Department of Mechanical Engineering, BOSE, Cuttack

VST (SET-1)

Sub:- Theory of Machines (TOM)

Fullmarks :- 80

Answer all the questions including no. 1 & no. 2

(1) Answer all the questions :- [2 × 10]

<a> Write down the difference between machine and mechanism.

<b> Define co-efficient of friction.

<c> Write down the formulae for velocity ratio in Belt drive.

<d> Define clutch.

<e> What is a reverted gear train.

<f> What is the function of cam and followers?

<g> Define time period and amplitude with respect to vibration.

<h> Define inversion with example.

<i> Write down the formula of length of belt for open belt drive and cross belt drive.

(j) Define law of gearing.

(2) Answer any six questions :- [5 × 6]

<a> Explain sliding pair, Rolling pair, Screw pair, Turning pair and Spherical pair with example.

<b> State the function of Bearing and explain Ball bearing and Roller Bearing.

<c> Explain simple and compound gear train with diagram.

<d> What are the advantages and uses of chain drive and rope drive.

<e> Explain Sensitivity, Stability and Isochronism of a governor.

<f> Give a comparison between governor and flywheel.

<g> Explain the causes and remedies of vibration.

(3) What is four bar chain? Explain any two inversion of four bar chain. [10]

(4) What is the function of Dynamometer and explain Prony Brake Dynamometer with a neat sketch. [10]

(5) Derive an expression for frictional torque in pivot bearing considering Uniform wear theory. [10]

(6) A body of weight 70N is placed on a rough horizontal plane. In order to just move the body on the horizontal plane, a push of 20N inclined at 20° to the horizontal plane is required. Find the co-efficient of friction. [10]

(7) A belt is running over a pulley of diameter 120 cm at 200 rpm. The angle of contact is 165° and coefficient of friction betn the belt and pulley is 0.3. If the maxm tension in the belt is 3000N. Find the power transmitted by the belt. [10]

MODEL QUESTION SET FOR 4th SEM.

MECH. ENGG.

Sub :- THEORY OF MACHINES.

F.M. = 80 TIME = 3 Hrs.

Answer any FIVE Questions including Q.No - 1&2

[2×10]

1. (a) Define Mechanism.
   (b) State the function of Bearings.
   (c) Define the diametrial pitch.
   (d) Define module in gear drive.
   (e) What is the difference between governor and flywheel
   (f) Define co-efficient of friction.
   (g) What is damped vibration?
   (h) Define isochronism of Governor.
   (i) What is the cause of balancing of masses?
   (j) What is a reverted gear train?

2. Answer any SIX questions. [5×6]
   (a) Explain four bar chain mechanism with a neat sketch.
   (b) Describe the working principle of Watt governor.
   (c) With neat sketch explain fast and loose pulleys.
   (d) Explain single plate clutch.
   (e) With neat sketch describe longitudinal, transverse and torsional free vibration.
   (f) Derive an equation for total frictional torque on a ~~belt~~ ~~conical~~ flat pivot bearing considering uniform pressure.

(g) Differentiate between static balancing and dynamic balancing.

[10]

3. ~~Describe~~ Classify the kinematic pair and describe each and every pair in detail.

[10]

4. ~~A~~ conical pivot supports a vertical shaft of 200mm diameter subjected to a load of 30 kN. The cone angle is 120^0 and the co-efficient of friction is 0.025. Find the power lost in friction when the speed is 150 rpm, assuming 1. Uniform pressure and 2. Uniform wear.

5. Define absorption dynamometer and describe ~~the~~ its different types (two) ~~of abs~~ with neat sketch. [10]

[10]

6. Find the power transmitted by a belt running over a pulley of 500 ~~rpm~~ mm diameter ~~and~~ at 200rpm. The co-efficient of friction between the belt and the pulley is 0.25, angle of lap is 160 and maximum tension in the belt is 2500 N.

