Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2018/2019

COURSE NAME	:	VIBRATION
COURSE CODE	:	BDA 31103
PROGRAMME CODE	:	BDD
EXAMINATION DATE	:	JUNE / JULY 2019
DURATION	:	3 HOURS
INSTRUCTION	:	**PART A:** ANSWER **ALL** QUESTIONS **PART B:** ANSWER **TWO (2)** QUESTIONS **ONLY**

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

PART A - ANSWER ALL QUESTIONS

Q1 (a) Fill in the blank with the right answer.

vibration	cycle	classification	vector
harmonic	deflection	damper	natural
amplitude	multiple	periodic	phase
kinetic	time	design	undamped

i. Vibration can lead to excessive _____ and failure on the machine and structures.

ii. Reduce the vibration through proper _____ of machines and their mounting.

iii. _____ is any motion that repeats itself after an interval of time.

iv. Vibration involves transfer of potential energy to _____ energy and vice versa.

v. General vibratory system consists of spring, mass and _____.

vi. Degree of freedom consists of single, two and _____.

vii. Free vibration and force vibration is a part of vibration _____.

viii. _____ define as maximum displacement of a vibrating body form its equilibrium position.

ix. Frequency is the number of cycles per unit _____.

x. _____ motion is motion that repeated after equal intervals of time.

(10 marks)

(b) Describe the differences of vibration analysis technique between time domain and frequency domain.

(6 marks)

(c) Demonstrate the human vibration measurements flow process in conducting field test assessment.

(4 marks)

(d) Examine the vibration total value, a_{hv} and daily vibration exposure, A(8) if the grinder operator exposed to hand arm vibration for 1 hour per day with A_{eq} value for x axis is 5 m/s^2, y axis is 2 m/s^2 and z axis is 4 m/s^2. State whether the A(8) value exceed Exposure Action Value (EAV) or not.

(5 marks)

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

1. Unit of level when the base of the logarithm is the 10^{th} root of 10	a. Equivalent sound level (L_{eq})
2. Unit representing the sound level measured with the A-weighting network on a sound level meter	b. Dose
3. The amount of actual exposure relative to the amount of allowable exposure	c. Decibel, A-weighted (dBA)
4. Measurement of cumulative noise exposure	d. Decibel (dB)

(4 marks)

(b) Before Alexander Graham introduces logs in noise scale, the measurement of sound pressure level was enormous and unwieldy number start with threshold value of 0.00001 Pa until maximum value of 100 Pa. Explain the mathematical concept used by Alexander Graham to develop a decibel (dB) scale.

(5 marks)

(c) Solve the following calculation by using suitable formula:

i. The RMS pressure of a sound is 100 Pa (N/m^2). Determine the Sound Pressure Level (SPL)?

ii. Characteristic acoustic impedance of air is 410 rayls. Determine the Sound Intensity Level (SIL) of a sound whose RMS is 100 Pa?

iii. Determine the Sound Power Level (SWL) of 0.02 watts?

(7 marks)

(d) A worker exposed to a noise dose of 90% while operating CNC machine at the production floor from 0800 until 2000 with an accumulation of two (2) hours

break. Analyze the equivalent sound level (L_{eq}) for 8 hours working time duration by using three (3) exchange rate approaches. Examine whether the noise level exceeds an excessive noise level of 82 dB(A). Recommend three (3) control measures which could reduce noise exposure to the worker.

(9 marks)

PART B - ANSWER TWO QUESTIONS ONLY

Q3 (a) A number degree of freedom system depend on the number of mass and number of movement either translation, rotational or torsional at each axis. Identify the correct match for the items in the two columns below:

1. Critically damped	a. $\omega_n \sqrt{1-\zeta^2}$
2. Resonance	b. Damping ratio, $\zeta > 1$
3. Overdamped	c. Damping ratio, $\zeta < 1$
4. Damping frequency	d. Forcing frequency equals to natural frequency
5. Underdamped	e. Damping ratio, $\zeta = 1$

(5 marks)

(b) An experimental setup as shown in **Figure Q3** was designed to identify whether copper could be used as the material for the second spring, k_2 = 15 N/m to withstand the reaction of the masses. The value of the masses given as mass 1, m_1 = 6.8 kg and mass 2, m_2 = 3.6 kg. Spring 1 and spring 3 is made of brass ($k_1 = k_3$ = 19 N/m).

(i) Derive the system equations of motion in matrix form complete with the values of masses, spring coefficients, and forces.

(4 marks)

(ii) Predict the natural frequencies of the system

(6 marks)

(iii) Illustrate and comment on the mode shapes of the system.

(10 marks)

Q4 The equation of motion for a multi degree of freedom system is as following:

$$\begin{bmatrix} 5 & 0 & 0 \\ 0 & 5 & 0 \\ 0 & 0 & 5 \end{bmatrix} \{\ddot{x}\} + \begin{bmatrix} 2 & -1 & 0 \\ -1 & 2 & -1 \\ 0 & -1 & 1 \end{bmatrix} \{x\} = \{0\}$$

(a) Estimate the highest natural frequency and the corresponding mode shape vector of the system by using Matrix Iteration method (Use ONE (1) decimal place only).

(11 marks)

(b) Compare the natural frequency and mode shape vector obtained in **Q4 (a)** with the ones obtained by using Eigenvalue and Eigenvector method.

(11 marks)

(c) Draw the mode shape diagram associated with the estimated mode shape vector in **Q4 (a)**.

