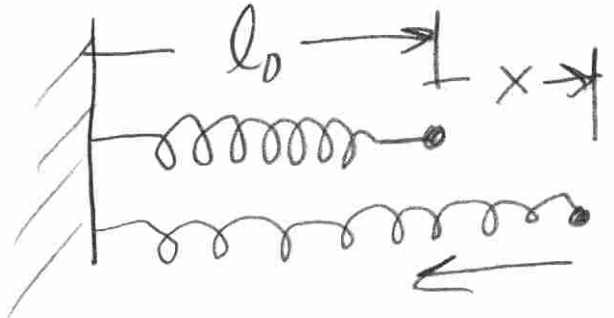
Spring: $F_s = -kx$ (x is displacement from equilibrium)




Work done by spring (not agency that moved spring):

$$W_s = \int_{x_i}^{x_f} (-kx)\,dx$$

$$= -\frac{1}{2}kx^2 \Big|_{x_i}^{x_f}$$

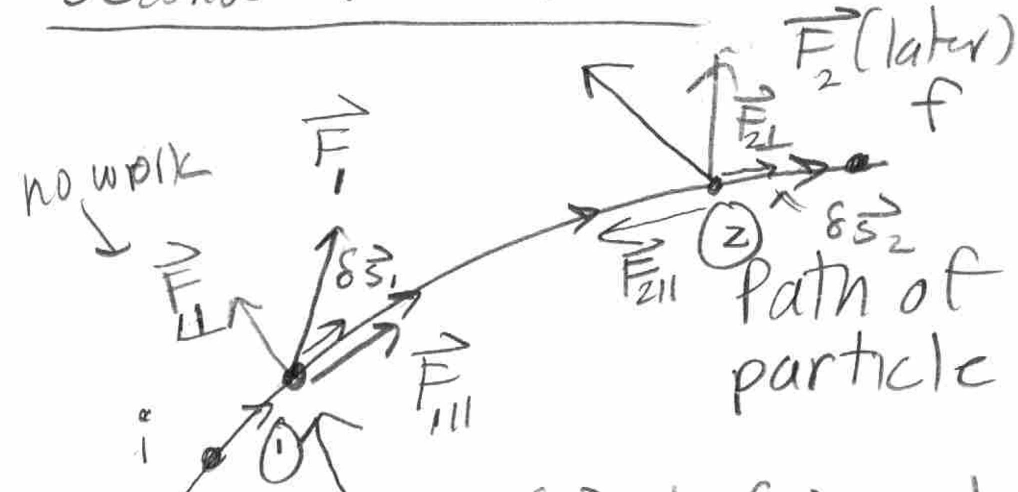
$$= \frac{1}{2}kx_i^2 - \frac{1}{2}kx_f^2$$

$x_i = 0 \quad x_f = x$

$$W_s = -\frac{1}{2}kx^2$$

$$W_{ext} = +\frac{1}{2}kx^2$$

## Second Dimension




$\delta\vec{s}_1$ & $\delta\vec{s}_2$ always $\parallel$

only $\vec{F}$'s component $\parallel$ to the path of the particle does work.

Best: break $\vec{F}$ in to LOCALLY $\perp$ and $\parallel$ components

at point #1: $\delta W_1 = F_{1\parallel}\,\delta s_1 = \vec{F}_1 \cdot d\vec{s}_1$

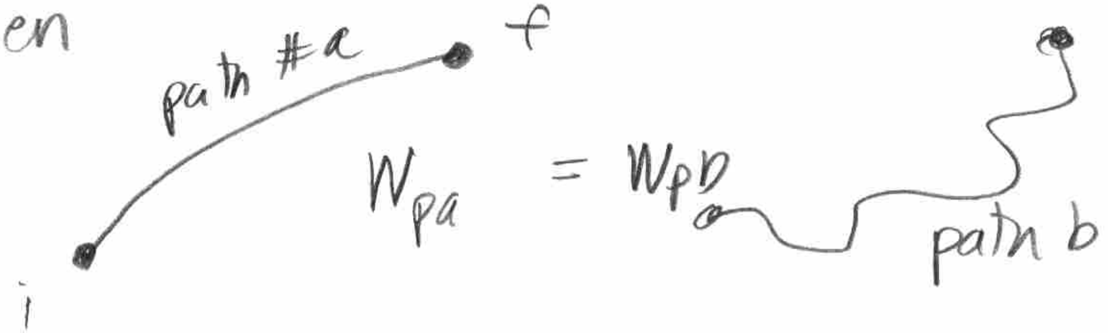
$> 0$

$$\delta W_2 = F_{2\parallel}\,\delta s_2 = \vec{F}_2 \cdot \vec{s}_2$$

$$W = \sum_{\text{path}} \delta W = \int_i^f \vec{F} \cdot d\vec{s}$$

Key qualitative point:

