Announcements 17 Apr 09

- Homework #10
  - Written homework due on Wednesday at the start of class
  - Online Homework due on Wednesday by 8 am
  - Girl on a trampoline problem: consider girl grabbing box like a collision (i.e. use momentum conservation)
- Monday April 20
  - Patriots' Day holiday
  - Monday schedule will be observed on Tuesday April 21:
    - Lecture at 9:05 am
    - Early office hours (2:00 to 3:30 pm)
    - SI session @ LRC (7:15 to 8:30 pm)

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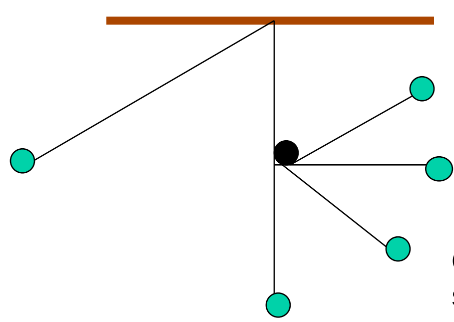
Pendulum question

PRS

A pendulum is pulled back and let go. When the pendulum reaches the bottom of its motion the string that holds the pendulum makes contact with a peg. How far will the pendulum rise after making contact with the peg?



A. Higher than starting height?

B. Same height?

C. Lower than starting height?

Answer: B

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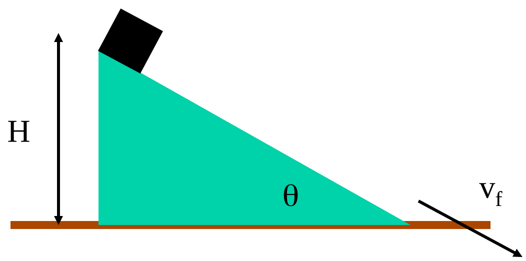
Problem solving using conservation of energy

Conservation of energy can be used to simplify problem solving.

Solve the following problem: A block slides down a ramp that is at an angle of θ. If the block starts at a height of *H* above the floor, what is the velocity of the block when it reaches the base of the ramp?

Solve this problem using two different methods:

1. Newton's 2nd law
2. Conservation of energy



1. Solve for velocity at base of ramp by Newton's 2nd law F=ma

Need to find components of the gravitational force perpendicular to the ramp and parallel to the ramp.

The component of force parallel to the ramp is given by

$F_x = mg \sin\theta$

This is hard!!!

$F_x = ma$

$ma = mg \sin\theta$

$a = g \sin\theta$

The distance down the ramp is given by

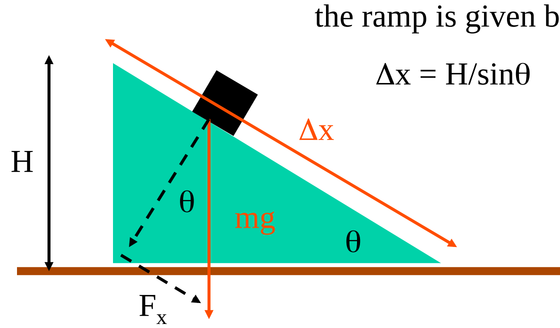
$\Delta x = H/\sin\theta$

$v_f^2 = v_i^2 + 2a\,\Delta x$

$v_f^2 = 2(g \sin\theta)(H/\sin\theta)$

$v_f^2 = 2gH$

$v_f = \sqrt{2gH}$



2. Now solve for velocity using conservation of energy

The initial energy is purely potential energy because the block is at rest.

$E_i = mgH$

This is a much easier!!

The final energy is pure kinetic, since the block is at the bottom of the ramp.

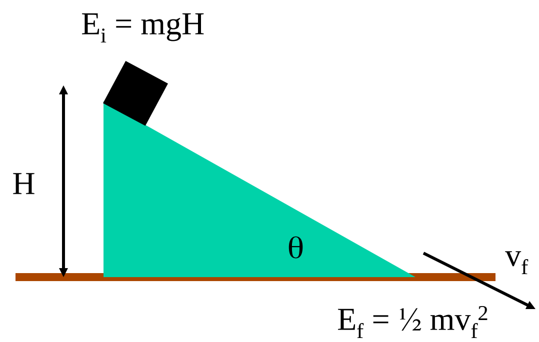
$E_f = ½ mv_f^2$

$E_i = E_f$

$mgH = ½ mv_f^2$

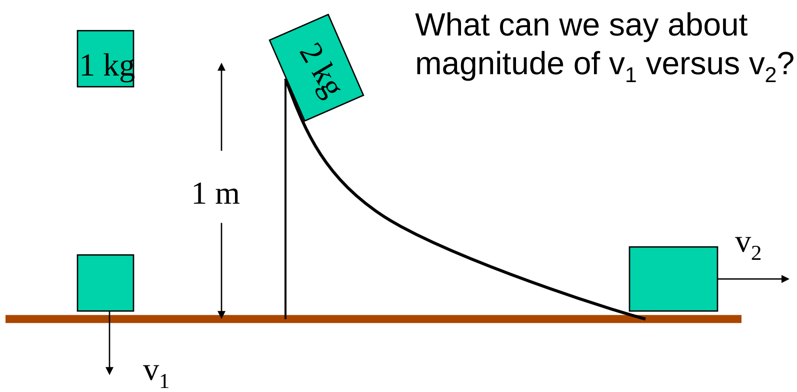
$v_f^2 = 2gH$

$v_f = \sqrt{2gH}$



Mechanical energy conservation problem

A block of mass 1 kg is dropped straight down, falling a vertical distance 1 m. Another block with mass 2 kg slides without friction down a *curved* ramp, dropping a vertical distance of 1 m. The final velocity of the 1 kg block is v_1 and the final velocity of the 2 kg block is v_2.



