UTHM
Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
(ONLINE)
SEMESTER II
SESSION 2020/2021

COURSE NAME	:	VIBRATION
COURSE CODE	:	BDA 31103
PROGRAMME CODE	:	BDD
EXAMINATION DATE	:	JULY 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 **NINE (9)** PAGES

PART A - ANSWER ALL QUESTIONS

Q1 (a) A mass, m of 2**P** kg consider one vertical motion only with angular displacement, $\theta = \omega t$, with spring coefficient, k of 1**Q** kN/m as shown in **Figure Q1**. If the system oscillates at free motion with amplitude, Y of 1**R** mm:

(i) Determine the natural frequency of the system, ω_n.

(2 marks)

(ii) Solve the time taken to complete one cycle of motion.

(2 marks)

(iii) Analyze the velocity of the mass, $\dot{y}$.

(3 marks)

(iv) Analyze the acceleration of the mass, $\ddot{y}$.

(3 marks)

(v) Examine the time taken at position A.

(5 marks)

Note: The values of **P**, **Q** and **R** depend on the 4th, 5th and 6th digit of your matric number as in the following matrix number format DD 171**PQR**. For example, if your matric number is DD 170**154** gives the value of m = **21** kg, k = **15** kN/m and Y = **14** mm.

(b) Briefly describe the functions for each instrument's components:

(i) Handheld Shaker.
(ii) Human Vibration Meter.
(iii) Pulse Analyzer.
(iv) Hand Arm Tri-axial Accelerometer.
(v) Non-contact Laser Doppler.

(10 marks)

Q2 (a) The frequency, f of an oscillating disturbance is equal to number of times (cycle) every second the disturbance passes from the one extreme position to other and back to original position. The number of times (cycles) per second is called Hertz. Basically, the frequency in pure tone sound wave namely pitch of the tone. Briefly describe the particular type of sound as shown in the **Figure Q2(a)**.

(3 marks)

(b) An operator in a textile mill is operating six machines. If the sound pressure levels of each machine at his position are given in **Table Q2(b)(i)**:

(i) Determine the total sound pressure level (in decibels) and total mean square pressure (in N/m^2) produced by all six machines at the operator position.

(4 marks)

(ii) If the two machines, M1 and M2 are turned off, and assuming that total sound pressure level is 120 dB, analyze the sound pressure level of the background noise (in decibels) and its mean square pressure (in N/m^2) at the operator position.

(6 marks)

(iii) If the data from **Table Q2(b)(i)** is converted to octave band as shown in **Table Q2(b)(ii)**, examine the total sound pressure level in dB(A) and total mean square pressure (in N/m^2).

(6 marks)

(iv) Describe briefly three method to control the noise if the answer in **Q2(b)(iii)** is SPL > 85 dB(A).

(6 marks)

Note: The values of **P**, **Q**, **R**, **S**, **T** and **U** depend on the 1st, 2nd, 3rd, 4th, 5th and 6th digit of your matric number as in the following matrix number format DD **PQRSTU**. For example, if your matric number is DD **170154** gives the value of sound pressure level of M1 is **91** dB, M2 is **87** dB, M3 is **90** dB, M4 is **71** dB, M5 is **65** dB and M6 is **84** dB.

Q3 A mass of flexible machine part, m_1 of 10 × **P** kg was observed to vibrate badly at frequency of 10 Hz. The vibration was caused by the application of a harmonic force, F of 10 × **Q** N to the flexible part. A judgment was made by a mechanical engineer that the vibration was excessive because the frequency of the harmonic force coincides with the natural frequency of the flexible part.

(a) Interpret the phenomena occurred that explained by the mechanical engineer.

(2 marks)

(b) If the flexible machine part was be modeled as a spring-mass-damper system, calculate the value of equivalent stiffness, k_1 of the system. Give final answer in unit of kN/m.

(4 marks)

(c) Analyze the mass and stiffness of an absorber that would eliminate vibrations of the flexible part at frequency of 10 Hz, if the amplitude motion of the absorber mass, X_a at 10 Hz was observed to be 0.1 × **R** cm.

(7 marks)

(d) If the flexible machine part is operated in the speed range of 500 to 750 rpm, justify whether the design of vibration absorber in **Q3(c)** is safe to be used or not.

(12 marks)

Note: The values of **P**, **Q** and **R** depend on the 4th, 5th and 6th digit of your matric number, respectively as shown in **Table Q3**. For example, if your matrix number is DD 170**154** gives the value of $m_1 = 10$ kg, $F = 50$ N and $X_a = 0.4$ cm.

