PHYSICS 247 Lecture 22 10/27/06

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Chapter 7 = Conservation of Energy (continued)

Reminder Midterm 2 on Nov 1, 2006

Conservation of Energy

Total energy is conserved.

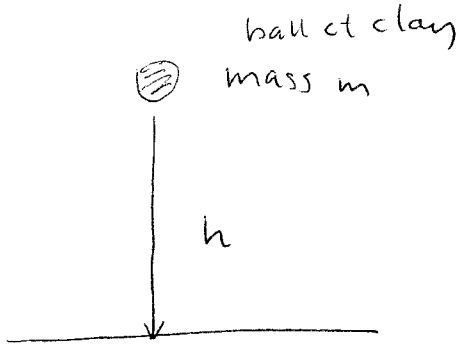
In addition to mechanical energy, other forms

$$E_{sys} = E_{mech} + E_{therm} + E_{chem} + E_{others}$$

Work - Energy Theorem

$$W_{ext} = \Delta E_{sys} = \Delta E_{mech} + \Delta E_{therm} + \Delta E_{chem} + \Delta E_{other}$$

Example Falling Clay



Apply Conservation laws to

① system of ball alone

② system of ball + earth + floor

① System of ball alone

$$W_{ext} = mgh$$

$$\Delta E_{mech} = \Delta\left(\frac{1}{2}mv^2\right) \qquad (\because \text{single particle system, no potential energy})$$

$$= 0$$

$$W_{ext} = \Delta E_{mech} + \Delta E_{therm}$$

$$\Rightarrow \boxed{\Delta E_{therm} = mgh}$$

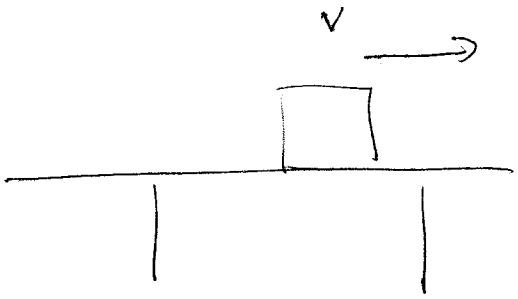
② System of ball + earth + floor

$$W_{ext} = 0$$

$$\Delta E_{mech} = -mgh$$

$$\Rightarrow \boxed{\Delta E_{therm} = -\Delta E_{mech} = mgh}$$

Kinetic friction



slides till it stops

Consider system of block + table

$$0 = \Delta E_{mech} + \Delta E_{therm}$$

$$= -\frac{1}{2} m v_i^2 + \Delta E_{therm}$$

$$\Delta E_{therm} = \frac{1}{2} m v_i^2$$

We can relate ΔE_{therm} to friction

$$-f = ma$$

↗ deceleration

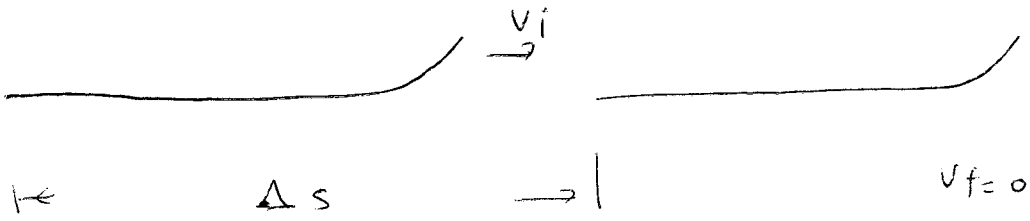
$$-f \Delta s = ma \quad \Delta s = m\left(\frac{1}{2} v_f^2 - \frac{1}{2} v_i^2\right)$$ constant a

$$= -\frac{1}{2} m v_i^2 = -\Delta E_{therm}$$

$$\boxed{f \Delta s = \Delta E_{therm}}$$

↑ not work done by friction on sliding block (see textbk)

