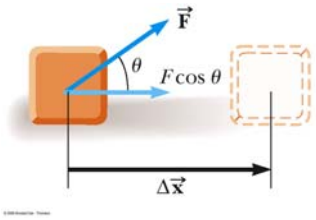
Physic² 121:
Phundament°ls of Phy²ics I

October 25, 2006

Work Summary

- Work is a scalar (not a vector); can be positive or negative
- We can calculate work done by each force in an object free-body diagram
- The total work done is the sum of the work done by each force separately

$$W = \vec{F} \bullet \Delta\vec{x}$$
$$= \left(F \cos\theta\right) \Delta x$$



$$\vec{F}_{Net} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3$$
$$W_{Net} = \vec{F}_{Net} \bullet \Delta\vec{x}$$
$$= \vec{F}_1 \bullet \Delta\vec{x} + \vec{F}_2 \bullet \Delta\vec{x} + \vec{F}_3 \bullet \Delta\vec{x}$$
$$= W_1 + W_2 + W_3$$

More thoughts on Work

- Look at Work definition:

$$W = \left(F \cos\theta\right) \Delta x$$

- If Force is along the direction of displacement, Work is positive
  - What happens to speed?
- If Force is opposite to direction of displacement, Work is negative
  - What happens to speed?
- If Force is perpendicular to displacement, Work is zero
  - What happens to speed?

- Conclusion:
  - Positive total work will make something speed up
  - Negative total work will make something slow down
  - Zero total work won't change speed
    - Doesn't mean direction can't change!

Work-Kinetic Energy Theorem

- When work is done by a net force on an object and the only change in the object is its speed, the work done is equal to the change in the object's kinetic energy
- $$W_{net} = KE_f - KE_i = \Delta KE$$
  - Speed will increase if work is positive
  - Speed will decrease if work is negative
- (The "only change speed" condition is there because this isn't true of the work causes the object to deform or heat up)

Kinetic Energy

- Energy associated with the motion of an object
- $$KE = \frac{1}{2}mv^2$$
- Scalar quantity with the same units as work
- Work is related to kinetic energy

Potential Energy

- Potential energy is associated with the position of the object within some system
  - Potential energy is a property of the system, not the object
  - A system is a collection of objects interacting via forces or processes that are internal to the system

Gravitational Potential Energy

- Gravitational Potential Energy is the energy associated with the relative position of an object in space near the Earth's surface
  - Objects interact with the earth through the gravitational force
  - Actually the potential energy is for the earth-object system

Reference Levels for Gravitational Potential Energy

- A location where the gravitational potential energy is zero must be chosen for each problem
  - The choice is arbitrary since the change in the potential energy is the important quantity
  - Choose a convenient location for the zero reference height
    - often the Earth's surface
    - may be some other point suggested by the problem
  - Once the position is chosen, it must remain fixed for the entire problem

Conservation of Mechanical Energy

- Conservation in general
  - To say a physical quantity is *conserved* is to say that the numerical value of the quantity remains constant throughout any physical process
- In Conservation of Energy, the total mechanical energy remains constant
  - *In any isolated system of objects interacting only through conservative forces, the total mechanical energy of the system remains constant.*

Conservation of Energy, cont.

- Total mechanical energy is the sum of the kinetic and potential energies in the system

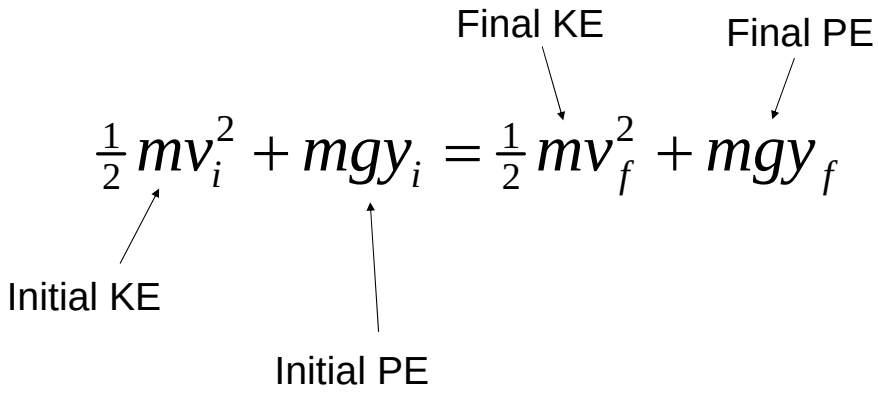
$$E_i = E_f$$

$$KE_i + PE_i = KE_f + PE_f$$

  - Other types of potential energy functions can be added to modify this equation

Conservation of E with Gravity

- If gravity is the only force acting:



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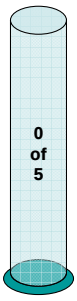
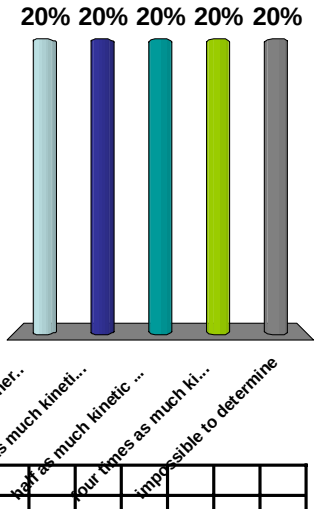
Two marbles, one twice as heavy as the other, are dropped to the ground from the roof of a building. Just before hitting the ground, the heavier marble has:

- as much kinetic energy as the lighter one
- twice as much kinetic energy as the lighter one
- half as much kinetic energy as the lighter one
- four times as much kinetic energy as the lighter one
- impossible to determine





1	2	3	4	5														

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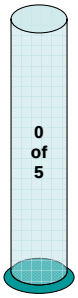
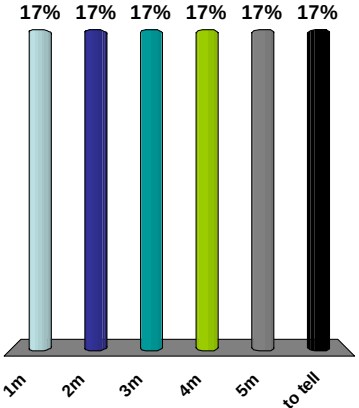
A cart on an air track is moving at 0.5 m/s when the air is suddenly turned off. The cart comes to rest after traveling 1 m. The experiment is repeated, but now the cart is moving at 1 m/s when the air is turned off. How far does the cart travel before coming to rest?

1. 1m
2. 2m
3. 3m
4. 4m
5. 5m
6. Impossible to tell





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