These three words mean definite things in physics.
(I will do things in a different order from the book)

We will learn (and use!):

**Kinetic Energy**

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

**Potential Energy**

\[ PE = mgh \]
\[ = mg \cdot y \]
\[ PE_s = \frac{1}{2}kx^2 \]

**Work Done by a Force**

\[ W = Fs \cos \theta \]

**Conservation of Energy**

Energy cannot be created or destroyed — but it can be converted from one form to another.
We'll start with energy. (Book starts with work)

(Note: If an object has energy it can do work)

**Kinetic Energy (KE or K.E.)**

A mass $m$ moving with speed $v$ has kinetic energy,

$$KE = \frac{1}{2} m v^2$$

This is a definition. Why introduce it? Because it's useful!

**Units of Energy:**

Units of $KE = \text{mass} \times (\text{length}/\text{time})^2$  

= $\text{kg} \cdot \text{m}^2/\text{s}^2 = \text{Joules (J)}$  

(Eg. 1kg moving with 1m/s: $KE = \frac{1}{2} J$)
Now let's define work.

Work done by a force $F$:

\[ W = F s \cos \theta \]

- $s$ = Distance object moves while $F$ is acting.
- $\theta$ = Angle between direction of $F$ and direction of $s$.

Example: Push a crate.

\[ W = F s \cos \theta \]

(Other forces are involved, but we are concerned with $F$.)
$W = F_s \cos \theta$

Why the $\cos \theta$?

Consider the crate (no friction)

**FBD**

HOR + VERT COMPONENTS:

$mg + F_{sm} \theta$

Only $F_{cos \theta}$ causes acceleration

$F_{sm} \theta$ component does nothing

$F_{cos \theta}$ component is parallel to $s$. 
Work is done by the component of $F$ parallel to $s$.

So

$W = F_s \cos \theta$

($\cos 0 = 1$)

And

$W = 0$

($\cos 90^\circ = 0$)

(i.e. press down on object moving with $v = \text{constant}$ along table (no friction))
The work done by the net force on an object is equal to the change in KE of the object.

\[ \text{Work} = \Delta \text{KE} = \frac{1}{2} m_f v_f^2 - \frac{1}{2} m_i v_i^2 \]

**By the Important Words Are:**

- Net force
- The force
- Work
- \( F \)
- Initial
- Final
- \( \Delta \text{KE} \)
IS THE W.E.T. A "NEW" LAW?
NOT REALLY!

CONSIDER 1-D MOTION:

\[ \begin{align*}
\Delta m & \rightarrow F \\
& \rightarrow a \\
\Delta u & \rightarrow v \\
\Delta x & \rightarrow x
\end{align*} \]

1-D EQUATION

\[ v^2 = u_0^2 + 2ax \]

\[ \text{or} \quad m v^2 = m u_0^2 + 2 m ax \]

\[ \text{or} \quad 2max = m v^2 - m u_0^2 \]

**But** \( F = ma \), so:
\[ 2Fx = m v^2 - m u_0^2 \]

Divide by 2:
\[ Fx = \frac{1}{2} mv^2 - \frac{1}{2} m u_0^2 \]

\[ \text{or} \quad W = KE_f - KE_i \]
(\text{OK, 1-D AND } F \parallel \vec{x}, \text{ SO NOT GENERAL})
This is a useful theorem!

Consider an object accelerated from rest by a force \( F \) acting over a distance \( x \) (in \( F \parallel x \)).

What is its final velocity?

W.E.T.:

\[ W = Fx = \frac{1}{2} m v^2 \]  \( (v_0 = 0) \)

So

\[ v = \sqrt{\frac{2Fx}{m}} \]

If there is more than one force acting, we can ask:

1) What is the work done by the net force?

2) What is the work done by each force?
**E.G.: Force Accelerates Mass on a Table (No Friction)**  
("A Smooth Table")

**Physics-Speak for No Friction**

\[ F_{\text{net}} = F \]  
\[ (n = mg) \]

1) **W.E.T.**  
\[ F_x = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2 \]

2) **(Work Done by \( F \))** = \( F_x \)  
   **(The Same)**

3) **(Work Done by \( mg \))**  
\[ = mg \cdot x \cdot \cos 90^\circ = 0 \]

4) **(Work Done by \( n \))**  
\[ = n \cdot x \cdot \cos 90^\circ = 0 \]
Now the same with friction and a constant speed

1. \( F \) is needed to "balance" \( F_k \)

\[
\begin{align*}
\mathbf{F}_k & \leq \mathbf{n} \\
\mathbf{F} & \geq m \mathbf{g} \\
\mathbf{F}_{\text{net}} & = 0 \\
\text{IE} \quad F &= F_k = \mu_k mg \\
& \text{(since } n = mg) \\
\end{align*}
\]

1) Work done by net force

\[
W_{\text{E}}: \quad 0 \times x = \frac{1}{2} mu^2 - \frac{1}{2} mv^2 = 0 \\
\checkmark
\]

2) Work done by \( F \)

\[
W_F = F \cdot x \Rightarrow F \cdot x (\cos 0^\circ = 1)
\]

3) Work done by \( F_k \):

\[
W_{F_k} = -\int F_k \cdot x = -F \cdot x \\
\leftarrow \rightarrow \\
\cos 180^\circ = -1
\]

Friction does negative work = such as energy out

4) (Work done by \( n, mg \)) = 0 as before