(3 marks)

Q5 A truck moves on a road in the sinusoidal surface as shown in **Figure Q5**. The road surface has a wavelength 5 m with 2 mm amplitude. The weight, W of truck including two (2) passengers is 14.715 N. With stiffness of the truck suspension is 400 kN/m.

(a) Determine the frequency ratio if the velocity is in V km/h.

(7 marks)

(b) Find the range of the truck velocity (km/h) in which the passengers perceived the vibration. Assume the horizontal movement, X is infinity which equal to 1.

(5 marks)

(c) What are the three (3) possible methods could be changed for improving the design to reduce the vibration.

(6 marks)

(d) If the suspension is replaced to a better shock absorber with c = 20 Ns/m and the truck moves with same velocity. What is the new vibration amplitude displacement perceived by passenger?

(7 marks)

-END OF QUESTION-

FINAL EXAMINATION

SEMESTER/SESSION : SEMESTER II / 2018/2019 PROGRAMME : BDD

COURSE NAME : VIBRATION COURSE CODE : BDA 31103

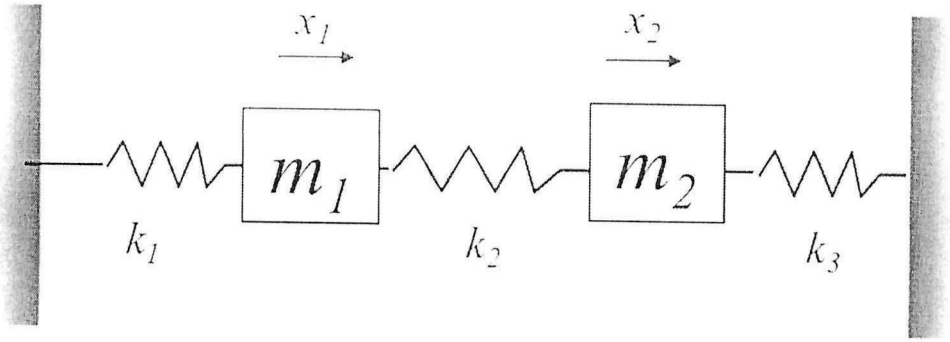

Figure Q3

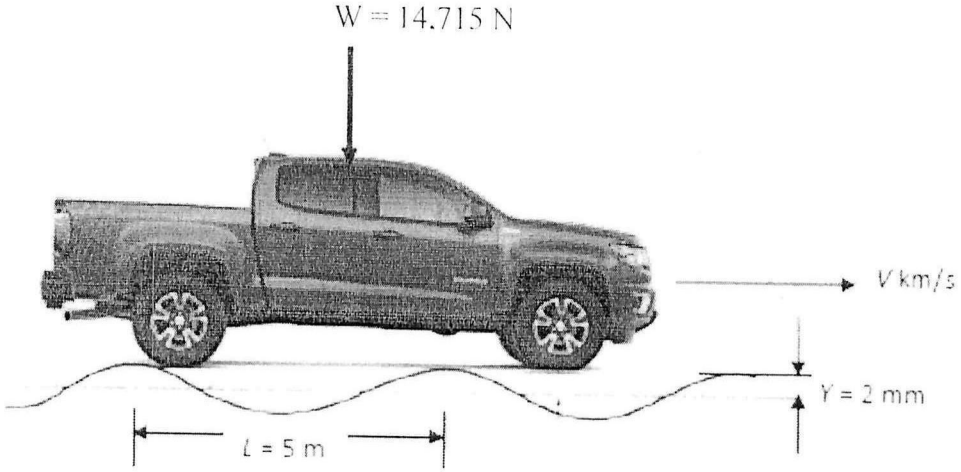

Figure Q5

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USEFUL FORMULAS:

Vibration total value:

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

Daily Vibration Exposure:

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

Sound Pressure Level:

$$SPL = 20 \log\left(\frac{P_{actual}}{P_{ref}}\right)$$

Pressure reference value:

$$P_{ref} = 20 \times 10^{-6}\ Pa$$

Intensity:

$$I = \frac{p^2}{\rho c}$$

Sound Intensity Level:

$$SIL = 10 \log\left(\frac{I_{actual}}{I_{ref}}\right)$$

Intensity reference value:

$$I_{ref} = 1 \times 10^{-12}\ W/m^2$$

Sound Power Level:

$$SWL = 10 \log\left(\frac{W_{actual}}{W_{ref}}\right)$$

FINAL EXAMINATION

SEMESTER/SESSION : SEMESTER II / 2018/2019 PROGRAMME : BDD

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Power reference value:

$$W_{ref} = 10^{-12}\ watts$$

Dose ratio:

$$\frac{Dose_1}{T_1} = \frac{Dose_2}{T_2}$$

Sound equivalent level for 8 hours:

$$L_{eq8h} = 85 + 9.97 \log\left(\frac{Dose}{100}\right)$$

Harmonic motion assumption:

$$\{x\} = \{A\} \sin \omega t$$

Cramer's rule:

$$\begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} = 0 \qquad (A_{11})(A_{22}) - (A_{21})(A_{12}) = 0$$

Amplitude ratio:

$$\frac{X}{Y} = \frac{1}{1 - r^2}$$

Damping Ratio:

$$\xi = \frac{C}{C_c}$$

Equation to converge to the **highest** natural frequency:

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

Characteristic determinant:

$$[\Delta] = |[M]^{-1}[K] - \lambda[I]| = 0$$