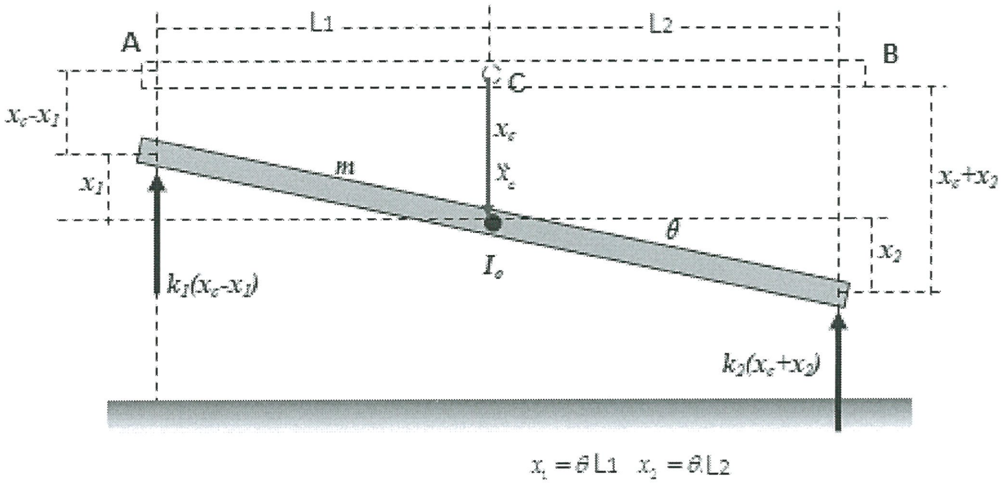
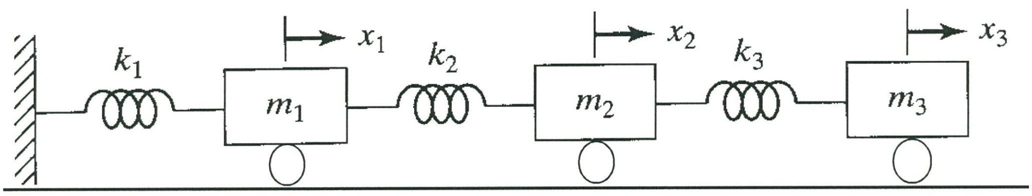


FIGURE Q2



$m_1 = m_2 = m_3 = m$

$k_1 = k_2 = k_3 = k$

FIGURE Q3

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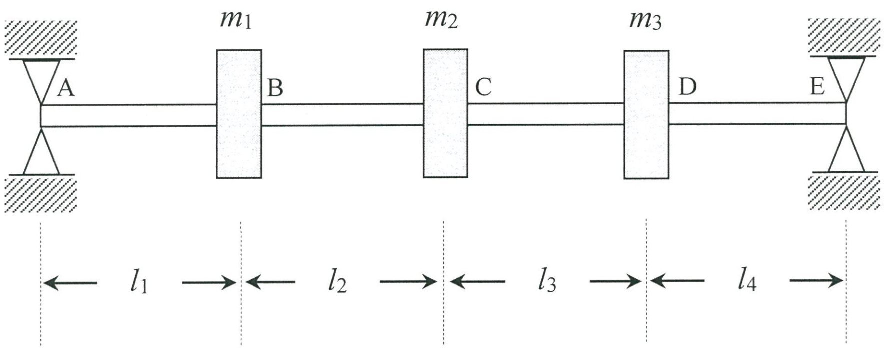

FIGURE Q4

USEFUL FORMULAS:

Transmission ratio

$$\frac{X}{Y} = T_r = \left\{\frac{1 + (2\xi r)^2}{(1 - r^2)^2 + (2\xi r)^2}\right\}^{\frac{1}{2}}$$

$$r = \frac{\omega}{\omega_n}$$

Dunkerly's formula

$$\frac{1}{\omega^2} = \frac{1}{\omega_{1n}^2} + \frac{1}{\omega_{2n}^2} + \cdots + \frac{1}{\omega_{nn}^2}$$

Rayleigh formula for shaft

$$\omega^2 = \frac{g(m_1 w_1 + m_2 w_2 + \cdots)}{(m_1 w_1^2 + m_2 w_2^2 + \cdots)}$$

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Deflection of a shaft due to a static load

Dunkerly's method:

$$w = \frac{Pa^2b^2}{3EIl}$$

Rayleigh's method:

$$w(x) = \begin{cases} \dfrac{Pbx}{6EIl}\left(l^2 - b^2 - x^2\right); & 0 \le x \le a \\ -\dfrac{Pa(l-x)}{6EIl}\left(a^2 + x^2 - 2lx\right); & a \le x \le l \end{cases}$$