## HOW to Nondimennionalize an Education

## Projectes

· scale the independent variables using characteristic value

$$-\ddot{x} = -\frac{g R^2}{(R+x)^2} \qquad R = radius of Earth \qquad \qquad L_3 + X_c = characteristic height } can tants$$

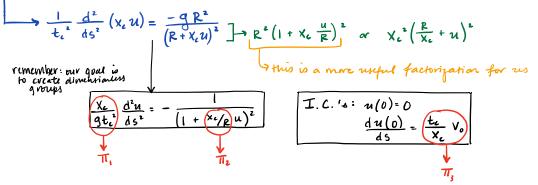
$$= \frac{1}{(R+x)^2} \qquad X = height + \frac{1}{2} ball/projective \qquad \qquad t_c = characteristic time }$$

u represents dimensionless height, & dimensionless time

Pecall the Chain Pule: 
$$\frac{d}{dt} = \frac{ds}{dt} = \frac{1}{ds} = \frac{1}{t_c} = \frac{d}{ds}$$

$$\frac{d^2}{dt^2} = \frac{d}{dt} \left(\frac{d}{dt}\right) = \frac{1}{t_c^2} \frac{d^2}{ds^2}$$

because s is new time variable  $3 = \frac{t}{t_c}$  :  $\frac{ds}{dt} = \frac{1}{t_c}$ 



Dimensionless groups:

1) do not involve variables only the parameters Xc, tc, q, R, V.

- @dimensionles: accomplished by rearranging our equations
- 3 they are independent: not possible to Ti in terms of Ti, Tx

Characteristic Values

Pull 1: Set  $\pi_i$  in I.C./B.C. equal to  $1 \longrightarrow \pi_3 = \frac{t_c}{X_c} V_o = 1$  ..  $X_c = V_o t_c \longrightarrow t_c = \frac{V_o}{q}$ Bull 2: Set  $\pi_i$  that appear in the reduced problem earl to 1

- the reduced problem is the equation that results when throw out very small or very large dimensialess group

or very large dimensialists group
$$\frac{d^2 u}{ds^2} = -\frac{1}{(1+\pi_c u)^2} = -1 \rightarrow \pi_i = \frac{x_c}{g + c^2} = 1 \quad \therefore \quad x_c = \frac{V_o^2}{g}$$
reduced problem

note that throwing but Tz means throwing but the nonlinear terms, making it easier to solve

by identifying what is exential to our problem, we can determine the characteristic length & time scale

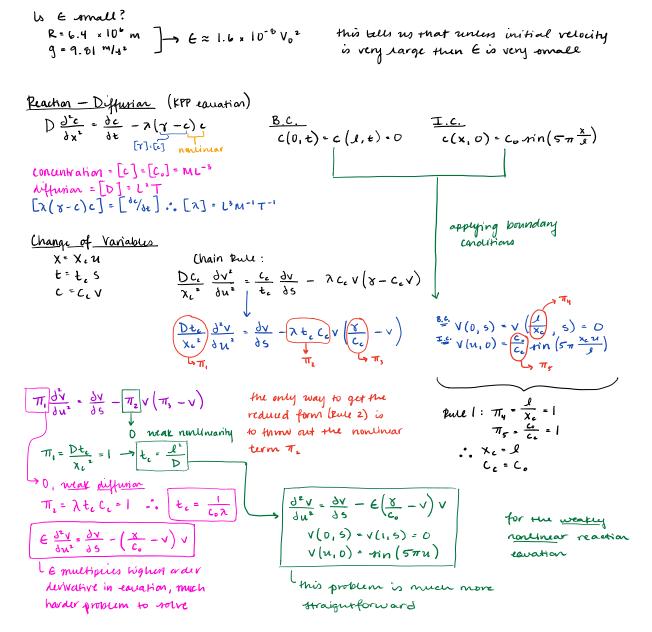
TI, is a small we'll refer as E parameter to small par

Dimensionless Education

$$\frac{d^2u}{ds^2} = -\frac{1}{\left(1 + \left(\sqrt[4]{\eta}\right)u\right)^2} \qquad u(0) = 0$$

$$\frac{du}{ds} = 1$$

$$\frac{du}{ds} = \frac{1}{(1 + \varepsilon u)^2}$$



we looked at 2 cases here: weak diffusion i weak nonlinear