Kinematics of Mechanisms

- Mechanical Advantage

Mechanical Advantage

- The Mechanism is a Conservative System
- Inertial Effects are Ignored for the System
  - $P_{in}=T_{in}*\omega_{in}=T_{out}*\ \omega_{out}=P_{out}$
  - $P_{in}=F_{in}*V_{in}=F_{out}*\ V_{out}=P_{out}$

Mechanical Advantage

- Force, Velocity, and Torque are typically constant for a linkage
- Definition: Ration of force-out over force-in

$$M.A. = \frac{F_{out}}{F_{in}} = \frac{\frac{T_{out}}{d_{out}}}{\frac{T_{in}}{d_{in}}} = \frac{d_{in}}{d_{out}} \cdot \frac{T_{out}}{T_{in}}$$

$$\Rightarrow P_{in} = T_{in} \cdot \omega_{in} = T_{out} \cdot \omega_{out} = P_{out} \Rightarrow \frac{T_{out}}{T_{in}} = \frac{\omega_{in}}{\omega_{out}}$$

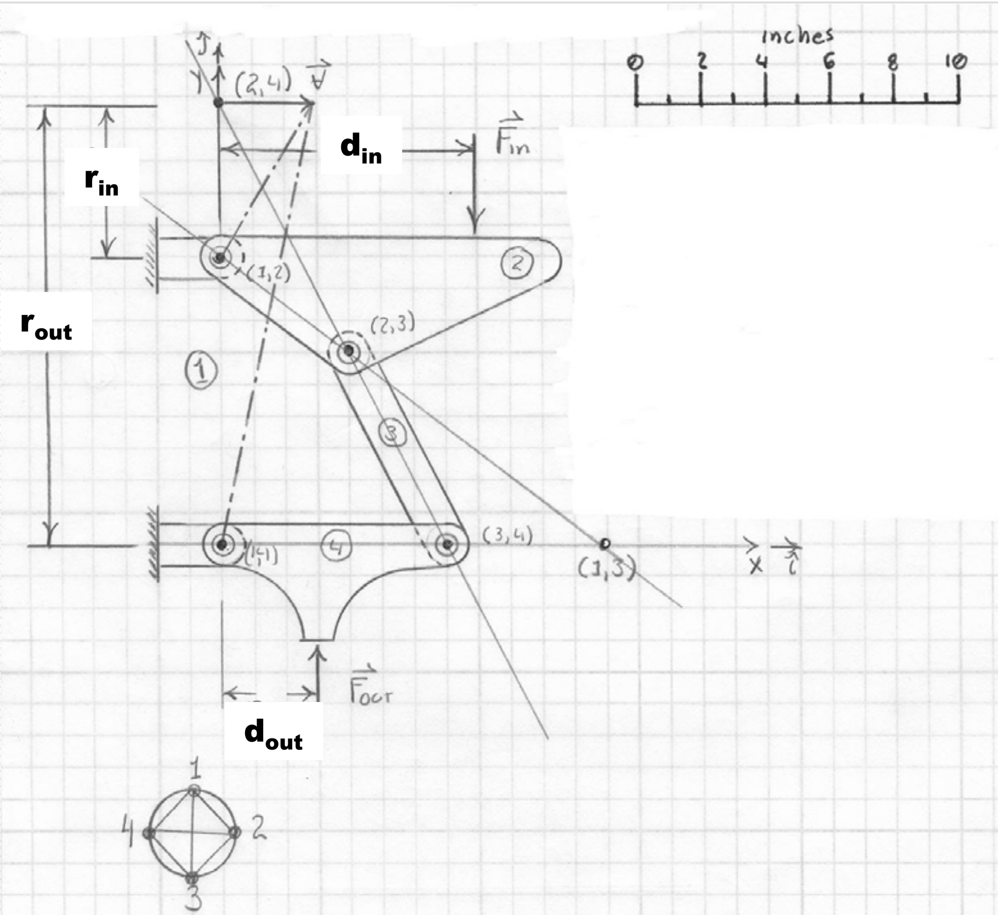
$$\Rightarrow M.A. = \frac{d_{in}}{d_{out}} \cdot \frac{\omega_{in}}{\omega_{out}}$$

