Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2019/2020

COURSE NAME	:	VIBRATION / NOISE AND VIBRATION
COURSE CODE	:	BDA 31103 / BDA 40603
PROGRAMME	:	BDD
EXAMINATION DATE	:	DECEMBER 2019 / JANUARY 2020
DURATION	:	3 HOURS
INSTRUCTION	:	**PART A:** ANSWER **ALL** QUESTIONS **PART B:** ANSWER **TWO (2)** QUESTIONS **ONLY**

THIS QUESTION PAPER CONSISTS OF **EIGHT (8)** PAGES

PART A - ANSWER ALL QUESTIONS

Q1 (a) A vibratory system is a dynamic system for which the variables such as the excitations (inputs) and responses (outputs) are time-dependent.

(i) List the component of general vibratory system.

(3 marks)

(ii) Differentiate between linear and angular coordinate for a single, two and three degree of freedom systems using simple diagrams.

(6 marks)

(iii) Choose the correct match for the items in the two columns below:

1. The maximum displacement of a vibrating body from its equilibrium position	a. Natural frequency
2. Motion repeated after equal intervals of time	b. Frequency
3. The number of cycles per unit time	c. Amplitude
4. System after an initial disturbance is left to vibrate on its own	d. Periodic motion
5. The frequency when the system vibrating at its natural modes	e. Free vibration

(5 marks)

(b) Hand arm vibration is a physical hazard which transmitted to worker hand during operating handheld machine.

(i) List four (4) types of occupational disease related to exposure of hand arm vibration.

(4 marks)

(ii) A general worker from grinding operation had been exposed to hand arm vibration with the acceleration value of 3.15 m/s^2 at x-axis, 5.42 m/s^2 at y-axis and 1.38 m/s^2 at z-axis. Assume that the working duration per day is 8 hours.

(i) Examine the vibration total value, a_{hv}, and daily vibration exposure, $A(8)$, if the worker only expose to vibration for a duration of 3 hours per day.

(ii) Justify whether the calculated daily vibration exposure, $A(8)$, exceed the exposure limit value of 5 m/s^2.

(7 marks)

Q2 (a) Identify the correct match for the items in the two columns below:

1. Peak action level of the Noise at Work Regulations 1989	a. 344 m/s
2. Unit of sound pressure	b. Watt
3. Unit of sound power	c. 140 dB
4. Speed of sound	d. Pa

(4 marks)

(b) Three water pumps located next to each other give individual sound pressure levels of 88, 108 and 99 dB, respectively.

(i) Determine the total sound pressure level when all of the pumps are switched on together.

(3 marks)

(ii) Noise measurement was made at 1 m from the noise source with a reading of 107 dB. If the workstation is located at 4 m from the noise source, estimate the sound pressure level received by the workers at the workstation. The workers need to be at the workstation for 8 hours daily.

(6 marks)

(iii) Based from your answer in **Q2(b)(ii)**, justify whether it is safe for the worker to be at the workstation 8 hours daily according to the 5 dB exchange rate.

(2 marks)

(c) List below is the detail information during noise personal monitoring:

- Work shift start from 8.00 am to 5.30 pm
- Morning tea break start from 10.30 am to 11.00 am
- Lunch break start from 1.30 pm to 2.30 pm

The dose measured for 8 hours is given as 120 %.

(i) Estimate the equivalent sound level (L_{eq}) for actual working time duration. Show the result of L_{eq} in three (3) and five (5) exchange rate.

(ii) Conclude whether the noise level exceed permissible exposure limit (PEL > 90 dB(A)) as per mention in Factories and Machinery (Noise Exposure) Regulation 1989.

(10 marks)

PART B - ANSWER TWO QUESTIONS ONLY

Q3 A newly launched Proton X5 as shown in **Figure Q3** having a mass m = 1200 kg and a mass moment of inertia of J_0 = 400 kg.m^2, is supported on suspension system modelled as elastic springs. If the stiffness of the supports is 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.

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

(7 marks)

(b) Evaluate the natural frequencies and the mode shape vectors of the vibrating car.
(12 marks)

(c) Illustrate the vibration mode shape for each of the natural frequencies.
(6 marks)

Q4 The vibration of an electric train made up of three cars can be modeled as a three degree of freedom system as shown in **Figure Q4**. The car body is connected by couplings of stiffness in function of the modulus E of the coupler. The equation of motion for the system is given below:

$$m\begin{bmatrix}1 & 0 & 0\\ 0 & 1 & 0\\ 0 & 0 & 1\end{bmatrix}\begin{bmatrix}\ddot{x}_1\\ \ddot{x}_2\\ \ddot{x}_3\end{bmatrix}+\frac{EI}{l^3}\begin{bmatrix}3 & -3 & 0\\ -3 & 6 & -3\\ 0 & -3 & 3\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}=\begin{bmatrix}0\\ 0\\ 0\end{bmatrix}$$

If $E = 6.9 \times 10^9$ N/m², $l = 2$ m, $m = 3000$ kg, and $I = 5.2 \times 10^{-6}$ m⁴, differentiate between the 1st, 2nd and 3rd vibration modes characteristics of the system based on the mode shape diagrams.

