Manipulating Equations

$$\begin{aligned} 2 \times 3 &= 6 \\ \frac{2 \times 3}{3} &= \frac{6}{3} \qquad \text{cancel the threes on the left} \\ 2 &= 2 \end{aligned}$$

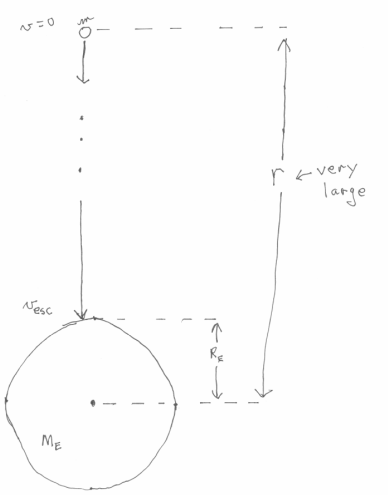
Quantity a times quantity b, or $a \times b$, is often written just as ab.

$$\begin{aligned} ab &= c \\ \frac{ab}{b} &= \frac{c}{b} \qquad \text{cancel each } b \text{ on the left} \\ a &= \frac{c}{b} \end{aligned}$$

$$\begin{aligned} \frac{a}{b} &= c \\ \frac{a}{b}b &= cb \\ a &= cb \end{aligned}$$

$K = \frac{1}{2}mv^2$	kinetic energy	$c = 2.998 \times 10^8 \,\mathrm{m}\,/\,\mathrm{s}$	speed of light
$U = -\frac{GMm}{r}$	potential energy	$G = 6.67 \times 10^{-11}$	gravitational constant
$E = k + U$	energy	$M_E = 5.974 \times 10^{24}\,\mathrm{kg}$	Earth's mass
		$R_E = 6371\,\mathrm{km}$	Earth's radius

Problem 1 Use energy to find the escape speed of the Earth. Use $R = R_E$ = radius of Earth and $M = M_E$ = mass of Earth.



a) When the object is at rest very far from the Earth, what is its kinetic energy K?

b) When the object is at rest very far from the Earth, what is its potential energy U? Think about this.

c) Find an expression for the object's energy, E_2 = kinetic energy + potential energy, when it is at rest very far from the Earth.

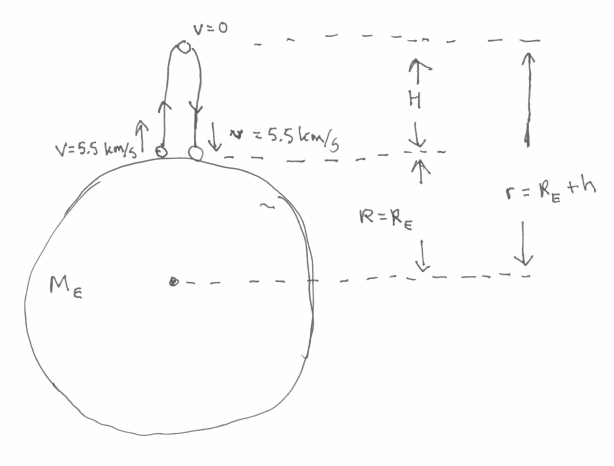
d) Find an expression for the object's kinetic energy when it gets to the Earth. Express you answer in terms of m and v_{esc}.

e) Find an expression for the object's potential energy when it gets to the Earth. Express your answer in terms of M_E, m, G, and R_E.

f) Find an expression for the object's energy, E_1 = kinetic energy + potential energy. when it reaches the Earth's surface.

g) The object's energy doesn't changes as it falls, so set $E_1 = E_2$, and find the escape speed v_{esc}.

Problem 2. Use energy to find the maximum height h when



a) Find an expression for the energy, E_1 = kinetic energy + potential energy, at launch.

b) Find an expression for the energy, E_2 = kinetic energy + potential energy, at maximum r.

c) These two energies are equal, i.e.,set $E_1 = E_2$, and cancel m from each of the terms.

d) Solve for the height h by Using $r = R_E + h$.

e) Find the height h.