$$W = F d \cos\theta = |\vec{F}| \cdot |\vec{d}| \cdot \cos\theta$$


$$= F_d \, d$$
$$= F \, d_F$$

unit of work = force × length
N × m

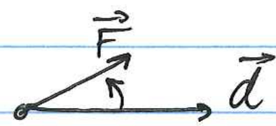
$1 \ N \cdot m = \underline{1 \ J, \ \text{Joule}}$

$1 \ cal = 4.186 \ J$ = energy needed to heat up 1 g of __water__ by 1 °C

$1 \ Cal = 1 \ kcal$

$250 \ Cal = 250\,000 \ cal$
$= (250\,000)(4.186) \ J$

$W > 0$




$\theta < 90° \rightarrow \cos\theta > 0$
$W > 0$

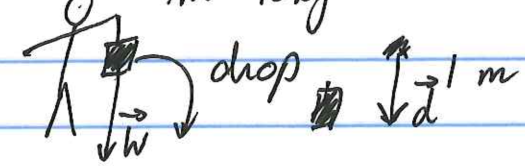
force is adding energy to the object

$W < 0$


$\theta > 90° \rightarrow \cos\theta < 0$
$W < 0$

energy is being removed from the object

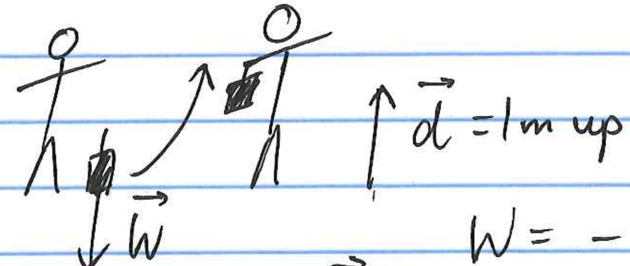
$W > 0$




$\theta = 0°$

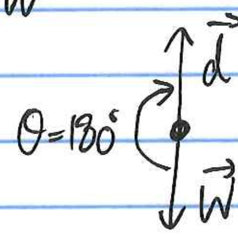
$$W = (mg)(1\,m) \cdot \cos 0° = (10\,kg)(10\,m/s^2)(1\,m) = 100\,J$$

$W < 0$




$\theta = 180°$

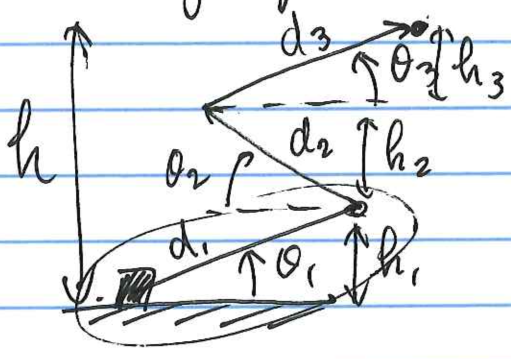
$W = -100\,J$



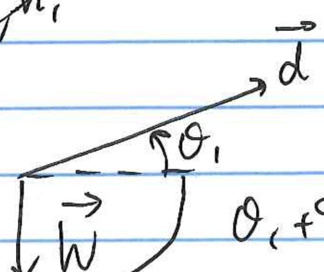



$\rightarrow \theta > 90° \longrightarrow W < 0$
$= 180°$

* Moving object under angles




$$W_{total} = W_1 + W_2 + W_3$$
$$= mg\, d_1 \sin\theta_1 + mg\, d_2 \sin\theta_2 + mg\, d_3 \sin\theta_3$$
$$= mg(h_1 + h_2 + h_3) = mgh$$




$\theta_1 + 90°$

Kinetic energy $KE = \frac{1}{2} m v^2$

$$\frac{1}{2} m v_f^2 = \frac{1}{2} m v_i^2 + W_{total}$$

$$\underline{W_{total}} = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2 = \underline{KE_f - KE_i}$$

Work/energy theorem: $\boxed{W_{net} = KE_f - KE_i}$

* Example:

