Fundamentals of Mechanical Vibrations

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Mechanical Vibration

Defined as oscillatory motion of bodies in response to disturbance.

Oscillations occur due to the presence of a restoring force

Vibrations are everywhere:

Vehicles: residual imbalance of engines, locomotive wheels

Rotating machinery: Turbines, pumps, fans, reciprocating machines

Musical instruments

Excessive vibrations can have detrimental effects:

Human body: eardrums, vocal cords, walking and running

Noise

Loosening of fasteners

Tool chatter

Fatigue failure

Discomfort

When vibration frequency coincides with natural frequency, resonance occurs.

Fundamentals

In simple terms, a vibratory system involves the transfer of potential energy to kinetic energy and vice-versa in

alternating fashion.

When there is a mechanism for dissipating energy (damping) the oscillation gradually diminishes.

In general, a vibratory system consists of three basic components:

A means of storing potential energy (spring, gravity)

A means of storing kinetic energy (mass, inertial component)

A means to dissipate vibrational energy (damper)

Simple Pendulum

This can be observed with a pendulum:

At position 1: the kinetic energy is zero and the potential energy is

$mgl(1 - \cos\theta)$

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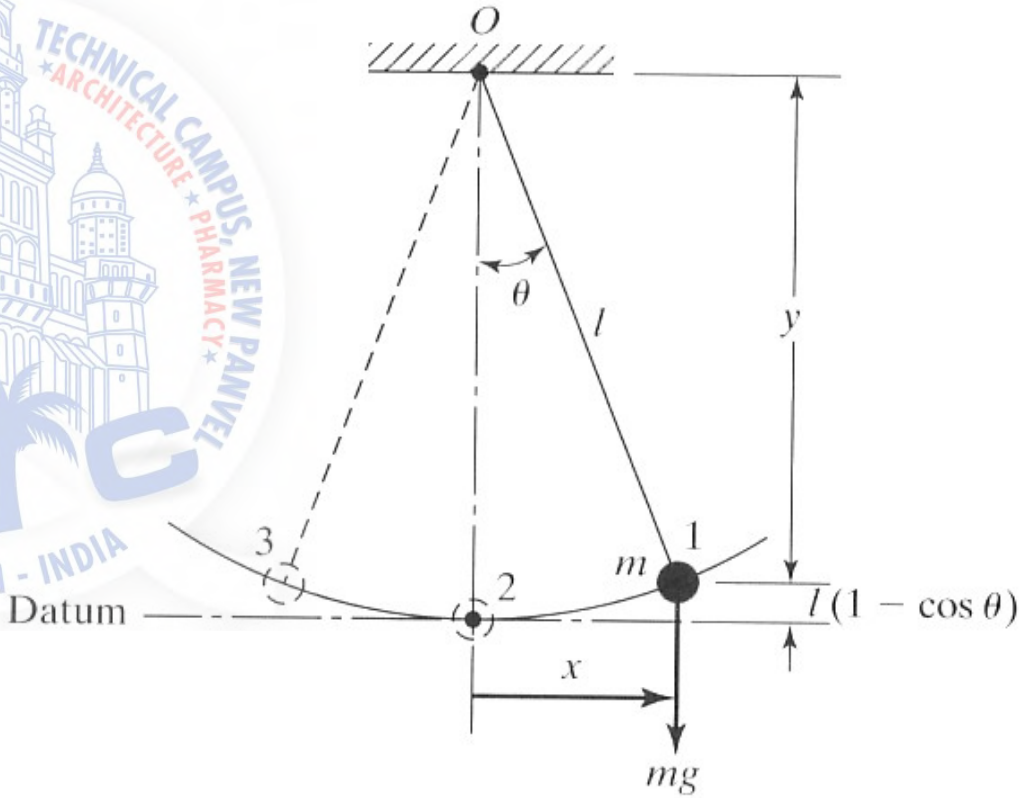
• At position 2: the kinetic energy is at its maximum

• At position 3: the kinetic energy is again zero and the potential energy at its maximum.

In this case the oscillation will eventually stop due to aerodynamic drag and pivot friction → HEAT

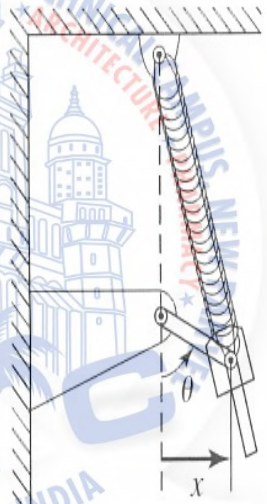


Degrees of Freedom

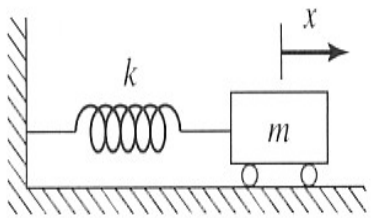
- The number of degrees of freedom : number of independent coordinates required to completely determine the

motion of all parts of the system at any time.

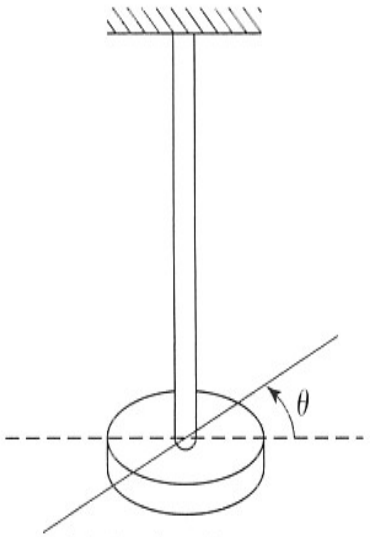
- Examples of single degree of freedom systems:



(a) Slider-crank-spring mechanism



(b) Spring-mass system



(c) Torsional system

Two DOF