Common Exam 3, Friday, April 13, 2007

8:30 – 9:45 A.M. at KUPF 205 (Arrive by 8:15)

Chaps. 6, 7, 8

Bring calculators

HW #8 and HW #9: Due tomorrow, April 6th(Fri)

Today….

- Chapter 8
- Hints for HW #9
- Quiz #10
- Course evaluation

Last class, we learned…

Chapter 8. Potential Energy and Conservation of Energy

Conservative forces → Work independent of path

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

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

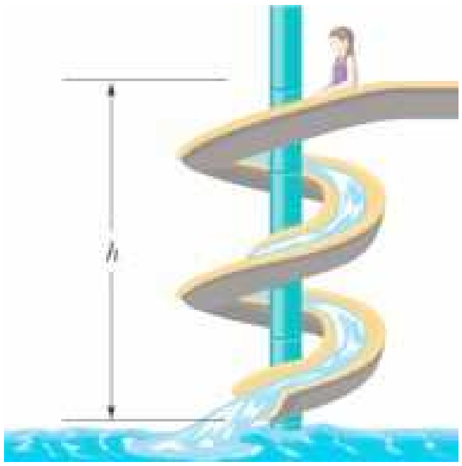
Mechanical energy: $E_{\mathrm{mec}} = K + U$

Conservation of mechanical energy

$$K_2 + U_2 = K_1 + U_1$$

Sample Problem 8-3

In Figure, a child of mass *m* is *released from rest* at the top of a water slide, at height *h* = 8.5 m above the bottom of the slide. Assuming that the slide is *frictionless* because of the water on it. Find the child's speed at the bottom of the slide.

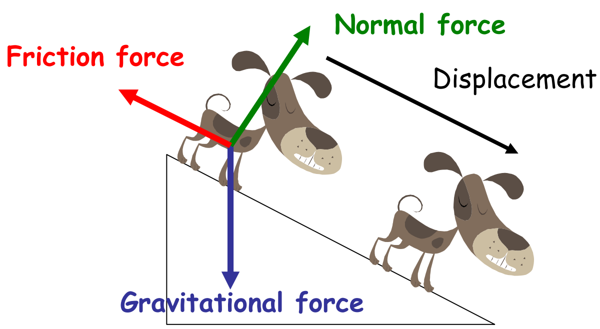


Work done on a system by non-conservative force

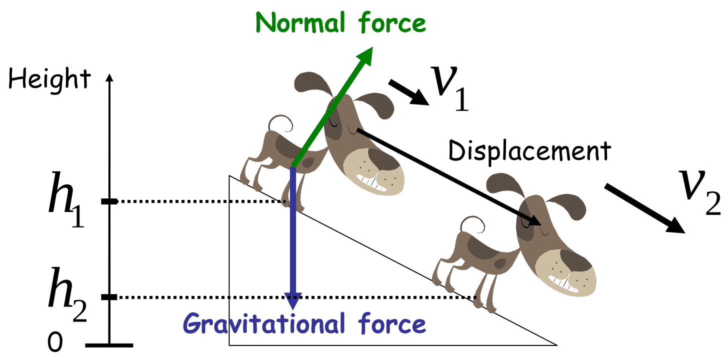
What if non-conservative forces do work on an object, in addition to conservative force?

Non-conservative force: friction force, tension, force from a hand, …

Example: Surface *with* friction



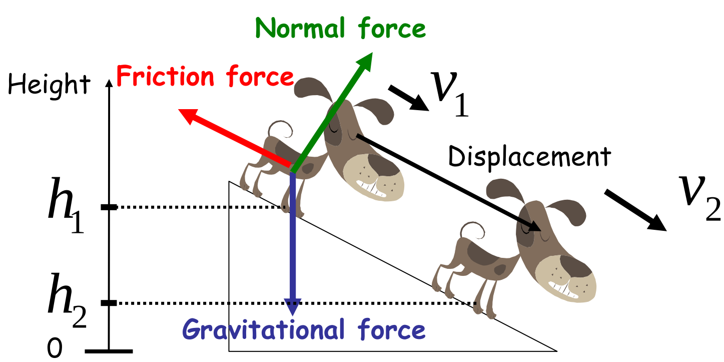
First, let's review sliding on surface *without* friction



$$E_{mech,1} = E_{mech,2} \quad \rightarrow \quad mgh_1 + \frac{1}{2}mv_1^2 = mgh_2 + \frac{1}{2}mv_2^2$$

$$\rightarrow \quad E_{mech,2} - E_{mech,1} = \Delta E_{mech} = 0$$

Now, *with* friction……



v_2 *with* friction is smaller than v_2 *without* friction.

