Physics Notes – 3/16/2007: Kinetic energy, Work-Energy Theorem, Work done by a Variable Force

You move book at constant velocity along a rough table with a constant horizontal force of magnitude $F_{\text{ext}} = 10$ N. The total displacement is $d = 1$ m.

Draw a diagram showing all of the forces acting on the book.

What is the work done by the external force?

What is the work done by the friction force?

What is the work done by the normal force?

What is the work done by the net force?

**Kinetic Energy**

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

$m =$ mass \hspace{1cm} $v =$ velocity \hspace{1cm} SI unit $= \text{kg} \ (\text{m/s})^2 = \text{joule}$

What is the kinetic energy of a bowling ball (weight = 17 lbs, mass = 7.7 kg) with a speed of 7.0 m/s (typical bowling speed)?

**Work-Energy Theorem**

- The work done by the net force on a single object is equal to the change in kinetic energy of that object.

$$W_{\text{net}} = W_{\text{ext}} = \Delta KE = KE_f - KE_i$$

An apple falls from a tree: \hspace{1cm} Toss apple up:

**Example 1:**

A 4.1-kg box of books is lifted vertically from rest a distance of 1.6 m by an upward applied force of 60.0 N. Find (a) the work done by the applied force, (b) the work done by gravity, and (c) the final speed of the box.
**Example 2:**
A boy exerts a force of 11.0 N at 29.0° above the horizontal on a 6.40-kg sled. Find the work done by the boy and the final speed of the sled after it moves 2.00 m, assuming the sled starts with an initial speed of .500 m/s and slides horizontally without friction.

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**Work done by a variable force**

![Diagram of a spring in different states: stretched, relaxed, compressed](image)

- **x** is the amount that the spring is stretched (+) or compressed (–).
- \( |F_{spring}| \propto |x| \)
- Double \(|x|\) \(\Rightarrow\) double \(|F_{spring}|\)

**Hooke's Law:**

\[
F_{spring} = -kx
\]

- \(k\) = spring constant = measure of stiffness, \(big k \Leftrightarrow stiff\ spring, \ small k \Leftrightarrow floppy\ spring\)
- units of \(k = [k] = [F]/[x] = \text{N/m (newtons per meter)}\)

**Example:**
If the work required to stretch a particular slinky is 2.0 J, what is the spring constant for the slinky?

How much work is required to stretch the slinky from 1.0 m to 2.0 m?
You move a book at constant velocity along a rough table with a constant horizontal force of magnitude \( F = 10 \text{ N} \). The total displacement is 1 m.

Draw a diagram showing all of the forces acting on the book.

What is the work done by the external force?

What is the work done by the friction force?

What is the work done by the normal force?

What is the work done by the net force?

**Kinetic Energy**

\[
KE = \frac{1}{2}mv^2
\]

m = mass

v = velocity

SI unit = kg \((m/s)^2\) = joule

What is the kinetic energy of a bowling ball (mass = 7.7 kg) with a speed of 7.0 m/s (typical bowling speed)?

**Work-Energy Theorem**

An apple falls from a tree: Toss apple up:

**Example 1:**

A 4.1-kg box of books is lifted vertically from rest a distance of 1.6 m by an upward applied force of 60.0 N. Find (a) the work done by the applied force, (b) the work done by gravity, and (c) the final speed of the box.
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**Work done by a variable force**

![Diagram of a spring with stretched, relaxed, and compressed positions.]

**Example:**
If the work required to stretch a particular slinky 1.0 m is 2.0 J, what is the spring constant for the slinky?

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How much work is required to stretch the slinky from 1.0 m to 2.0 m?