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

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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

Motivation

Why do we learn about potential energy and conservation of mechanical energy?

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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,

→ $E_{mech,f} = E_{mech,i}$

"Conservation of mechanical energy"

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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

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

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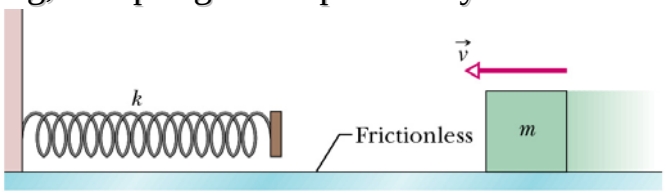
iClicker Quiz

When the block is momentarily stopped by the spring, the spring is compressed by distance d.



1. If the mass is doubled, what would be the compressed distance?

(a) 0.5d (b) d (c) $\sqrt{2}$d (d) 2d (e) 4d

2. If the initial speed is doubled, what would be the compressed distance?

(a) 0.5d (b) d (c) $\sqrt{2}$d (d) 2d (e) 4d

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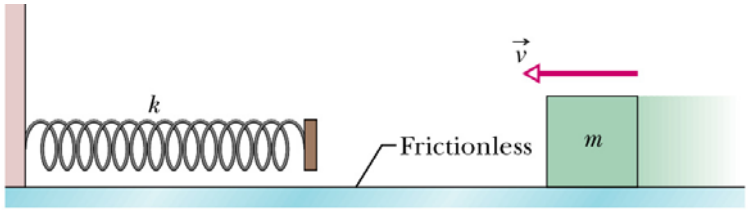
Example: Spring potential

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



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Mechanical Energy and Non-conservative force

If both non-conservative and conservative forces do work,

(conservative forces: gravity, spring)

(non-conservative forces:
Friction, Normal force, Tension, Other applied forces)

then

$$E_{mech,\,f} - E_{mech,i} = \Delta E_{mech} = W_{nc}$$

(Work by non-conservative force) = (Change in mech. E.)

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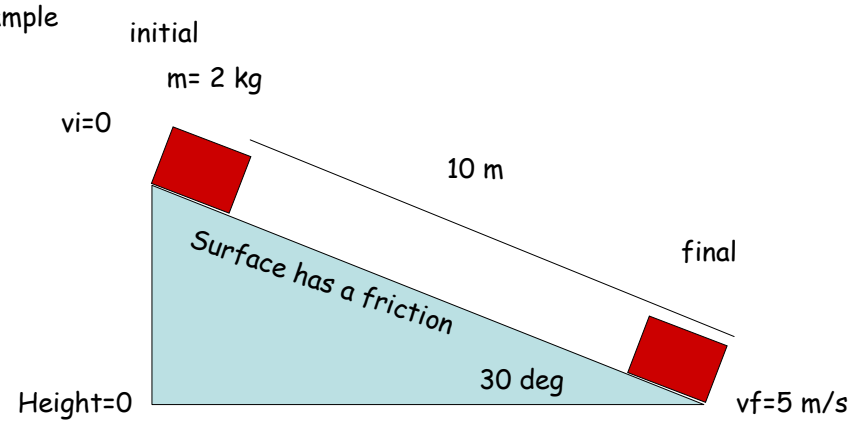
Example



Find the initial and final mechanical energy.

Find the work done by friction force.

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Example. A car with a mass of 5 T and with good tires can decelerate on a rainy day at about 2.5 m/s^2 when braking with its wheels locked. If the car is initially traveling at 90 km/h, and then stops after braking, what is the work done on it by the friction force?

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