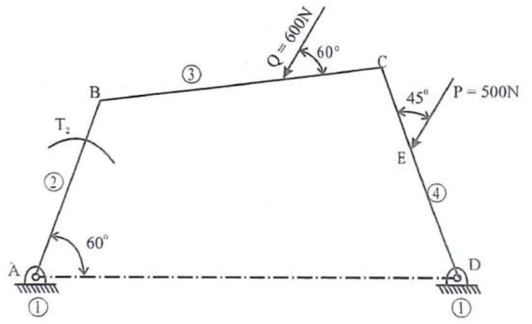
Internal Assessment Test II – Oct. 2019

Sub:	Dynamics of Machinery					**Code:**	17ME52
Date:	12/ 10 / 2018	Duration: 90 mins	Max Marks:	50	**Sem:** V	**Branch:**	MECH

Note: Answer all questions.

		Marks	OBE	
			CO	RBT
1 a	Explain types of Vibration	**8**	CO4	L1
b	Define i) Degree of freedom ii) Simple Harmonic Motion	**2**		
2a	State the conditions for the equilibrium of following systems: i) Two force member ii) Three force member iii) Member with two force and torque			
b	Explain Beats Phenomenon			
3	Add the following motions analytically and check the solution graphically $x_1 = 4\cos(\omega t + 10^\circ)$ $x_2 = 6\sin(\omega t + 60^\circ)$	**10**	CO4	L2
4	A four bar mechanism under the action of two external forces is as shown in fig. Determine the torque to be applied on link AB for static equilibrium. AB = 50mm, BC = 66mm, CD = 55mm, CE = 25 mm, CF = 30 mm, AD = 100mm 	**20**	CO4	L3

Solution for Internal Assessment Test II – Oct. 2019

Subject: Dynamics of Machinery {17ME52}

1. a Types of Vibration

1. Free and Forced Vibrations

Free Vibration: If a system, after an initial disturbance, is left to vibrate on its own, the ensuing vibration is known as free vibration. No external force acts on the system. The oscillation of a simple pendulum is an example of free vibration.

Forced Vibration: If a system is subjected to an external force (often, a repeating type of force), the resulting vibration is known as forced vibration.

Machine tools, electric bells etc.. are the suitable examples of forced vibration.

If the frequency of the external force coincides with one of the natural frequencies of the system, a condition known as resonance occurs, and the system undergoes dangerously large oscillations. Failures of such structures as buildings, bridges, turbines, and airplane wings have been associated with the occurrence of resonance.

2. Damped and Undamped Vibrations

If the vibratory system has a damper then there is a Reduction in amplitude over every cycle vibration since the energy of the system will be dissipated due to friction. This type of vibration is called damped vibration.

If the vibratory system has no damper, then the vibration is called undamped vibration.

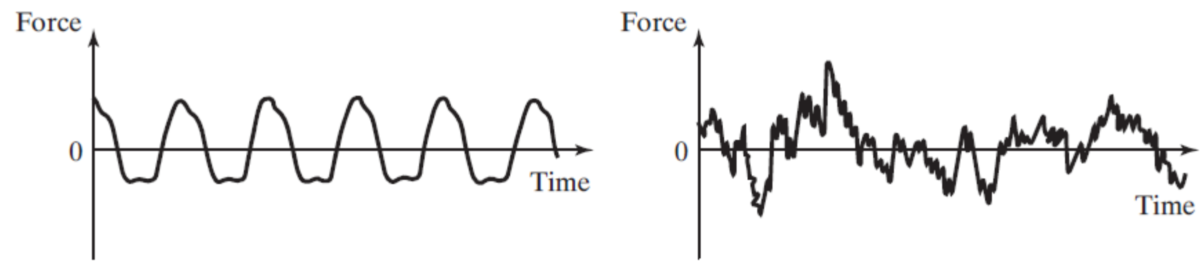
3. Linear and Nonlinear Vibration

If all the basic components of a vibratory system the spring, the mass, and the damper behave linearly, the resulting vibration is known as *linear vibration*. If, however, any of the basic components behave nonlinearly, the vibration is called *nonlinear vibration*.

