Marking Scheme
AU3EL08 / ME3EL02 Mechanical Vibrations

Q.1 i. In spring mass system if the mass of the system is doubled with spring stiffness halved, the natural frequency of longitudinal vibration **1**
(c) Is halved

ii. The reciprocal of the interval of time taken by a vibrating body to complete a cycle is called **1**
(a) Frequency

iii. In the case of Coulomb's damping, the damping force is _______ with respect to relative velocity. **1**
(c) Independent

iv. The amount of damping, necessary for a system to be critically damped, is known as **1**
(c) Critical damping co-efficient

v. In vibration isolation system if ω/ω_n is less than $\sqrt{2}$, then for all values of damping factor, the transmissibility will be **1**
(c) Greater than unity

vi. The ratio of the maximum displacement of the forced vibration to the deflection due to the static force, is known as **1**
(d) Magnification factor

vii. For a multi-degree freedom system having n d.o.f., the number of natural frequency possible will be **1**
(c) n

viii. In semi definite system one of the natural frequencies is **1**
(a) Zero

ix. Seismic instruments are used to measure **1**
(d) All of these

x. Vibration analysis is a technique adopted under **1**
(c) Predictive maintenance

Q.2 i. (a) What is beat phenomena **4**

Definition 1 mark
Diagram 1 mark

(b) Find the natural frequency of the system

Equivalent stiffness in parallel = 5000 N/m 1 mark
ω_n = 31.62 rad/sec 0.5 mark
f_n = 5.03 Hz 0.5 mark

ii. Determine the natural frequency of the system shown in Fig. [2] by energy method **6**

Solution
Energy Method 3 marks
Energy equation

$$K.E = \frac{1}{2}m\dot{x}_1^2 + \frac{1}{2}I\dot{\theta}^2$$

$$P.E = \frac{1}{2}kx_2^2$$

1 mark

Equation for simple harmonic motion 1 mark

$$\ddot{\theta} + \left(\frac{kR^2}{mr^2+I}\right)\theta = 0$$

Natural frequency 1 mark

$$\omega_n = \sqrt{\frac{kR^2}{mr^2+I}}$$

OR iii. Determine the natural frequency for small oscillation about the lowest point **6**

Solution
K.E equation
Translation 1 mark

$$\frac{1}{2}m(R-r)^2\dot{\theta}^2$$

Rotational 1 mark

$$\frac{1}{4}mr^2\left(\frac{R}{r}-1\right)^2\dot{\theta}^2$$

P.E equation 1 mark

$$mg(R-r)(1-\cos\theta)$$

Equation for harmonic motion 2 marks

$$\frac{3}{2}(R-r)\ddot{\theta} + g\theta = 0$$

Natural frequency 1 mark

$$\omega_n = \sqrt{\frac{2g}{3(R-r)}}$$

Q.3 i. Discuss in brief, various types of damping. **2**

Definition 0.5 mark for each (0.5 mark * 4)

ii. find: **8**

(a) Critical damping coefficient, 2 marks
(b) Damping factor, 2 marks
(c) Logarithmic decrement 2 marks
(d) Ratio of two consecutive amplitudes. 2 marks

OR iii. What will be its displacement from equilibrium position at the end of first second? **8**

