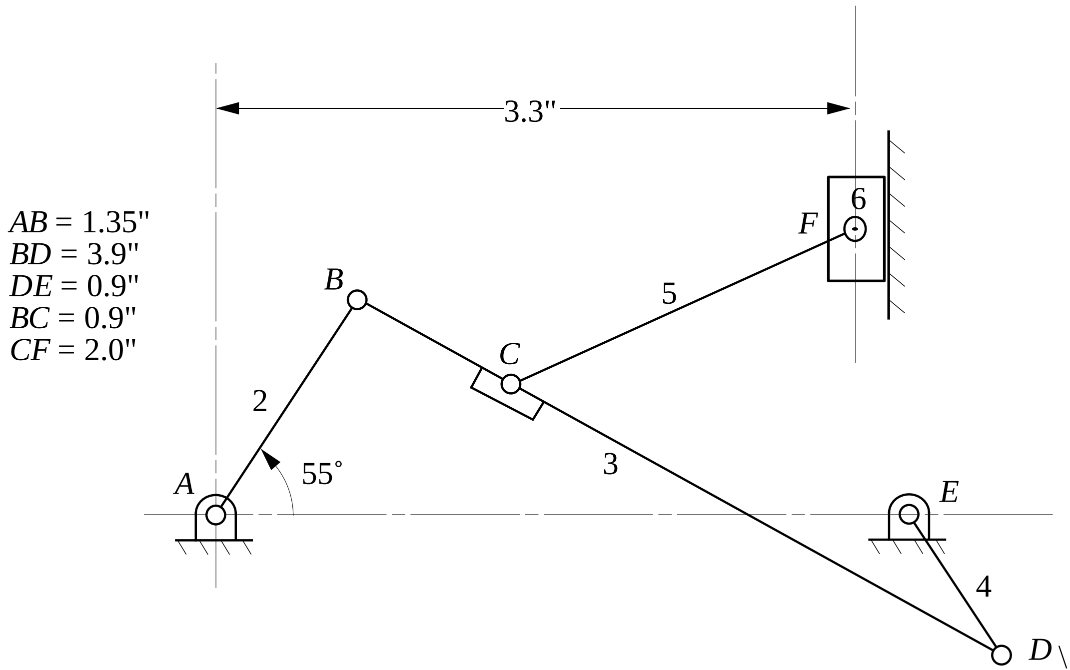
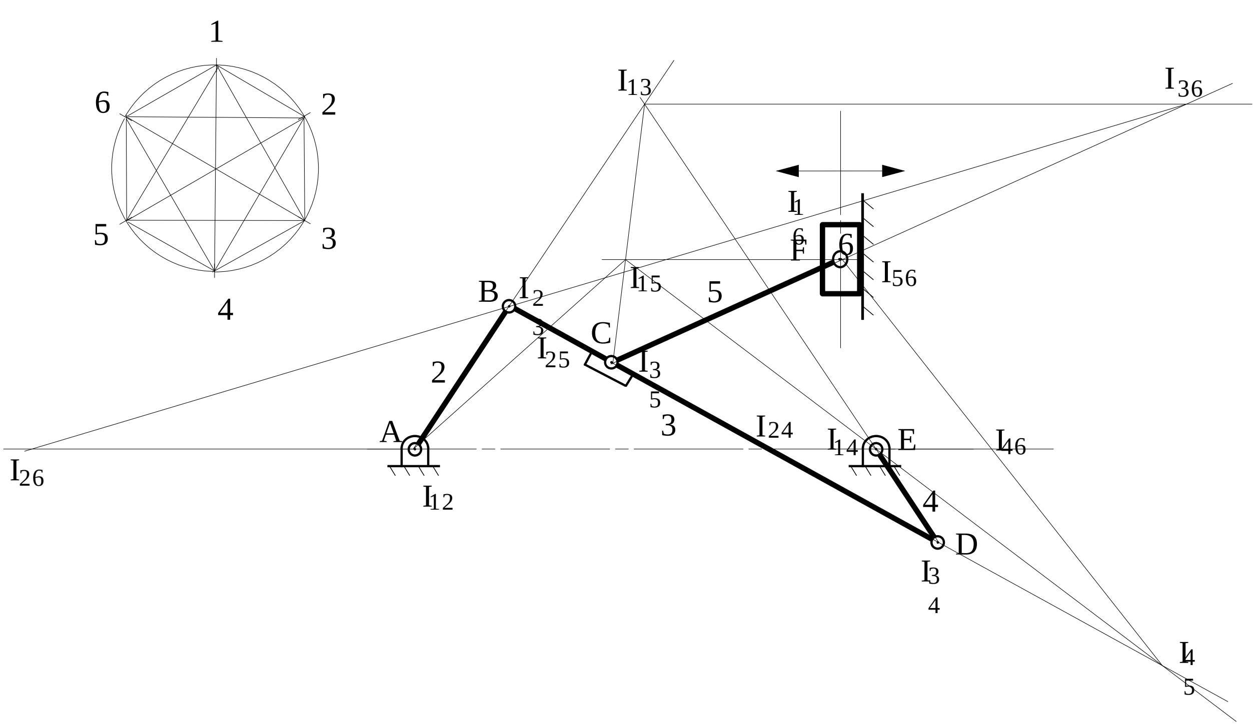
Problem 4.3

