Skill 29: Work-Energy Theorem-Calculating work for each axis of motion

In order for an object to gain energy, work must be done. Work done is equal to force time distance (in the direction of the force)

In a FRICTIONLESS SYSTEM

$$W = Fd = \Delta E_T$$

A. Vertical Work/ Work done against gravity - **Force** is equal to weight ($F_g = mg$) since it is a force against the gravitational field (remember gravity is a factor only in vertical fields $d_y=h$)

$$W = F_g d = mgd = mgh = PE$$

WORK DONE ON AN OBJECT IN A VERTICAL DIRECTION (FRICTIONLESS) IS CONVERTED INTO GRAVITATIONAL POTENTIAL ENERGY (PE=mgh)

B. Horizontal Work – Force equals the net horizontal force Remember $F_x=F_A \cos\Theta$

$$W = F_{(netx)}d = mad = \tfrac{1}{2} mv^2 = KE$$

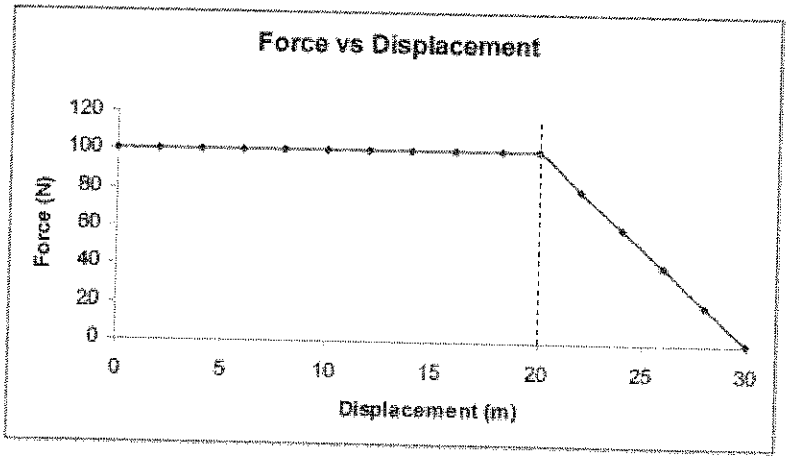
Rearrange $v_f^2=v_i^2 + 2ad$, where $v_i = 0$ solve for "ad"

$1/2v^2=ad$ So $mad = 1/2mv^2$

WORK THAT IS DONE ON AN OBJECT IN A HORIZONTAL DIRECTION (FRICTIONLESS) IS CONVERTED INTO KINETIC ENERGY

For force that is not constant it is usually represented as graph. Remember that if Work=Force x distance then the amount of work could be found using the area under the graph.

Example: The graph below represents the force used to push an object over a distance of 30m.



Determine the amount of work done. (Show your calculations)

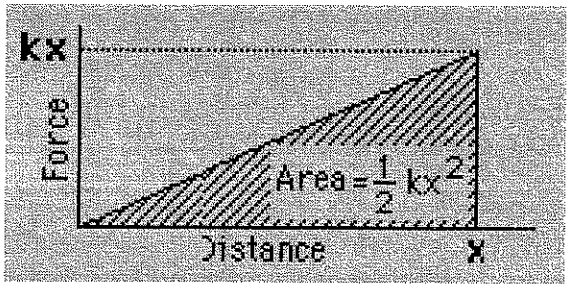
Area = rectangle + triangle
= (100N)(20m) + 1/2(100N)(10m)
= 2000Nm+500Nm
= 2500Nm=2500J

C. Elastic or Spring System Work – Force equals **Average Spring Force (F_s=kx)** and distance equals stretch (x). Average spring force $\overline{F}_s$ equals, $F_s/2$.

$$W_{spring} = \overline{F}_s d = \overline{F}_s x = 1/2\ kx\ (x) = \tfrac{1}{2}\ kx^2 = PE_s$$

WORK THAT IS DONE ON A SPRING (FRICTIONLESS) IS CONVERTED TO ELASTIC POTENTIAL ENERGY

F_s=kx



Spring force varies with stretch, so you must take average force.

For vertical and horizontal work, the force is

x

$$W = \frac{F_s}{2}x = \frac{kx}{2}x = \frac{1}{2}kx^2 = PE_s$$

D. Work done against friction accounts for loss of total mechanical energy and an increase in heat of the object. Equal to ΔE_T. If and object is pushed across a horizontal surface and it does not speed up (constant velocity), work done is against friction (no KE is gained).

$$W = F_f d = E_T = Q$$

Skill 30: Defining Power

Power is the rate of work or rate of energy change for an object. Since work and energy are both measured in Joules, Power can be measured in Joules per second (J/s) which is also known as a **Watt**

$$P = \frac{W}{t} = \frac{Fd}{t} = F\bar{v}$$

Power and time have an inverse relationship. In other words if two machines both accomplish the same work, but one takes half the time, the faster machine is more powerful.