Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
(ONLINE)
SEMESTER II
SESSION 2019/2020

COURSE NAME	:	VIBRATION
COURSE CODE	:	BDA 31103
PROGRAMME CODE	:	BDD
EXAMINATION DATE	:	JULY 2020
DURATION	:	3 HOURS
INSTRUCTION	:	**PART A:** ANSWER **ALL** QUESTIONS. **PART B:** ANSWER **TWO (2)** QUESTIONS **ONLY.** **OPEN BOOK EXAMINATION**

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

PART A - ANSWER ALL QUESTIONS

Q1 (a) Choose the correct answer for the items below either A or B:

(i) Vibration can lead to excessive _____ and failure on the machines and structures

A. stress
B. deflection

(ii) General vibratory system consists of:
I. spring or elasticity, k
II. mass or inertia, m
III. damper, c

A. I & II
B. I, II & III

(iii) Vector representation of harmonic motion are:
I. displacement: $x = A \sin \omega t$
II. velocity: $\frac{dx}{dt} = -\omega A \sin \omega t$
III. acceleration: $\frac{d^2x}{dt^2} = -\omega^2 A \sin \omega t$

A. I, II & III
B. I & III

(iv) Main function accelerometer calibrator is

A. to check its sensitivity
B. to check its frequency range

(v) Which one of two situations below induce high risk to hand arm vibration syndrome.

A. 2 hours using polishers
B. 1 hour using impact wrenches

(5 marks)

(b) (i) A vibratory system is a dynamic system for which the variables such as the excitations (inputs) and responses (outputs) are time dependent. Illustrate the vibration analysis standard procedure step.

(4 marks)

(ii) Compare three (3) different statements between vibration time domains against frequency domains.

(3 marks)

(c) (i) Distinguish the different between amplitude, period and frequency in a definition of terminology and diagram.

(4 marks)

(ii) Demonstrate the process flow for hand arm vibration management and control at workplace.

(4 marks)

(iii) A worker exposed to hand arm vibration during operating jigsaw for 30 minutes per 8 hours working day. The company engage industrial hygienist to assess the level of vibration exposure using vibration meter. Vibration exposure, A_{eq} readings from each axes are 5.5 m/s^2 at x-axis, 1.9 m/s^2 at y-axis and 2.1 m/s^2 at z-axis. Examine the vibration total value, a_{hv} and daily vibration exposure, $A(8)$. Evaluate whether the $A(8)$ exceed than exposure limit value (ELV) or exposure action value (EAV).
***Note*:** The calculation shall up to two (2) decimal points.

(5 marks)

Q2 (a) Choose the correct answer for the items below either A or B:

(i) Sound power or acoustic power is the sound energy _____ per unit time.

A. emitted, reflected, transmitted or received
B. transmitted, reflected or absorbed

(ii) Define hearing range of human.

A. 20 to 20,000 Hz
B. 20 to 2,000 Hz

(iii) Intensity is the amount of energy passing through unit area per unit time.

A. True
B. False

(iv) 90 dB(A) + 90 dB(A) = _____

A. 93 dB(A)
B. 96 dB(A)

(v) 90 dB(A) – 80 dB(A) = 90 dB(A)

A. True
B. False

(5 marks)

(b) (i) Compare the numerical wavelength difference between sound frequency level of 500 Hz and 2,000 Hz travelling in air medium. Use 344 m/s as speed of sound, c.

(3 marks)

(ii) Define the definition of decibels (dB) scale and support with two (2) reasons why decibels (dB) scale is reliable as compared to Pascal (Pa) scale.

(4 marks)

(c) Solve the case study below using suitable sound or noise formula.

(i) The free-field noise from Mitsubishi diesel generator produces 110 dB(A) measured from 1 meter distance. Determine whether the noise perceived by the employee at a location from 4 meters is exceeded than noise exposure limit of 85 dB(A).

(3 marks)

(ii) Shipyard grinder using their hand held metal grind for cumulative of 3 hours during eight (8) hour workday. The remaining cumulative of 5 hours used for welding activities. Noise level during grinding activities is 94 dB(A) meanwhile noise level during welding activities is 85 dB(A). Evaluate the equivalent continuous noise level, L_{eq}.

(3 marks)

(iii) Examine the dose exposure from question **Q2(c)ii**. Daily exposure duration limit for 85 dB(A) is 8 hours and 94 dB(A) is 1 hour.

(3 marks)

(iv) From the monitoring conducted, worker was exposed to noise at 85 dB(A) measured by noise dosimeter. Determine the effective duration, *Te* if the measurement is not taken during lunch break. Evaluate the daily noise exposure level, L_{EX} and daily personal noise dose, D for 8 hours whether exceed than noise exposure limit as per stated in Regulation 6 Occupational Safety & Health (Noise Exposure) Regulations 2019. Detail work schedule as below:

Working hours	: 12 hours
Morning break	: 20 minutes
Lunch break	: 1 hour
Tea break	: 20 minutes

(4 marks)

PART B - ANSWER TWO (2) QUESTIONS ONLY

Q3 (a) Vibration of systems that require two independent coordinates to describe their motion is called two-degree-freedom systems. It follows that two equations of motion are required to define the motion for a system with two degrees of freedom. Based on this,

(i) State the general rule for the computation of the number of degrees of freedom.

