Solving Problems Involving Energy and Work

1) Identify object(s) of interest. Identify other object(s) that interact with them; decide if you want to include these objects in your system or not. **Define your system.**

2) Identify the initial and final states of your system. Where are all objects? Are they moving? Label unknown quantities with appropriate subscripts (for example v_i, h_f, etc.). *Note: you may consider more than two states of a particular problem (for example, the ball as it's at rest in your hands, the ball as it leaves your hands, the ball at the top of its flight, etc)… conservation of energy can be applied to* ***any two*** *states at one time.*

3) Look for forms of energy which exist in the system (initial *and* final). There may be more than one… look for kinetic energy (is anything moving?), gravitational potential energy (does anything rise or fall?), elastic potential energy (are there any springs or cords or surfaces that stretch, compress, or flex?), heat energy (does anything heat up or cool down?). If a form of energy is present, *but does not increase or decrease*, it does not need to be included in your analysis.

4) Look for objects that are *outside* your system that exert forces on the system. If there are any such forces, they will do work. If they add energy, the work will be positive; if they remove energy, the work will be negative.

5) Write out conservation of energy: $E_i + W = E_f$.
Plug in all energy and work terms identified in (2). Solve for unknowns.

Here's a table that outlines how to deal with three specific interactions, depending on whether or not you've decided to include certain objects in your system.

	IN THE SYSTEM	**NOT IN THE SYSTEM**
EARTH	GPE = mgh = $(-Gm_1m_2/r)$ (energy of relative position of two objects in system)	$W = F_g \Delta r \cos\theta$ (gravity is external force and does work)
SPRING/ELASTIC/ FLEXIBLE SURFACE	EPE = $(1/2)kx^2$ (energy stored in spring that is stretched or compressed a distance x)	$W = -[(1/2)kx_f^2 - (1/2)kx_i^2]$ (energy in [..] is change in spring's stored energy; neg. sign out front shows that what is *gained* by spring is *lost* by system & vice versa)
SURFACE (friction) & AIR (drag)	$E_{th} = F_{fr}\,\Delta x$ (energy *stays* in system in thermal form, so *positive* thermal energy)	$W = -F_{fr}\,\Delta x$ (energy *leaves* system, so *negative* work)

Kinetic Energy = KE = $(1/2)mv^2$

General form for work done by a constant force: $W = F\Delta r \cos\theta$
If work is done by a force pointing along (against) the direction of motion: $W = (-)F\Delta r$.
No work is done by a force that is perpendicular to motion.