(25 marks)

Q5 A sensitive electronic system, weighs 294 N, 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.
(7 marks)

(d) If it is required to achieve a displacement transmissibility of no more than 10 percent at the electronic system, evaluate the stiffness and damping constant that needed to design a suitable isolation system.
(8 marks)

-END OF QUESTIONS –

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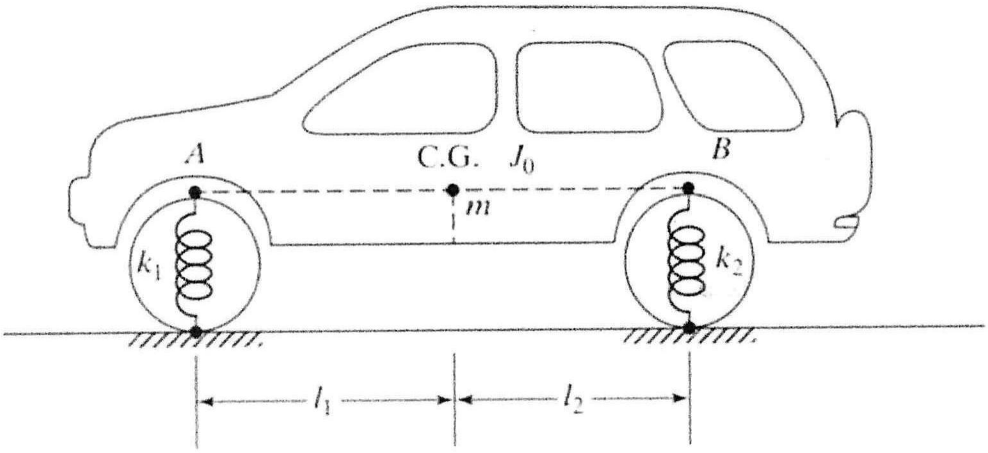
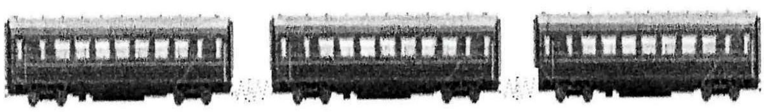
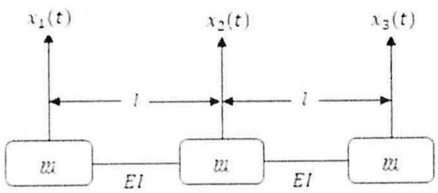


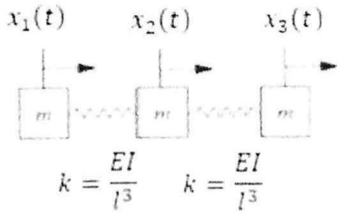
Figure Q3



(a) Electric train



(b) Coupler deflection model



(c) Spring-mass model

Figure Q4

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USEFUL FORMULAS:

Vibration total value:

$$a_{hv} = \sqrt{a_{hwx}^2 + a_{hwy}^2 + a_{hwz}^2}$$

Daily Vibration Exposure:

$$A(8) = a_{hv}\sqrt{\frac{T}{T_0}}$$

Total sound pressure level:

$$L_p = 10\log\left[\left(10^{L1/10}\right) + \left(10^{L2/10}\right) + \cdots \left(10^{Ln/10}\right)\right]$$

Difference in sound pressure level (Inverse Square Law):

$$dL = 20\ log\left(\frac{R_2}{R_1}\right)$$

$$dL = Lp_1 - Lp_2$$

Relationship between Dose and L_{eq} for 3dB exchange rate:

$$Leq_8 = 90 + 9.97\ log\left(\frac{D}{100}\right)$$

Relationship between Dose and L_{eq} for 5dB exchange rate:

$$Leq_8 = 90 + 16.61\ log\left(\frac{D}{100}\right)$$

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USEFUL FORMULAS:

Allowable exposure time for 3 dB exchange rate:

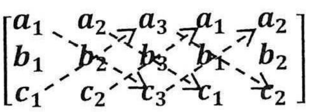
3 dB Exchange Rate	
dB	**Exposure time (hours)**
87	16
90	8
93	4
96	2

Allowable exposure time for 5 dB exchange rate:

5 dB Exchange Rate	
dB	**Exposure time (hours)**
85	16
90	8
95	4
100	2

Sarrus Rule:

$$\begin{bmatrix} a_1 & a_2 & a_3 \\ b_1 & b_2 & b_3 \\ c_1 & c_2 & c_3 \end{bmatrix}$$



$$= (a_1b_2c_3 + a_2b_3c_1 + a_3b_1c_2) - (c_1b_2a_3 + c_2b_3a_1 + c_3b_1a_2)$$

Displacement Transmissibility, T_d:

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

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USEFUL FORMULAS:

Undamped Natural Frequency:

$$\omega_n = \sqrt{\frac{k}{m}}$$

Frequency Ratio:

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

Damping Ratio:

$$\xi = \frac{c}{c_m} = \frac{c}{2\omega_n m}$$