$\rightarrow E_{mech,2} - E_{mech,1} = \Delta E_{mech} \neq 0$ → Mechanical energy changes

Relation between ΔE_{mech} & friction force? $\Delta E_{mech} = W_{friction}$

Generally, $\Delta E_{mech} = W_{non-conservative}$ (see p.180 for proof)

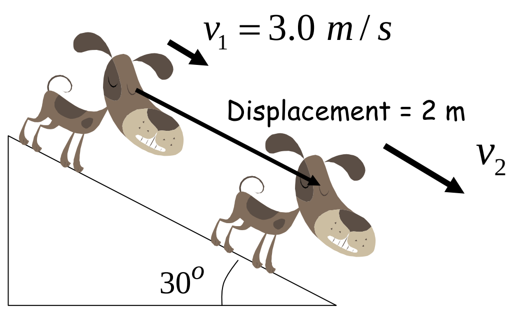
Work done on a system by non-conservative force

If non-conservative forces do work on an object, in addition to conservative force,

→ Mechanical energy changes
by the amount of work done by the non-conservative force.

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

Example: Surface *with* friction



Mass of the dog = 10 kg

Friction force = 10 N

Find the velocity, v_2 .

Thermal energy and Work done by friction force

Mechanical energy is reduced by friction force.

Where has this mechanical energy gone?

Observation : Friction heats up the object and the surface

Some Mechanical Energy is converted to Thermal Energy

$$\Delta E_{thermal} = \left| W_{friction} \right| = -W_{friction} = -\Delta E_{mech}$$

→ $E_{total} = E_{mech} + E_{thermal}$

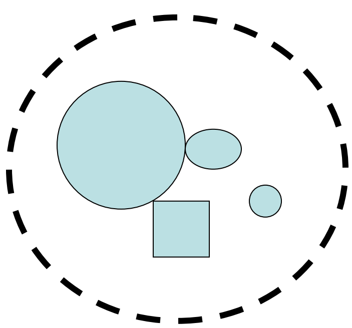
Total energy of the whole system, dog + surface, is conserved.

Many types of energy

Mechanical energy, thermal energy, chemical energy,
light energy, electric energy, magnetic energy,………

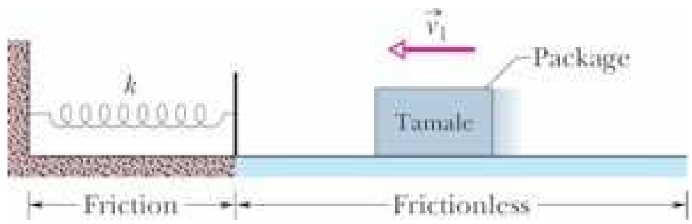
General principle of Conservation of Energy

Total energy of an isolated system is conserved.



Sample Problem 8-7

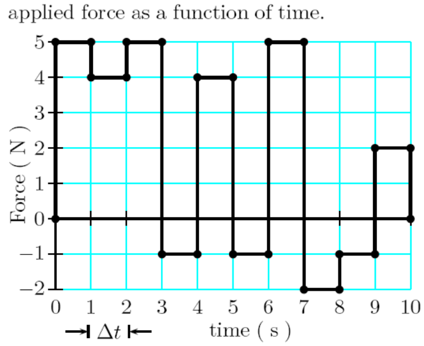
In Figure, a 2.0 kg package of tamale slides along a floor with speed $v1$ = 4.0 m/s. It then runs into and compresses a spring, until the package momentarily stops. Its path to the initially relaxed spring is frictionless, but as it compresses the spring, a kinetic frictional force from the floor, of magnitude 15 N, acts on the package. If k = 10 000 N/m, by what distance d is the spring compressed when the package stops?



Hints for HW#9 (Note: Hints for HW#8 are in Lecture Note 10 Part2)

001 (part 1 of 1) 10 points

A 0.47 kg mass is initially at rest and is free to move with negligible friction along the x-axis. The figure below shows the value of an applied force as a function of time.



Calculate the kinetic energy K of the mass when it reaches 9 s. Answer in units of J.

