

HW #10 Potential Energy : Due 1pm central time, Nov. 9, Monday

1

## Work and Energy

Conservative vs. Non-conservative forces

Gravitational Potential Energy

Last class...

Spring force and spring potential energy

Conservation of Mechanical Energy

Work by Non-conservative force

Today...

Power

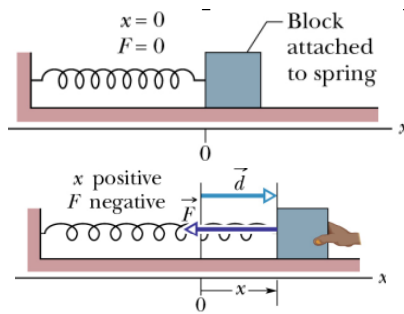
2

## Spring force

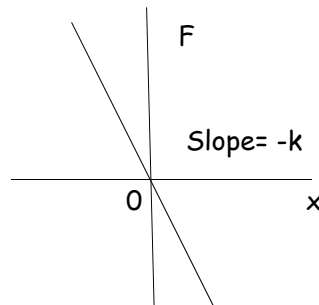
Hooke's law:

$$F_{spring}(x) = -kx$$

x: displacement from relaxed position  
k: spring constant (N/m)



For  $x$  negative,  $F$  positive



3

## Spring Potential Energy

Spring (elastic) potential energy :

$$U_{spring}(x) = U_s = \frac{1}{2}kx^2$$

x: displacement from relaxed position

k: spring constant (N/m)

Either compressed or stretched spring has a positive potential energy.

4

### iClicker Quiz 2

A spring stretched by 0.1 m has 1 J spring potential energy.

What would be the spring potential energy if the same spring is compressed by 0.2 m?

- a) 2 J
- b) 4 J
- c) -2 J
- d) -4 J

5

### Spring force

Hooke's law:

$$F_{spring}(x) = -kx$$

x: displacement from relaxed position

k: spring constant (N/m)

### Spring Potential Energy

Spring (elastic) potential energy :

$$U_{spring}(x) = U_s = \frac{1}{2}kx^2$$

$$W_s = -\Delta U_s = -(U_{s,f} - U_{s,i})$$

→ Work done by spring is negative of spring P.E. change

6

Conservation of Mechanical Energy with spring and gravity

Work-Energy Theorem:  $K_f - K_i = W_{net}$

Mechanical energy :

$$E_{mech} \equiv K + U_g + U_s = \frac{1}{2}mv^2 + mgh + \frac{1}{2}kx^2$$

If  $W_{net} = W_g + W_s$

or, if gravity and spring are the only forces that do work,

$\rightarrow E_{mech,f} = E_{mech,i}$  (see textbook for derivation)

"Conservation of mechanical energy"

7

**Mechanical Energy**

(Mechanical Energy)

= (Kinetic Energy) + (Potential Energy)

$$E_{mec} = K + U$$

Kinetic energy:  $K = \frac{1}{2}mv^2$

Gravitational Potential energy:  $U_g(h) = mgh$

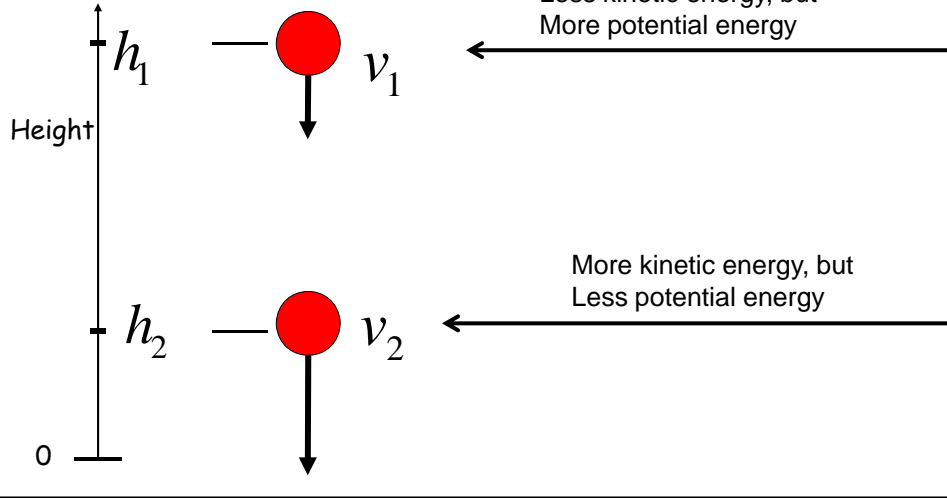
Elastic (or, Spring) Potential Energy:  $U_{elastic}(x) = \frac{1}{2}kx^2$

**Conservation of Mechanical Energy**

$$K_2 + U_2 = K_1 + U_1$$

If conservative forces only cause energy changes, the kinetic and potential energy can change, but their sum, the mechanical energy  $E_{\text{mec}}$  of the system, cannot change.