Solution
Natural frequency ω_n = 15.33 rad/sec 1 mark

		Critical damping coefficient = 613.2 N.s/m	2 marks	
		Damping ratio = 0.2397	2 marks	
		Displacement equation	1 mark	
		Displacement = 0.0437×10^{-3}m	2 marks	
Q.4	i.	Magnification factor and how does it vary with frequency ratio		3
		Definition	2 marks	
		Diagram	1 mark	
	ii.	Determine the amplitude ratio of the trailer when fully loaded and empty.		7
		Solution		
		Empty trailer		
		Forcing frequency = 34.896 rad/sec	1 mark	
		Natural frequency = 37.416 rad/sec	1 mark	
		Frequency ratio = 0.933	1 mark	
		Ratio of amplitude of vibration = 1.4518	1 mark	
		Fully loaded trailer		
		Natural frequency = 18.708 rad/sec	1 mark	
		Frequency ratio = 1.8653	1 mark	
		Ratio of amplitude of vibration = 0.6819	1 mark	
OR	iii.	Solution		7
		Stiffness (K) = 49×10^5N/m	1 mark	
		Forcing frequency = 157 rad/sec	1 mark	
		Natural frequency = 70 rad/sec	1 mark	
		Frequency ratio = 2.2428	1 mark	
		The force transmitted to the foundation (F_T) = 798.8 N	1 mark	
		The amplitude of vibration of machine (A) = 1.207×10^{-4}m	1 mark	
		The phase lag = -12.5^o or $167^o25'$	1 mark	
Q.5	i.	Any three difference between a Vibration Absorber and a Vibration Isolator.		3
		1 mark for each	(1 mark * 3)	
	ii.	Determine the natural frequency of oscillation of double pendulum		7
		Solution		
		Equations of motion	1 mark	
		$\ddot{\theta}_1 + \frac{m_2 l_2}{(m_1+m_2)l_2}\dot{\theta} + \frac{g}{l}\theta_1 = 0$		
		Amplitude Ratio equation	2 marks	
		$\frac{A_1}{A_2} = \frac{m_2 l_2 \omega^2}{(m_1+m_2)l_2(-\omega^2 + \frac{g}{l})}$		
		Frequency equation	2 marks	
		$\omega^4 - \frac{(m_1+m_2)\omega^2(l_1+l_2)}{m_1 l_1 l_2} g + \frac{(m_1+m_2)g^2}{m_1 l_1 l_2} = 0$		
		Natural frequency	2 marks	
		$\omega_1 = 11.56$rad/ sec $\omega_2 = 4.8$rad/ sec		
OR	iii.	Find the natural frequency of the 3-d.o.f. system.Use matrix method.		7
		Solution		
		Equation of motion	1 mark	
		$4m\ddot{x}_1 + 4kx_1 - kx_2 = 0$		
		$2m\ddot{x}_2 + 2kx_2 - kx_1 - kx_3 = 0$		
		$m\ddot{x}_3 + kx_3 - kx_2 = 0$		
		Matrix Equation	1 mark	
		$[m]\{\ddot{x}\} + [k]\{x\} = 0$		
		$\{\ddot{x}\} + [c]\{x\} = 0$		
		$[m]^{-1} = \frac{adj(m)}{\lvert m \rvert}$		
		$[\lambda I - c]\{x\} = 0$		
		Roots of quadratic equation	2 marks	
		$\left[\lambda^2 - 2\lambda\left(\frac{k}{m}\right) + \frac{km^2}{8m^2}\right] = 0$		
		$\lambda_1 = 0.21(k/m)$ $\lambda_2 = 0.21(k/m)$		
		Natural frequency	3 marks	
		$\omega_1 = \sqrt{\frac{k}{m}}$ $\omega_2 = 0.458\sqrt{\frac{k}{m}}$ $\omega_3 = 1.337\sqrt{\frac{k}{m}}$		
Q.6		Write short notes on any two:		
	i.	Seismic Measuring Instrument		5
		Diagram	2 marks	
		Working principle	2 marks	
		Application	1 mark	
	ii.	Condition Monitoring		5
		Basic concept	2 marks	
		Method	2 marks	
		Advantages	1 mark	
	iii.	FFT Analyser		5
		Working principle	2 marks	
		Importance of the FFT Analyser to Mechanical Engineers	2 marks	
		Application	1 mark	

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OR iii. Find the natural frequency of the 3-d.o.f. system shown in Fig. [5]. Use matrix method. **7**

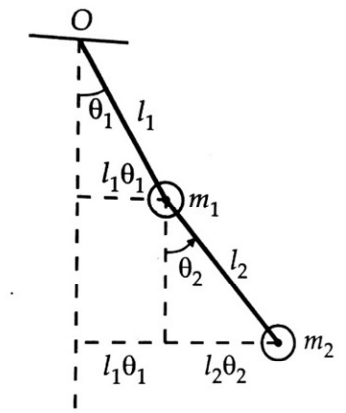

Fig. 4

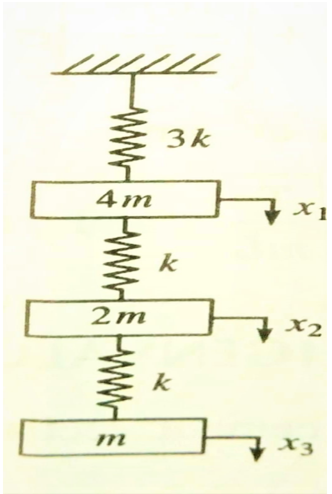

Fig. 5

Q.6 Write short notes on any two:

i. Seismic Measuring Instrument **5**

ii. Condition Monitoring **5**

iii. FFT Analyser **5**

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Total No. of Questions: 6 *Total No. of Printed Pages:2*

Enrollment No.....................................

Faculty of Engineering

End Sem (Even) Examination May-2019

AU3EL08 / ME3EL02 Mechanical Vibrations

Programme: B.Tech. Branch/Specialisation: AU/ME

Duration: 3 Hrs. **Maximum Marks: 60**

Note: All questions are compulsory. Internal choices, if any, are indicated. Answers of Q.1 (MCQs) should be written in full instead of only a, b, c or d.

