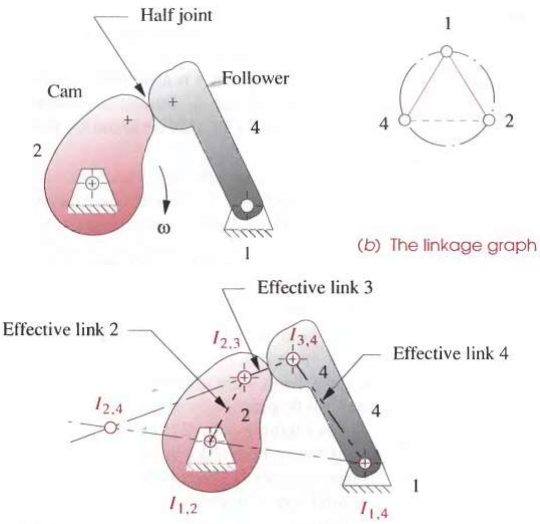
ME 222: Kinematics of Machines and Mechanisms

[L25] Velocity Analysis-4

Outline

- Angular velocity ratio
- Mechanical advantage
- Centrode

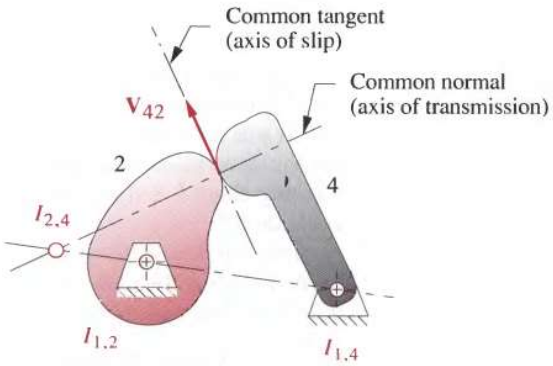
Instant Center: Cam & follower



(b) The linkage graph

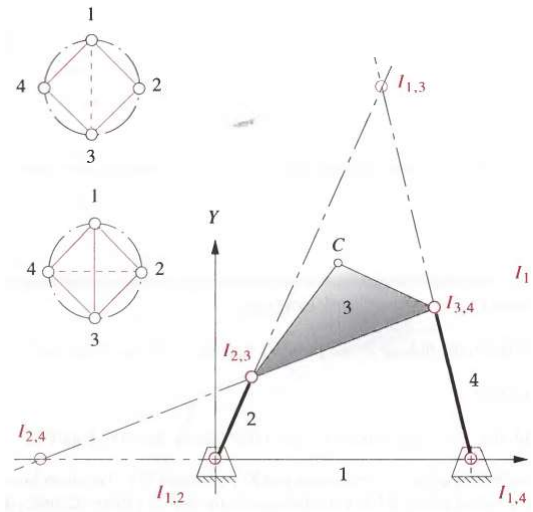
(c) The instantaneously equivalent "effective linkage"

