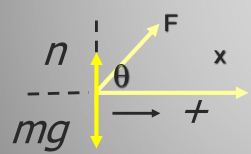
Procedure for Calculating Work

1. Draw sketch and establish what is given and what is to be found
2. Draw free-body diagram choosing positive x-axis along displacement.

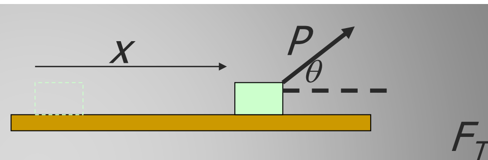


$$Work = (F \cos \theta)\, \Delta x$$

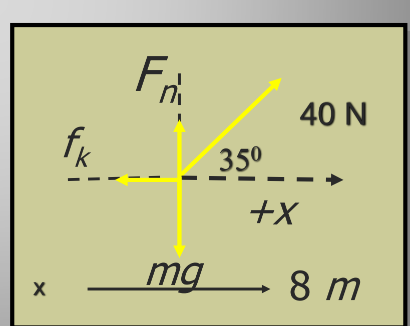
3. Find work of a single force from formula.
4. Resultant work is work of resultant force.

<u>Example 2:</u> A 40-N force pulls a 4-kg block a horizontal distance of 8 m. The rope makes an angle of 35^0 with the floor and u_k = 0.2. What is the work done by each acting on block?

1. Draw sketch and find given values.
   - P = 40 N
   - x = 8 m
   - u_k = 0.2
   - θ = 35^0
   - θ m = 4 kg

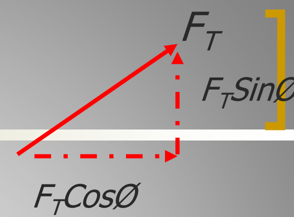


2. Draw free-body diagram showing all forces



$$Work = (F \cos \theta)\, \Delta x$$
$$Work = F_{net}\, \Delta x$$

Continue problem



Work = $F_{net}\,\Delta x$

We need the net force in the X direction, because that is where displacement occurs

$\Sigma F_{net} = F_T \cos\varnothing - F_f$

$F_f = \mu_s F_n$

$\Sigma F_y = F_N + F_T \sin\varnothing - mg = 0$

$F_N = mg - F_T \sin\varnothing$

$\Sigma F_{net} = F_T \cos\varnothing - \mu_s (mg - F_T \sin\varnothing)$

$F_{net} = 40N\cos35 - 0.20\,(4kg*9.8m/s^2 - 40N\sin35)$

$F_{net} = 30N$

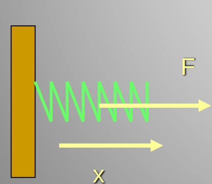
Work = 30N * 8 m

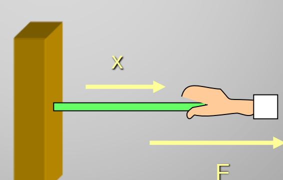
Work = 240 N m

Work of a Varying Force

Our definition of work applies only for a **constant** force or an **average** force.

What if the force varies with displacement as with stretching a spring or rubber band?

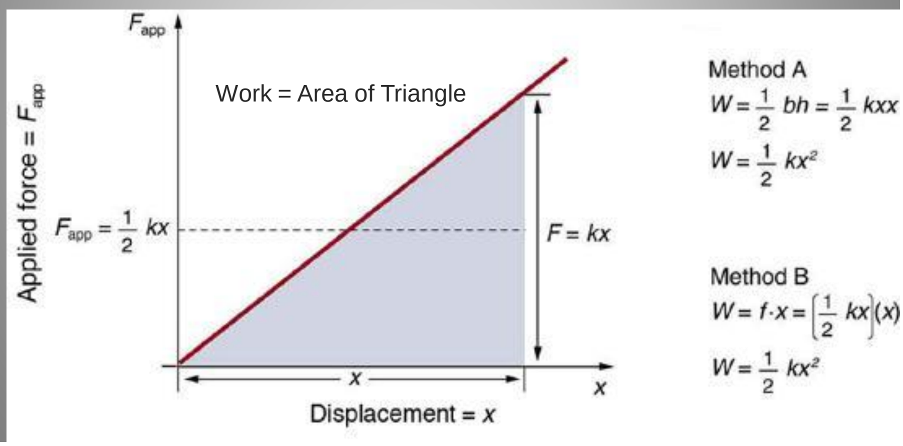




Work Done in Stretching a Spring

Work done ON the spring is positive;
Work BY the spring is negative.

Work = ½ kx^2



Hooke's Law

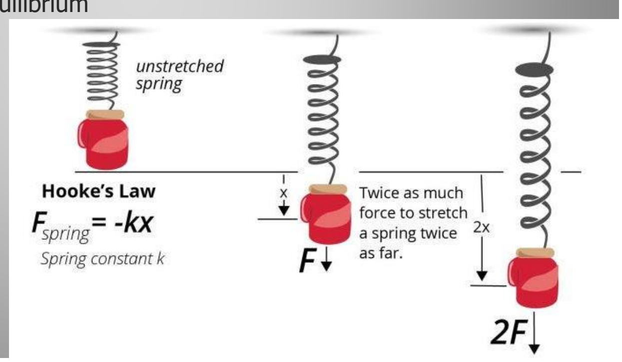
Hooke's Law – relationship between force and displacement

$\mathbf{F_{elastic} = - kx}$

F = spring force (N)
k = spring constant (N/m)
x = displacement from equilibrium

Each spring has an associated **spring constant K**, which measures how "tight" the spring is

Note:
The (–) sign means the spring force is opposite the direction of the mass displacement



General Case for Springs:

If the initial displacement is not zero, the work done is given by:

$$Work = \frac{1}{2}kx_2^2 - \frac{1}{2}kx_1^2$$