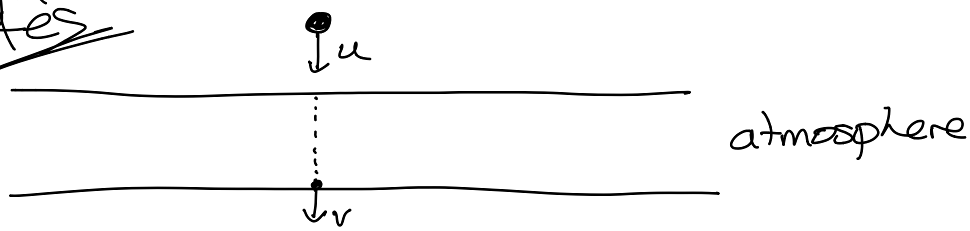
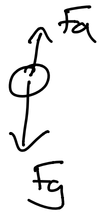
Rough Notes



FBD



$$F_{net} = \underbrace{F_g}_{\uparrow \; mg} - \underbrace{F_a}_{kv^2} = ma.$$

Simplist case → assume g is constant
→ assume ρ, T etc atm - constant

Drag equation : $F_a = C_d \rho v^2 \frac{A}{2}$

$$F_a = -kv^2$$

$+\downarrow$

$$\therefore mg - kv^2 = ma \qquad a = \frac{\Delta v}{\Delta t}$$

$$mg - kv^2 = m\frac{dv}{dt}$$

$$\frac{dv}{dt} = g - \frac{k}{m}v^2$$

differential equation: $\frac{dv}{dt} = g - \frac{C_d \rho A}{2m} v^2$

1. Differentiation
2. ~~Numerical integration:~~

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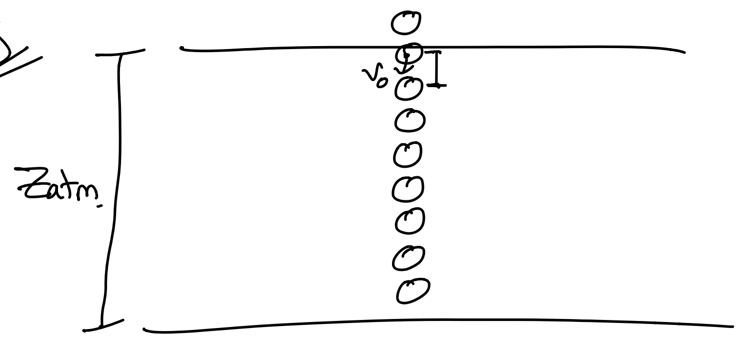


$$\Delta V = \left[g - \left(\frac{C_d \rho A}{2m} \right) v^2 \right] \Delta t.$$

$$\Delta z = V \Delta t$$

at $t=0$ $z=0$ $u=V$

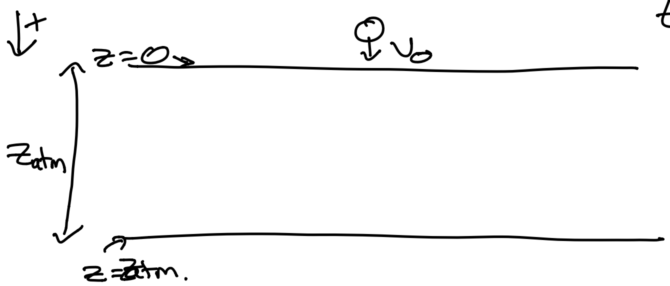
at $t_1 = \Delta t$ $z_1 = z_0 + V_0 \Delta t$

$$V_1 = V_0 + \left[g - \frac{C_d \rho A}{2m} V_0^2 \right] \Delta t$$

loop until $z = z_{atmosphere}$.

Meteorite slowing through the atmosphere.

Start → asteroid velocity perpendicular to earth's surface
→ constant density atmosphere of a given thickness
→ assume acceleration due to gravity is constant
→ assume asteroid size and mass is constant
→ assume drag coefficient is constant



$t=0$
impact velocity $= v_0$

time step, Δt

calculate position and speed at each new time.

Forces: grav: $F_g = mg$ ↓ ∴ +ve.

air resistance: $F_a = \frac{C_d \rho A}{2} v^2$ ↑ ∴ −ve.

$F_{net} = mg - \frac{C_d \rho A}{2} v^2$

N's 2^{nd}: $ma = mg - \frac{C_d \rho A}{2} v^2$

$a = \frac{\Delta v}{\Delta t}$ $\quad \cancel{m}\frac{\Delta v}{\Delta t} = \cancel{m}g - \frac{C_d \rho A}{2m} v^2$

$$\Delta v = \left(g - \frac{C_d \rho A}{2m} v^2\right)\Delta t$$

Position → assume close enough constant acceleration within Δt

const. al. eq: $s = ut + \frac{1}{2}at^2$

$$\Delta z = v\Delta t + \frac{1}{2}\left(g - \frac{C_d \rho A}{2m} v^2\right)\Delta t^2$$

Base simulation:

Initial cond: $v = V$
$z = 0$
$t = 0$

end when $z > z_{atm}$.

$$z_1 = z_0 + \Delta z$$

$$z_1 = z_0 + v_0 \Delta t + \frac{1}{2}\left(g - \frac{C_d \rho A}{2m} v_0^2\right)\Delta t.$$

$$V_1 = V_0 + \Delta V$$

$$V_1 = V_0 + \left(g - \frac{C_d \rho A}{2m} v_0^2\right)\Delta t$$

output ⇒ final v.

Possible variations:
- initial speed
- z_{atm}
- → ρ (or $\rho(z)$)
- → g (or $g(z)$)
- → C_d
- → m
- → A

$\left.\begin{matrix} m \\ A \end{matrix}\right]$ → think about ablation → how asteroid "burns up" through atmosphere,

Concerns → error analysis needed *

Alec research: Find initial values to use:
asteroid: V_0, m, A
atmosphere: z_{atm}, ρ ← constant density model.
$g = 9.81\ ms^{-2}$
drag coefficient ??

Things to explore:
- atmosphere models - const. den, isothermal, adiabatic, real .....
- g as a function of position ← is it worth it?
- asteroid impacts → initial vel & asteroid properties.