Mechanical Advantage

- M.A. is a product of two factors
  - Ratio of distances that depend n the placement of the input and output forces
  - An angular velocity ratio
    - Can be expressed entirely in terms of direct distances
    - Based on the instant center development
- M.A. can be expressed entirely in terms of ratios of distances

$$M.A. = \frac{d_{in}}{d_{out}} \cdot \frac{\omega_{in}}{\omega_{out}}$$

M.A. for a Mechanism

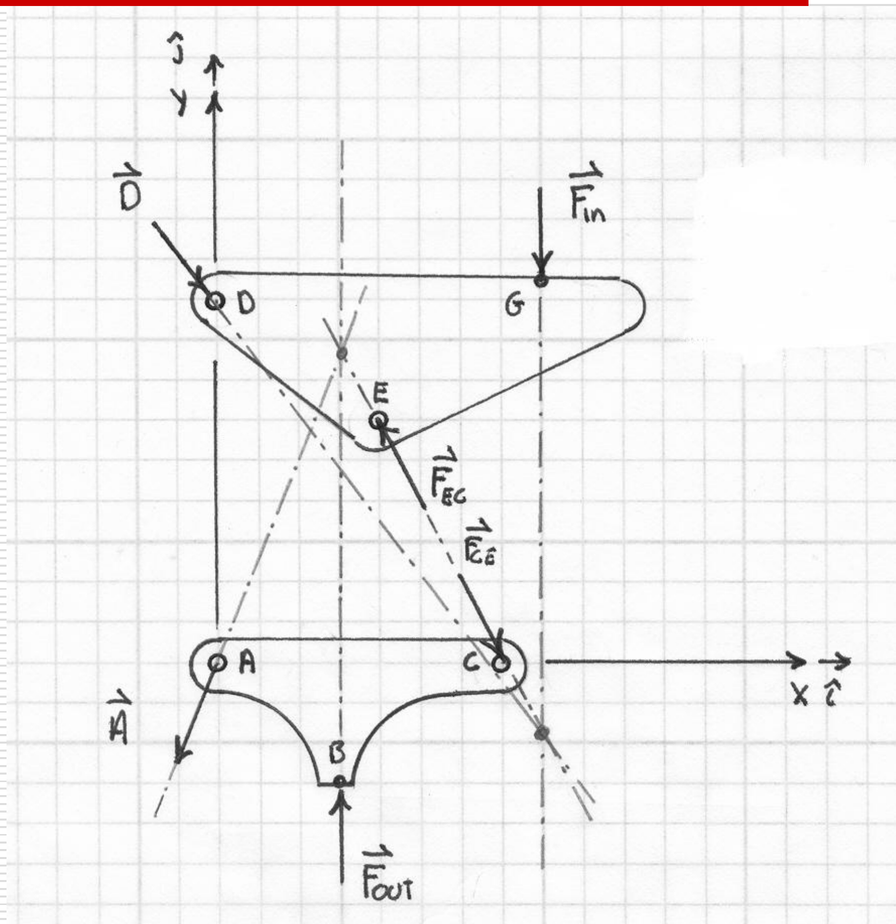


$$M.A. = \frac{d_{in}}{d_{out}} \cdot \frac{\omega_{in}}{\omega_{out}}$$

$$= \frac{d_{in}}{d_{out}} \cdot \frac{V/r_{in}}{V/r_{out}}$$

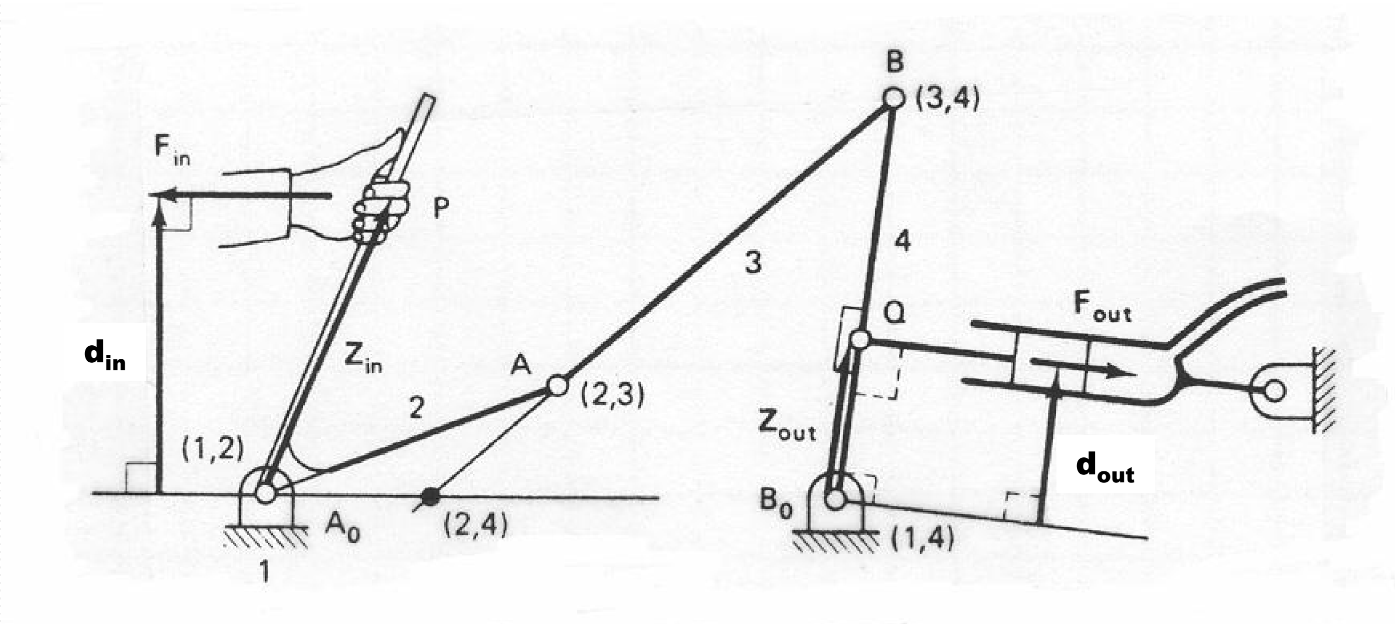
$$= \frac{d_{in}}{d_{out}} \cdot \frac{r_{out}}{r_{in}}$$

Kinetics Approach to M.A.