[10]

7. Four masses m_1, m_2, m_3 and m_4 are 200kg, 300kg, 250kg and 270 kg respectively. The corresponding radii of rotation are 0.2m, 0.15m, 0.25m and 0.3m resp. and the angles between successive masses are 45^0, 75^0 and 135^0. Find the position and magnitude of the balance mass required, if its radius of rotation is 0.2m.

— o —

BEST OF LUCK.

LECTURE NOTES

FROM

SMT. SABITARANI SAHOO (LECT. IN, MECH. ENGG.) FOR 4TH SEMESTER MECHANICAL ENGG.IN THE SUBJECT **THEORY OF MACHINE**

Chapter-5

Balancing of Machine

Concept of static and dynamic balancing.
Static balancing of rotating parts.
Principles of balancing of reciprocating parts.
Causes and effect of unbalance.
Difference between static and dynamic balancing

Syllabus:

Concept of static balancing:

A system of rotating masses is said to be in static balance if the combined mass centre of the system lie on the axis of rotation. The given figure shows a rigid rotor revolving with a constant angular velocity wrad/sec.

A no. of masses, say 3, are depicted by point masses at different radii in the same transverses plane. They may represent different kinds of rotating masses such as turbine blades, eccentric disc, etc. if m1, m2 and m3 are the masses revolving at radii r1, r2 and r3 respectively in the sam,e plane then each mass produces a centrifugal force acting radially outwards from axis of rotation.

Dynamic balancing:

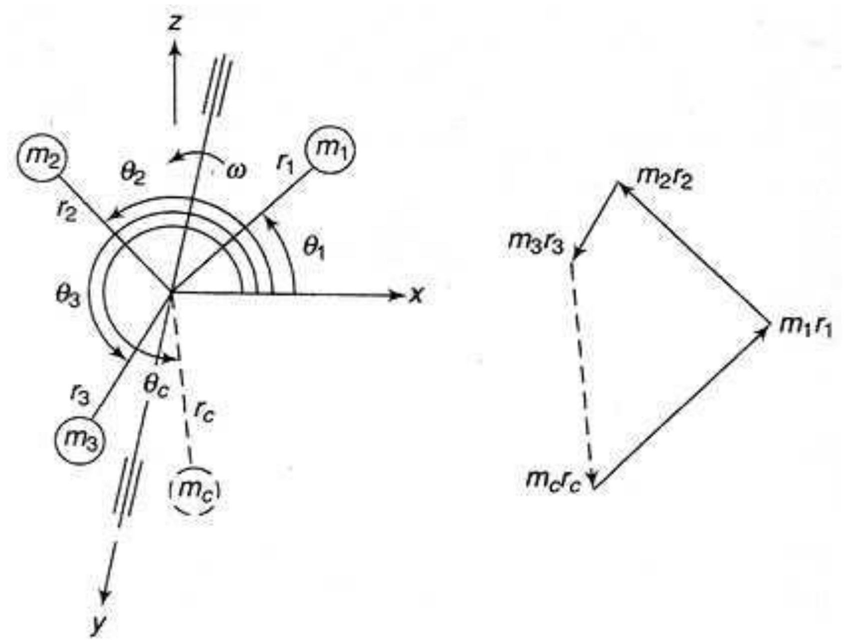
When several masses rotate in different planes, the centrifugal forces, in addition to being out of balance also forms coupkle. A system of rotating masses is in dynamic balance when there doesn't exist any resultant centrifugal force as well as resultant couple:

In the work that follows the product of mr and mri (instead of mrw), usually, have been reform as force and couple respectively as it is more convenient to draws force and couple polygon with these quantities

If m1 m2 are two masses as in figure revolving diametrically opposite to each other in different planes such that m1r1 = m2r2, the centrifugal forces are balanced but an unbalanced couple of magnitude m1r1i = m2r2i is introduced. The couple act in a plane that contains the axis of rotation and the two masses. Thus, the couple is a constant magnitude but variable direction.

Static balancing of rotating parts:

Consider a number of masses of magnitude m1,m2,m3,m_c at distance of r1,r2,r3,r_e from the axis of the rotating shaft.