Instant Center: Cam & follower

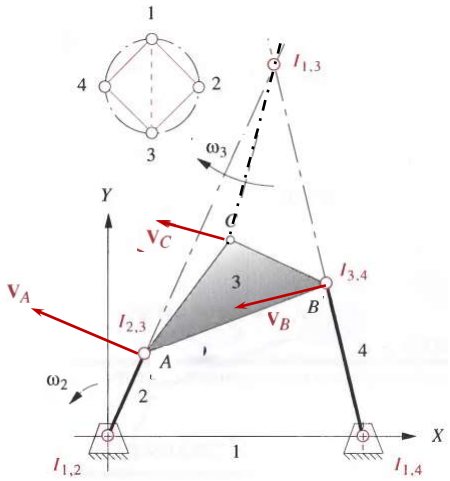


(d) Finding $I_{2,4}$ without using the effective linkage

Instant Center: Four-bar



Instant Center: Velocity analysis



$$v_a = (AO_2)\omega_2$$

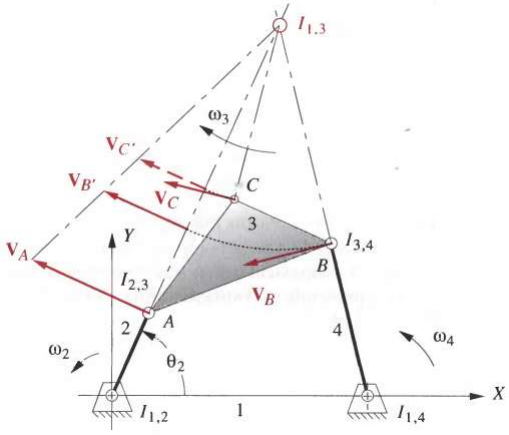
$$\omega_3 = \frac{v_A}{(AI_{1,3})}$$

$$v_B = (BI_{1,3})\omega_3$$

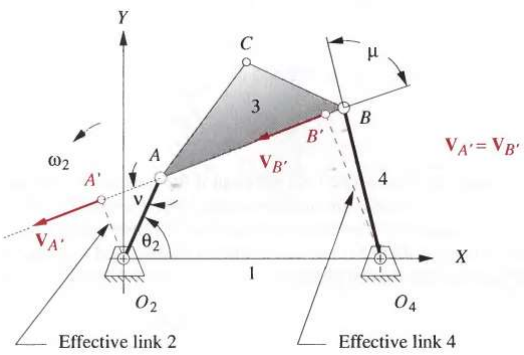
$$\omega_4 = \frac{v_B}{(BO_4)}$$

$$v_C = (CI_{1,3})\omega_3$$

Instant Center: Velocity analysis



Angular Velocity Ratio



$$O_2A' = (O_2A)\sin\nu$$

$$O_4B' = (O_4B)\sin\mu$$

$$m_V = \frac{\omega_4}{\omega_2}$$

$$V_{A'} = (O_2A')\omega_2 \quad V_{B'} = O_4B'\omega_4$$

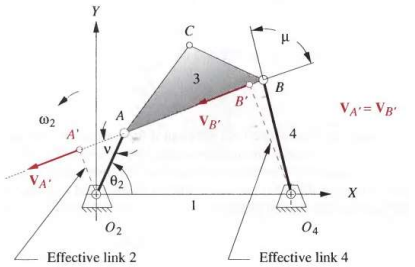
$$V_{A'} = V_{B'}$$

$$O_2A'\omega_2 = O_4B'\omega_4$$

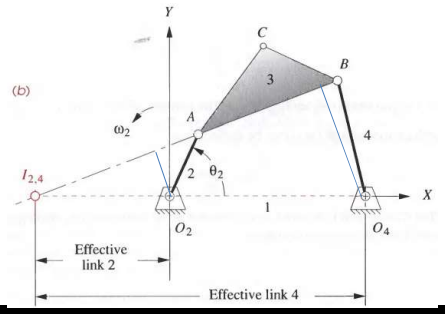
$$\frac{\omega_4}{\omega_2} = \frac{O_2A'}{O_4B'}$$

$$\frac{\omega_4}{\omega_2} = \frac{O_2A\sin\nu}{O_4B\sin\mu} = m_V$$

Angular Velocity Ratio



$$\frac{\omega_4}{\omega_2} = \frac{O_2 A \sin \nu}{O_4 B \sin \mu} = m_V$$



$$m_V = \frac{\omega_4}{\omega_2} = \frac{O_2 I_{2,4}}{O_4 I_{2,4}}$$

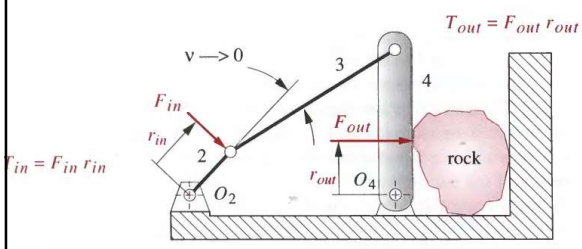
Mechanical Advantage

Mechanical advantage (m_A) can be defined as:

$$m_A = \frac{F_{out}}{F_{in}}$$

Assuming that the input and output forces are applied at some radii r_{in} and r_{out},

$$F_{out} = \frac{T_{out}}{r_{out}} \qquad F_{in} = \frac{T_{in}}{r_{in}}$$



$$m_A = \left(\frac{T_{out}}{T_{in}}\right)\left(\frac{r_{in}}{r_{out}}\right)$$

Mechanical Advantage

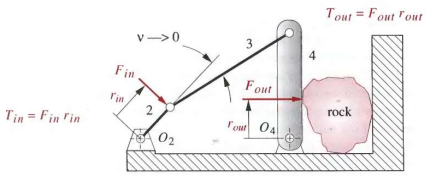
$$P = \mathbf{F} \cdot \mathbf{V} = F_x V_x + F_y V_y$$