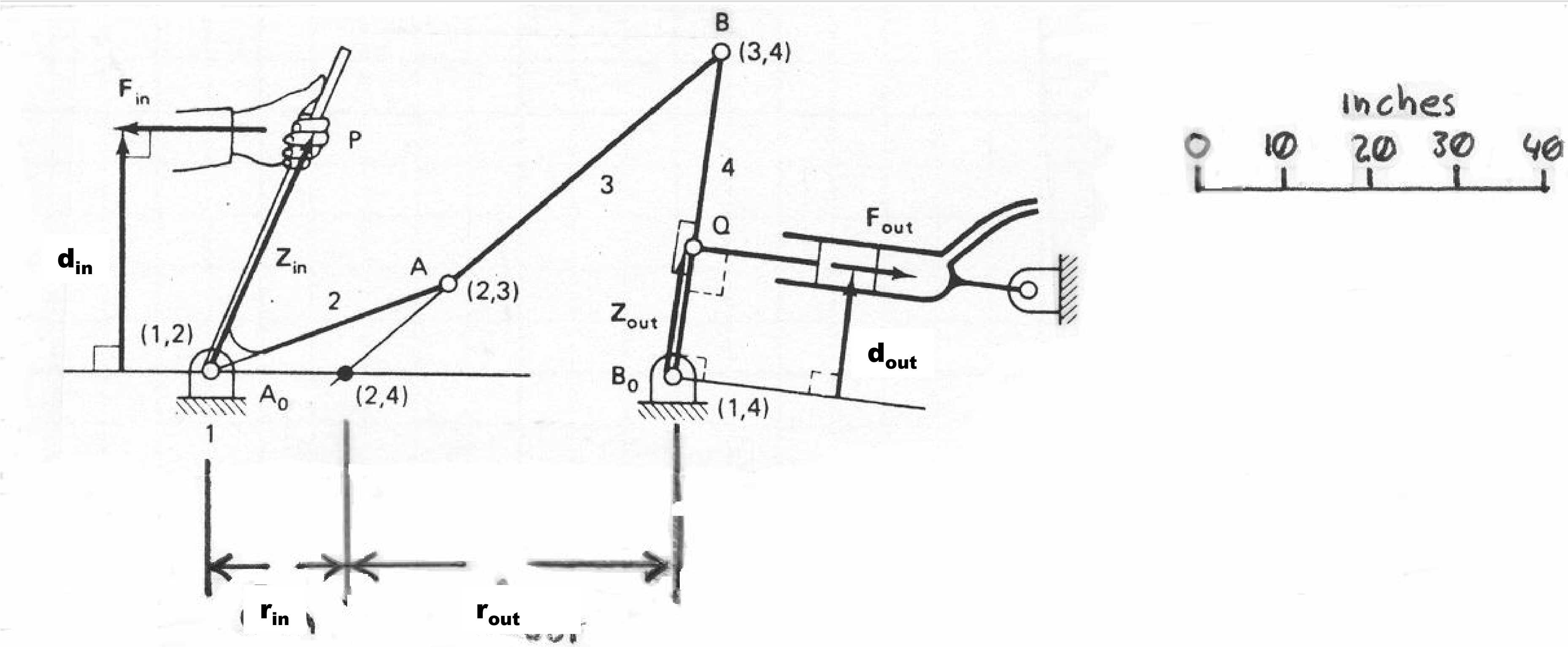


Drive Mechanism Example

- Handle is being pulled to left with force F_{in}
- Pressure difference across the piston in the cylinder is resisting the movement by a force equal and opposite to F_{out}

