PHY131H1F Centre-screen notes
Wednesday Sep. 19, 2012

Equations of Constant Acceleration.

Definition of average acceleration:

$$a_{avg} = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{\Delta t}$$

If acceleration is constant, then $a = a_{avg}$.

Solve for v_f:

$$v_f - v_i = a\,\Delta t$$

$$\boxed{v_f = v_i + a\,\Delta t} \qquad \text{Eq. 1}$$

If $s = s_i$ at $t = 0$ (s = position)

and $s = s_f$ at $t = \Delta t$

$$v = \frac{ds}{dt}$$

From eq. 1:

$$v = v_i + a\,t$$

$$\int v\,dt = \int ds$$

$$\int (v_i + at)\,dt = \int ds$$

$$\left[v_i t + \frac{1}{2}a t^2\right]_0^{\Delta t} = \left[s\right]_i^f$$

$$v_i\,\Delta t + \frac{1}{2}a(\Delta t)^2 = s_f - s_i$$

$$\boxed{s_f = s_i + v_i\,\Delta t + \frac{1}{2}a(\Delta t)^2} \qquad \text{Eq. 2.}$$

If we wish to eliminate Δt from Eq. 2, we can solve for Δt in Eq. 1:

$$\Delta t = \frac{v_f - v_i}{a} \leftarrow \text{plug into Eq. 2}$$

$$S_f = S_i + V_i\left(\frac{V_f - V_i}{a}\right) + \frac{a}{2}\left(\frac{V_f - V_i}{a}\right)^2$$

$$S_f - S_i = \cancel{\frac{V_i V_f}{a}} - \frac{V_i^2}{a} + \frac{V_f^2}{2a} - \cancel{\frac{V_f V_i}{a}} + \frac{V_i^2}{2a}$$

$$a(S_f - S_i) = -V_i^2 + \frac{V_f^2}{2} + \frac{V_i^2}{2}$$

$$= \frac{V_f^2}{2} - \frac{V_i^2}{2}$$, solve for V_f^2:

$$\boxed{V_f^2 = V_i^2 + 2a(S_f - S_i)}$$ Eq. 3

Lastly, from the definition of average velocity, $V_{avg} = \frac{S_f - S_i}{\Delta t}$

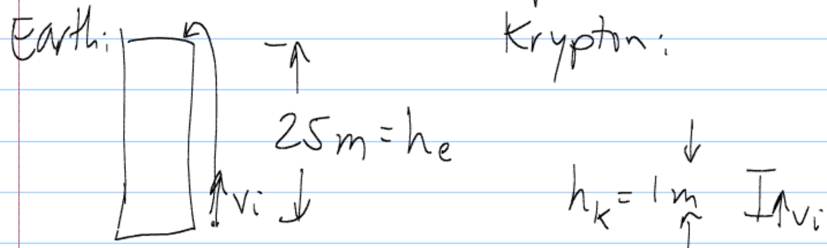
When a is constant, $V_{avg} = \frac{V_f + V_i}{2}$

$$\frac{V_f + V_i}{2} = \frac{S_f - S_i}{\Delta t}$$

$$\boxed{S_f = S_i + \left(\frac{V_f + V_i}{2}\right)\Delta t}$$ Eq. 4

Superman:

MODEL superman as particle



V_i is same on both planets (same legs)

$V_f = 0$ at top of path.

$a_e = -9.8\, m/s^2$

Need to find a_k

Don't care about Δt, so use eq. 3:

Earth:
$$v_f^2 = v_i^2 + 2a(\Delta s)$$

$$v_f^2 = v_i^2 + 2a_e h_e$$
$$0 = v_i^2 + 2a_e h_e$$
$$v_i^2 = -2a_e h_e$$

Krypton, similarly:
$$v_i^2 = -2a_k h_k$$

Eliminate v_i^2, since we don't know it:
$$v_i^2 = v_i^2$$
$$-2a_e h_e = -2a_k h_k$$
$$a_k = a_e h_e / h_k$$
$$= -9.8\, m/s^2\, (25\, m)/1m$$
$$\boxed{a_k = -250\, m/s^2}$$