Rotating System: $P = T\omega$

$$P_{in} = P_{out} + losses$$

Mechanical Efficiency:

$$\varepsilon = \frac{P_{out}}{P_{in}}$$



$$P_{out} = P_{in}$$

$$P_{in} = T_{in}\omega_{in} \qquad P_{out} = T_{out}\omega_{out}$$

$$T_{out}\omega_{out} = T_{in}\omega_{in}$$

$$\frac{T_{out}}{T_{in}} = \frac{\omega_{in}}{\omega_{out}}$$

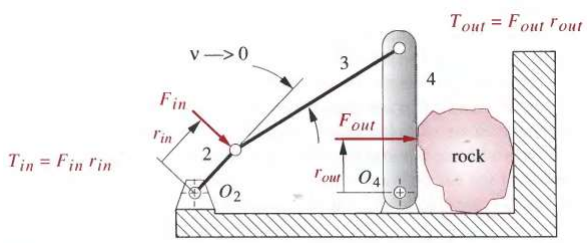
Mechanical Advantage

$$m_A = \left(\frac{T_{out}}{T_{in}}\right)\left(\frac{r_{in}}{r_{out}}\right)$$

$$\frac{T_{out}}{T_{in}} = \frac{\omega_{in}}{\omega_{out}}$$

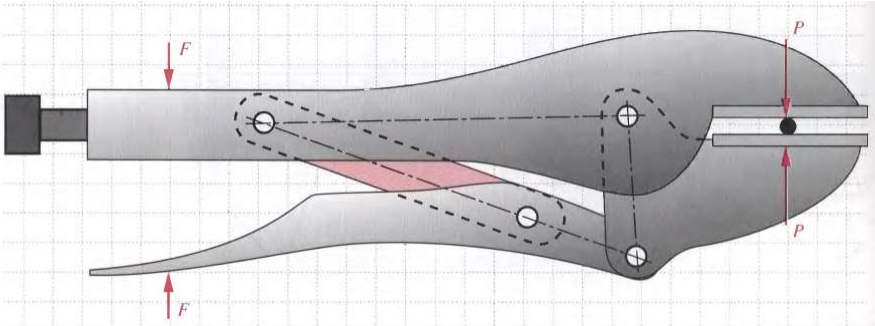
$$m_A = \left(\frac{\omega_{in}}{\omega_{out}}\right)\left(\frac{r_{in}}{r_{out}}\right)$$

$$\frac{\omega_4}{\omega_2} = \frac{O_2 A \sin \nu}{O_4 B \sin \mu} = m_V$$



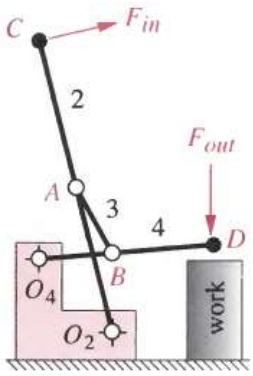
$$m_A = \left(\frac{O_4 B \sin \mu}{O_2 A \sin \nu}\right)\left(\frac{r_{in}}{r_{out}}\right)$$

Some more applications



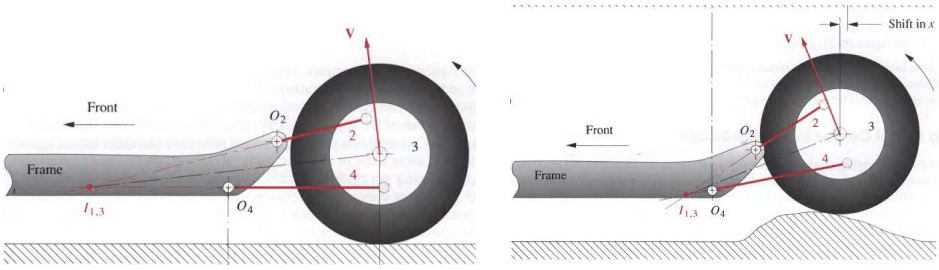
Home work (Problem 6.59a)

Calculate its mechanical advantage of the clamping mechanism shown below for the position shown.