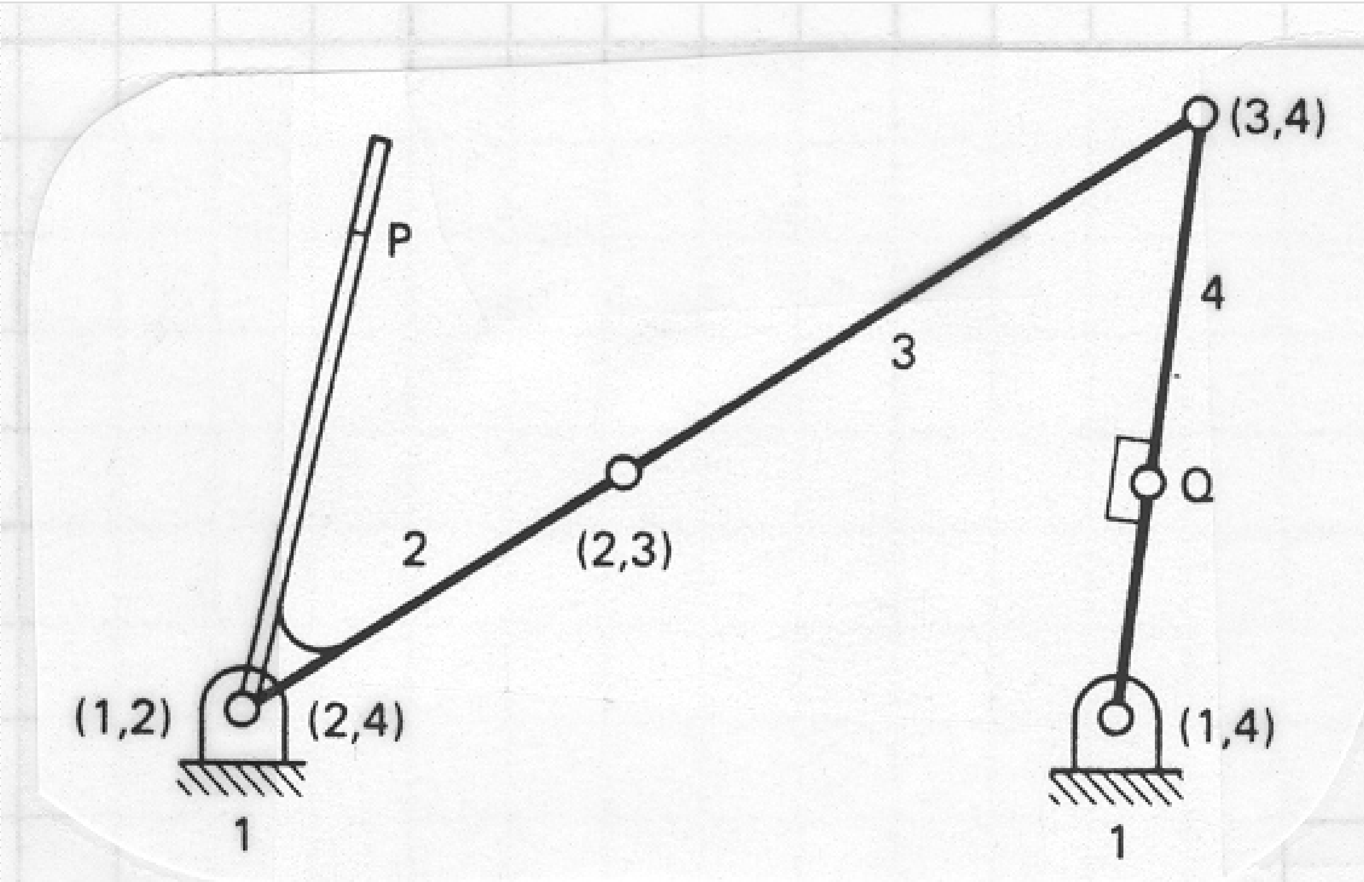


Solution

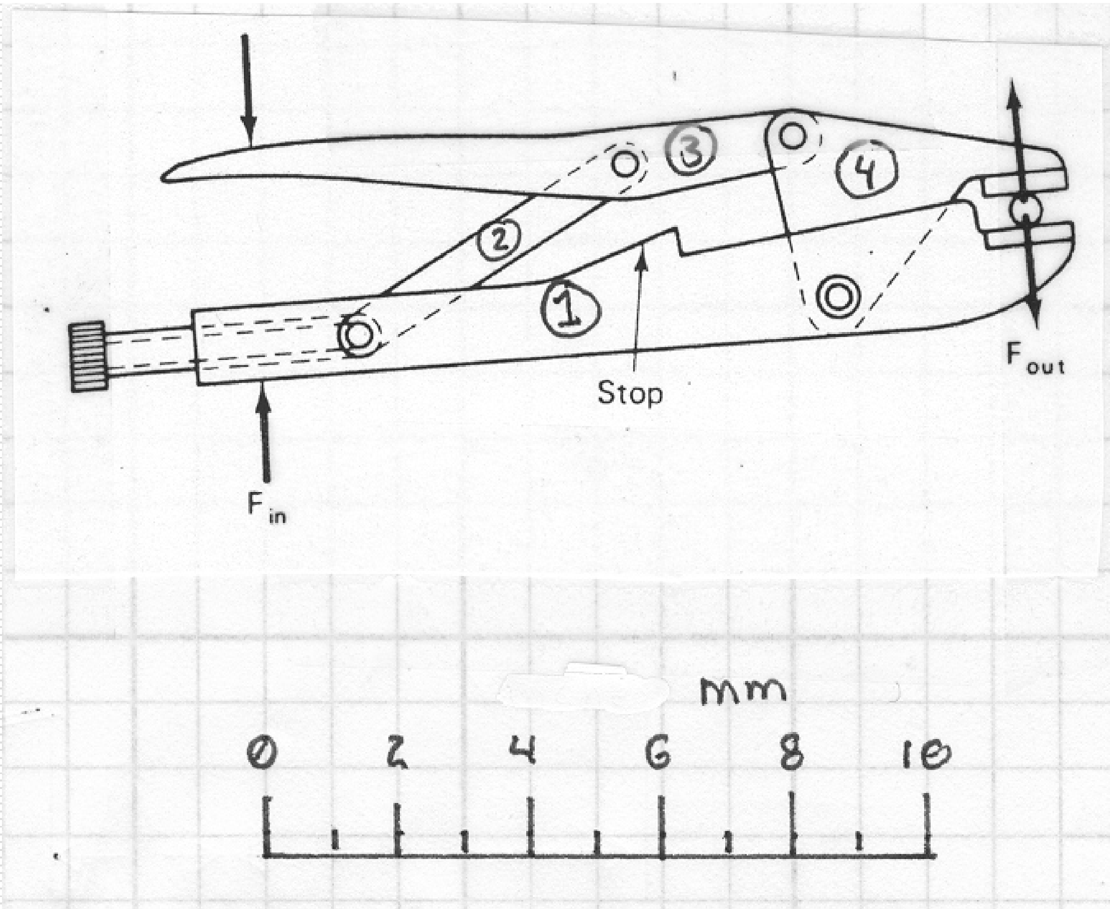


B
(3,4)
F_{in}
P
4
3
Q
F_{out}
d_{in}
Z_{in}
A
(2,3)
2
Z_{out}
(1,2)
d_{out}
B_0
A_0
(2,4)
(1,4)
1
r_{in}
r_{out}
inches
0 10 20 30 40

