UTHM
Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
(ONLINE)
SEMESTER I
SESSION 2020/2021

COURSE NAME	:	VIBRATION
COURSE CODE	:	BDA 31103
PROGRAMME CODE	:	BDD
EXAMINATION DATE	:	JANUARY/FEBRUARY 2021
DURATION	:	3 HOURS
INSTRUCTION	:	**PART A:** ANSWER **ALL** QUESTIONS. **PART B:** ANSWER **ONE (1)** QUESTION **ONLY**. **OPEN BOOK EXAMINATION**

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

PART A - ANSWER ALL QUESTIONS

Q1 (a) Consider the forging hammer shown in **Figure Q1**. It consists of a frame, a falling weight known as the tup, an anvil, and a foundation block. The anvil is mounted on an elastic pad to mitigate the transmission of vibration to the foundation block and the frame. Forging hammer activity can be modelled by considering.

- Mass of the anvil as m_{anvil} and mass of the foundation block as m_{block}
- Elasticity of elastic pad as k_{pad} and elasticity of soil as k_{soil}
- Damping of elastic pad as c_{pad} and damping of soil as c_{soil}

Develop a sequence of two mathematical model (single and two degrees of freedom) system using a gradual refinement of the modeling process.

(4 marks)

(b) Harmonic motion is the simplest type of periodic motion at which the motion is repeated at equal interval of time.

(i) Discuss two approaches used to represents harmonic motion. Support your answers with suitable illustration.

(6 marks)

(ii) A harmonic motion has an amplitude of 0.1 m and a frequency of 15 Hz. Find its period, maximum velocity and maximum accelerations.

(5 marks)

(c) (i) Hand Arm Vibration Management and Control is necessary to prevent in such a disease of Carpal Tunnel Syndrome (CTS). Some of the risk assessment to workers may involve level, type and duration of exposure. Discuss five (5) safe work practices in order to prevent and control the risk of CTS.

(5 marks)

(ii) An employee uses a hand compactor for approximately 3 hours a day. An acceleration of 1.2, 6.4 and 9.7 ms^{-2} for the x, y and z axes is measured at the handle while it is in use. Analyze the 8 hours exposure level, *A(8)* of the employee. Evaluate whether the *A(8)* exceed than exposure limit value (ELV) or exposure action value (EAV).
Note: The calculation shall up to three (3) decimal points.

(5 marks)

Q2 (a) A man bring his dog to the park for a walk. In about 1 meter from their location, a stranger blow a whistle that produce frequency level of 25,000 Hz. Surprisingly, the dog became annoyed and barking continuously while the man (owner of the dog) was confused about the situation

(i) Define the type of sound produced by the whistle

(1 mark)

(ii) State **two (2)** reasons why the dog acting strangely as soon as the stranger blow the whistle while the man (owner of the dog) did not feel annoyed with the sound produced by the whistle

(4 marks)

(b) A high speed water pump produced noise with a Root Mean Square (RMS) value of Y Pascal during its continuous operation. The characteristic acoustic impedance of air, $\rho c = 410$ rayls and the threshold intensity $I_{ref} = 1\text{x}10^{-12}$ W/m^2.

Here, the value of Y depends on the 5th digit of your matric number as shown in **Table 1**. For example, if your matrix number is AD 110135 gives the value of $Y - 3$.

Table 1

5th digit of matrix number	Y	6th digit of matrix number	Z
0	10	0	10
1	1	1	1
2	2	2	2
3	3	3	3
4	4	4	4
5	5	5	5
6	6	6	6
7	7	7	7
8	8	8	8
9	9	9	9

(i) Determine the sound pressure level (in decibels) produced by the high speed water pump.

(4 marks)

(ii) If an additional water pump with the RMS value of Z Pascal was added next to the high speed water pump, estimate the total sound pressure level (in decibels) produced by both water pumps.

Here, the value of Z depends on the 6th digit of your matric number respectively as shown in **Table 1**. For example, if your matrix number is AD 110135 gives the value of $Z = 5$.

(6 marks)

(iii) The sound pressure level measured at 1 meter from both water pumps was 106 dB. Predict the maximum daily exposure limit of the technician if his workstation is located at 8 meter from both water pumps.