In the linkage shown below, locate all of the instant centers.

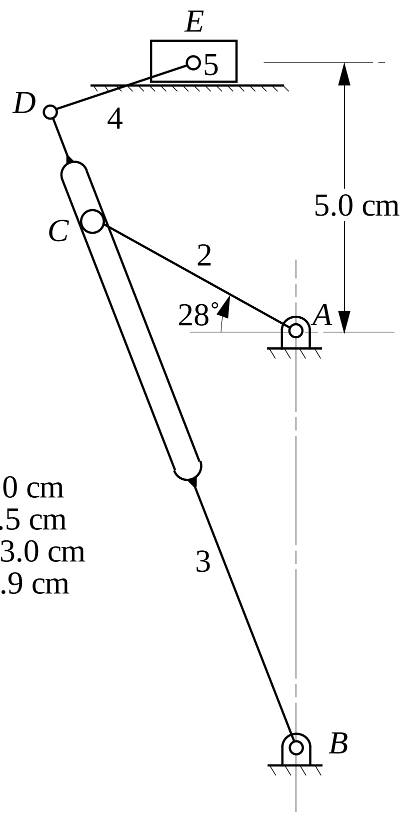


Solution

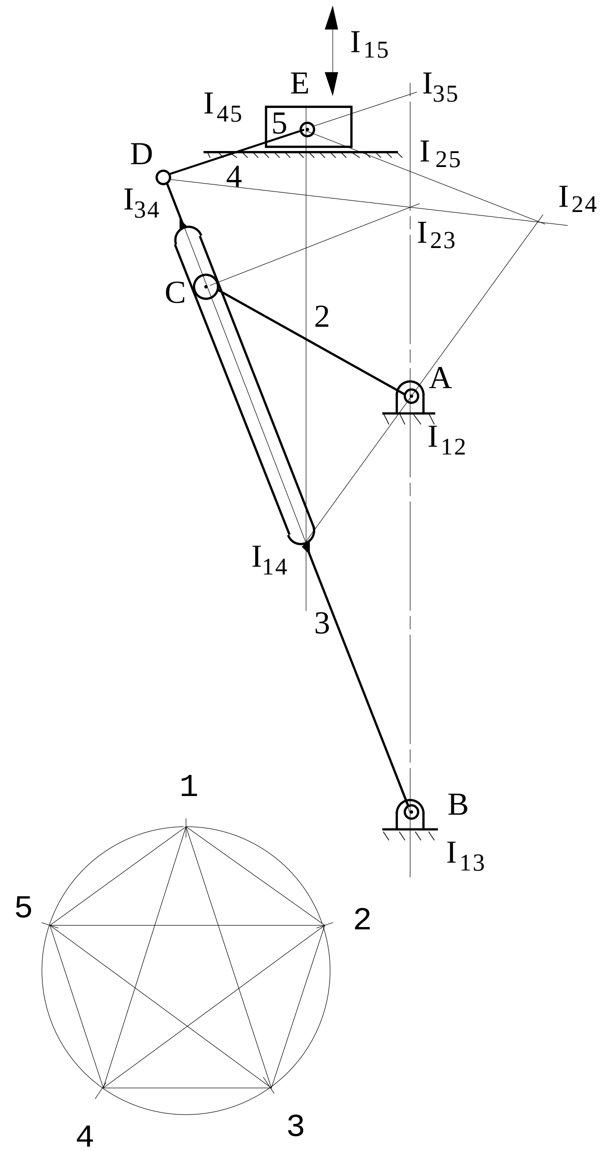


Problem 4.4

Find all of the instant centers of velocity for the mechanism shown below.