4. Deterministic and Random Vibrations

If the magnitude of the excitation force or motion acting on a vibrating system is known then the excitation is known as deterministic. The resulting vibration is called the deterministic vibration

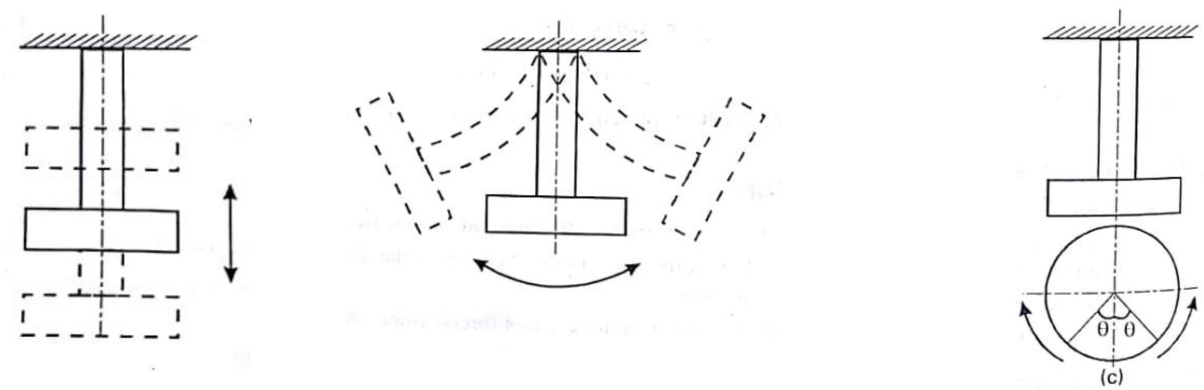
If the magnitude of the excitation force or motion acting on a vibrating system is unknown, but the averages and deviations are known then the excitation is known as non-deterministic. The resulting vibration is called random vibrations.



(a) A deterministic (periodic) excitation (b) A random excitation

5. Longitudinal, Transverse and Torsional Vibrations

When the particles of the shaft or disc moves parallel to the axis of shaft, then the vibrations are known as longitudinal vibrations and are shown in Figure (a).



(a) (b) (c)

When the particles of the shaft or disc moves approximately perpendicular to the axis of the shaft, then the vibrations are known as transverse vibrations and is shown in Figure (b).

When the particles of the shaft or disc moves in a circle about the axis of the shaft i e if the shaft gets alternately twisted and untwisted on account of vibratory motion, then the vibrations are known as torsional vibrations and is shown in Figure(c).

1. b Degree of freedom

Number of independently variable factors affecting the range of states in which a system may exist, in particular any of the directions in which independent motion can occur.

Simple Harmonic Motion

Any motion which repeats itself in equal intervals of time is known as periodic motion. Simple harmonic motion (SHM) is the simplest form of periodic motion. A simple harmonic motion is a reciprocating motion. The motion is periodic and its acceleration is always directed towards the mean position and is proportional to the displacement from the mean position.

If ***x(t)*** represents the displacement of a mass in a vibrating system, the motion can be expressed by the equation

$$x = A \sin \omega t$$

$$\dot{x} = A\, \omega \cos \omega t$$

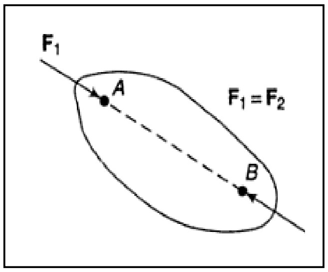
$$\ddot{x} = -A\, \omega^2 \sin \omega t = -\omega^2 x$$

Where $x, \dot{x}\ and\ \ddot{x}$ represent the displacement, velocity and acceleration of the body respectively.

2.a **Equilibrium of Two Force Members**

A member under the action of two forces will be in equilibrium if

- The forces are of the same magnitude,
- The forces act along the same line, and the forces are in opposite directions



Equilibrium of Three Force Members

A member under the action of three forces will be in equilibrium if

- The resultant of the forces is zero, and
- The lines of action of the forces intersect at a point (known as *point of concurrency).*

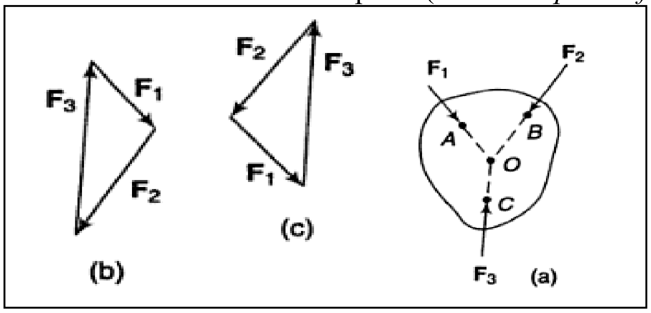


Figure (a) indicates an example for the three force member and (b) and (c) indicates the force polygon to check for the static equilibrium.

