

The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Mechanical Engineering



061

Study Programme	Bachelor of Science Honours in Engineering
Name of the Examination	Final Examination
Course Code and Title	DMX5201 Advance Engineering Mechanics
Academic Year	2024
Date	16 th February 2025 (Sunday)
Time	13.30 - 16.30 hrs
Duration	03 hours

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of in **Four (4)** Pages.
3. Answer **All Questions**.
4. This is a Closed Book Test (CBT).
5. Answers should be in clear handwriting.

QUESTION 1 (16 marks)

Determine the moment of inertia of the rod shown in Figure Q1 about the O-a axis.

$$I_{Oa} = I_{xx}u_x^2 + I_{yy}u_y^2 + I_{zz}u_z^2 - 2I_{xy}u_xu_y - 2I_{yz}u_yu_z - 2I_{zx}u_zu_x$$

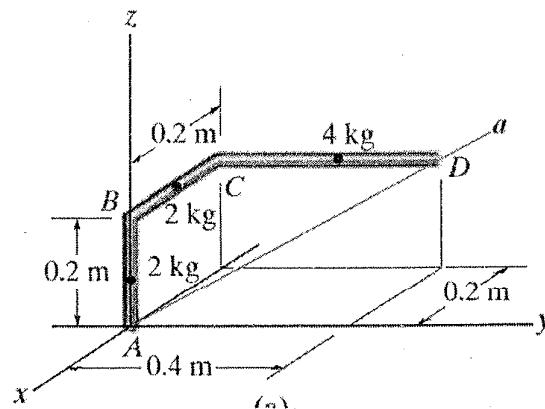


Figure Q1

QUESTION 2 (20 marks)

The vibrations of a system are governed by the differential equation

$$2\ddot{x} + 40\dot{x} + 1800x = 0$$

with the initial conditions $x_0 = 0.001$ m and $\dot{x}_0 = 3$ m/s. Calculate or specify the following.

- (a) The natural frequency, ω_n
- (b) The damping ratio,
- (c) Whether the system is underdamped, critically damped, or overdamped
- (d) The undamped period, T
- (e) Undamped frequency in Hz, f
- (f) The damped natural frequency (if appropriate),
- (g) The damped period (if appropriate),
- (h) The logarithmic decrement (if appropriate),
- (i) The amplitude of vibrations, A
- (j) The phase between the response and a pure sinusoid (if appropriate),
- (k) The free response of the system

QUESTION 3 (16 marks)

Figure Q3 shows a vibrating system consisting of two masses m_1 and m_2 . This represents a simple multi degree of freedom vibrating system. It can be assumed that the system is frictionless, and the boundaries are rigid.

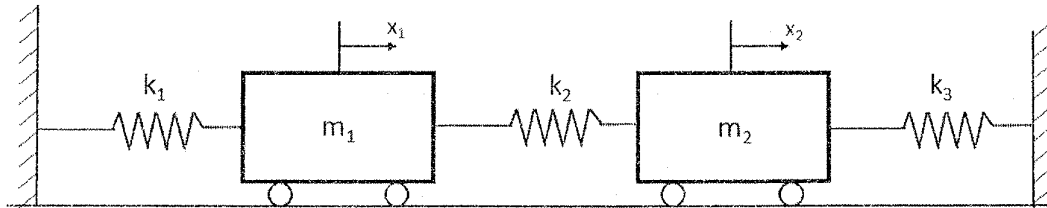


Figure Q3

- (a) Write the governing equations for the motion of mass m_1 and m_2 of the system.
- (b) Write the governing equation of motion for the system in matrix form.
- (c) If $m_1 = 8$ kg, $m_2 = 16$ kg, $k_1 = k_2 = 2 \times 10^5$ N/m and $k_3 = 3 \times 10^5$ N/m find the natural frequencies ω_n and mode shapes of the system.
- (d) When the motion starts (at $t = 0$) $x_1 = 0.001$ m, $x_2 = 0$, $\dot{x}_1 = 0$ and $\dot{x}_2 = 0$. Find the complete solution of this vibrating system. The general solution of such system with usual notations can be written as

$$x(t) = A_1 x_1 \sin(\omega_1 t + \varphi_1) + A_2 x_2 \sin(\omega_2 t + \varphi_2)$$

QUESTION 4 (16 marks)

A torsional vibration system consists of four rotors, 1, 2, 3, and 4, mounted on a steel shaft of diameter 50 mm. Moments of inertia of the rotors and the lengths of the sections of the shaft are given in the Table Q4(a) and Q4(b).

Moments of Inertia of Rotors (kgm²)	
Rotor 1	0.50
Rotor 2	0.25
Rotor 3	0.16
Rotor 4	0.30

Table Q4(a)

Lengths of Sections of Shafts between Rotors (m)	
Between rotors 1 and 2	0.60
Between rotors 2 and 3	0.30
Between rotors 3 and 4	1.20

Table Q4(b)

To find the natural frequencies and the mode shapes it is decided to use Holzer method to obtain them. The modulus of rigidity of the shaft material is given as **80 GN/m²**

- (a) Estimate a suitable initial frequency value.
- (b) Find the natural frequencies and the mode shapes using Holzer method.
- (c) Sketch the mode shape of vibration and find the position of the node.

QUESTION 5 (16 marks)

- (a) Explain, what a Vibration Exciter is? Name three different types of vibration exciters.
- (b) With the aid of sketches, briefly describe one of the vibration exciters you mentioned above.
- (c) Briefly explain the procedure to find the response of a system subjected to random vibrations
- (d) Explain Dunkerly's Method.

QUESTION 6 (16 marks)

The wheel is spinning about shaft AB with an angular velocity of $\omega_s = 10 \text{ rad/s}$, which is increasing at a constant rate of $\dot{\omega}_s = 6 \text{ rad/s}^2$, while the frame precesses about the z axis with an angular velocity of $\omega_p = 12 \text{ rad/s}$, which is increasing at a constant rate of $\dot{\omega}_p = 3 \text{ rad/s}^2$. Determine the velocity and acceleration of point C located on the rim of the wheel (along x axis) at this instant.

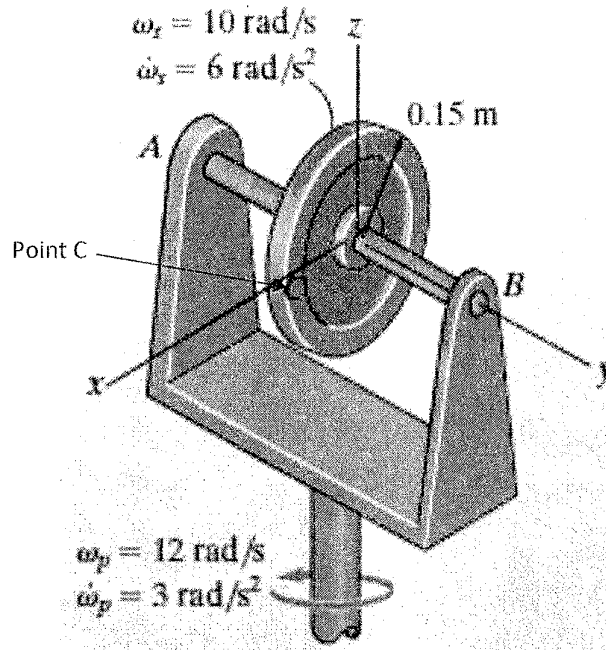


Figure Q6

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