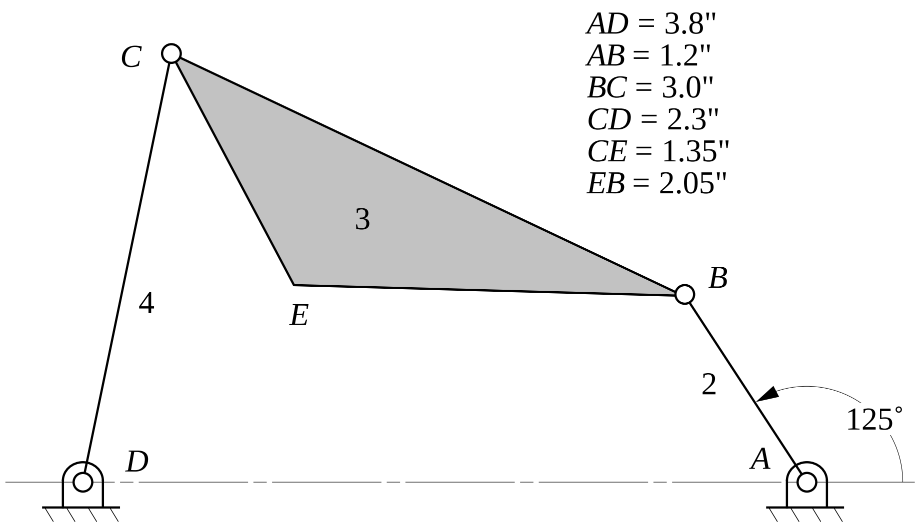
AB = 8.0 cm
AC = 4.5 cm
BD = 13.0 cm
DE = 2.9 cm



Solution

Problem 4.5

Locate all of the instant centers in the mechanism shown below. If link 2 is turning CW at the rate of 60 rad/s, determine the linear velocity of points *C* and E using instant centers.



<u>Velocity Analysis</u>

The two points of interest are on link 3. To find the angular velocity of link 3, use I_{13} and I_{23}. Then

$$ {}^1\boldsymbol{v}_{I_{23}} = {}^1\boldsymbol{\omega}_2 \times \boldsymbol{r}_{I_{23}/I_{12}} = {}^1\boldsymbol{\omega}_3 \times \boldsymbol{r}_{I_{23}/I_{13}} $$

Therefore,

$$ \left|{}^1\omega_3\right| = \left|{}^1\omega_2\right| \frac{\left|r_{I_{23}/I_{12}}\right|}{\left|r_{I_{23}/I_{13}}\right|} = 60\,\frac{1.2}{4.07} = 17.7 \ \text{rad/s} $$

Because the instant center I_{23} lies between I_{12} and I_{13}, ${}^1\omega_3$ is in the opposite direction of ${}^1\omega_2$. Therefore, ${}^1\omega_3$ is counterclockwise.