Member with two forces and a torque

A member under the action of two forces and an applied torque will be in equilibrium if

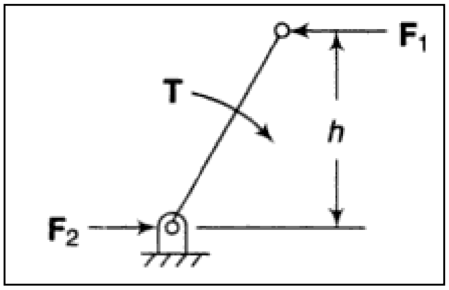
- The forces are equal in magnitude, parallel in direction and opposite in sense and
- The forces form a couple which is equal and opposite to the applied torque.

Figure shows a member acted upon by two equal forces $\mathbf{F_1}$, and $\mathbf{F_2}$ and an applied torque **T** for equilibrium,

$$T = F_1 h = F_2 h$$

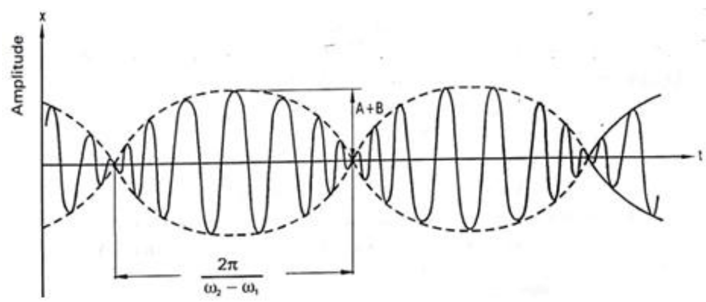
Where *T, F_1 and F_2 are the magnitudes of* ***T***, $\boldsymbol{F_1}$ *and* $\mathbf{F_2}$ respectively.

T is clockwise whereas the couple formed by $\mathbf{F_1}$, and $\mathbf{F_2}$ is counter-clockwise.



2. b Beats Phenomenon

If two harmonic motions passes through a point simultaneously then the resultant displacement at that point is the vector sum of the displacement due to the two motions. This super position of motion is called interference. The phenomenon of beat occurs as a result of interference between two waves of slightly different frequencies moving along the same straight line in the same direction.



Consider a particle subjected to two different harmonic motions,

$$x_1 = A \sin \omega_1 t$$

$$x_2 = B \sin \omega_2 t$$

The resultant motion is given by

$$x = x_1 + x_2 = A \sin \omega_1 t + B \sin \omega_2 t$$

Where ω_1 and ω_2 are circular frequencies. If ω_1 and ω_2 are different then the resultant motion is not sinusoidal. In some special cases, when the two frequencies are slightly differ from each other, under these conditions the phase difference between the rotating vectors keeps on shifting slowly and continuously.

At a time when they are in phase with each other the amplitude of resultant vibration is equal to the sum of the amplitude of individual motions that is (a + b). When they are out of phase, the amplitude is equal to the difference of the individual amplitudes that is (a - b). Thus the resultant amplitude continuously keeps on changing from maximum of (a + b) to minimum (a - b) with a frequency equal to the difference between the individual components frequencies as shown in fig. The phenomenon is known as Beats. The frequency of the beats is $(\omega_2 - \omega_1)$ and it is neccesary that this frequency be small in order to experience the beats phenomenon.

3

$x_1 = 4\cos(\omega t + 10^\circ)$; $x_2 = 6\sin(\omega t + 60^\circ)$

Sol :

$$x = A\sin(\omega t + \theta)$$

$$x = x_1 + x_2$$

$$A\sin(\omega t + \theta) = 4\cos(\omega t + 10^\circ) + 6\sin(\omega t + 60^\circ)$$

$$A\sin\omega t \cdot \cos\theta + A\cos\omega t \cdot \sin\theta = 4\cos\omega t \cdot \cos 10^\circ - 4\sin\omega t \cdot \sin 10^\circ + 6\sin\omega t \cdot \cos 60^\circ + 6\cos\omega t \cdot \sin 60^\circ$$

$$\sin\omega t(A\cos\theta) + \cos\omega t(A\sin\theta) = \sin\omega t(-4\sin 10^\circ + 6\cos 60^\circ) + \cos\omega t(4\cos 10^\circ + 6\sin 60^\circ)$$

$$\sin\omega t(A\cos\theta) + \cos\omega t(A\sin\theta) = \sin\omega t(2.305) + \cos\omega t(9.135)$$

