CONCEPT: Escape Velocity

● Escape velocity is the *minimum* launch speed for an object to **escape** → object stops very far away & never returns.

- When an object goes *really* far away, F_G → _____
- When an object *stops*, $\mathbf{v_f} =$ ____
    - If $\mathbf{v_f} > 0$, then it wasn't the *minimum* launch speed.

Final *(farrrr)*
K_F = ______
U_F = ______

Initial
$K_i = \frac{1}{2}mv_i^2$
$U_i = -\frac{GMm}{r_i}$

● Escape Velocity comes from Conservation of Energy:

$v_{esc} =$ ______

- v_{esc} only depends on big mass **M** and initial distance **r.**

EXAMPLE: How fast must a 5kg rock be thrown to escape the Sun, if thrown directly outward near Earth's orbital distance?

EQUATIONS	CONSTANTS
$F_G = \frac{Gm_1m_2}{r^2}$ $\quad r = R + h$	$G = 6.67\times10^{-11}\ \frac{m^3}{kg\cdot s^2}$
$K_i + U_i + W_{NC} = K_f + U_f$	$r_{Sun\text{-}Earth} = 1.5\times10^{11}$ m
$v_{esc} = \sqrt{\frac{2GM}{r}}$	$M_{Sun} = 2\times10^{30}$ kg $R_{Sun} = 6.96\times10^{8}$ m

PRACTICE: a) How fast does a spaceship have to go to escape Earth, starting from the launch pad on the surface? Assume it burns all its fuel very fast and then shuts off the engines. b) One idea to make getting to space easier is to build a space elevator, a large platform high above Earth's surface where spaceships can land and take off. How high above Earth would this platform have to be for the escape velocity to be 1/5 of its surface value?

EQUATIONS	CONSTANTS
$F_G = \frac{Gm_1m_2}{r^2}$ $r = R + h$	$G = 6.67 \times 10^{-11} \frac{m^3}{kg \cdot s^2}$
$K_i + U_i = K_f + U_f$	$M_E = 5.97 \times 10^{24}$ kg
$v_{esc} = \sqrt{\frac{2GM}{r}}$	$R_E = 6.37 \times 10^6$ m

<u>EXAMPLE</u>**:** You land on the surface of a large, spherical asteroid**.** You set off walking in one direction and you realize you've arrived back to your spaceship after walking 25km**.** You grab a tool from your toolbox and drop it, noting it takes about 30 seconds to hit the ground from 1.4 m high**.** How fast would you have to jump to escape this asteroid?

EQUATIONS	CONSTANTS
$F_G = \frac{Gm_1m_2}{r^2}$ $\quad r = R + h$	$G = 6.67\times10^{-11}\ \frac{m^3}{kg\cdot s^2}$
$g_{surf} = \frac{GM}{R^2}$ $\quad g = \frac{GM}{r^2}$	$M_E = 5.97\times10^{24}$ kg
$K_i + U_i = K_f + U_f$	$R_E = 6.37\times10^{6}$ m
$v_{esc} = \sqrt{\frac{2GM}{r}}$	