Toggle Position

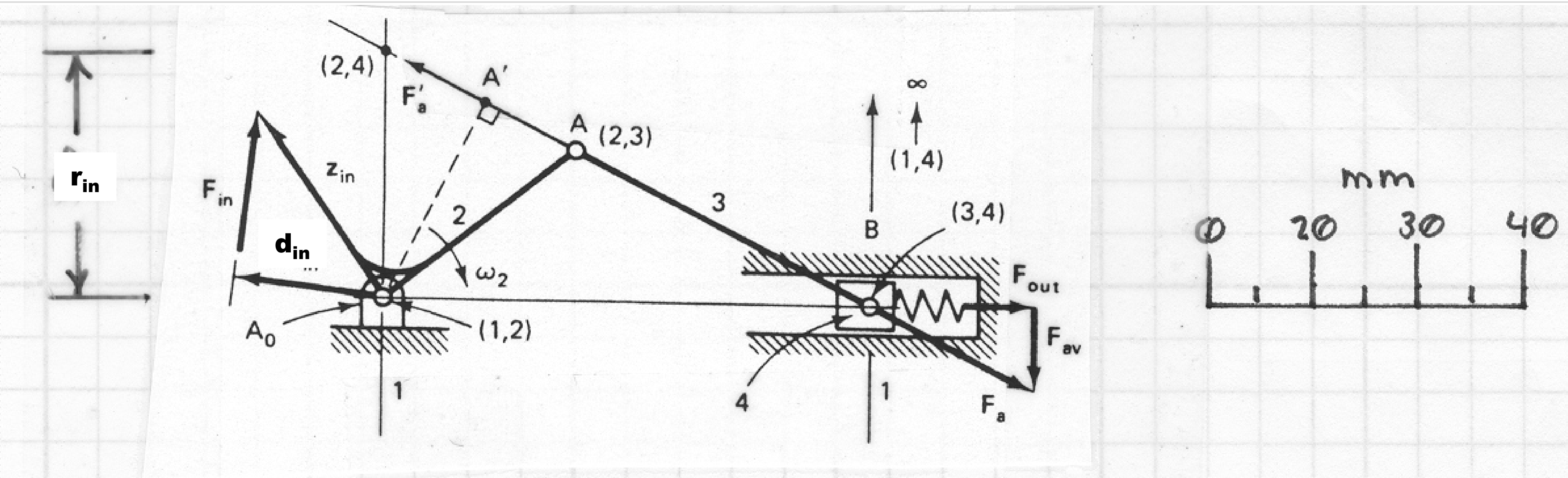


Example #2



MA for a Slider Crank

- MA needs to be modified
  - Link 4 Constrained to move in the horizontal direction
  - I_{24} is constrained to be in the horizontal direction