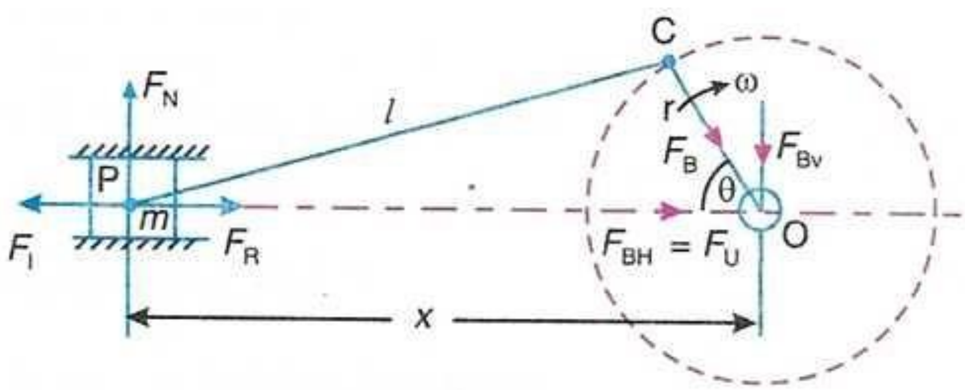
Principles of balancing of reciprocating parts.

For complete balancing of the reciprocating parts, the following condition must be fulfilled:

1. Primary forces must balance, i.e. primary force polygon is enclosed.
2. Primary couples must balance, i.e. primary couple polygon is enclosed.
3. Secondary forces must balance, i.e. secondary forces polygon is enclosed.
4. Secondary couples must balance, i.e. secondary couple polygon is enclosed.

Usually, it is not possible to satisfy all the above conditions fully for a multicylinder engine. Mostly some unbalanced force or couple would exist in the reciprocating engines.

Balancing of reciprocating masses:



Causes & effect of unbalance:

Often an unbalance of force is produce in rotary or reciprocating machinery due to the inertia force associated with the moving masses.

Balancing is the force of designing or modifying machinery that the unbalanced is reducing to an acceptable and possible is eliminated entirely.

In a revolving centre the centrifugal force remains balanced as long as the centre of the mass of the rotor, lies on axis of the shaft when of the mass does lie on the axis or there is an eccentricity, an unbalanced force is produced.

This type of un balanced is very common in case of steam turbines rotors , engine crankshaft, rotary compressor & centrifugal force .

In high speed machinery, the unbalanced force results .there force attracted on the frame by the moving machine members a varying, impact vibration motion on the frame & produced noise . also there are hum an discomfort, determinable effect of machine performance & structural inter grids of the machine foundation .the most common approach lie balancing by disturbing them the mass which may be accomplished by addition or removal of mass from various machine members .

5.5 Difference between static and dynamic balancing:

Static balancing	Dynamic balancing
It would refer to balancing in a single plane	It would refer to balancing in more than one plane
It is also known as primary balancing. It is a balance force due to action of gravity.	It is also known as secondary balancing. It is a balance due to action of inertia forces.
Rotation of fly wheels, grinding wheels, car wheels are treated as static balancing problems as most of their masses concentrated in or very near one plane.	Rotation of shaft of turbo-generator is a case of dynamic balancing problems
Static balance occurs when the centre of gravity of an object is on the axis of rotation	A rotating system of mass is in dynamic balance when the rotation doesn't produce any resultant centripetal force of couple. Here the mass axis is coincidental with the rotational axis.

Chapter-6

Vibration of machine parts

Introduction to Vibration and related terms
(Amplitude, time period and frequency, cycle)
Classification of vibration.
Basic concept of natural, forced & damped vibration
Torsional and Longitudinal vibration.
6.6 Causes & remedies of vibration.

Syllabus:

Introduction to Vibration and related terms (Amplitude, time period and frequency,cycle)

Amplitude:

It is defined as its maximum displacement of a vibrating body from its equilibrium position.

