Understanding the relationships between All Forms of Energy, Conservation of Energy, and Work Energy Theorem are extremely essential for success on the AP Exam. The review here is very limited, since this critical information is given substantial emphasis in the course overview. Often energy is either the only way to progress in an AP Free Response problem, or it is the easiest (quickest) way to solve the problem. Students who have a thorough understanding of energy will achieve success on the AP Exam and arrive at college as a more accomplished physics student.

Energy is conserved: It cannot be created or destroyed, but it can change forms.

Can energy be lost? No! Lost energy goes to the environment. A car (system) looses energy due to air resistance, so air molecules (environment) gain energy and move faster. Energy is conserved.

When we did kinematics, problems might have started at 205.65 *m* from where we were standing. But, to make it easier we said the problem started at 0 *m*. For energy pretend the system has zero internal energy initially. Then only worry about the other forms of energy. We can then solve for how much the internal energy changes in the problem.

Work An object or problem has a certain amount of energy starting the problem (potential energy due to position and/or kinetic energy due to motion). Remember were pretending internal energy is zero. Think of work as the energy that is added (+***W***) to the system or subtracted (-***W***) from the system. If you add a force to something that is standing still it will begin to move a distance. This requires positive work, the product of the force used and distance moved.

$W = Fs\cos\theta$ Force applied over a distance. ***Force and distance must be parallel.*** Note: this does not mean the ***x*** axis which **cos**θ usually goes along with. θ is the angle between direction of motion and applied force.

Work is the Area Under the Force Distance Curve: This is the integral of the force distance function in a calculus based course. But, our functions will be simple enough to allow us to use geometry to find the area.

Kinetic Energy	$K = \frac{1}{2}mv^2$	Energy of moving matter. Note that doubling mass doubles kinetic energy, but doubling velocity quadruples kinetic energy. So you car at 60 *mph* is 4 times more lethal than at 30 *mph*.
Potential Energy		
Gravitational	$U = mgh$	Depends on height. Consider the lowest point in the problem to be zero height. This isn't correct, but who wants to add the radius of the earth to every number in the problem. Radius factors out at the end anyway.
Electric	$U_E = qV$	Energy of a particle experiencing an electric potential.
Spring	$U_S = \frac{1}{2}kx^2$	Energy of a compressed spring with spring constant ***k***.
Capacitor	$U_C = \frac{1}{2}QV = \frac{1}{2}CV^2$	Energy of capacitor.
Energy of Photons	$E = h\nu = pc$	Used in modern physics

Work Energy Theorem

Work put into a system = the change in energy of the system. If you do work on a system you add energy (+***W***). If the system moves to a lower energy state (dropping a bowling ball on your toe), then the system does work on the environment (-***W***). It can transfer energy to the environment. The bowling ball has –***W*** while your toe gets +***W*** (toe gets energy)

$W = \Delta U$ $W = \Delta U_E$ $W = \Delta U_s$ $W = K$ $W = Q_{heat\ energy}$ etc.

But, what if the energy changes from zero to some amount or from some amount to zero.

$W = U$ $W = U_E$ $W = U_s$ $W = K$ $W = Q_{heat\ energy}$ etc.

Work and work-energy theorem are great for changes in energy, when energy moves from one thing to another or is added or subtracted. But what if a system doesn't exchange energy with the environment or another system. What if it has certain types of energy in the beginning of the problem, but it has a different amount of each energy at the end?

Conservation of Energy

Energy cannot be created or destroyed, but can change form and be transferred.

The big picture: $Internal\ Energy_i + K_i + U_i + Any\ other\ energy_i = Energy_f + K_f + U_f + Any\ other\ energy_f$

However, the problem may only talk about two forms of energy.

As an example: If the problem only involves Potential Energy and Kinetic Energy

$U_i + K_i = U_f + K_f$ then substitute known equations $mgh_i + \frac{1}{2}mv^2{}_i = mgh_f + \frac{1}{2}mv^2{}_f$

Here are some other possibilities: The first is accelerating charges, the second is for springs.

$qV_i + \frac{1}{2}mv^2{}_i = qV_f + \frac{1}{2}mv^2{}_f$ $\frac{1}{2}kx^2{}_i + \frac{1}{2}mv^2{}_i = \frac{1}{2}kx^2{}_f + \frac{1}{2}mv^2{}_f$ etc.

The following formulas are specific short cuts usually applied when there are two extremes in the problem.

Gravity $mgh = \frac{1}{2}mv^2$ A mass ***m*** starts at the highest point and ends at the lowest point, or vice versa.

Electric $qV = \frac{1}{2}mv^2$ When a charge ***q*** is accelerated by charged plates with a potential difference ***V***.

Spring $\frac{1}{2}kx^2 = \frac{1}{2}mv^2$ If a compressed spring extends to the equilibrium position, or vice versa.

Electrons $h\nu = \frac{1}{2}mv^2$ When energy of a photon is transferred to an electron, or vice versa.

Collisions

$E_{1i} + E_{2i} = E_{1f} + E_{2f}$ Can be used by itself and with conservation of momentum below.

$K_{1i} + K_{2i} = (K_{1f} + K_{2f}) + K_{dissipated}$ In collisions ***total energy is conserved***, but ***kinetic energy is not***.

Unlike momentum, kinetic energy can decrease in collisions which are not ***perfectly elastic***. But where does it go? The deformation of colliding bodies turns into heat (internal energy). So if you take the Kinetic energy at the start, it will equal the kinetic energy at the end plus the amount of kinetic energy dissipated. The energy dissipated is conserved: transfers to internal energy.

Power: Rate at which work is done. Powerful machines do more work in the same time, or the same work in less time.

$P = \frac{W}{t}$ $P = Fv$ Work or Energy delivered as a rate of time.

It involves work. Making this another of the very important concepts.

As an example you can go from ***energy*** to ***work*** to ***power*** then to ***voltage and current*** $P = IV$

Energy and time: Think Power when you see energy and time, Joules and seconds.

Momentum $p = mv$ inertia in motion. Measure of how difficult it is to stop an object.

Impulse $Ft = \Delta p$ Trade off between time taken to stop and force needed to stop.

Conservation of Momentum Total momentum before a collision must match total momentum after. Not given on the AP exam. One object might be standing still at the start or after.

$m_1v_{1i} + m_2v_{2i} = m_1v_{1f} + m_2v_{2f}$ Completely Elastic Collision: Bounce off completely.

$m_1v_{1i} + m_2v_{2i} = v_f(m_1 + m_2)$ Inelastic Collision: The objects stick together, mass adds, one velocity.

Oscillations

Period $T = \frac{1}{f}$ Time for one revolution, measured in seconds

Frequency The number of revolution, turns, vibrations, oscillations, rotations per second.

Springs

Restoring force $F = -kx$ displace a spring and it will return to equilibrium, center.
k is the spring constant, the minus sign is not mathematical

Period of a spring $T_s = 2\pi\sqrt{\frac{m}{k}}$ Depends on mass of object attached to spring and ***k***.

Pendulum $T_p = 2\pi\sqrt{\frac{\ell}{g}}$ Depends on length of the pendulum and ***g***.