Electric propulsion

Chemical rockets

Thrust $\longrightarrow$ Exhaust velocity $\longrightarrow$ Temperature in combustion

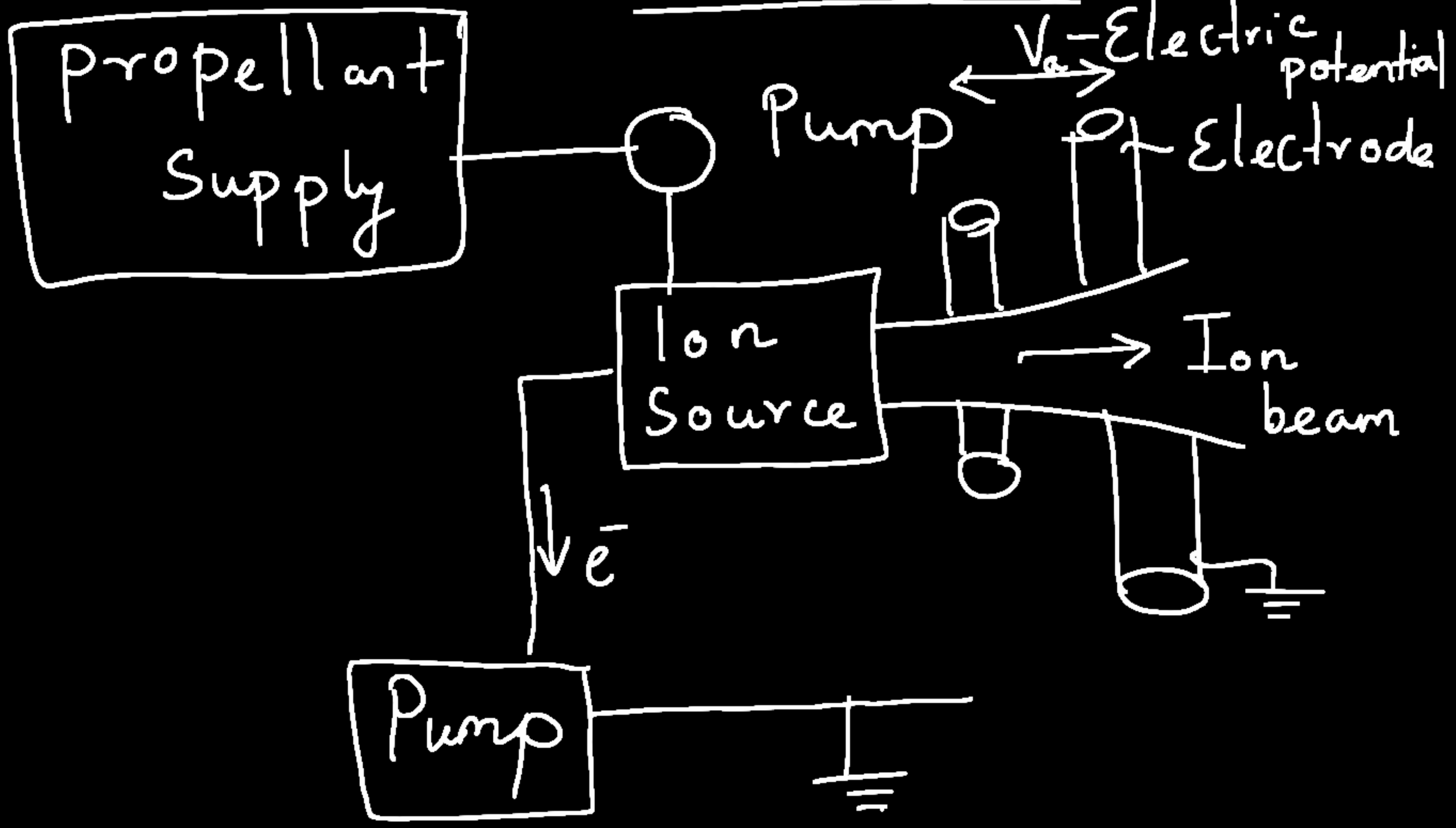
I_{sp}

$\sim 500\ s \longleftarrow \sim 3500\ k$ (material limit)

$$\Delta u = u_{eq} \ln R = g_e I_{sp} \ln R$$

Velocity increment $\Delta u \propto I_{sp}$

Ion Thruster



Electric propulsion $I_{sp} \sim 2500\,s$

Disadv: $T = \dot{m} u_e \Rightarrow$ very small

1) Deep space / instellar mission (long mission ~ years) $\sim mN \sim N$ [best] $\sim MN$ [chemical rockets]

2) Attitude / orbit maneuver Control of spacecrafts / satellites

Performance calculation

1) Thrust, 2) I_{sp}, 3) Electric power required

Kinetic energy $\frac{1}{2} m u_e^2 = q V_a$

m – mass of a single ion

q – charge

V_a – Electric potential

q/m – charge to mass ratio

$$u_e = \sqrt{2 \left(\frac{q}{m}\right) V_a}$$

$$I_{sp} = \frac{u_e}{g_e} = g_e \sqrt{2 \left(\frac{q}{m}\right) V_a}$$

$$T = \dot{m} u_e \,, \quad \text{Beam current } I = \dot{m}\left(q/m\right)$$

$$T = \frac{I}{(q/m)}\sqrt{2(q/m)V_a}$$

$$\boxed{T = I\sqrt{\frac{2V_a}{(q/m)}}}$$

Electrical power, $P_b = IV_a$
in the beam

$$\frac{P_b}{T} = \frac{g_e I_{sp}}{2}$$

Power required for the propulsion System $= P_b + P_{ionization} + P_{loss}$