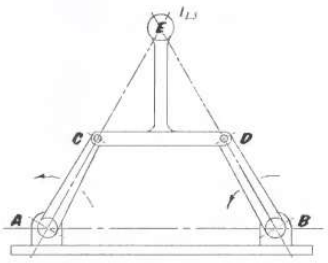


Using Instant Centers in Linkage Design

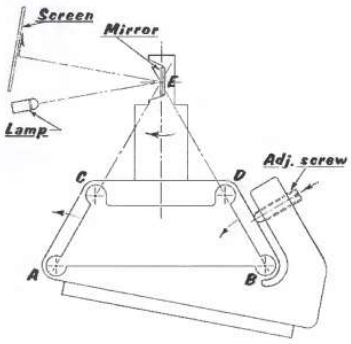
A rear suspension design from a domestic car of 1970's had a disturbing tendency to 'bump steer," i.e., turn the rear axle when hitting a bump on one side of the car.



Using Instant Centers in Linkage Design



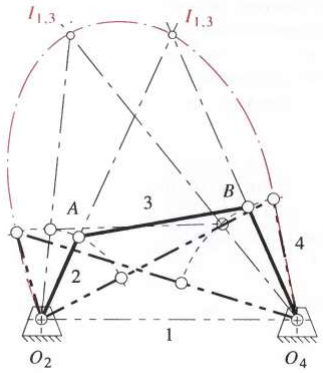
The Mechanism



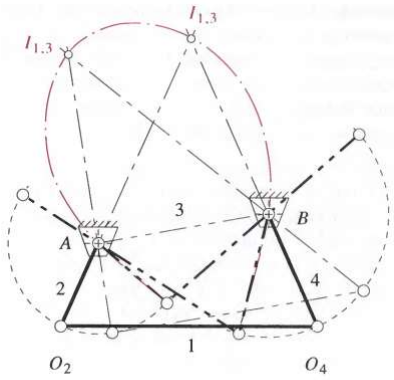
The Final Product of Keivan Towfigh

CENTRODES

- Path, or locus, of the instant center is called the centrode.
- There will be two centrodes associated with any one instant center.

