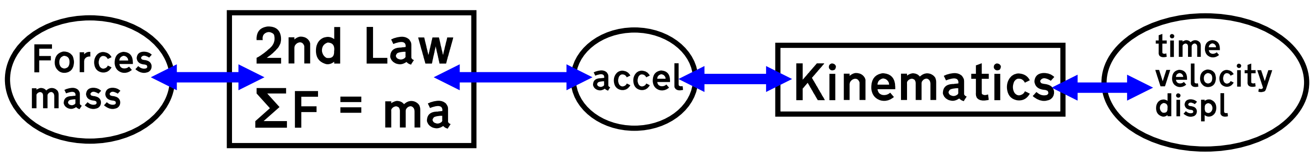
Cycle 10 Notes: Work & Kinetic Energy

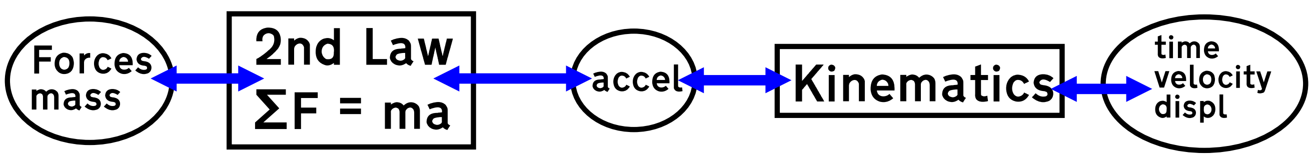
Forces model



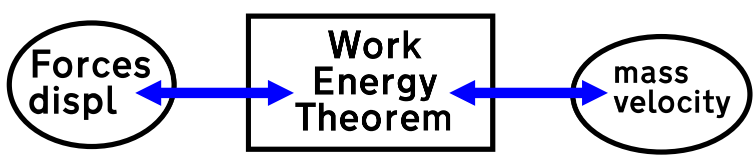
Isn't there an easier way?

Models

Forces model vectors



Energy model scalars



The Work Energy Theorem

$$\boxed{W_{total} = K_f - K_i}$$

total work = change in kinetic energy

$$W_{\text{Total of all Forces}} = W_{net\,F} = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$

Work

Is a scalar quantity

Is measured in Newton-meter (Nm) which is defined as a Joule (J)

$W = Fs \cos \theta$

$W = F_x s_x + F_y s_y$

example:

+ vs - Work

+ WORK = force and displacement at less than 90^{o}

- WORK = force and displacement at more than 90^{o}

What if the force and displacement are exactly at 90^{o} to each other?

example:

Kinetic Energy

Is a scalar quantity

Is measured in $kg\text{-}m^2/s^2$ which is defined as a Joule (J)

$K = 1/2mv^2$

example:

$K = \frac{1}{2}mv^2$ $\qquad kg\,\frac{m^2}{s^2}$

2000kg

5m/s $\qquad \frac{1}{2}(2000)(5)^2 \qquad \left(kg\frac{m}{s^2}\right)m$

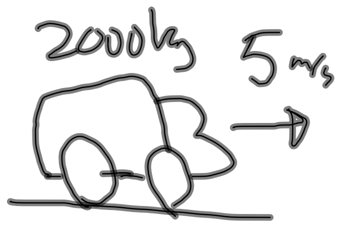
$= 25{,}000\ J$

Work Energy Theorem

Relates the work done **ON** an object to
the change in kinetic energy **OF** the object

$$\boxed{W_{total} = K_f - K_i}$$

example:



$$W_{total} = 100{,}000\ J$$

$$W_{total} = K_f - K_i$$

$$W_{total} = \frac{1}{2}m\left(v_f^2 - v_i^2\right)$$

$$100{,}000\ J = \frac{1}{2}(2000)\left(v_f^2 - 5^2\right)$$

$$200{,}000 = 2000\left(v_f^2 - 25\right)$$

$$100 = v_f^2 - 25$$

$$125 = v_f^2$$

$$\sqrt{125} = v_f$$

$$11\ m/s \approx v_f$$

More examples

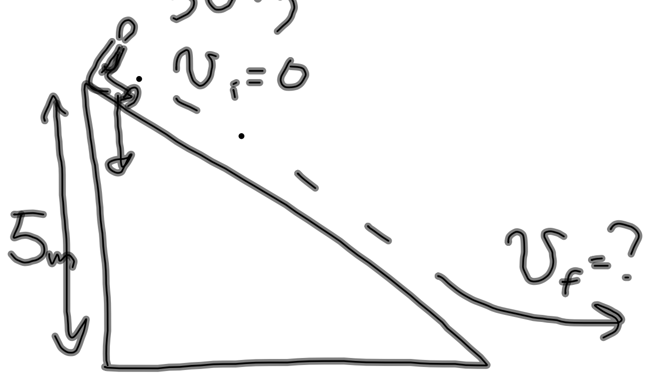
The sliding board

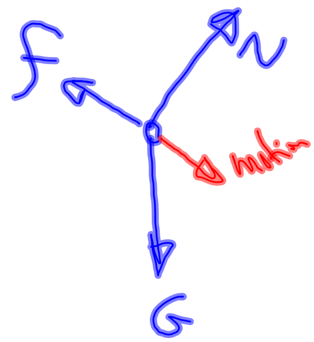
The loading dock

The pendulum

$\boxed{f=0}$

$W_{TOTAL} = \Delta K$





$W_G = G \cdot s$

$= (30 \text{ kg})(10 \text{ m/s}^2)(5 \text{ m})$

$= 1500 \text{ J}$

$W_{TOTAL} = \Delta K$

$1500 \text{ J} = \frac{1}{2} m (v_f^2 - v_i^2)$

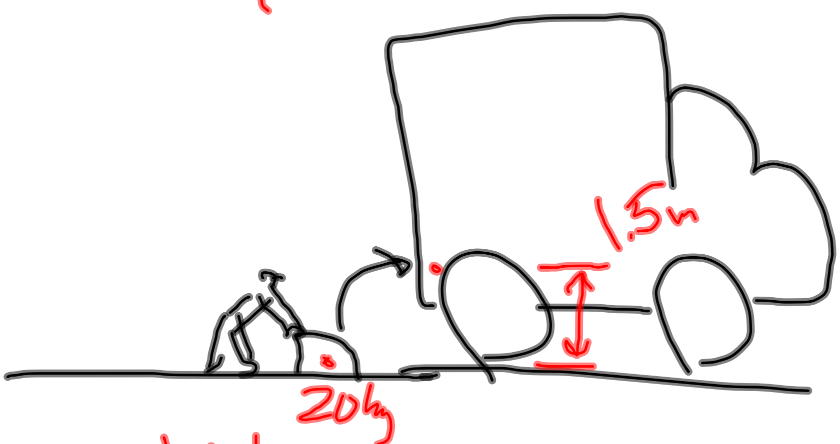
$= \frac{1}{2}(30)(v_f^2 - 0^2)$

$1500 = 15 v_f^2$

$100 = v_f^2$

$10 \text{ m/s} = v_f$

$v_i = 0 \quad v_f = 0$



$W_{TOTAL} = 0$

DOWN $\rightarrow W_G^{+}$