$v_f = 0$

$v_i = 0$

$m = 10\,kg$

$d = 1\,m$

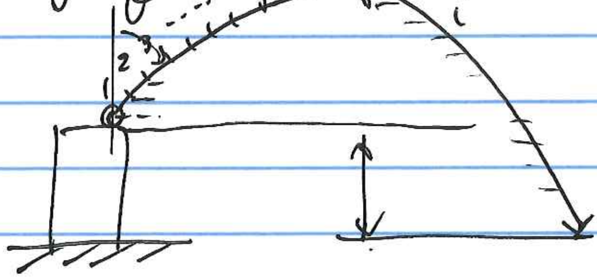
$$\underline{W_{net}} = KE_f - KE_i = 0$$

$$W_g = -Fd = -mgd = -100\,J$$

$$W_{mechanical\ energy} + W_g = \underset{0}{\underset{\parallel}{W_{net}}}$$

$\hookrightarrow W_{mechanical\ en} = 100\,J$

* Objects in free fall




$$W_{total} = W_1 + W_2 + \cdots$$
$$= -mg\,\underline{d_1 \cos\theta_1} +$$
$$- mg\,\underline{d_2 \cos\theta_2} + \cdots$$

$$W_{total} = -mg h_1 - mg h_2$$
$$- mg h_3 + \cdots$$
$$- mg(\underset{<0}{h_i})$$

$$W_{total} = -mg(\underbrace{y_f - y_i}_{h})$$

~~[illegible]~~ Potential energy in gravity

$$PE = mgy$$

$$\underline{W_{total}} = -(PE_f - PE_i)$$

$$W_{total} = KE_f - KE_i = -(PE_f - PE_i)$$

↳ conservation of energy:

$$KE_f + PE_f = KE_i + \cancel{KE_f} PE_i$$

Recap: $W = Fd\cos\theta$

$W > 0$ if work is done by the force on the system such that the energy increases

$KE = \frac{1}{2}mv^2$ = energy of motion of an object with mass $m$

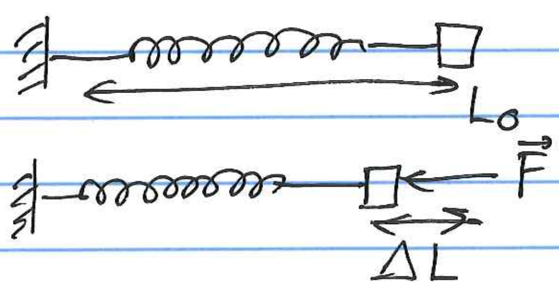
$\underline{PE = mgy}$ for $\underline{\text{gravity}}$ only
= capacity of an object to do work by virtue of its position with respect to Earth

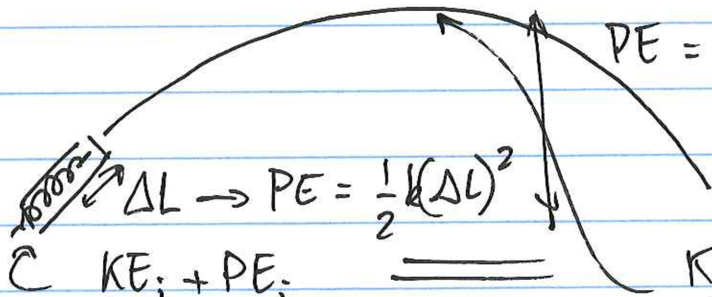
Work/energy theorem: $W_{net} = KE_f - KE_i$

For $\underline{\text{gravity}}$: $W_{net} = -(PE_f - PE_i)$
$KE_i + PE_i = KE_f + PE_f$

* Other examples of potential energy

Hooke's law: $F = k\Delta L \longrightarrow \underline{PE = \frac{1}{2}k(\Delta L)^2}$





$PE = mgh$

$\Delta L \rightarrow PE = \frac{1}{2}k(\Delta L)^2$

$$KE_i + PE_i = KE_f + PE_f$$

$$\underset{0}{KE_i} \quad \frac{1}{2}k(\Delta L)^2 + \cancel{mgy_0} = 0 \cdot 0 + mg(\cancel{y_0} + h)$$

$$\frac{1}{2}k(\Delta L)^2 = mgh$$

$$h = \cancel{\frac{2mg}{k}} \quad \frac{k(\Delta L)^2}{2mg}$$