$$A\cos\theta = 2.305 \rightarrow (1)$$

$$A\sin\theta = 9.135 \rightarrow (2)$$

Squaring & adding $A^2\cos^2\theta + A^2\sin^2\theta = 2.305^2 + 9.135^2$

$$\boxed{A = 9.42}$$

② ÷ ①

$$\frac{A \sin\theta}{A \cos\theta} = \frac{9.135}{2.305}$$

$$\tan\theta = 3.963$$

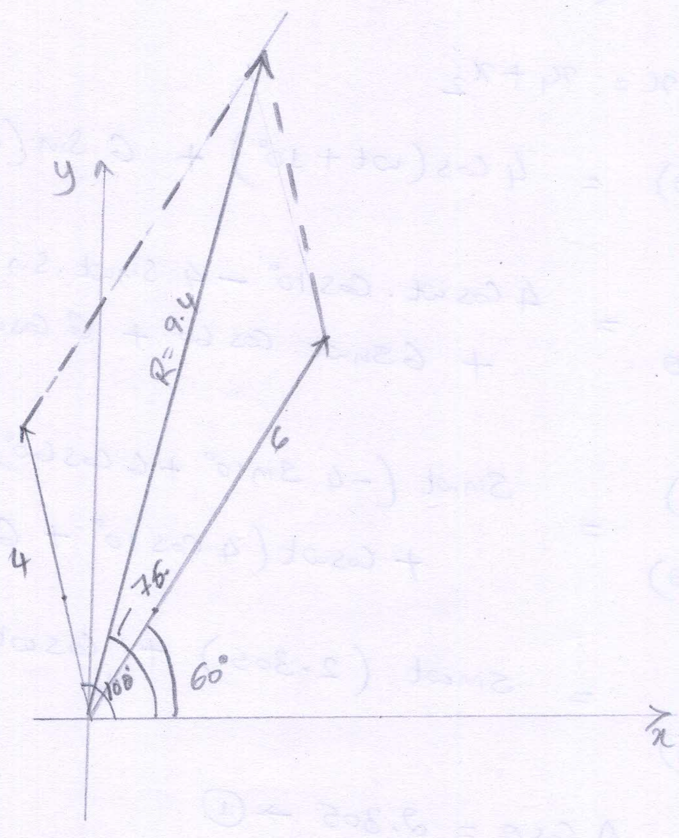
$$\boxed{\theta = 75.84°}$$

$$\therefore \quad x = 9.42 \sin(\omega t + 75.84°)$$

Graphical Method

$$x_1 = 4\cos(\omega t + 10°) = 4\sin(\omega t + 100°)$$

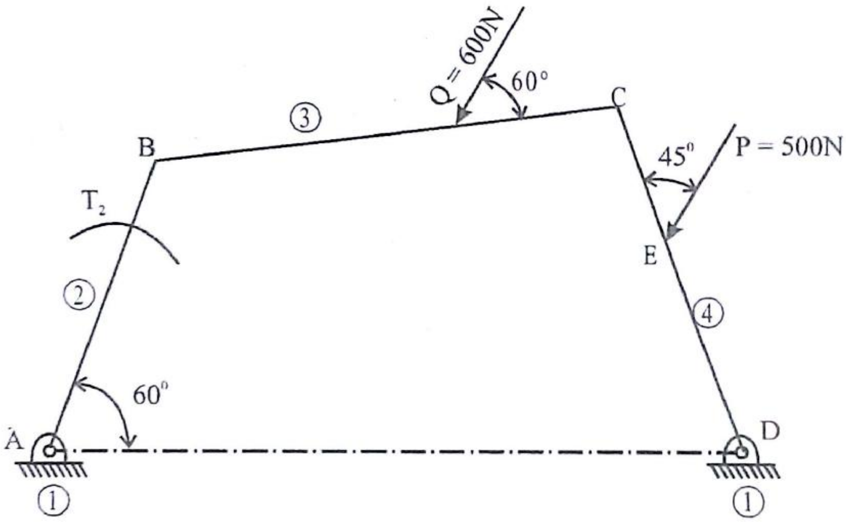
$$x_2 = 6\sin(\omega t + 60°)$$



$$x = 9.4 \sin(\omega t + 76°)$$

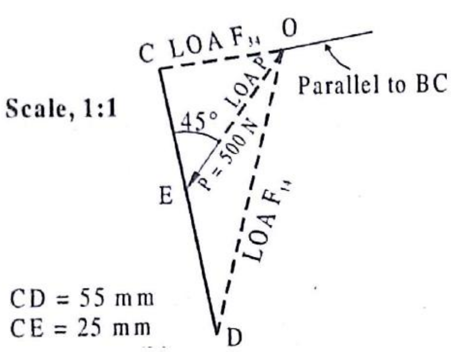
Problem

A four bar mechanism under the action of two external forces is as shown in fig. Determine the torque to be applied on link AB for static equilibrium. AB = 50mm, BC = 66mm, CD = 55mm, CE = 25 mm, CF = 30 mm, AD = 100mm

