COURSE CODE: *MCE 304*

COURSE TITLE: *Mechanics of Machines II*

NUMBER OF UNITS: *3 Units*

COURSE DURATION: *Six hours per week (3 hrs Lecture & 3 hrs practical)*

COURSE DETAILS:

Course Coordinator: **Engr. Adekunle, N .Olatunde** B.Sc, M.Sc.
Email: noadekonle@yahoo.com
Office Location: **Room 4 PG School**
Other Lecturers: **None**

COURSE CONTENT:

Vibration of machinery: free and forced vibration, damping, natural frequency and critical speeds. Transverse vibration of beams, whirling of shafts , torsional vibrations. Friction in machines.

COURSE REQUIREMENTS:

This is a compulsory course for all students in engineering. In view of this, students in the college of engineering are strongly advised to attend classes regularly and have a minimum of 75% attendance to be eligible to write the final examination.

READING LIST:

LECTURE NOTES

INTRODUCTION

Engineering systems possessing mass and elasticity are capable of relative motion. If the motion of such system repeats itself after a given interval of time, the motion is known as vibration. Vibration, in general, is a form of wasted energy and undesirable in many cases.

This is particularly true in machinery; for it generates noise, breaks down parts, and transmits unwanted forces and movements to close-by objects.

To eliminate the adverse effects of most vibration, one of the approaches is to make a complete study of the equation of motion of the system in question. The system is first idealized and simplified in terms of mass, spring, and dashpot, which represent the body, the elasticity, and the friction of the system respectively.

The equation of motion, then, expresses displacement as a function of time or will give the distance between any instantaneous position of the mass during its motion and the equilibrium position.

The important property of a vibrating system, the natural frequency, is then obtained from the equation of motion.

DEGREE OF FREEDOM

Many systems can vibrate in more than one manner and direction. If a system is constrained so that it can vibrate in only one mode or manner, or if only one independent coordinate is required to specify completely the geometric location of the masses of the system in space, it is a single-degree-of-freedom system. Number of co-ordinate that can be used to define a system.

Lecture Two

Free Vibration

– it occurs when an elastic material / system is acted upon by the internal restoring force of the system.

Linear motion of an elastic system,

Restoring force = stiffness x displacement obtain the expression for the period / natural frequency.

Angular motion of an elastic system.

Restoring torque= torsional stiffness x angular displacement.

How to solve free vibration problems.

Newtons law method .

Obtain the equation of motion.

Obtain the Natural frequency. Energy method

Energy method

- Obtain potential energy for the system P.E

Obtain Potential energy for the system K.E

Examples 1. A simple spring mass system.

Write the equation of motion.

Solve the Differential equation .

Determine the natural frequency of vibration

Obtain equivalent spring stiffness for 3 – springs arrange in series, parallel connection. A simply – supported beam with a concentrated load placed at the centre of the beam.

A spring – mass pulley system. A simple pendulum allowed to swing about a fixed point

Lecture Three:

Forced Vibration

A system of body acted upon by a restoring force per unit displacement from equilibrium position and also experience an external harmonic force introduced into the system.

At forced vibration, the system will tend to vibrate at its own natural frequency as well as to follow the frequency of the excitation force. In the presence of friction, that portion of motion not sustained by the sinusoidal excitation force will gradually die out.

As a result, the system will vibrate at the frequency of the excitation force regardless of the initial conditions or the natural frequency of the system.

Forced Linear Vibration –a mass spring system with external Force. Angular Vibration – rotating motor with external

Determination of the solution of forced free vibration The complementary solution represent free vibration .

The steady state solution represent effect of external force.

Periodic Force transmitted to support.

Force transmitted to support. It will be observed that if a body is attached to a spring, the other end of which is attached to a rigid support, then, a dynamic force will be support, then, a dynamic force will be transmitted to the support. Maximum dynamic force transmitted to the support can be obtained from the equation below

Max dynamic force = spring const x amplitude of vibration.

Maximum total force = weight of body + max dynamic force.

Periodic movement of the support

This occurs when a body is subjected to a disturbing force due to the movement of the spring support rather than by a force applied directly to the body.

Draw the diagram to illustrate the motion, write the equation of motion for the system.

Obtain the two solutions for the differential equation.

Solution for complimentary function, steady state function

Lecture Four

Damped Vibration Damped vibration system occurs when a body is subjected to a damping force, this force is usually due to (a) viscous friction (as obtained in the dash-pot), here, the resistance offered is assured to be proportional to the velocity, or (b) Coulumb friction (occurs between two dry surfaces), in this case, the resistance is assured to be independent of the velocity of vibrating system.

Types of Damped Vibrations :Free damped vibration

Forced damped vibration

Free damped vibration

Linear vibration with viscous damping (Illustrate with the aid of diagram)

Angular vibrations with viscous damping Linear vibrations with coloumb damping

Condition for damping:

Heavy damped – the motion is term aperiodic motion

Critically damped – the motion is term aperiodic motion

Under damped.

Damping ratio c/co

Diagram showing the variation of Amplitude of vibration with periodic time.

Example 1.A free damped vibration consisting of two parallel spring arrangement with damper.

Example 2 . A mechanical system with a rotating part e.g. engine of a vehicle

A mass of 2.4kg hanging from the lower end of a vertical spring is pulled downward through a definite distance and then released. If the resulting motion is controlled by viscous damping such that the ratio of the first downward displacement to the third is 4:1 and five vibrations are completed in 4s, find the stiffness of the spring and the damping force

A light uniform bar of mass m and length l is hinged at one end while the other end is carried by a spring of stiffness S so that in its rest position the bar is horizontal. Half-way along the bar a dash-pot is attached which produces a damping force of c per unit velocity.

Write down the equation of motion obtained by talking moments about the hinge, and give an expression for the time period.

Lecture Five

Forced Damped Vibration

When a body of mass is attached to the spring, with damper is usually acted upon by a restoring force per unit displacement offered by the spring, a damping force per unit velocity and also by an external harmonic force pcospt.

Newton's law of motion is usually used in the analysis of the motion.

Solution of Forced- Damped Vibration

The problem also have two solutions: 1.complementary function Solution and

2.Steady state solution

Cases to discuss

(a) Forced Damped Linear Vibration

(b) Forced – Damped Angular Vibration