TOPIC 4B

Skill 31: Applying conservation of energy to transfer within a system

- The Law of Conservation of Energy states that the total amount of energy in a closed system must remain constant
- In a frictionless system, mechanical energy (PE and KE) is conserved without heat (or internal energy, Q) produced.
- In a system with friction, the difference between the starting mechanical energy (PE and KE) of a system and the ending mechanical energy of the system is the result of work done by friction and will become internal energy or heat (Q).

For systems with FRICTION (Remember Q is energy lost to friction)

$$E_T = PE + KE + Q$$

A chart like this can be used to account for changes in the distribution of energy at various points in the scenario.

(With friction include Q)

	E_T	PE	KE	Q
Top	REMAINS CONSTANT			
Mid-point or other defined				
Bottom				

For FRICTIONLESS (vertical, horizontal or elastic) systems

$$E_T = PE + KE$$

	E_T	PE	KE
Top	REMAINS CONSTANT		
Mid-point or other defined			
Bottom			

Common Energy conversions (FRICTIONLESS)

VERTICAL SYSTEMS

- **Object falling from rest**
  PE (gravitational) lost becomes KE (Equal to work **against** gravity $W=F_gd$ or F_gh)

(For objects falling to the ground $PE_{top} = KE_{bottom}$, For mid points you must use Δh)

$PE = mg\Delta h$ is set equal to $KE = \frac{1}{2} mv^2$ **v is the final velocity (v_f)**

$$mg\Delta h = \frac{1}{2} mv^2 \text{ so}$$

$$\text{so } gh = \frac{1}{2} v^2 \text{ which becomes } \mathbf{V_f} = \sqrt{2g\Delta h}$$

If the height of a fall for an object doubles, the velocity will ______________________

- **Object launched vertically**
  KE lost becomes PE (gravitational) (Equal to work done on object **by** gravity W=Fgd or Fgh)

$$\frac{1}{2} mv^2 \text{ so} = mg\Delta h$$

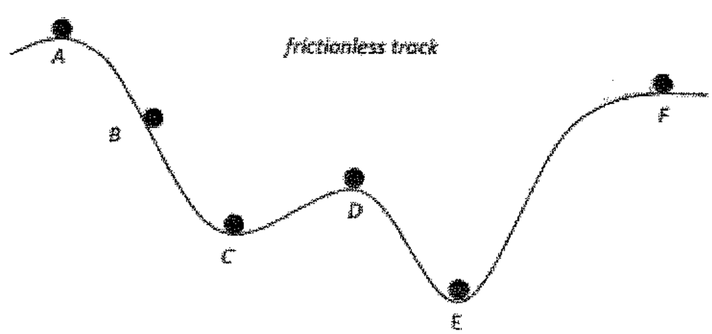
$$\text{So } \Delta h = \frac{v^2}{2g}$$

FRICTIONLESS SLOPES (Still a vertical change problem)

KE + PE = E_T is also true on any frictionless track, slope etc. Without friction all energy is conserved in the object.

At all points on the track

KE + PE = E_T



In the track above the total mechanical energy is always equal to the PE at A or the KE at E (assume that is ground level). The energy is redistributed as KE and PE depending on changes in height.

Equation at each point:

A: $E_T = PE = mgh$ (which equals KE at point E)

B, C, D, F: $E_T = PE + KE = mgh + \frac{1}{2} mv^2$ (to find v use $vf = \sqrt{2g\Delta h}$)

E: $E_T = KE = \frac{1}{2} mv^2$ (which equals PE at point A)

HORIZONTAL FRICTIONLESS SYSTEMS

Kinetic Energy equals work done on horizontal axis

$$KE = F_{netx}d = \frac{1}{2} mv^2 = F_x d \quad \text{or} \quad \frac{1}{2} mv^2 = mad$$

(The F is the net force which causes the object to speed up)

SPRING SYSTEMS

- **Objects launched horizontal or stopped by a spring**
  PE_s becomes KE or KE becomes PE_s (Equals W on spring $W=F_{avg}x$)

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

- **Objects launched vertically by a spring**
  PE_s becomes PE (gravitational)

$$\frac{1}{2}kx^2 = mgh$$

THE KEY TO SOLVING ENERGY CONSERVATION PROBLEMS IS TO

FIND TOTAL MECHANICAL ENERGY BY IDENTIFYING POINTS IN THE SCENARIO WHERE ALL ENERGY IS PRESENT IN A SINGLE FORM. (FOR OTHER POINTS SET THE SUM OF ALL THE FORMS OF ENERGY/WORK EQUAL TO THAT TOTAL)

Skill 32: Determining internal energy, work against friction or energy "loss" to heat within a system.

Whenever total mechanical energy present at the beginning does not equal total mechanical available at the end, some of the work or mechanical energy has been converted to heat or work against friction.
Remember Total Mechanical Energy (E_T) = Work done.

$$E_T = PE + KE + Q \qquad Q = E_T - (PE + KE)$$

$$[\text{So } Q = W - (PE + KE)]$$

Q equals the difference between work done and energy gained