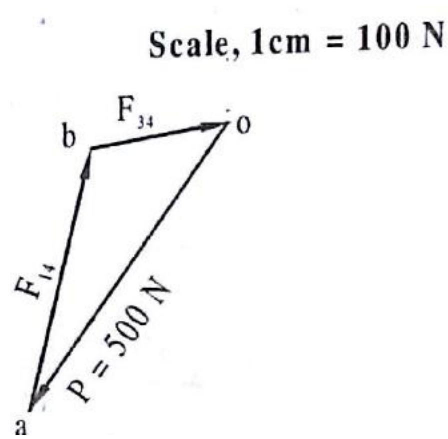


Solution:

Considering link 4



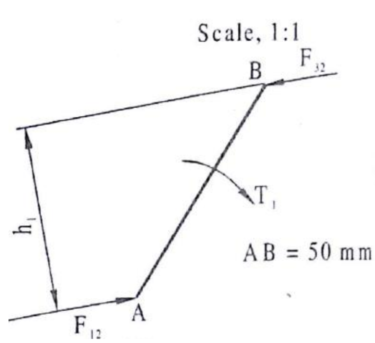
Force Polygon



$\mathbf{F_{34} = 190\ N}$

$\mathbf{F_{34}} = \mathbf{-F_{43} = F_{23} = -F_{32}}$

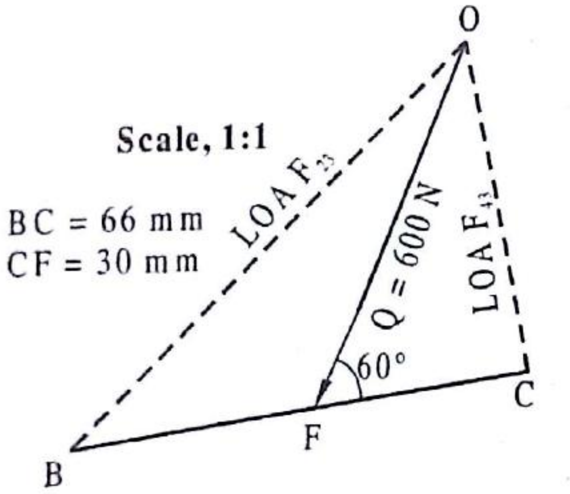
Considering link 2

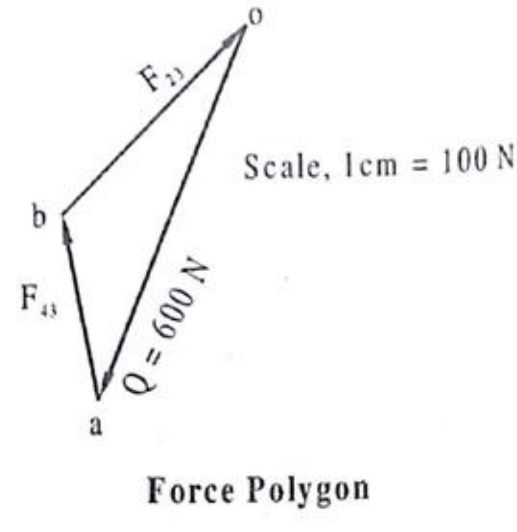


$h_1 = 38.5$ mm

$\mathbf{T_1} = F_{32} \times h_1 = 190 \times 38.5 = \mathbf{7.3\ Nm}$

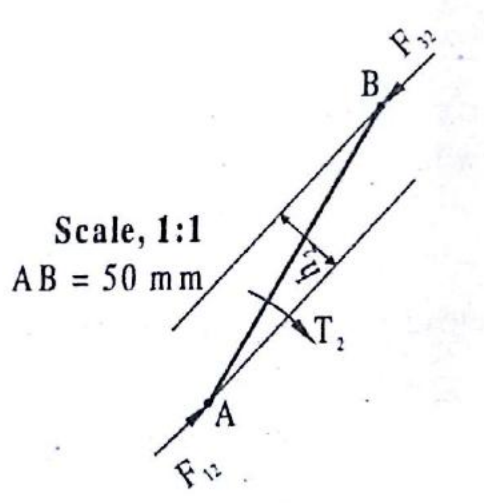
Considering link 3





F_{23} = 400 N

$F_{23} = - F_{32}$



h_2 = 11 mm

T_2 = $F_{32} \times h_2$ = 400 × 11 = **4.4 Nm**

Total Torque = $T_1 + T_2$ = 7.3 + 4.4 = 11.7 Nm