Time Period:

`It is the time taken by a motion to repeat itself, and is measured in seconds.

Frequency:

Frequency is the number of cycles of motion completed in one second. It is expressed in hertz (Hz) and is equal to one cycle per second.

DEFINITIONS:

I. Free (natural) vibrations elastic vibrations in which there is no friction and external forces after the initial release of the body are known as free or natural vibrations.

II. Damped vibrations when the energy of a vibrating system is gradually dissipated by friction and other resistances, the vibrations are said to be damped. The vibrations gradually cease and the system rests in its equilibrium position.

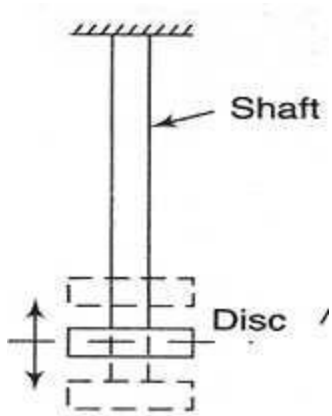
III. Forced vibrations when a repeated force continuously acts on a system, the vibrations are said to be forced. The frequency of the vibrations is that of the applied force and is independent of their own natural frequency of vibrations.

TYPES OF VIBRATIONS

Consider a vibrating body, e.g., a rod, shaft or spring. Figure shows a mass less shaft, one end of which is fixed and the other end carrying a heavy disc. The system can execute the following types of vibrations.

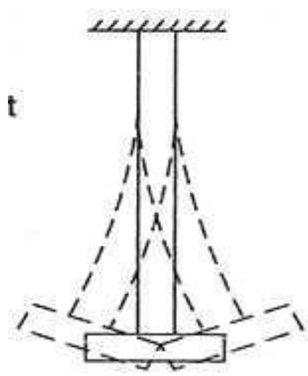
I. Longitudinal vibrations:

If the shaft is elongated and shortened so that the same moves up and down resulting in tensile and compressive stresses in the shaft, the vibrations are said to be longitudinal. The different particles of the body move parallel to the axis of the body.



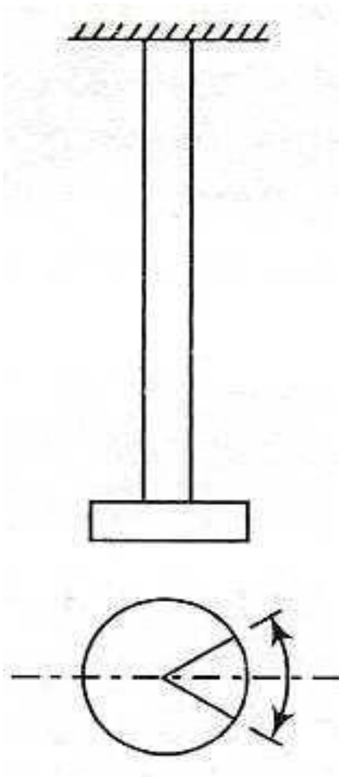
II. Transverse vibrations

When the shaft is bent alternately and tensile and compressive stresses due to bending result, the vibrations are said to be transverse. The particles of the body move approximately perpendicular to its axis.