**Example: Falling ball**

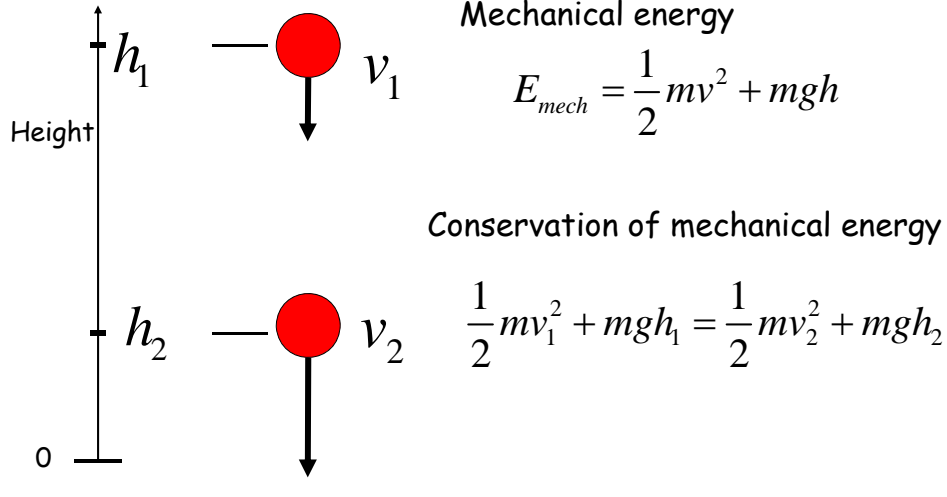


**Conservation of Mechanical Energy**

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**Example: Falling ball**



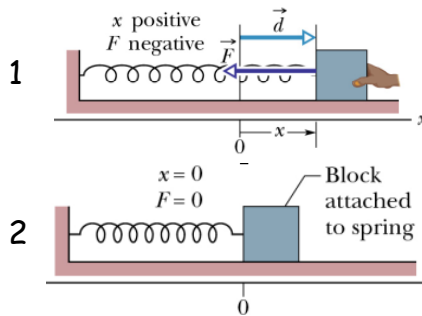
### Conservation of Mechanical Energy for Spring

Elastic (or, Spring) Potential Energy:  $U_{elastic}(x) = \frac{1}{2}kx^2$

Mechanical energy:  $E_{mech} = \frac{1}{2}mv^2 + \frac{1}{2}kx^2$

Conservation of mechanical energy

$$\frac{1}{2}mv_1^2 + \frac{1}{2}kx_1^2 = \frac{1}{2}mv_2^2 + \frac{1}{2}kx_2^2$$



$$U = \frac{1}{2}kx^2 \quad K = 0$$

$$U \rightarrow K$$

$$U = 0 \quad K = \frac{1}{2}mv^2$$

### iClicker Quiz

A person throws a ball 30 degree from horizontal from the top of a 20 m high building. Neglect the air resistance.

True or false?

(1) The ball has zero kinetic energy at the maximum height.

(a) True (b) False

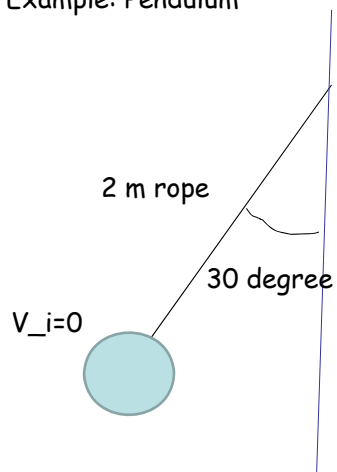
(2) If he throws the ball at a different angle but with the same speed, the ball would hit the ground at a different speed.

(a) True (b) False

Example. A car with its engine off coasts along a straight highway, which goes uphill. How far along the highway will the car go before it stops, if its initial speed was 80 km/h, and the slope is  $15^\circ$ ?

13

Example: Pendulum

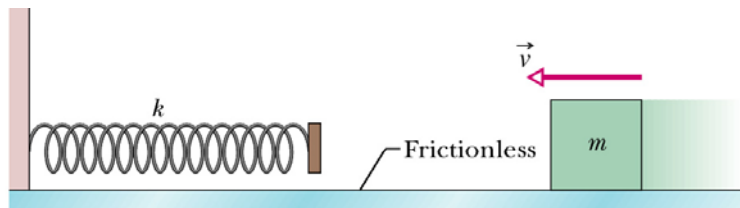


What is the speed at the bottom?

14

### Example: Spring potential

A block of mass  $m = 0.40 \text{ kg}$  slides across a horizontal frictionless counter with a speed of  $v = 0.50 \text{ m/s}$ . It runs into and compresses a spring of spring constant  $k = 750 \text{ N/m}$ . When the block is momentarily stopped by the spring, by what distance  $d$  is the spring compressed?



15

A 60-kg block is dropped from rest a distance of 1.20 m onto a platform of negligible mass supported by a stiff spring. The block sticks to the platform and the block + platform move another 6 cm before their speed become equal to zero for the first time. What is the value of the spring constant ?

16