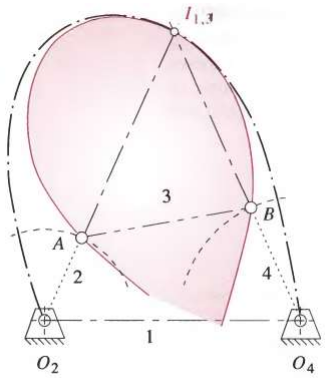


(a) The fixed centrode

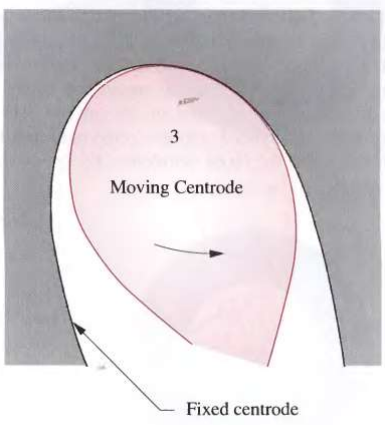


(b) The moving centrode

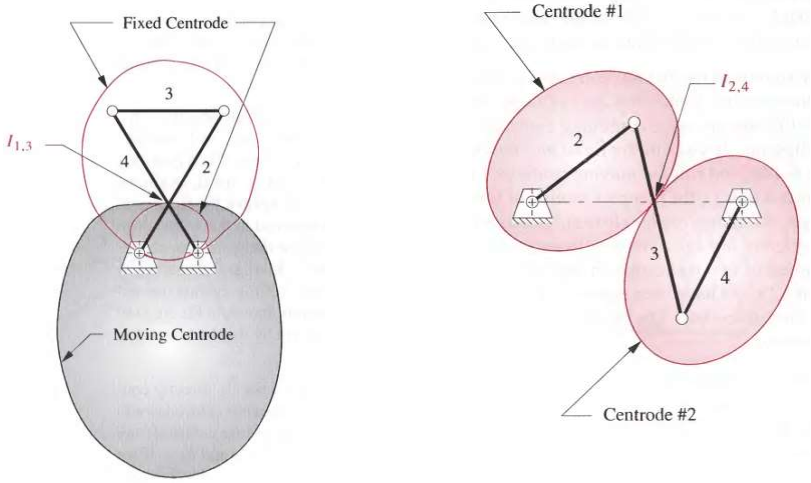
CENTRODES



(c) The centrodes in contact



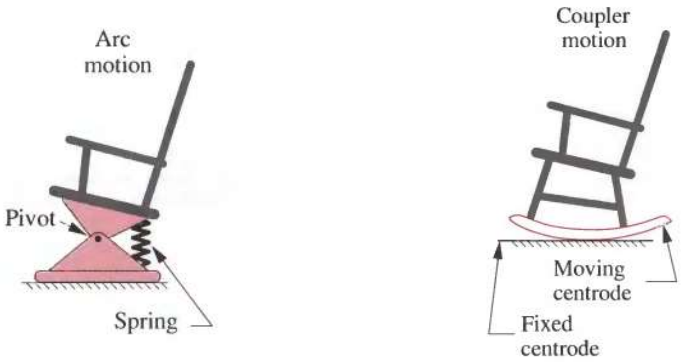
(d) Roll the moving centrode against the fixed centrode to produce the same coupler motion as the original linkage



(a) Closed-loop centrodes of $I_{1,3}$ for a Grashof double-crank linkage

(b) Ellipsoidal centrodes of $I_{2,4}$ for a special-case Grashof anti-parallelogram linkage

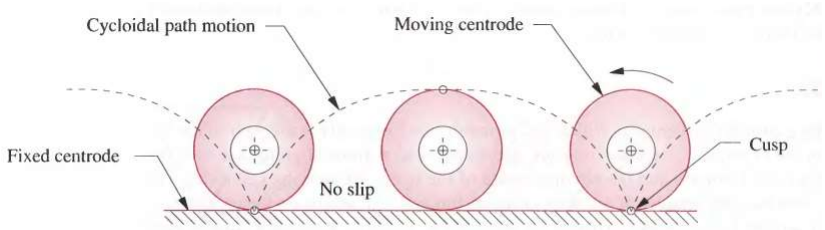
A "Linkless" Linkage



(b) Platform rocker

(a) Boston rocker

Cusps

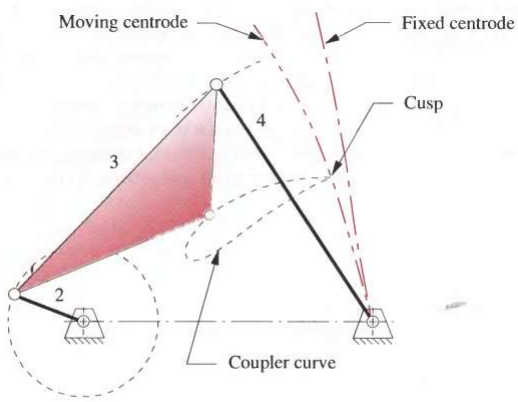


(a) Cycloidal motion of a circular, moving centrode rolling on a straight, fixed centrode

- All points on the contact surface of the tire move along cycloidal coupler curves and pass through a cusp of zero velocity when they reach the fixed centrode at the road surface
- All other points on the tire and wheel assembly travel along coupler curves which do not have cusps.

Cusps

If a coupler point is chosen to be on the moving centrode at one extreme of its path motion then it will have a cusp in its coupler curve.



(b) Coupler curve cusps exist only on the moving centrode

Thank you

Next Class: Acceleration Analysis