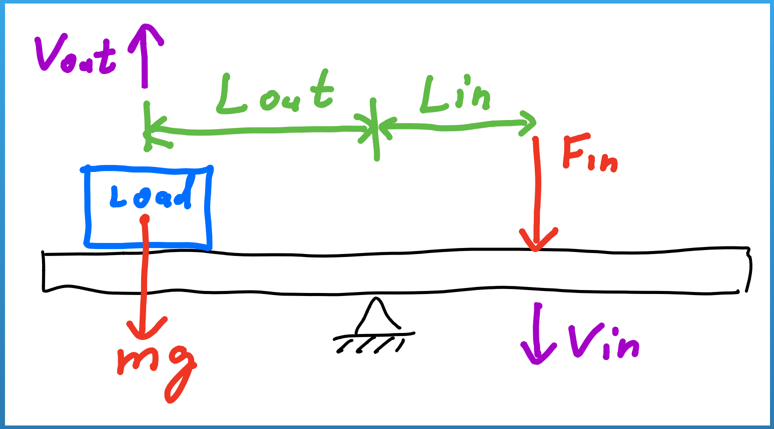
Consider Simple Seesaw. If Lin is increased:



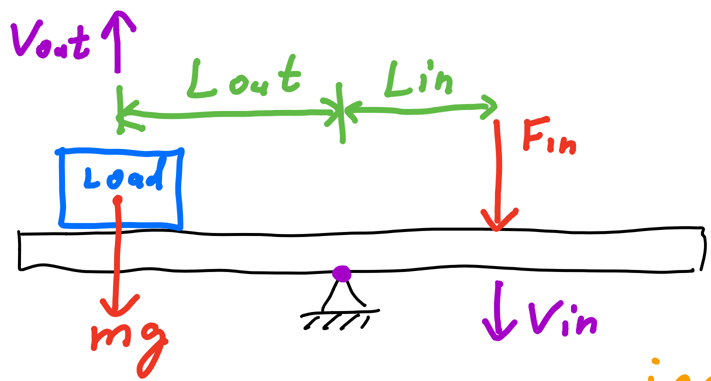
A. Max Load is increased and Vout is increased.

B. Max Load is increased and Vout is decreased.

C. Max Load is decreased and Vout is increased.

D. Max Load is decreased and Vout is decreased.

Force Balance



input torque

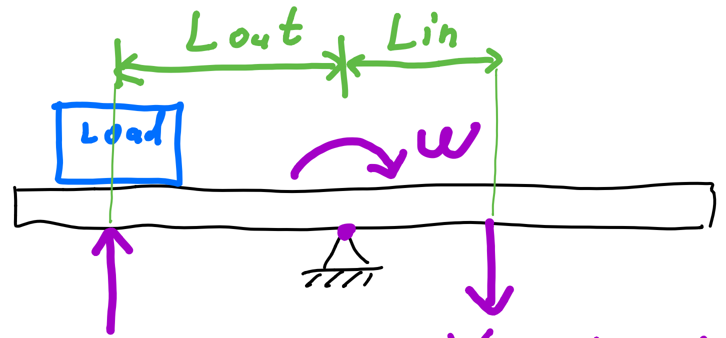
Moment Balance: $F_{in} \cdot L_{in} = mg \cdot L_{out}$

Mechanical Advantage: $\frac{\text{Force Out}}{\text{Force In}}$

Mechanical Advantage: $\frac{mg}{F_{in}} = \frac{L_{in}}{L_{out}}$

Increases as Lin Increases

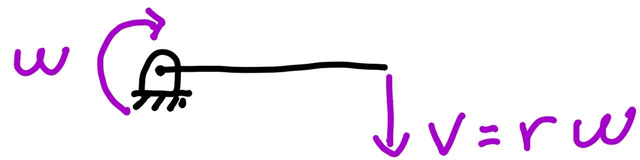
Velocity Relationships



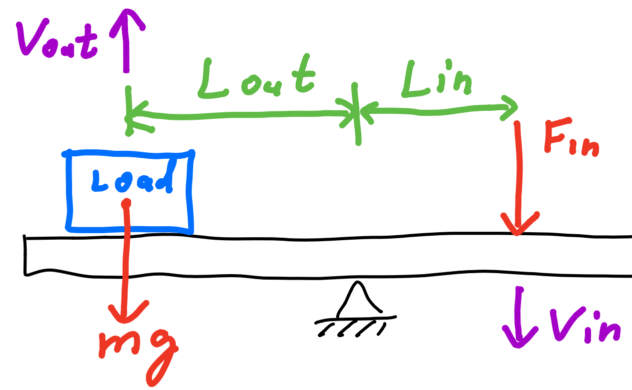
$V_{out} = L_{out}\,\omega$ $V_{in} = L_{in}\,\omega$

