Energy and Work

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Work

- Definition
  - The transfer of energy from one object to another
  - force applied over a distance
  - distance must be in the same direction as the force
  - SI Unit of Joules
- Equation

$$\text{Work} = \text{Force x Distance}$$
$$W = Fd$$

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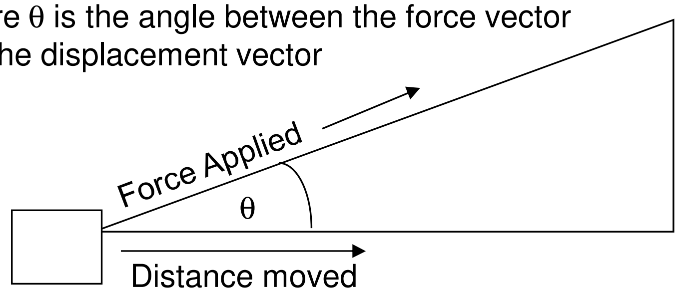
Work and Direction of Force

- Work is only done if the force is exerted in the direction of motion.
- Force applied at an angle:

$$W = (F_A \cos\theta)d$$

Where θ is the angle between the force vector and the displacement vector



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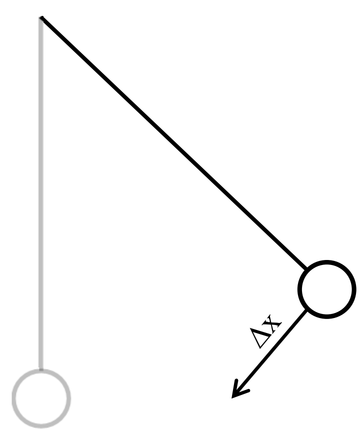
Work on Pendulums

- Draw all of the forces acting on the pendulum.

What force causes the motion?



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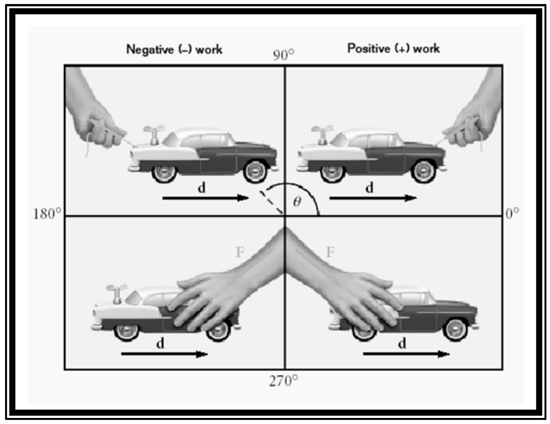
The Sign of Work

- When is the work negative?
- What common force that we have studied does negative work?



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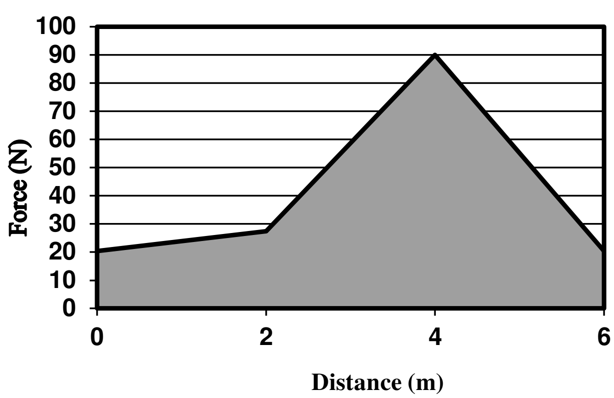
Varying Forces

- Work can be found by finding the <u>area</u> under a Force vs. Distance graph



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Varying Forces - Springs

- Any object that has an elastic property can have elastic potential energy.
- The force felt is directly proportional to the distance the object is stretched.
- This proportionality is dependent on the object itself, defined as the force constant, k.

$$F_{spring} = k\Delta x \quad (Hooke's\ Law)$$

$$W_{spring} = \frac{1}{2}k\Delta x^2$$

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Sample Problem

- A 200.0 g mass is hung from a spring with a spring constant of 33.6 N/m. How far will the spring stretch from its original position? How much work is done in stretching the spring?

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Energy

- Definition
  - The ability to do work
- Relation of energy and work
  - When you work, you are transferring energy to the object that you are working on.
- Unit of Measure
  - Joule (J)

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Mechanical Energy

- (Gravitational) Potential Energy
  - energy of vertical position

$$U_g = mgh$$

- Kinetic Energy
  - Object's energy due to velocity

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

- Potential Energy in a spring
  - energy of a spring based on the amount of compression or stretch

$$U_{spring} = \frac{1}{2}k\Delta x^2$$

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Work-Energy Theorem

- The net work done on an object is equal to the change in its energy

$$W_{net} = \Delta K$$
$$W_{net} = K_{final} - K_{initial}$$

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Law of Conservation of Energy

- Within a closed and isolated system, energy can change form; but the total amount of energy is constant.
- Energy cannot be created or destroyed, but it can change form.