PART B - ANSWER ONE (1) QUESTION ONLY

Q4 Company ABC that manages wastewater treatment plant in Sri Gading, Johor has decided to replace the foundation supporting the motor-pump system with two springs as shown in **Figure Q4**. Thus, the manager of the company ABC has assigned an engineer to lead the task of studying the vibration of the system using two-degrees-of-freedom system. By considering the parameters of motor-pump system as a rigid bar of having mass, m and mass moment of inertia, J_0 about the center of gravity (C.G) with two springs (k_1 and k_2) at their ends;

(a) Draw a simple mass-spring of a motor-pump system by considering the above parameters.

(4 marks)

(b) Sketch the free-body diagram of the system based on the model of mass-spring system in **Q4(a)**.

(3 marks)

(c) Consider, mass, m and mass moment of inertia, J_0 of the rigid bar are **P** kg and **Q** kg-m^2, respectively, and two springs stiffness k_1= 0.5 kN/m and k_2= 0.2 kN/m. Derive the equations of motion of the system in terms $x(t)$ and $\theta(t)$ and arrange it in matrix form by substituting all values of unknowns in the equations. Assume the distances between C.G and springs as l_1= 40 cm and l_2= 60 cm.

(8 marks)

(d) Based on the analysis in **Q4(c)**, illustrate the concept of coordinate coupling.

(3 marks)

(e) Analyze the natural frequencies of the vibration of the system.

(7 marks)

Note: The values of **P** and **Q** are depending on the 5th and 6th digit of your matric number respectively as shown in **Table Q4**. For example, if your matric number is DD 170**154** gives the value of **P** = 80 kg and **Q** = 200 kg.

Q5 Samarang Offshore Installation Platform under management of Petronas Carigali Sdn Bhd planned to install compress gas turbine due to raising electricity demand. As a fresh rotating engineer, project manager gives a task for you to predict the angular displacement values before commissioning process take place with the operating angular velocity of 2 rad/s. From the tender document's specification, you found out that the mass moments of inertia, J of reduction gear is $10 \times \mathbf{P}$ kgm^2, compressor is $20 \times \mathbf{P}$ kgm^2 and turbine is $30 \times \mathbf{P}$ kgm^2. The shaft stiffness, k_t that connecting between reduction gear, compressor and turbine give value of $20 \times \mathbf{Q}$ N/m. The three-dimension model design of compress gas turbine shown in **Figure Q5**. Use external moments value acting on reduction gear is 10 Nm, compressor is 20 Nm and turbine is 30 Nm.

(a) State the standard operating procedure steps to derive equations of rotational motion using Lagrange's equation.

(4 marks)

(b) Demonstrate a free body diagram that will simplify the 3D model design of compress gas turbine into three degree of freedom system. Include value of mass moments of inertia, J and shaft stiffness, k_t.

(3 marks)

(c) Establish the equation of rotational motion using Lagrange's equation and transform into the matrix form of $[J]\{\ddot{\theta}\} + [k]\{\theta\} = \{M_t\}$.

(8 marks)

(d) By assuming free rotational harmonic motion, $\theta(t) = \theta \sin 0.7t$ occurred at shaft bearing, analyze the angular displacement of each θ_1, θ_2 and θ_3 at t = 10 seconds. Use two decimal point in calculation.

(7 marks)

(e) Sketch the angular displacement of rotational eccentricity deviation at reduction gear, compressor and turbine using angular displacement answer in **Q5(d)**.

(3 marks)

Note: The values of **P** and **Q** depends on the 5th and 6th digit of your matric number respectively as shown in **Table Q5**. For example, if your matric number is DD 170**154** gives the value of **P** = 6 and **Q** = 1.

-END OF QUESTION-

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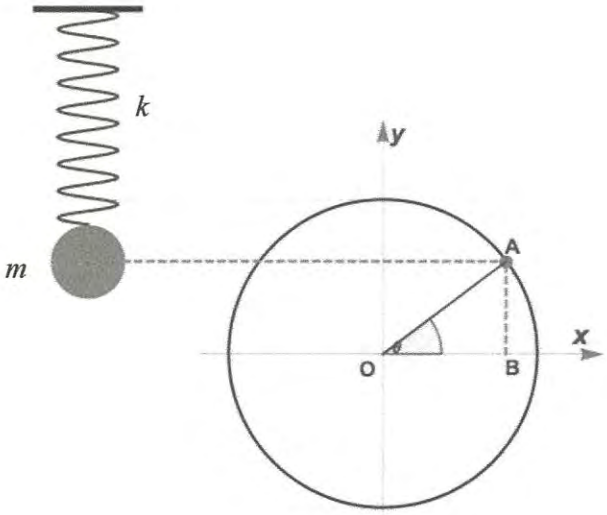