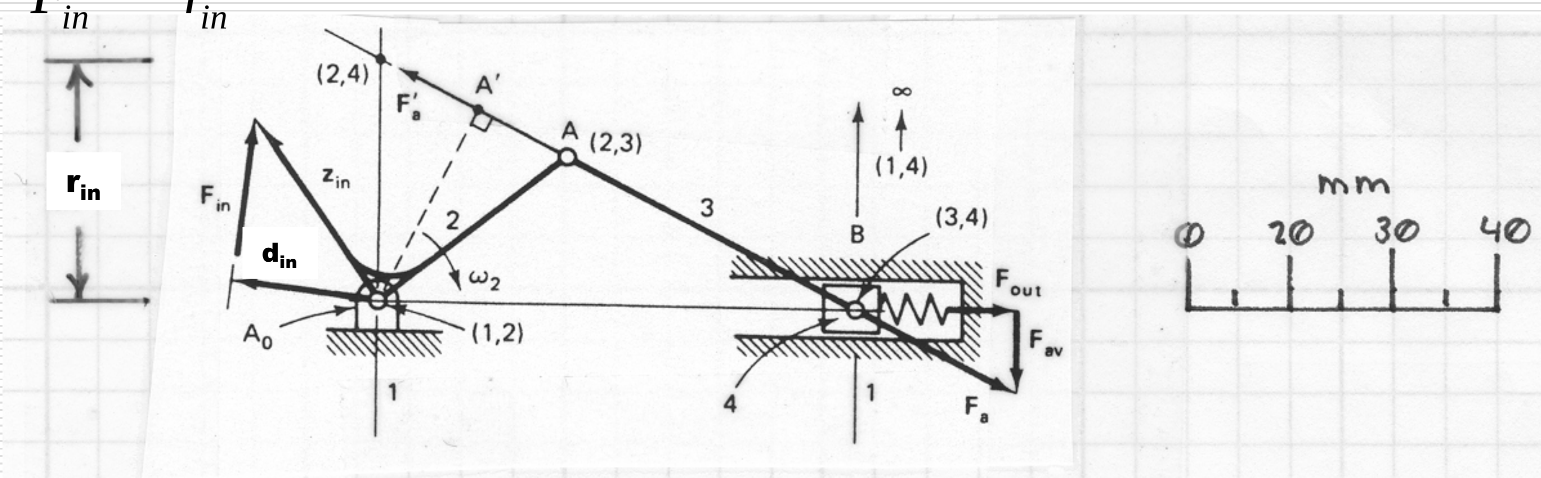
MA Slider Crank

$$(Power)_{in} = (Power)_{out}$$

$$\vec{T}_2 \circ \vec{\omega}_2 = \vec{F}_{out} \circ \vec{v}_B \qquad where\ \vec{v}_B = r_{in} \cdot \omega_2$$

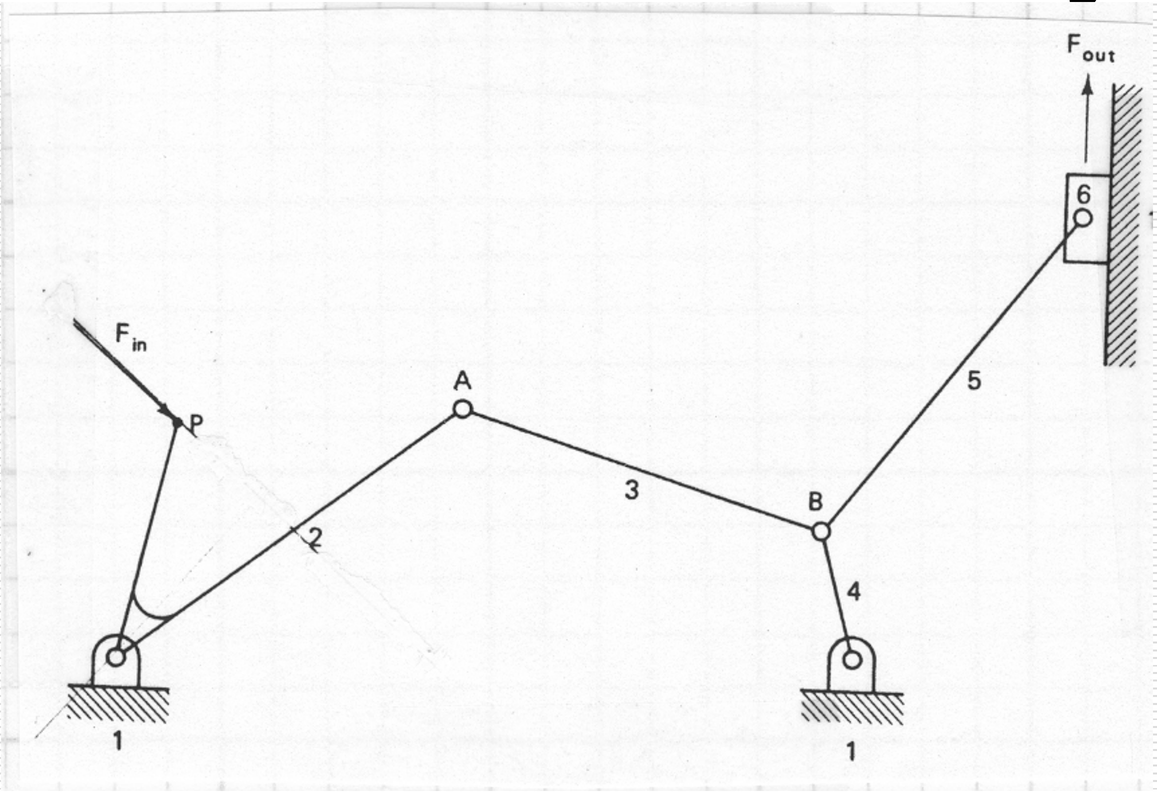
$$d_{in} \cdot F_{in} \cdot \omega_2 = r_{in} \cdot F_{out} \cdot \omega_2$$