III. Torsional vibrations:

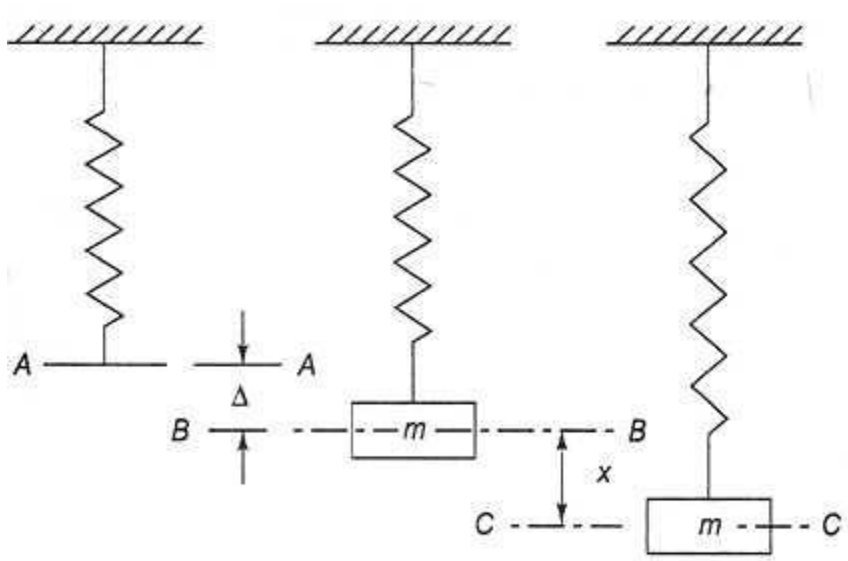
When the shaft is twisted and untwisted and untwisted alternately and torsional shear stresses are induced, the vibrations are known as torsional vibrations. The particles of the body move in a circle about the axis of the shaft.



Free longitudinal vibrations:

The natural frequency of a vibrating system may be found by any of the following method.

Equilibrium method:



It is based on the principle that whenever a vibratory system is in equilibrium, the algebraic sum of forces and moments acting on it is zero. This is in accordance with D'almbert's principle that the sum of the inertia forces and the external forces on a body in equilibrium must be zero.

Figure shows a helical spring suspended vertically from a rigid support with its free end at A-A.

If a mass m is suspended from the free end, the spring is stretched by a distance Δ and B-B becomes the equilibrium position thus Δ is the static deflection of the spring under the weight of the mass m.

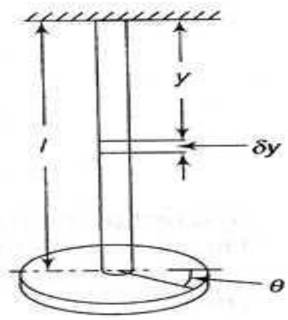
Let s = stiffness of the spring under the weight of the mass m.

In the static equilibrium position,

Upward force = downward force

Free torsional vibrations (single rotor)

Consider a uniform shaft of length/rigidly fixed at its upper end and carrying a disc of moment of inertia/ at its lower end. The shaft is assumed to be massless. If the disc is given a twist about its vertical axis and then released, it will start oscillating about the axis and will perform torsional vibrations.



Negative signs have been used as both of this torques act opposite to the angular displacement. For equilibrium, the sum of all torques acting on the disc must be zero.

Causes & remedies of vibration:

Causes of vibration:

Some of the important causes of vibration in machines are listed below

1. Unbalanced reciprocating machine parts
2. Unbalanced rotating machine parts
3. Incorrect alignment of the transmission elements such as coupling etc
4. Use of simple spur gears for power transmission
5. Warm-out teeth of the gears of the power transmission
6. IOmpact taking parttsd of ther machine of axplosion or impact of working fluids of prime movers
7. Loose transimission bekts and chains.
8. Loose fastenings of the moving parts.
9. Vibration waves from other sources and machines installed neardy, due to improper isolatrion of vibrations from them.
10. Due to more material constact such as bases plates on the foundations for the pedestal bearings.
11. Non-rigid machine foundations due to lack of compact soil below, causing settlement of machine compounents.

Remedies of vibration:

Although it is impossible to eliminate the vibrations, yet these can be reduced by adopting various remedies, some of the remedies are listed below:

1. Partial balancing of reciprocating masses.
2. Balancing of unbalanced rotating masses.
3. Using helical gears instead of spur gases.
4. Proper tightening and locking of fastening and periodically ensuring it again.
5. Correcting the mis-0alingnmemnt of rotating components and checking it from time to time.
6. Timly replacement of work-out moving parts, slides and bearings with excessive clearance.
7. Isolating vibrations from other machines and sources by providing vibration insulation pads in the machine foundations.
8. Making machine foundatioins on compact ground and making them sufficiently strong, so that they do not yield or settle under the load of the machine.