What can we say about magnitude of v_1 versus v_2?

Solution:

First find total energy of dropped block

Initial energy = $m_1 g y$

Final energy = $\frac{1}{2} m_1 v_1^2$

By conservation of energy: Initial energy = final energy

$m_1 g y = \frac{1}{2} m_1 v_1^2$

$g y = \frac{1}{2} v_1^2$

$2 g y = v_1^2$

$v_1 = \sqrt{2gy}$

Now find energy of sliding block

Initial energy = Final energy

$m_2 g y = \frac{1}{2} m_2 v_2^2$

$g y = \frac{1}{2} v_2^2$

$2 g y = v_2^2$

$v_2 = \sqrt{2gy}$

Therefore, the velocities are the same!!

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Projectile motion question

PRS

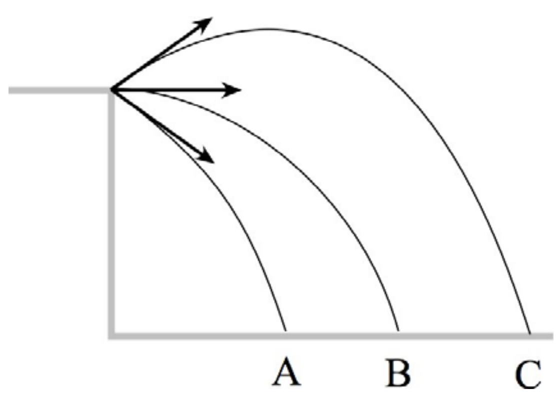
Three balls are thrown off a cliff with the same speed, but in different directions. Which ball has the greatest speed just before it hits the ground?

A. Ball A

B. Ball B

C. Ball C

D. All balls have the same speed



Answer: D

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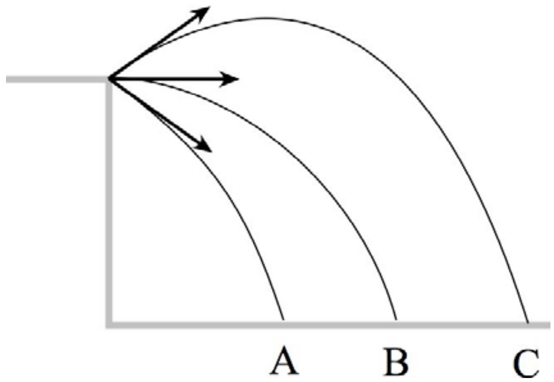
Projectile motion question

PRS



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Cons. of energy problem

A 2.0 g desert locust can achieve a takeoff speed of 3.6 m/s (comparable to the best human jumpers) by using energy stored in an internal "spring" near the knee joint.

A. When the locust jumps, what energy transformation takes place?

B. What is the minimum amount of energy stored in the internal spring?

C. If the locust were to make a vertical leap, how high could it jump?

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Problem solving

$$K_i + U_i$$
$$= K_f + U_f$$
(10.7)

$$K_i + U_i + W$$
$$= K_f + U_f + \Delta E_{th}$$
(10.6)

MP PROBLEM-SOLVING STRATEGY 10.1 **Conservation of energy problems**

PREPARE Choose what to include in your system (see Tactics Box 10.1). Draw a before-and-after visual overview, as outlined in Tactics Box 9.1. Note known quantities, and determine what quantity you're trying to find. If the system is isolated and if there is no friction, your solution will be based on Equation 10.7, otherwise you should use Equation 10.6.

Identify which mechanical energies in the system are changing:

- If the *speed* of the object is changing, include K_i and K_f in your solution.
- If the *height* of the object is changing, include $(U_g)_i$ and $(U_g)_f$.
- If the *length* of a spring is changing, include $(U_s)_i$ and $(U_s)_f$.
- If kinetic friction is present, ΔE_{th} will be positive. Some kinetic or potential energy will be transformed into thermal energy.

If an external force acts on the system, you'll need to include the work W done by this force in Equation 10.6.

SOLVE Depending on the problem, you'll need to calculate initial and/or final values of these energies and insert them into Equation 10.6 or 10.7. Then you can solve for the unknown energies, and from these any unknown speeds (from K), positions (from U), or displacements or forces (from W).

ASSESS Check the signs of your energies. Kinetic energy, as we'll see, is always positive. In the systems we'll study in this chapter, thermal energy can only increase, so that its change is positive. In Chapters 11 and 12 we'll study systems for which the thermal energy can decrease.

Cons. of energy problem

m = 2.0 g, v = 3.6 m/s

A. E transformation:

B. E conservation for the leap off the ground:

Cons. of energy problem

m = 2.0 g, v = 3.6 m/s

C. E conservation for the height of the jump:

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Cons. of energy problem

m = 2.0 g, v = 3.6 m/s

A. E transformation: $U_s \to K$ then $K \to U_g$

B. E conservation for the leap off the ground:

$$K_i + (U_g)_i + (U_s)_i = K_f + (U_g)_f + (U_s)_f + \Delta E_{th}$$

$$(U_s)_i = K_f + \Delta E_{th}$$

$$(U_s)_{i\ \min} = K_f = \tfrac{1}{2}mv^2 = 0.5 \times (0.002kg) \times (3.6m/s)^2 = 0.013J$$

C. E conservation for the height of the jump:

$$K_i + (U_g)_i = K_f + (U_g)_f$$

$$K_i = (U_g)_f$$

$$0.013J = mgh$$

$$\Rightarrow h = \frac{0.013J}{mg} = \frac{0.013J}{(0.002kg) \times (9.8m/s^2)} = 0.635m$$

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