$$MA = \frac{F_{out}}{F_{in}} = \frac{d_{in}}{r_{in}}$$

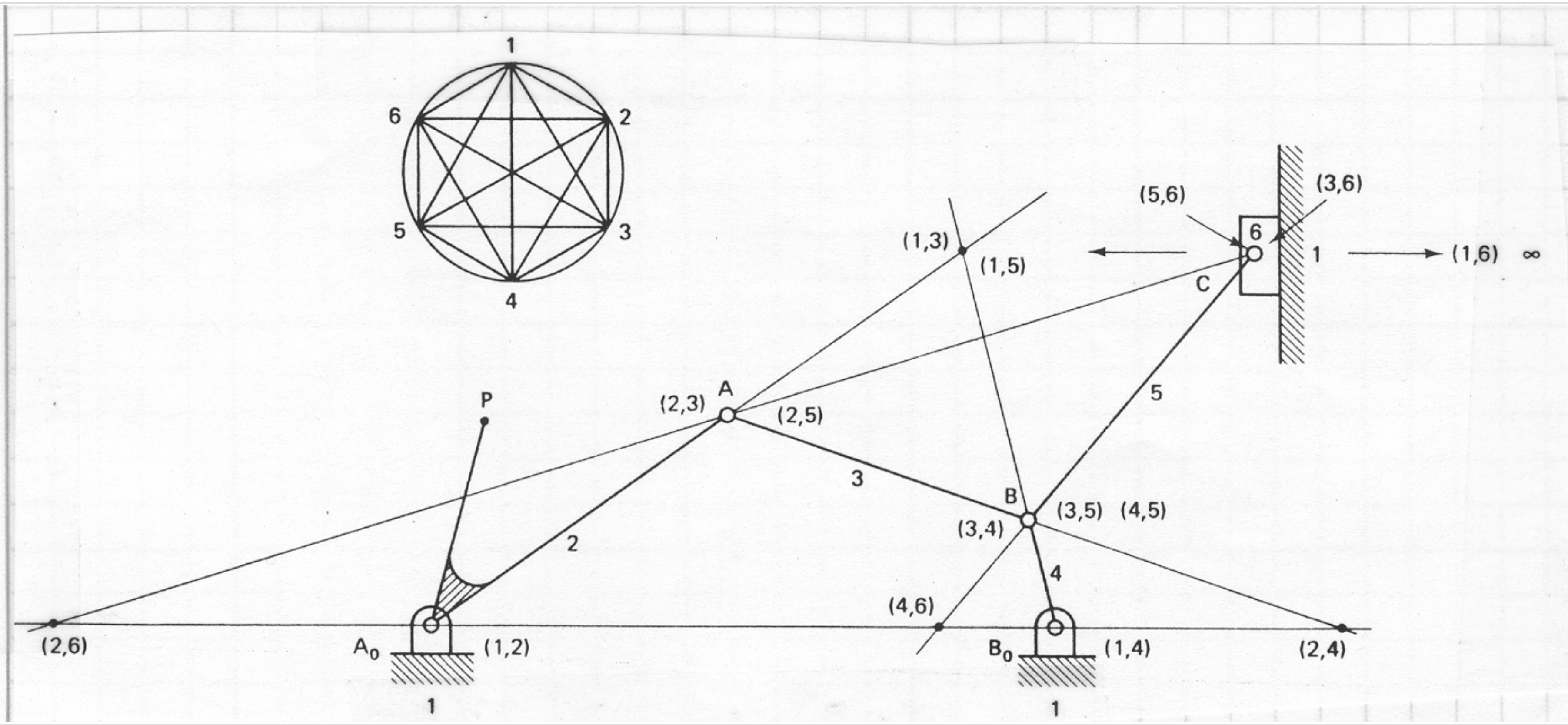


Six Bar Linkage

- Determine the MA of this system



Instant Centers for 6 Bar Linkage



Can Crusher Example