Energy - Ability to do Work

↳ always Conserved

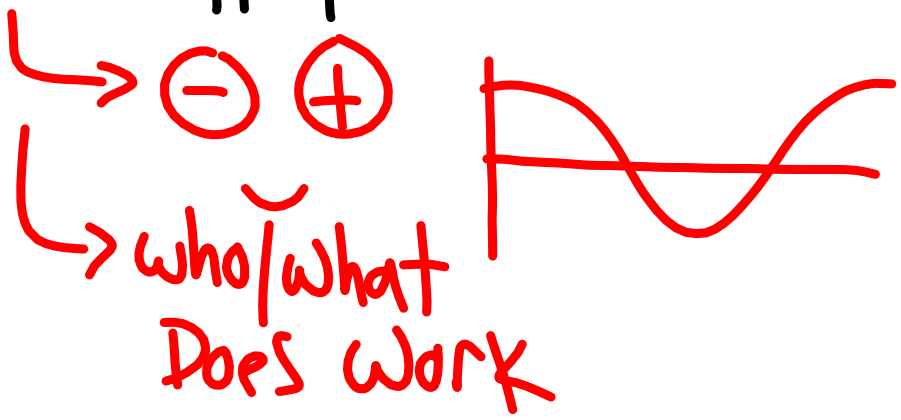
↳ $E_i = E_f$

$W = Fd$ ok

$W = \vec{F}\vec{s}$ Good

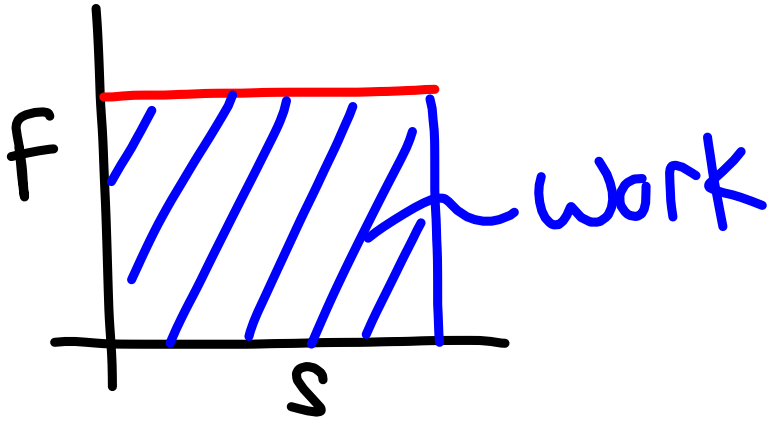
$W = \vec{F} \cdot \vec{s}$ Better

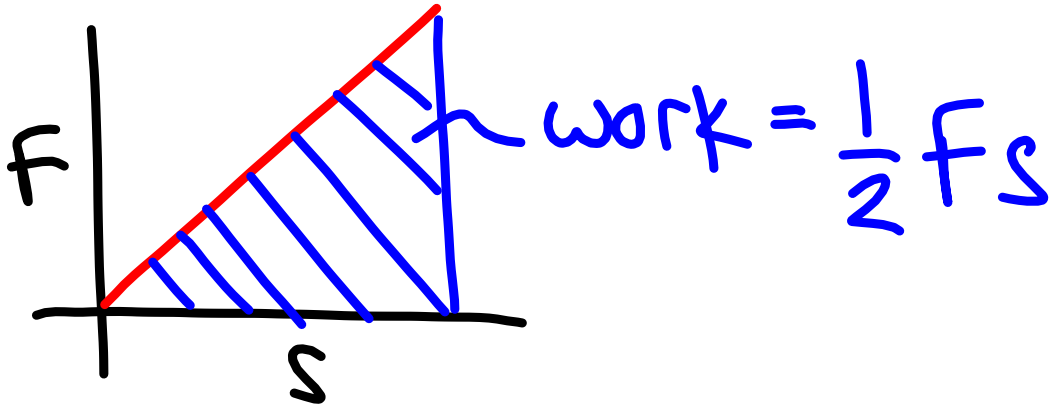
$W = |F||s|\cos\theta$ Betterer



$$W = \int F(s)\,ds$$ Best!

ex:





What if F(s) is from a Spring?