(5 marks)

(c) A personal noise monitoring was conducted on a worker where the worker was exposed to a noise level of 85 dB(A) as measured by the noise dosimeter. The detail information during personal noise monitoring are as follow.

Working hours	: 11 hours
Morning break	: 30 minutes
Lunch break	: $Z \times 10$ minutes
Tea break	: 30 minutes

Here, the value of Z depends on the 6th digit of your matric number respectively as shown in **Table 2**. For example, if your matrix number is AD 110135 gives the value of $Z = 5$.

Table 2

6th digit of matrix number	Z
0	10
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9

(i) Determine the effective duration, T_e if the measurement was paused during morning and tea break.

(1 marks)

(ii) Estimate the daily noise dose for 8 hours equivalent exposure.

(2 marks)

(iii) Justify whether the daily noise dose exceeded the noise exposure limit as per stated in Regulation 6 Occupational Safety & Health (Noise Exposure) Regulations 2019.

(2 marks)

Q3 The box contains a 250 kg fragile instrument is transported by a truck that subjected to a vertical harmonic motion given by $y(t) = 0.02 \sin 3t$. Assume that the instrument only moves in vertical translation and it is supported by four springs with stiffness, $k = 250 \times Y$ N/m as simplified in **Figure Q3**.

Here, the value of Y depends on the 5th digit of your matric number respectively as shown in **Table 3**. For example, if your matrix number is AD 110135 gives the value of $Y = 3$.

Table 3

5th digit of matrix number	Y	6th digit of matrix number	Z
0	4	0	80
1	4	1	80
2	4	2	80
3	3	3	50
4	3	4	50
5	3	5	50
6	2	6	80
7	2	7	80
8	1	8	50
9	1	9	50

(a) Determine the maximum displacement, velocity and acceleration experienced by the instrument.

(10 marks)

(b) Evaluate the percentage of vibration transmitted from the truck bed to the instrument and justify outcome.

(4 marks)

(c) Analyze the best possible solution to allow only $Z\%$ of vibration transmitted to the instrument. Please support your answer with calculation and draw a mass spring system for this solution.

Here, the value of Z depends on the 6th digit of your matric number respectively as shown in **Table 3**. For example, if your matrix number is AD 110135 gives the value of $Z = 50$.

(11 marks)

PART B - ANSWER ONE (1) QUESTION ONLY

Q4 **Figure Q4** shows an aeroplane approaching the runaway for landing. The aeroplane consists of front and rear landing gear set which have different stiffness value. The front landing gear set have stiffness coefficient value, $k_1 = 609$ kN/m while the rear landing gear set have stiffness coefficient value, $k_2 = 750$ kN/m. The distance of each landing gear to the center of gravity is $l_1 = 9$ m and $l_2 = 2.5$m respectively. The mass of the aeroplane is given as $m =$ 10,000 kg while the radius of gyration, $r_G = 1.96$ m. By neglecting the damping coefficient of the landing gear:

(a) Illustrate the problem as mass spring damper system.

(2 marks)

(b) Construct the equation of motion complete with all values.

(5 marks)

(c) Evaluate the natural frequencies of the system.

(9 marks)

(d) Estimate the mode shape of the system complete with its mode shape diagram.

(9 marks)

Q5 A simplified multi-degree of freedom of an undamped-structural-system is shown in **Figure Q5**. The equations of motion derived using the displacements of the masses, x_1, x_2 and x_3 as its degree-of-freedom system. By assuming that, $m_1 = m,\ m_2 = 2m,\ m_3 = m,\ k_1 = k_2 = k$, and $k_3 = 2k$,

(a) Develop the equation of motion for the system either using Newton's second law of motion or Lagrange Equation.