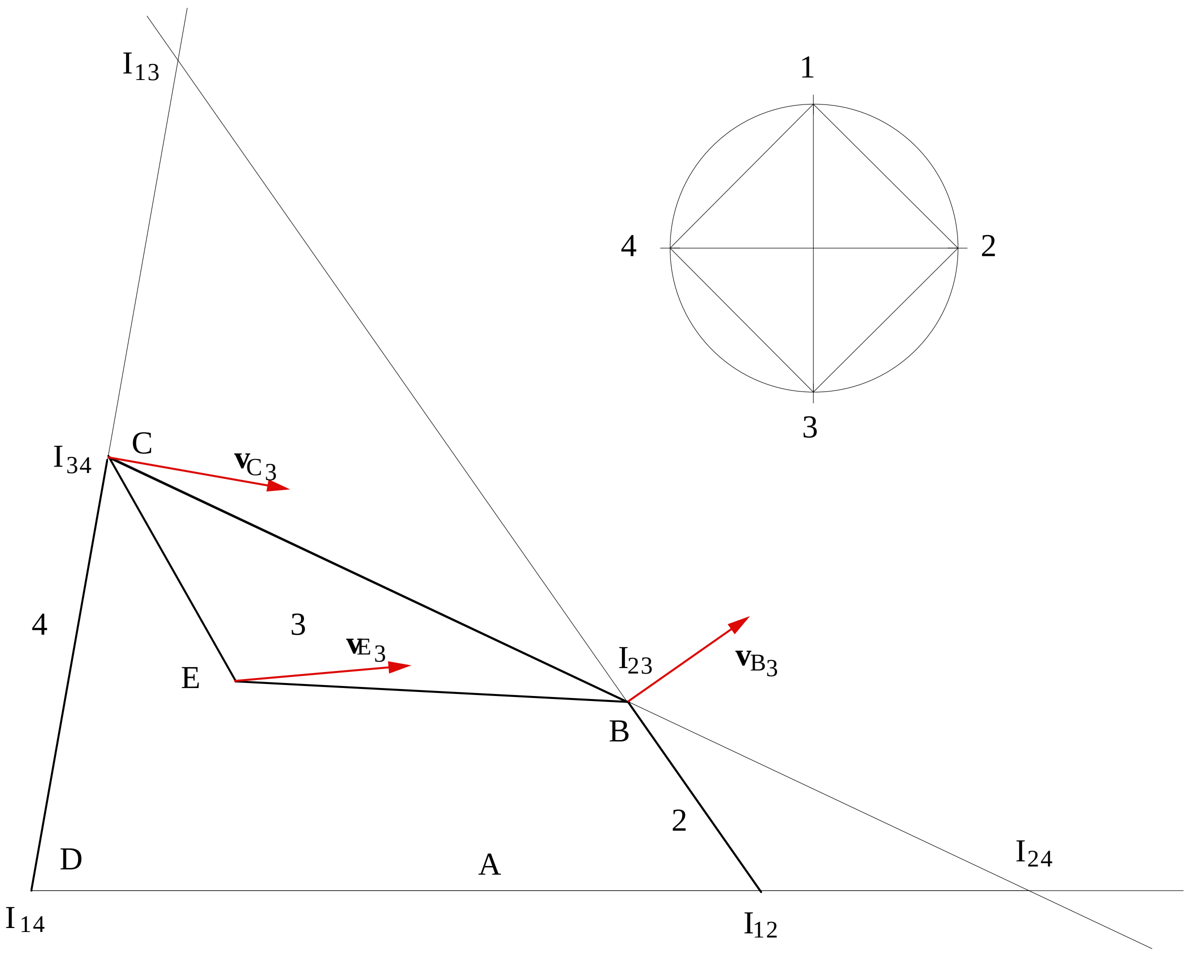
Then,

$$ {}^1\boldsymbol{v}_{C_3} = {}^1\boldsymbol{\omega}_3 \times \boldsymbol{r}_{C/I_{13}} \Rightarrow \left|{}^1\boldsymbol{v}_{C_3}\right| = \left|{}^1\omega_3\right|\left|r_{C/I_{13}}\right| = 17.7\cdot 2.11 = 37.3 \text{ in/s} $$

and

$$ {}^1\boldsymbol{v}_{E_3} = {}^1\boldsymbol{\omega}_3 \times \boldsymbol{r}_{E/I_{13}} \Rightarrow \left|{}^1\boldsymbol{v}_{E_3}\right| = \left|{}^1\omega_3\right|\left|r_{E/I_{13}}\right| = 17.7\cdot 3.25 = 57.5 \text{ in/s} $$

