MASTERJEE CLASSES

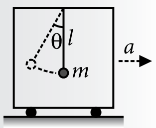
BRAIN MAP

CLASS XI

WORK AND ENERGY

Pendulum Suspended in an Accelerating Trolley

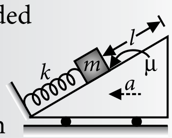
- For a pendulum suspended from the ceiling of a trolley moving with acceleration a, the maximum deflection θ of the pendulum from the vertical is $\theta = 2\tan^{-1}\left(\frac{a}{g}\right)$



Work Energy Theorem for Non-inertial Frames

For a block of mass m welded with light spring (relaxed). When the wedge fitted moves with an acceleration a, block slides through maximum distance l relative to wedge,

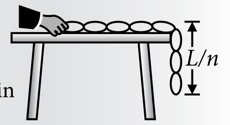
$$l = \frac{2m}{k}[a(\cos\theta - \mu\sin\theta) - g(\sin\theta + \mu\cos\theta)]$$



Work Done in Pulling the Chain

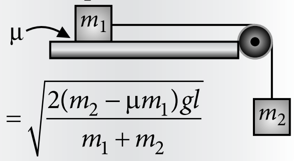
$$W = \frac{MgL}{2n^2}$$

{M = Mass of chain
L = Length
n = Fraction of chain hanged}



Motion of Blocks Connected with Pulley

- Two blocks connected by a string, as shown. If they are released from rest. After they have moved a distance l, their common speed is



$$v = \sqrt{\frac{2(m_2 - \mu m_1)gl}{m_1 + m_2}}$$

Nature of Work Done

- Positive work $(0° \le \theta < 90°)$
  Component of force is parallel to displacement
- Negative work $(90° < \theta \le 180°)$
  Component of force is opposite to displacement
- Zero work $(\theta = 90°)$
  Force is perpendicular to displacement

Different cases explained using work energy theorem

Work Energy Theorem

Work done by a force acting on a body is equal to the change in the kinetic energy of the body. It is valid for a system in presence of all types of forces.

$W_{total} = \Delta K$

Work

Work done by a force (F) is equal to the scalar product of the force and the displacement (S) of the body.

$W = \vec{F}\cdot\vec{S}$ (θ is the angle between F and S)

$W = FS\cos\theta$

Energy

The energy of a body is defined as its capacity for doing work. Energy is a scalar quantity.

Unit and dimensions for both energy and work are same

Dimensions : $[ML^2T^{-2}]$

S.I. Unit : joule (J)

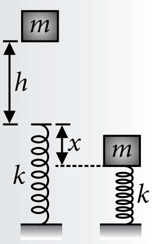
Work Depends on Frame of Reference

With change of the frame of reference (inertial), force does not change while displacement may change. So the work done by a force will vary in different frames.

An Application of Conservation of Energy

- A block of mass m, falling from height h, on a mass less spring of stiffness k.
  - The maximum compression in the spring will be

$$x = \frac{mg}{k}\left[1 + \sqrt{1 + \frac{2kh}{mg}}\right]$$



- If block is released slowly $(h = 0)$, maximum compression, $x = \frac{2mg}{k}$
- Work done in bringing the block to stable equilibrium, $W_{ext} = -\frac{m^2g^2}{2k}$

Work Done by Friction

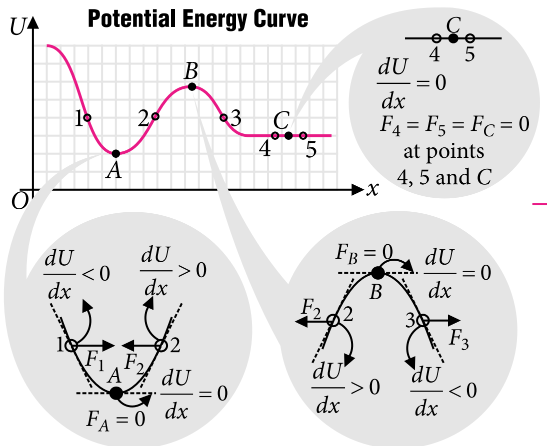
- Work done by static friction is always zero.
- Work done by kinetic friction on the system is always negative.

Work Done by a Spring Force

- Work done for a displacement from x_i to x_f

$$W_s = -\frac{1}{2}k\left(x_f^2 - x_i^2\right)$$

Potential Energy Curve



Potential Energy

It is the ability of doing work by a conservative force. It arises from the configuration of the system or position of the particles in the system.

Relation between Conservative Force and Potential Energy

Negative gradient of the potential energy gives force.

$$F = -\frac{dU}{dr}$$

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