ω ⇒ rotation in radians/second

Tangential velocity due to rotation about a pivot



$$\frac{V_{out}}{V_{in}} = \frac{L_{out}}{L_{in}}$$ } Decreases as Lin Increases



input torque ($F_{in} \cdot L_{in}$)

Moment Balance: $F_{in} \cdot L_{in} = mg \cdot L_{out}$

Angular Velocity of seesaw = $\omega \left(\frac{\text{radians}}{\text{second}}\right)$

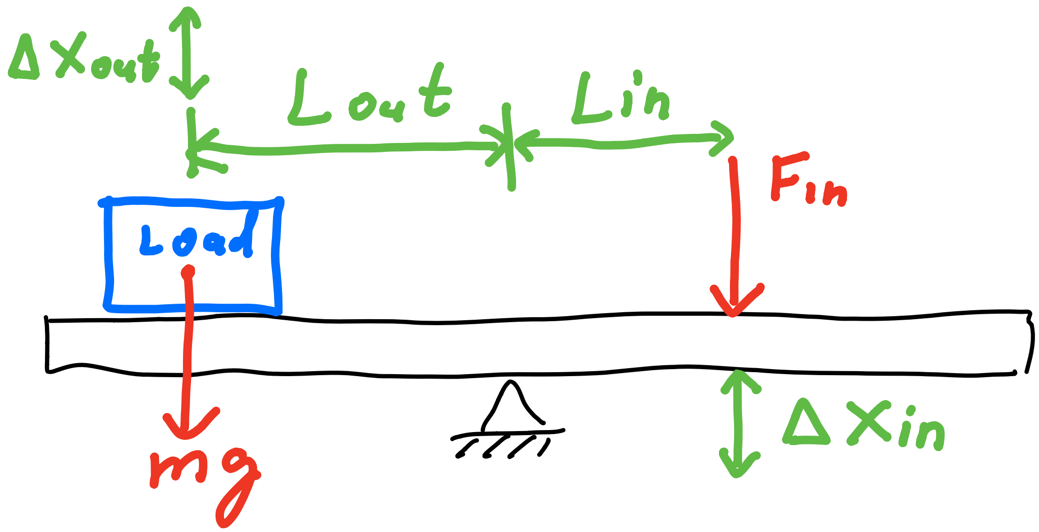
$V_{in} = \omega L_{in}$ $\quad V_{out} = \omega L_{out}$

$$\frac{V_{out}}{V_{in}} = \frac{L_{out}}{L_{in}}$$

∴ Increasing L_{in}, increases max load, but decreases V_{out}.

A lever can increase either output load or velocity but not both

The Tradeoff Between Force and Speed Can Be Interpreted in Terms of Energy Conservation: Consider a Short Duration ΔT