Example : sliding on slow, μ = coefficient of friction



Conservation of energy (system = sled + snow)

$$W_{ext} = \Delta E_{mech} + \Delta E_{therm}$$

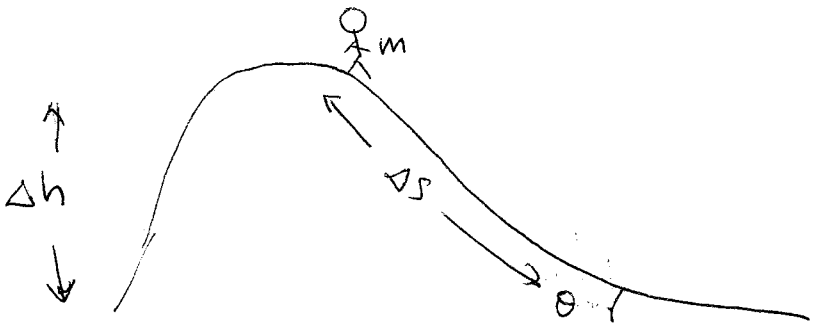
$$= (\Delta U + \Delta K) + f \Delta s$$

$$0 = \left(0 + \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2\right) + f \Delta s$$

$$= -\frac{1}{2} m v_i^2 + \mu_k m g \Delta s$$

$$\boxed{\Delta s = \frac{v_i^2}{2 \mu_k g}}$$

Example Playground slide



System
= child + earth
+ slide

μ = coefficient of friction

$$W_{ext} = \Delta E_{mech} + \Delta E_{therm}$$

$$= (\Delta U + \Delta K) + f \Delta s$$

$$0 = -mg\Delta h + \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 + f\Delta s$$

$$\Delta h = \Delta s \sin\theta$$

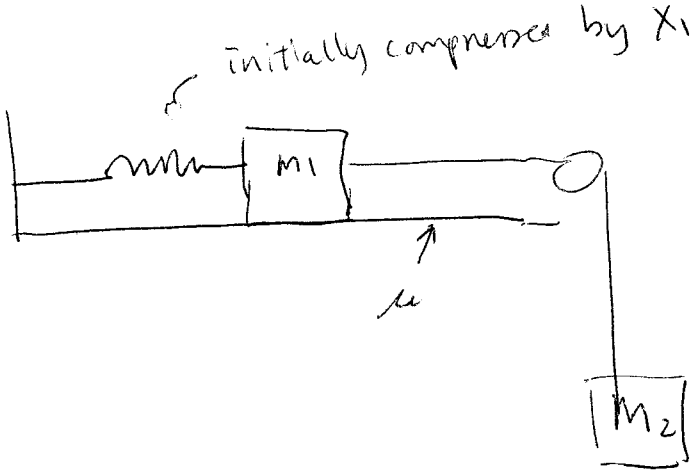
$$f = \mu_k F_n = \mu_k mg\cos\theta$$

$$\Rightarrow \quad 0 = -mg\Delta s\sin\theta + \frac{1}{2}mv_f^2 + \mu_k mg\cos\theta\Delta s$$

$$\Rightarrow \quad \boxed{v_f = \sqrt{2g\Delta s(\sin\theta - \mu_k\cos\theta)}}$$

independent of m

Example



System = everything in figure + Earth

$$W_{ext} = \Delta E_{mech} + \Delta E_{therm}$$

$$0 = \Delta U_g + \Delta U_s + \Delta K + f \Delta s$$

gravity spring

$$= -m_2 g \Delta s - \frac{1}{2} k X_i^2 + \frac{1}{2}(m_1 + m_2) v_f^2 + \mu_k m g \Delta s$$

$$v_f^2 = \frac{k X_i^2 + 2 m_2 g \Delta s - 2 \mu_k m_1 g \Delta s}{m_1 + m_2}$$

Chemical Energy

Climbing stairs

System = you

$W_{ext} = -mgh$ gravity

$-mgh = \Delta E_{mech} + \Delta E_{therm} + \Delta E_{chem}$

$\Delta E_{mech} = 0$

$-mgh = \Delta E_{therm} + \Delta E_{chem}$