(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)

-END OF QUESTION-

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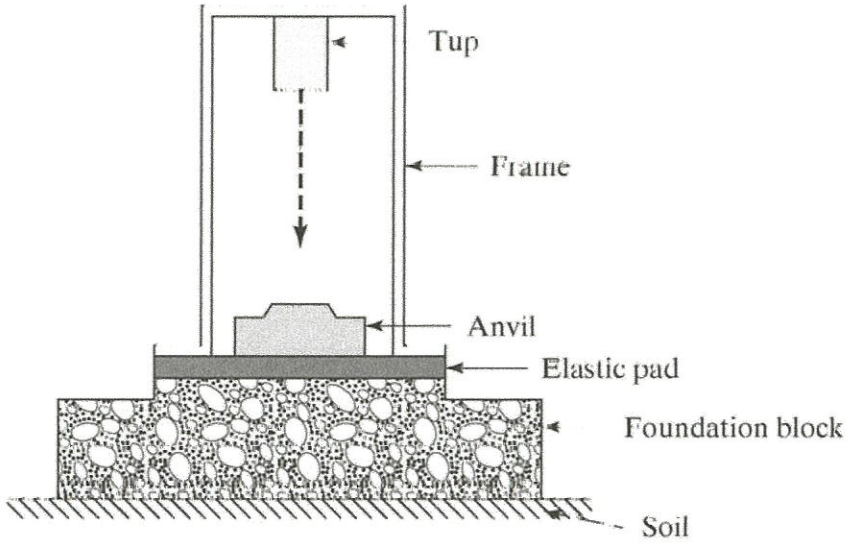

Figure Q1

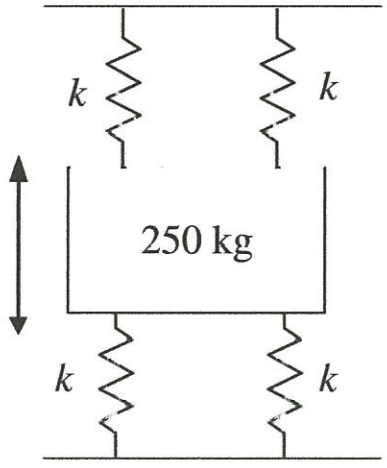

Figure Q3

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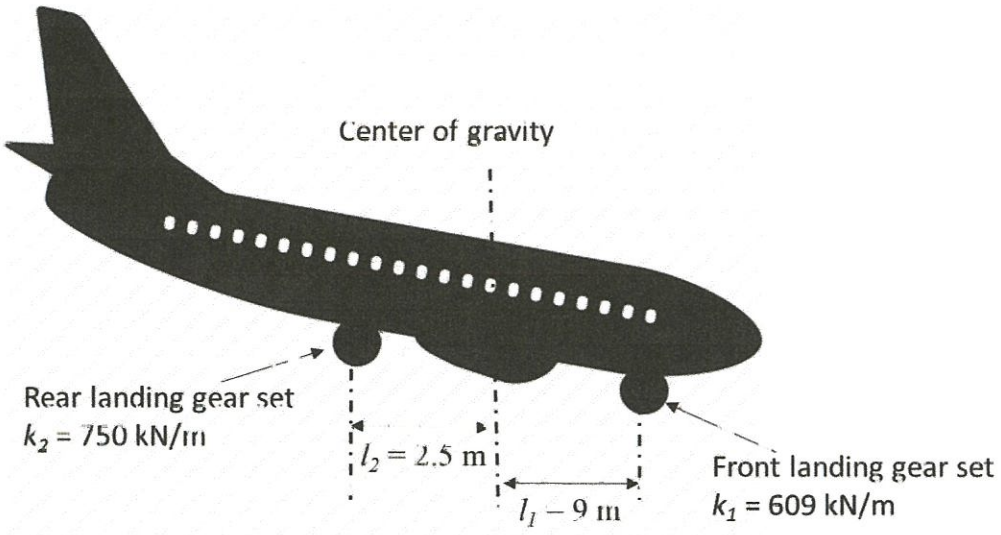

Figure Q4

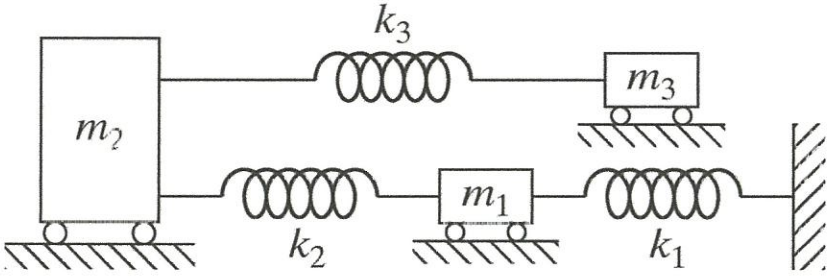

Figure Q5