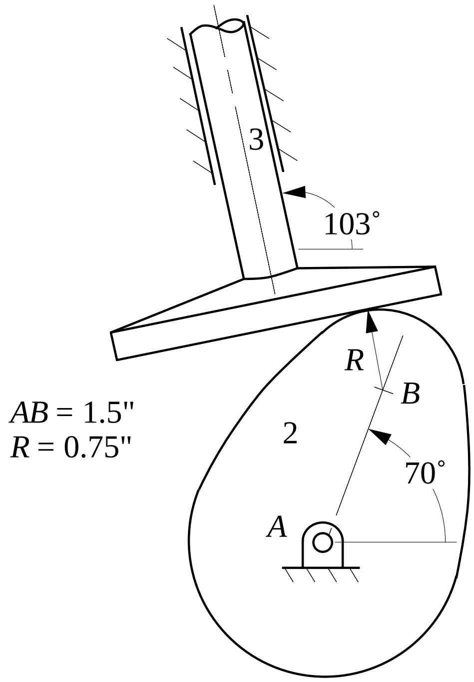
The directions for the velocity vectors are shown in the drawing.



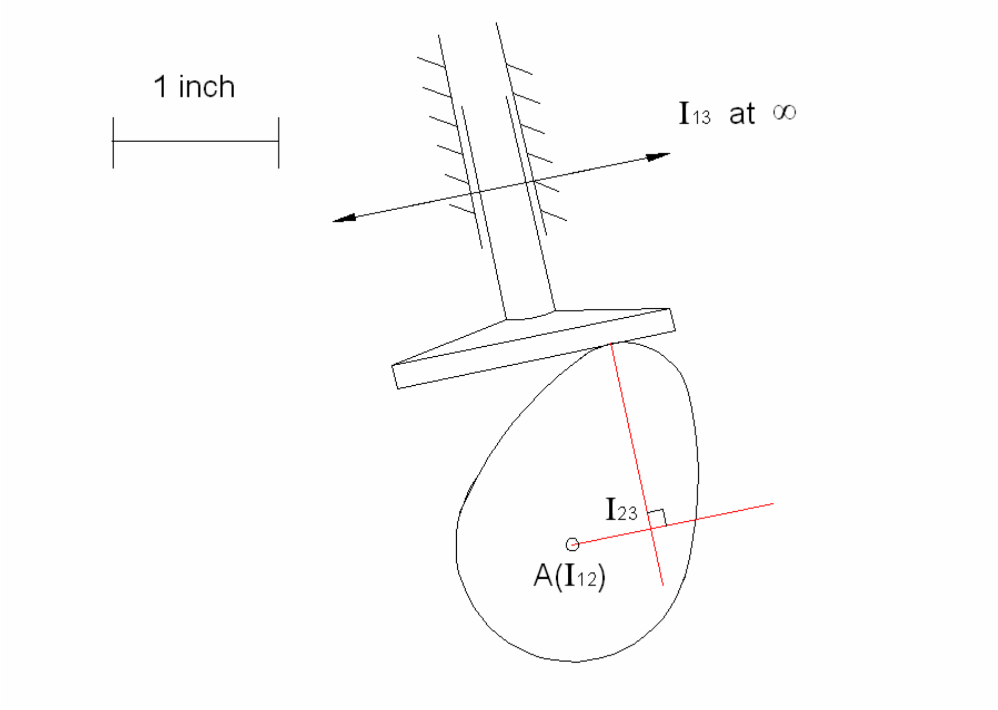
I13
1
4
2
3
I34
C
vC3
4
3
vE3
E
I23
vB3
B
2
D
A
I24
I14
I12

Problem 4.6

Locate all of the instant centers in the mechanism shown below. If the cam (link 2) is turning CW at the rate of 900 rpm, determine the linear velocity of the follower using instant centers.



Instant Centers



Velocity of the Follower

Convert the angular velocity from “rpm” to “rad/s”

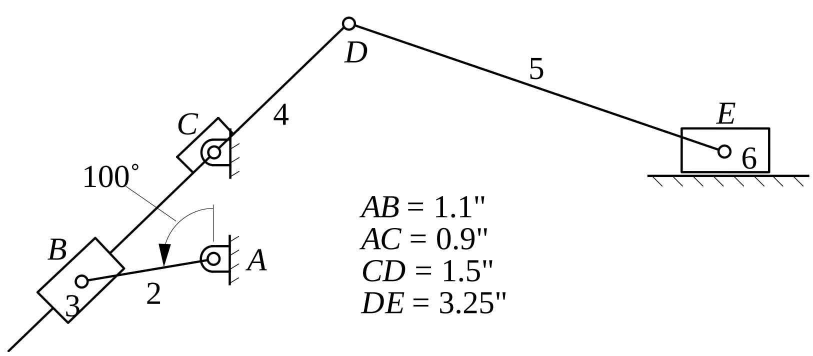
$$^{1}\omega_2 = 900\ rpm = \frac{900(2\pi)}{60\sec} = 94.25\ rad/s\quad CW$$