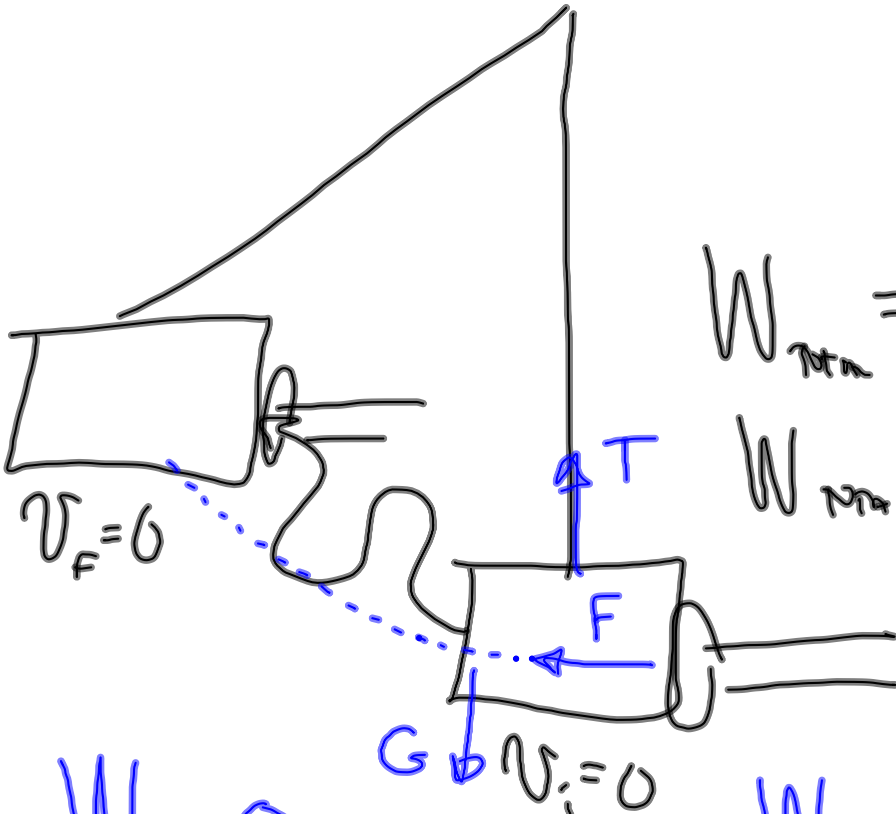
UP $\rightarrow W_G^{-}$

$W_p + W_G = 0$

$W_p + (20\,kg)(10\,m/s^2)(1.5\,m)\cos 180 = 0$

$W_p + {}^{-}300\,J = 0$

$W_p = 300\,J$

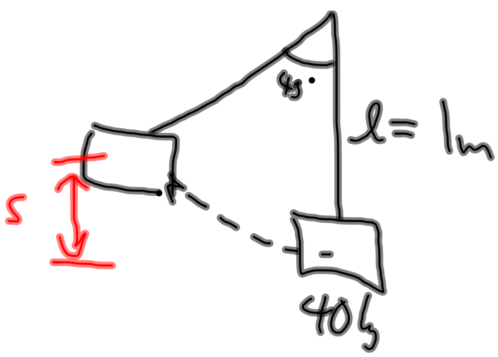


$W_{net} = \Delta K$

$W_{net} = 0$

$W_T = 0$

$W_p + W_G = 0$



$s = l - l\cos\theta$

$= 1m - 1m\cos 45$

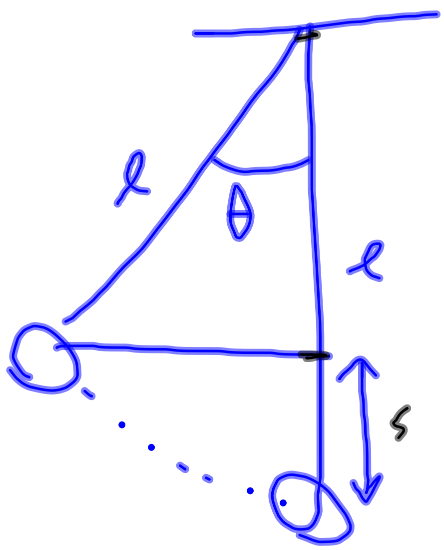
$= 1m - 0.707$

$= 0.29\,m$

$W_G = (40)(10)\,0.29$

$\approx 120\,J$

$\therefore W_p = 120\,J$



$$s = l - l\cos\theta$$

Springs

stretch or compress

Force proportional to displacement

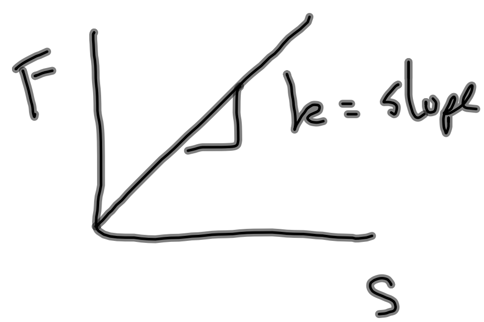
Spring Constant k relates force to displacement

$$\boxed{F = -ks}$$

spring constant

10 N/m

example:



What about non-constant forces?

Work becomes an integral

$$\boxed{W = \int F\, ds}$$

spring

example: $W = \int (-ks)\, ds$

$= -k \int s\, ds$

$= -\frac{ks^2}{2}$

$W_{spring} = -\frac{1}{2}ks^2$