$F_s = kx$ or $F_s = ks$

From before: $W = \frac{1}{2}FS$

$W = \frac{1}{2}kss$

$W_s = \frac{1}{2}ks^2$

Work done by/on a Spring

this works backward

$$W = \Delta E$$

$$v_f^2 = v_i^2 + 2ad \qquad F = ma$$

$$v_f^2 - v_i^2 = 2ad \qquad F = m\left(\frac{v_f^2 - v_i^2}{2d}\right)$$

$$\frac{v_f^2 - v_i^2}{2d} = a \qquad Fd = m\left(\frac{v_f^2 - v_i^2}{2}\right)$$

$$Fd = \frac{mv_f^2}{2} - \frac{mv_i^2}{2}$$

Work

$$W = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$

$$W = \Delta E$$

Kinetic Energy

How much work to accelerate a prius from 0-60 mph?

$$W = \Delta E$$

$60\ \text{mph} = 26.8\ \frac{m}{s}$

$m_p = 1{,}317\ kg$

$W = E_f - E_i$ ($E_i \to 0$)

$W = \frac{1}{2} m v_f^2$

$W = \left(\frac{1}{2}\right)(1317)(26.8)^2$

$W = 4.73 \times 10^5\ J$

$$E_k = \frac{1}{2}mv^2 \qquad W = \vec{F} \cdot \vec{s}$$

$$kg\,\frac{m^2}{s^2} \qquad N \cdot m$$

$$kg \cdot \frac{m}{s^2} \cdot m = kg \cdot \frac{m^2}{s^2}$$

$$\hookrightarrow J \hookleftarrow$$

another look at K

$$W = \vec{F} \cdot \vec{s}$$

$$W = \int F(s)\, ds$$

$F = ma$

$$W = \int ma\, ds$$

$$W = \int m\frac{dv}{dt}\, ds$$

$$W = \int m \frac{ds}{dt}\, dv$$

$$W = m \int v\, dv$$

$$W = m \frac{v^2}{2}$$

$$W = \frac{1}{2} m v^2 \quad \left| \quad \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2 \right.$$

Gravitational Potential Energy

$$W = \int F(s)\,ds$$

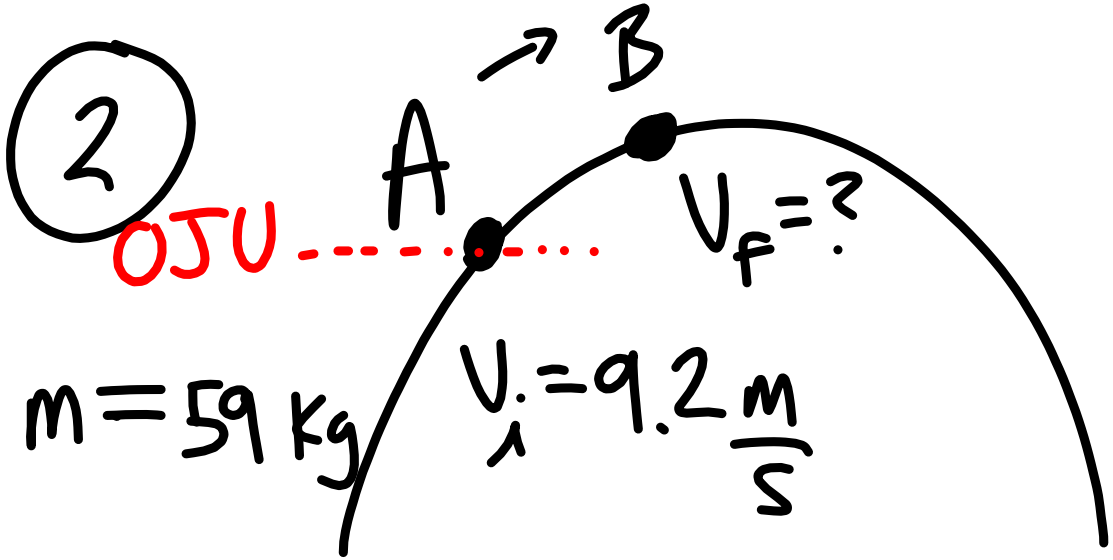
$F_g = mg$ $\quad W = \int mg\,ds$

$$W = mgs \Big| mgs_f - mgs_i$$

h_i can be anywhere!

$$W = mgh_f - mgh_i \rightarrow U$$

2



$E_i = E_f$

$K_i = K_f + U_f$

$$\frac{1}{2}mV_i^2 = \frac{1}{2}mV_f^2 + mgh$$

$$\frac{1}{2}V_i^2 = \frac{1}{2}V_f^2 + gh$$

$$\frac{1}{2}v_i^2 = \frac{1}{2}v_f^2 + gh$$

$$\frac{1}{2}v_i^2 - gh = \frac{1}{2}v_f^2$$

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

$$\sqrt{v_i^2 - 2gh} = v_f$$