$$E_i = E_f$$

$$W_i + U_{g_i} + U_{s_i} + K_i = W_f + U_{g_f} + U_{s_f} + K_f$$

$$(Fd + mgh + \frac{1}{2}kx^2 + \frac{1}{2}mv^2)_{initial} = (Fd + mgh + \frac{1}{2}kx^2 + \frac{1}{2}mv^2)_{final}$$

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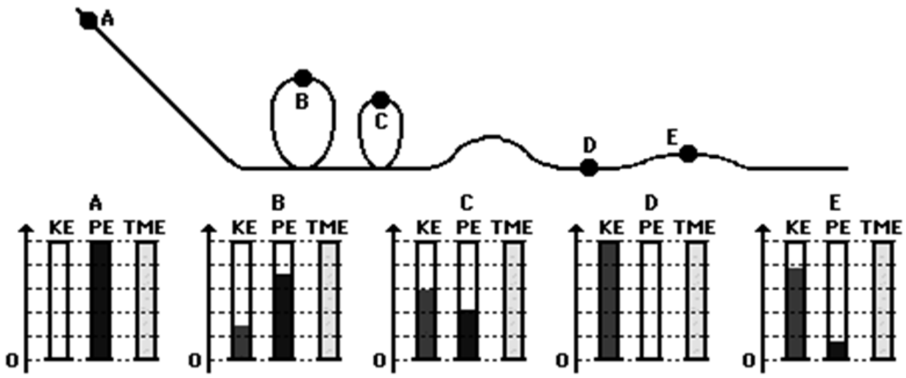
Graphing Energy

- Total Mechanical Energy (TME) is the same, but the amount of each type of energy can change.



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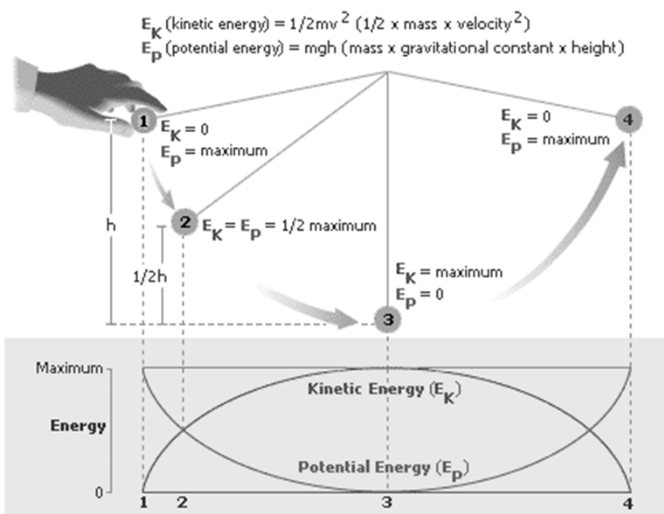
Graphing Energy of a Pendulum



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Classifying Forces

- Conservative
  - those forces that conform the law of conservation of energy
  - Ex: Gravitational, Elastic
- Dissipative
  - forces that produce deviations from the law of conservation of energy
  - produce forms of energy other than mechanical. Ex: friction

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Sample Problem

- If a 15.0 kg slides down a 2.35 m incline, what is the velocity of the block when it leaves the incline? (Assume no friction)

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Sample Problem 2

- A spring (k = 850 N/m) is compressed 0.4 m. Calculate the speed it can impart to a 500 g ball.

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Sample Problem 3

- A baseball (m = 140 g) traveling at 30 m/s moves a fielder's glove backward 35 cm when the ball is caught. Calculate the average force exerted by the ball on the glove.

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Sample Problem 4

- A bus slams on brakes to avoid an accident. The tread marks of the tires are 25 m long. If $\mu_k = 0.7$, what was the speed before applying brakes?

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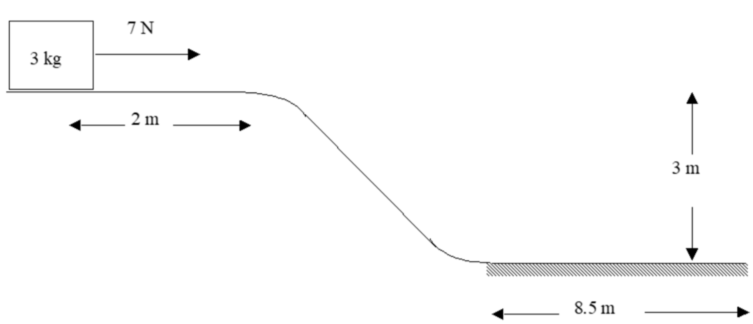
Sample Problem 5

- A 3 kg mass is pushed along a horizontal surface by a constant 7 N force for 2 m, then released and allowed to slide down a 3 m high frictionless ramp. Calculate the coefficient of friction between the two surfaces at the bottom of the ramp if the block stops 8.5 m after entering the final horizontal section.



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