At the point I_{23} the linear velocity of follower and cam is same.

$$^{1}\mathbf{v}_{I_{23}} = {}^{1}\mathbf{v}_{A_2} + {}^{1}\mathbf{v}_{I_{23}/A_2} = 0 + {}^{1}\omega_2 \times \mathbf{r}_{I_{23}/A} = (94.25\ rad/s)(0.82\,in) = 77.285\ in/s\quad Down$$

Problem 4.7

Locate all of the instant centers in the mechanism shown below. If link 2 is turning CW at the rate of 36 rad/s, determine the linear velocity of point B_4 by use of instant centers. Determine the angular velocity of link 4 in rad/s and indicate the direction. Points C and E have the same vertical coordinate, and points A and C have the same horizontal coordinate.



Solution:

Find all instant centers and linear velocity of point B_2.

$$^{1}\mathbf{v}_{B_2} = {}^{1}\omega_2 \times \mathbf{r}_{B_2/A_2} \Rightarrow \left|{}^{1}\mathbf{v}_{B_2}\right| = \left|{}^{1}\omega_2\right| \cdot \left|\mathbf{r}_{B_2/A_2}\right| = 36 \cdot 1.1 = 39.6\ \text{in/s}$$

Using rotating radius method,

$$|{}^1\boldsymbol{v}_{B_4}| = 32.5\ \text{in}/\text{s}$$

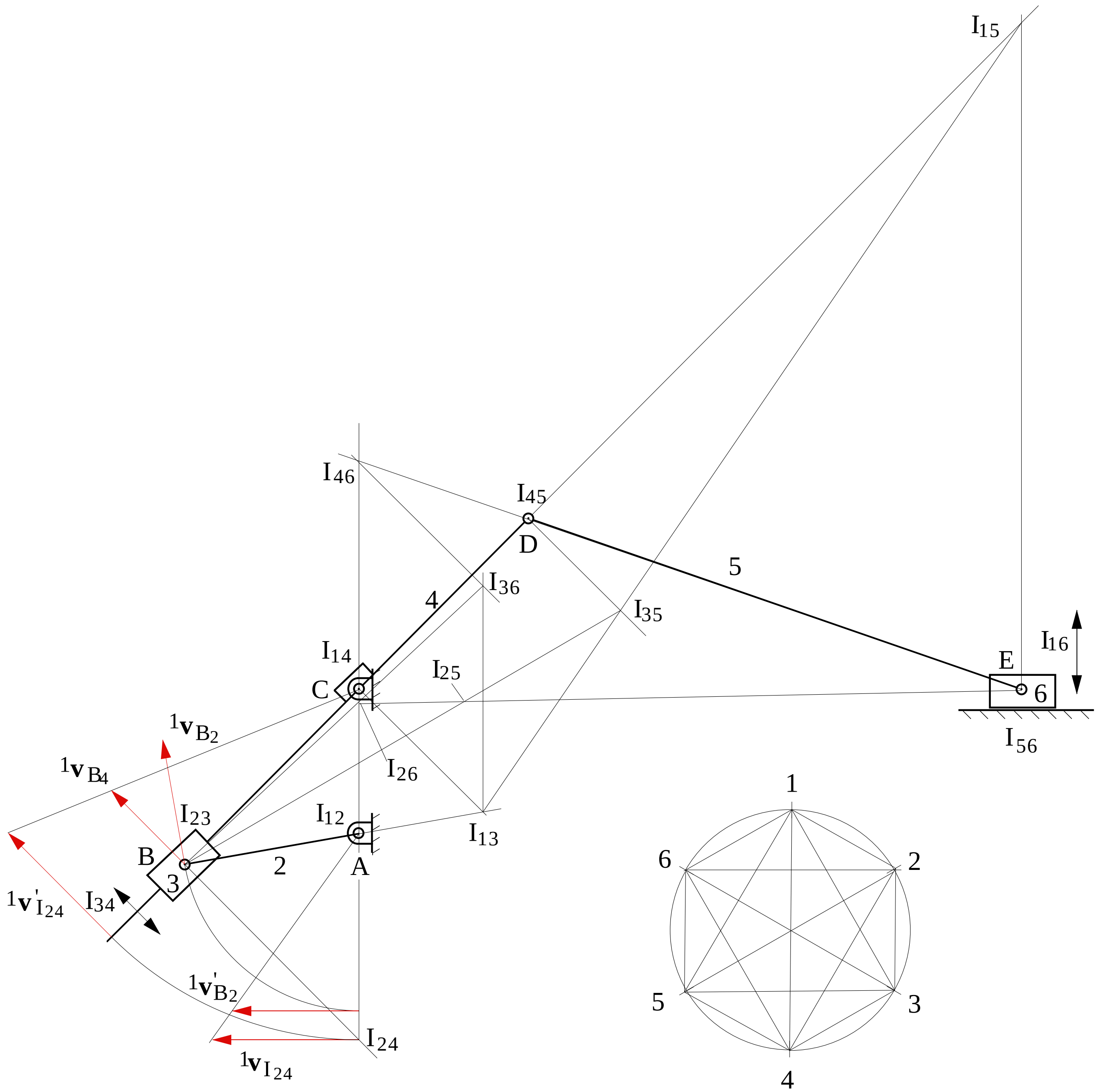
To calculate the angular velocity of link 4, we can use the relations between related instant centers.