Work in =

Energy out =

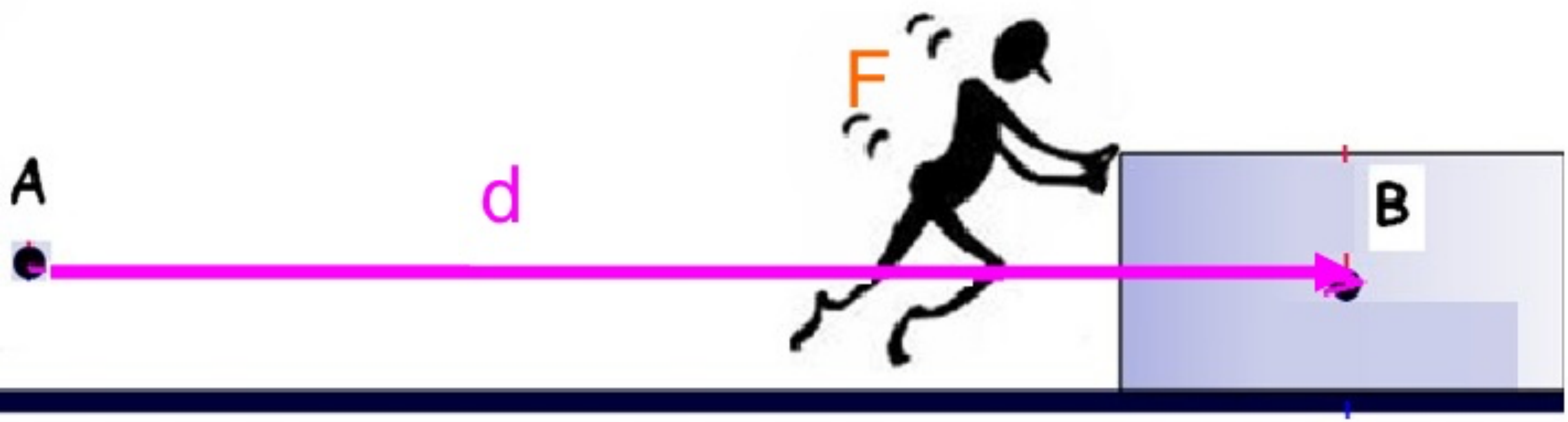
5.1.1 Energy. Units

In physics we define mechanical work as the amount of energy transferred by a force acting through a distance

$$W = F \cdot d$$

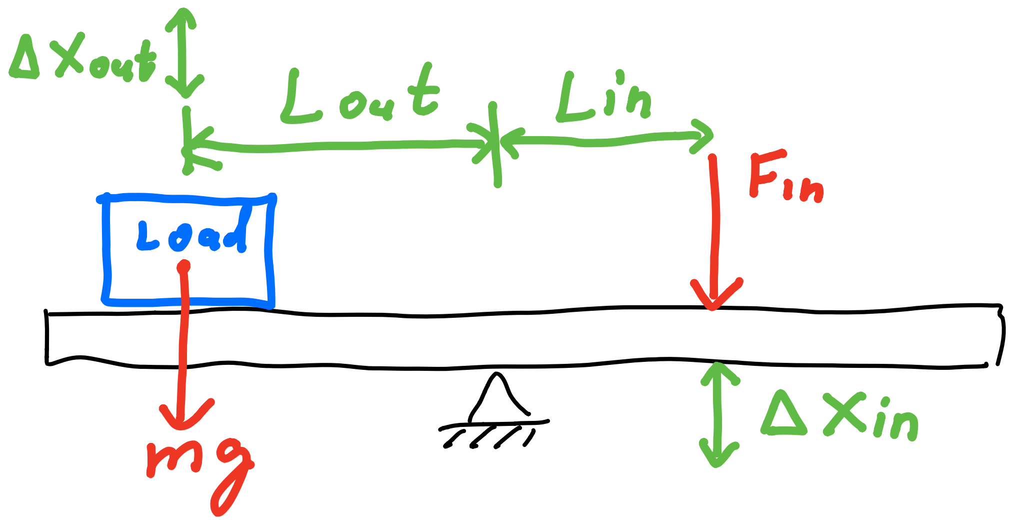
d= distance between A and B

F= Force applied to move the object



Dot product of Force and Distance indicates aligned vector directions.
Figure by hebertecnologia

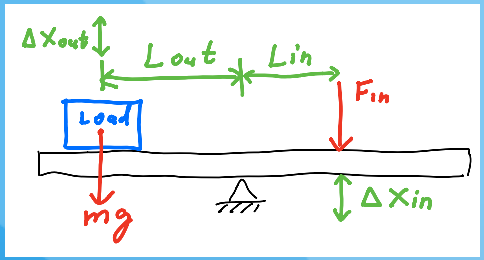
For a Short Duration ΔT



Work in = $F_{in} \cdot \Delta X_{in}$

Energy out = $\Delta PE + \Delta KE$ + Frictional Losses

Energy Balance Approach



When appropriate the following assumptions can be made:

- Acceleration is low: $\Delta KE \approx 0$
- Friction can be neglected: Frictional Losses ≈ 0

The geometric constraint for small rotation $\Delta\theta$ of seesaw

- $\Delta x_{in} = \Delta\theta\, L_{in}$ and $\Delta x_{out} = \Delta\theta\, L_{out}$ and ➔ $\Delta x_{in}/L_{in} = \Delta x_{out}/L_{out}$

Energy Balance: Work in = Energy Out

- $F_{in}\, \Delta x_{in} = mgh = mg\, \Delta x_{out}$

Mechanical Advantage: $mg/F_{in} = \Delta x_{in}/\Delta x_{out} = L_{out}/ L_{in}$

Velocity : $v_{out}/v_{in} = (\Delta x_{in}/\Delta t)/(\Delta x_{out}/\Delta t) = L_{in}/ L_{out}$