See Lecture 9 notes

Work done by variable force equals to the + or - area in F vs x plot, which is the kinetic energy change.

Here, the plot is F vs. t.

So, you have to find x from t.

At each interval, force is constant, meaning motion with a constant acceleration.

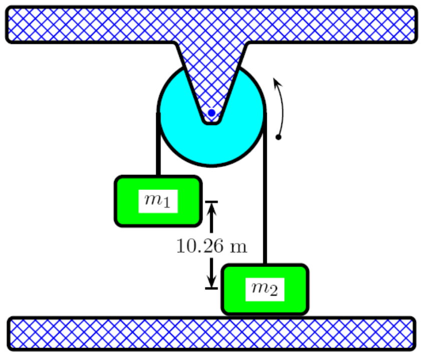
Use
$$x = x_0 + v_0 t + \frac{1}{2} a t^2$$

where a=F/m

002 (part 1 of 2) 10 points

A simple Atwood's machine uses two masses m_1 and m_2. Starting from rest, the speed of the two masses is 7.6 m/s at the end of 2.7 s. At that time, the kinetic energy of the system is 51 J and each mass has moved a distance of 10.26 m.

The acceleration of gravity is 9.81 m/s^2 .



Find the value of heavier mass. Answer in units of kg.

003 (part 2 of 2) 10 points

Find the value of lighter mass. Answer in units of kg.

Consider two masses as one system.

Heavy mass (say, m1) will go down, and light mass (say, m2) will go up.

Find initial kinetic and potential energy

Find total final kinetic and potential ener

Use conservation of energy

004 (part 1 of 2) 10 points

A horizontal force of 156 N is used to push a 49.0 kg packing crate a distance of 6.00 m on a rough horizontal surface.

The acceleration of gravity is 9.81 m/s^2 .

If the crate moves with constant velocity, calculate

a) the work done by the force. Answer in units of J.

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005 (part 2 of 2) 10 points

b) the coefficient of kinetic friction.

See Lecture Note 9

Work done by a constant force

$$W = Fd\cos\theta$$

The horizontal force and the friction force are doing work on the object.

$$W_{total} = W_1 + W_2 = K_f - K_i$$

006 (part 1 of 1) 10 points

It takes 6.1 J of work to stretch a Hooke's-law spring 13.2 cm from its unstressed length.

How much the extra work is required to stretch it an additional 8.4 cm? Answer in units of J.

Using

$$W_{spring} = \frac{1}{2}kx_i^2 - \frac{1}{2}kx_f^2$$

find the spring constant, k.

Use it again, to find the extra work.

007 (part 1 of 2) 10 points

The force required to stretch a Hooke's-law spring varies from 0 N to 48 N as we stretch the spring by moving one end 7.21 cm from its unstressed position.

Find the force constant of the spring. Answer in units of N/m.

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008 (part 2 of 2) 10 points

Find the work done in stretching the spring. Answer in units of J.

See Lecture Note 9

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

→ Find the force constant, k.

For (b), use

$$W_{spring} = \frac{1}{2}kx_i^2 - \frac{1}{2}kx_f^2$$

009 (part 1 of 2) 10 points
An elevator has a mass of 901 kg and carries a maximum load of 613 kg. A constant frictional force of 3610 N retards its motion upward.

The acceleration of gravity is 9.8 m/s^2.

What must be the minimum power delivered by the motor to lift the elevator at a constant speed of 2.55 m/s? Answer in units of W.

Forces on the elevator:
Gravity, friction, and force from motor

To have a constant speed, the forces need to be balanced, which will gives the force from the motor.

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010 (part 2 of 2) 10 points
What power must the motor deliver at an instantaneous speed of 2.55 m/s if the elevator is designed to provide an upward acceleration of 0.878 m/s^2? Answer in units of W.

For part 2……

Now the elevator accelerates upward, which means the net upward force.

Find the force from the motor to give that net force.

Then, calculate instantaneous power with

$$P = Fv\cos\theta$$

011 (part 1 of 1) 10 points
An advertisement claims that a(n) 2000 kg car can accelerate from rest to 28 m/s in 7.9 s.

Given: Unit conversion: 746 W/hp.

What average power must the motor produce to cause this acceleration, if we ignore friction and air resistance? Answer in units of hp.

$$P_{average} = \frac{W}{\Delta t}$$

$$W = K_f - K_i$$

$$K = \frac{1}{2}mv^2$$