Figure Q1

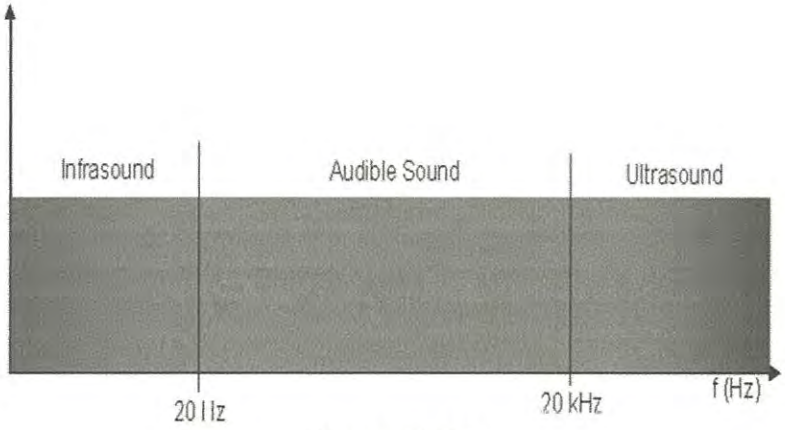

Figure Q2(a)

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Table Q2(b)

Machine No.	Level (dB)
M1	9P
M2	8Q
M3	9R
M4	7S
M5	6T
M6	8U

Table Q2(c)

Machine No.	Level (dB)	A weighting (dB)
250	9P	-8.6
500	8Q	-3.2
1000	9R	0
2000	7S	1.2
4000	6T	1
8000	8U	-1.1

Table Q3

4th digit of matrix number	P	5th digit of matrix number	Q	6th digit of matrix number	R
0	10	0	10	0	10
1	1	1	10	1	1
2	2	2	10	2	2
3	3	3	10	3	3
4	4	4	15	4	4
5	5	5	15	5	5
6	6	6	15	6	6
7	7	7	20	7	7
8	8	8	20	8	8
9	9	9	20	9	9

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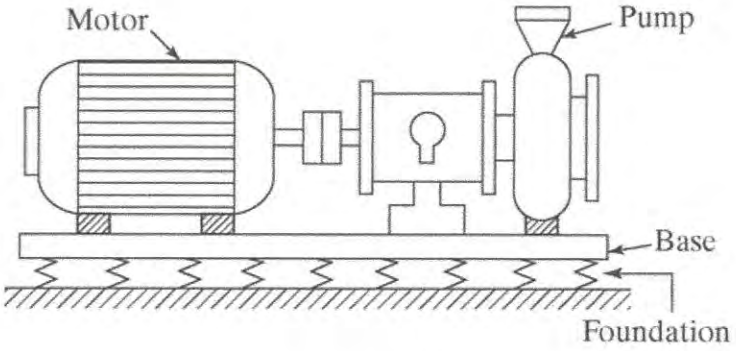

Figure Q4

Table Q4

5th digit of matric number	P	6th digit of matrix number	Q
0	70	0	150
1	70	1	150
2	70	2	150
3	80	3	200
4	80	4	200
5	80	5	200
6	90	6	150
7	90	7	150
8	100	8	200
9	100	9	200

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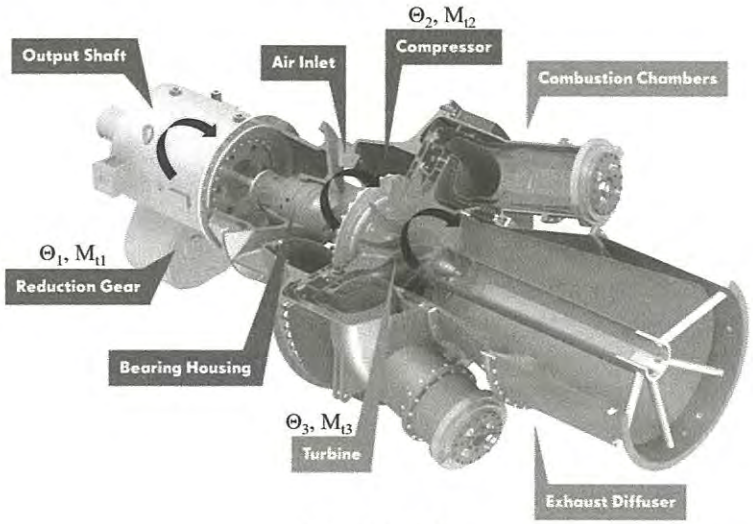

Figure Q5

Table Q5

5th digit of matric number	P	6th digit of matrix number	Q
0	8	0	3
1	8	1	3
2	8	2	3
3	6	3	1
4	6	4	1
5	6	5	1
6	4	6	3
7	4	7	3
8	2	8	1
9	2	9	1