(2 marks)

(ii) Explain equation of the motion that involved in two-degree-freedom systems and their natural frequencies.

(3 marks)

(b) A steel shaft of different diameter carries a pulley and a motor as shown in **Figure Q3**. The weights of the pulley and the motor are 200 kg and 500 kg respectively with a similar radius of gyration 0.2 m. Assuming a shear modulus of shaft is given as $G = 9 \times 10^{11}$ N/m^2, examine:

(i) The natural frequencies of the system.

(13 marks)

(ii) The mode shapes of the system.

(7 marks)

Useful equation:

$$\text{Torsional stiffness},\ k = \frac{\pi d^4 G}{32l}$$

Q4 A three car train set are coupled by two springs as shown in **Figure Q4**. Given that the train mass, $m_1 = 5m$, $m_2 = 0.6m_1$, and $m_3 = 0.4m_1$ while the stiffness coefficient of the coupling, $k_1 = 8k$ and $k_2 = 0.5k_1$ respectively. By neglecting the friction between the mass and the surface:

(a) Using Lagrange Equation, develop the equation of motion for the system as

$$\begin{bmatrix} 5m & 0 & 0 \\ 0 & 3m & 0 \\ 0 & 0 & 2m \end{bmatrix} \begin{bmatrix} \ddot{x}_1 \\ \ddot{x}_2 \\ \ddot{x}_3 \end{bmatrix} + \begin{bmatrix} 8k & -8k & 0 \\ -8k & 12k & -4k \\ 0 & -4k & 4k \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = 0$$

(7 marks)

(b) Estimate the natural frequency of the system.

(12 marks)

(c) Determine the mode shape of the system.
Note: No need to draw the mode shape diagram.

(6 marks)

Q5 (a) Identify whether the following statements is **True** or **False**:

(i) Vibration control means the elimination or reduction of vibration
(ii) The natural frequency of a system can be changed by varying its damping
(iii) The force transmitted to the foundation of an isolator with rigid foundation can never be infinity
(iv) Undamped vibration absorber can eliminate structural vibration effectively if its frequency coincides with the natural frequency of the system and the excitation frequency.

(4 marks)

(b) An air compressor of mass 50 kg operates at 1200 rpm. Assuming that the damping ratio of the shock isolator is 0.1 and providing that 75 percent vibration isolation to the base;

(i) Determine the static deflection produced by the isolator

(11 marks)

(ii) If a shock isolator of the compressor is replaced with an isolator consisting of a similar spring stiffness with negligible damping, compare the force transmitted to the base before and after the isolator replacement by assuming that compressor produces 50 N force. Justify your answer with a graph explanation.

(10 marks)

-END OF QUESTION-

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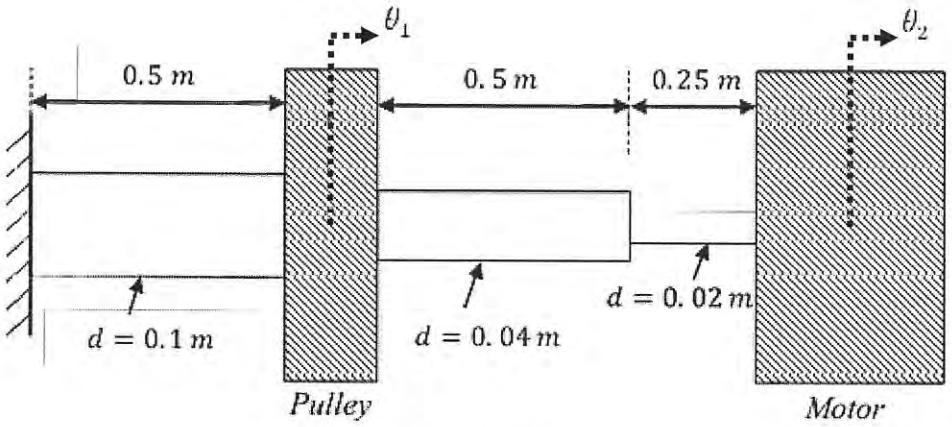

Figure Q3

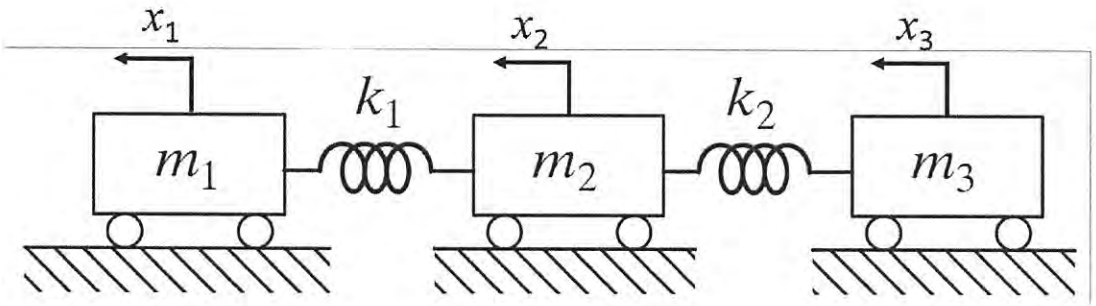

Figure Q4