Q.1 i. In spring mass system if the mass of the system is doubled with spring stiffness halved, the natural frequency of longitudinal vibration **1**

(a) Remained unchanged (b) Is doubled

(c) Is halved (d) Is quadrupled

ii. The reciprocal of the interval of time taken by a vibrating body to complete a cycle is called **1**

(a) Frequency (b) Period (c) Amplitude (d) None of these

iii. In the case of Coulomb's damping, the damping force is _______ with respect to relative velocity. **1**

(a) Directly proportional (b) Inversely proportional

(c) Independent (d) None of these

iv. The amount of damping, necessary for a system to be critically damped, is known as **1**

(a) Damping factor

(b) Magnification factor

(c) Critical damping co-efficient

(d) Logarithmic decrement

v. In vibration isolation system if ω/ω_n is less than $\sqrt{2}$, then for all values of damping factor, the transmissibility will be **1**

(a) Less than unity (b) Equal to unity

(c) Greater than unity (d) Zero.

vi. The ratio of the maximum displacement of the forced vibration to the deflection due to the static force, is known as **1**
(a) Damping factor (b) Damping coefficient
(c) Logarithmic decrement (d) Magnification factor

vii. For a multi-degree freedom system having n d.o.f., the number of natural frequency possible will be **1**
(a) 2 (b) 3 (c) n (d) ∞

viii. In semi definite system one of the natural frequencies is **1**
(a) Zero (b) Non-zero (c) Infinite (d) One

ix. Seismic instruments are used to measure **1**
(a) Displacement (b) Velocity
(c) Acceleration (d) All of these

x. Vibration analysis is a technique adopted under **1**
(a) Breakdown maintenance (b) Proactive maintenance
(c) Predictive maintenance (d) Preventive maintenance

Q.2 i. (a) What is beat phenomena? **4**
(b) Find the natural frequency of the system shown in Fig. [1]

ii. Determine the natural frequency of the system shown in Fig. [2] by energy method. **6**

OR iii. The cylinder of mass m and radius r rolls without slipping on a circular surface of radius R. Determine the natural frequency for small oscillation about the lowest point Fig. [3]. **6**

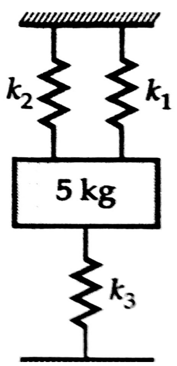

Fig. 1

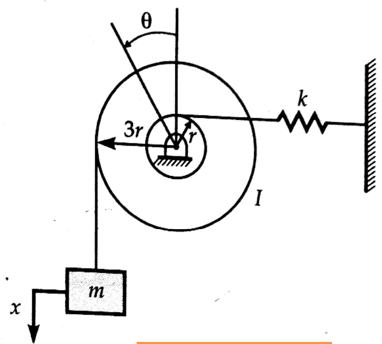

Fig. 2

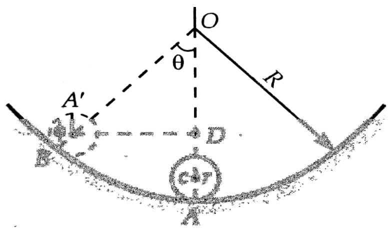

Fig. 3

Q.3 i. Discuss in brief, various types of damping. **2**

ii. The measurements on a mechanical vibrating system show that it has a mass of 8 kg and that the springs can be combined to give an equivalent spring of stiffness 5.4 N/mm. If the vibrating system have a dashpot attached which exerts a force of 40 N when the mass has a velocity of 1 m/s, find: **8**
(a) Critical damping coefficient,
(b) Damping factor,
(c) Logarithmic decrement
(d) Ratio of two consecutive amplitudes.

OR iii. A 20 kg mass is resting on a spring of 4700 N/m and dashpot of 147 N-sec/m in parallel. If a velocity of 0.10 m/sec is applied to the mass at the rest position, what will be its displacement from equilibrium position at the end of first second? **8**

Q.4 i. What is Magnification factor and how does it vary with frequency ratio? **3**

ii. A trailer has 1000 kg mass when fully loaded and 250 kg when empty. The spring of the suspension is 350 kN/m. The damping factor is 0.5 when the trailer is fully loaded. The speed is 100 km/hr. The road varies sinusoidally with a wave length of 5 m. Determine the amplitude ratio of the trailer when fully loaded and empty. **7**

OR iii. A machine of mass one tonne is acted upon by an external force of 2450 N at a frequency of 1500 rpm. To reduce the effects of vibration, isolator of rubber having a static deflection of 2 mm under the machine load and an estimated damping $\zeta = 0.2$ are used. Determine: **7**
(a) The force transmitted to the foundation,
(b) The amplitude of vibration of machine
(c) The phase lag.

Q.5 i. Write any three difference between a Vibration Absorber and a Vibration Isolator. **3**

ii. Determine the natural frequency of oscillation of double pendulum as shown in Fig. [4]. Find its value when $M_1 = M_2 = 5$kg, $L_1 = L_2 = 25$ cm. **7**