When




$W_{pa} = W_{pb}$

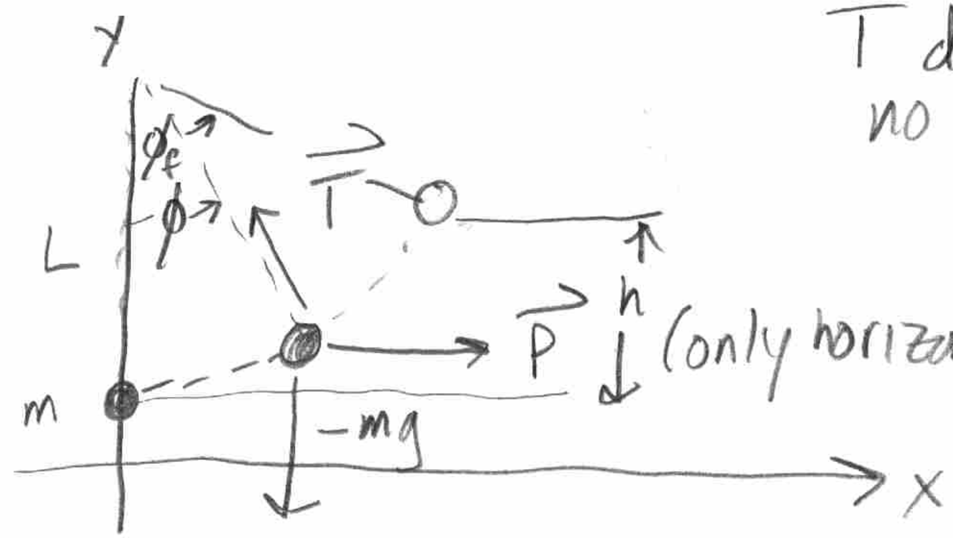
called a <u>conservative</u> force

⇒ Gravity
⇒ E&M (static)
⇒ Strong Force "
⇒ Weak Force.

Non-Conservative

⇒ Friction.
⇒ Air Resistance
⇒ When <u>work</u> goes into <u>heat</u>.

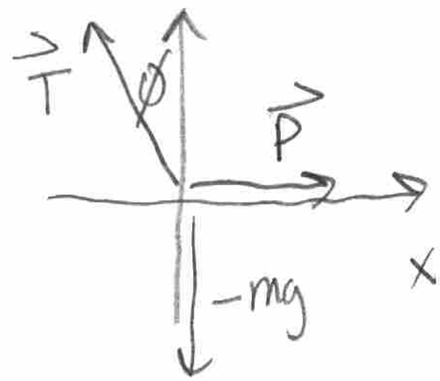
## Example




T does no work.

Instantaneously at rest.

Work done by P? mgh !!!




x: $P - T\sin\phi = 0$

y: $T\cos\phi - mg = 0$

eliminate T

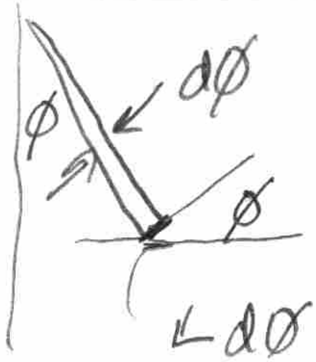
$$T = \frac{mg}{\cos\phi}$$

$$P - mg\tan\phi = 0$$

$$\boxed{P = mg\tan\phi}$$

$\phi = 0$
$= 0$

$$W_p = \int_0^{\phi_f} P\,dx \Leftarrow \text{LOOK OUT}$$



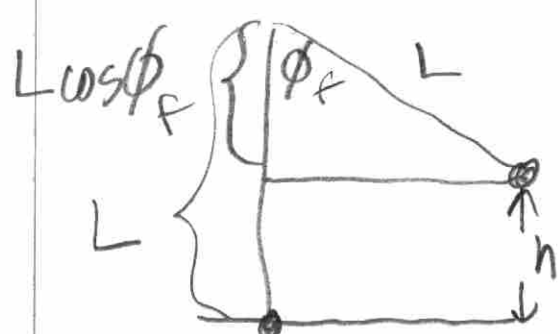

$$dx = \cos\phi \, L \, d\phi$$

$$W_p = mgL \int_0^{\phi_f} \tan\phi \cos\phi \, d\phi$$

$$= mgL \int_0^{\phi_f} \sin\phi \, d\phi$$

$$mgL \left( -\cos\phi \Big|_0^{\phi_f} \right)$$

$$= mgL(1 - \cos\phi_f)$$




$$\boxed{W_p = mgh}$$ !