$$^1\omega_2 \times \boldsymbol{r}_{I_{24}/I_{12}} = {}^1\omega_4 \times \boldsymbol{r}_{I_{24}/I_{14}}$$

$$|{}^1\omega_4| = |{}^1\omega_2| \cdot \frac{|\boldsymbol{r}_{I_{24}/I_{12}}|}{|\boldsymbol{r}_{I_{24}/I_{14}}|} = 36 \cdot \frac{1.283}{2.186} = 21.1\ rad/s$$

Therefore,

$$|{}^1\omega_4| = 21.1\ rad/s \quad CW$$

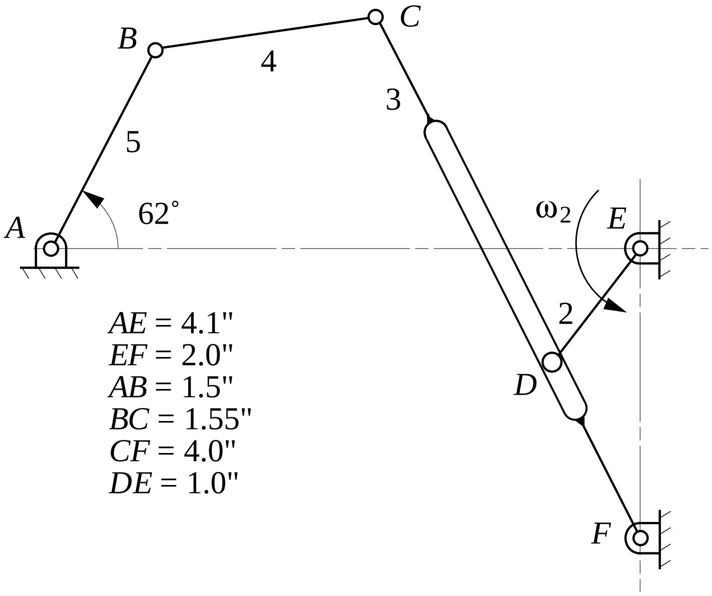


Problem 4.8

Using the instant-center method, find angular velocity of link 6 if link 2 is rotating at 50 rpm CCW.

Problem 4.12

If ω_2 = 5 rad/s CCW, find ω_5 using instant centers.



Solution:

Draw linkage to scale and find necessary instant centers (I_{12}, I_{15}, and I_{25}).

The relationshp between ${}^1\omega_2$ and ${}^1\omega_5$ is

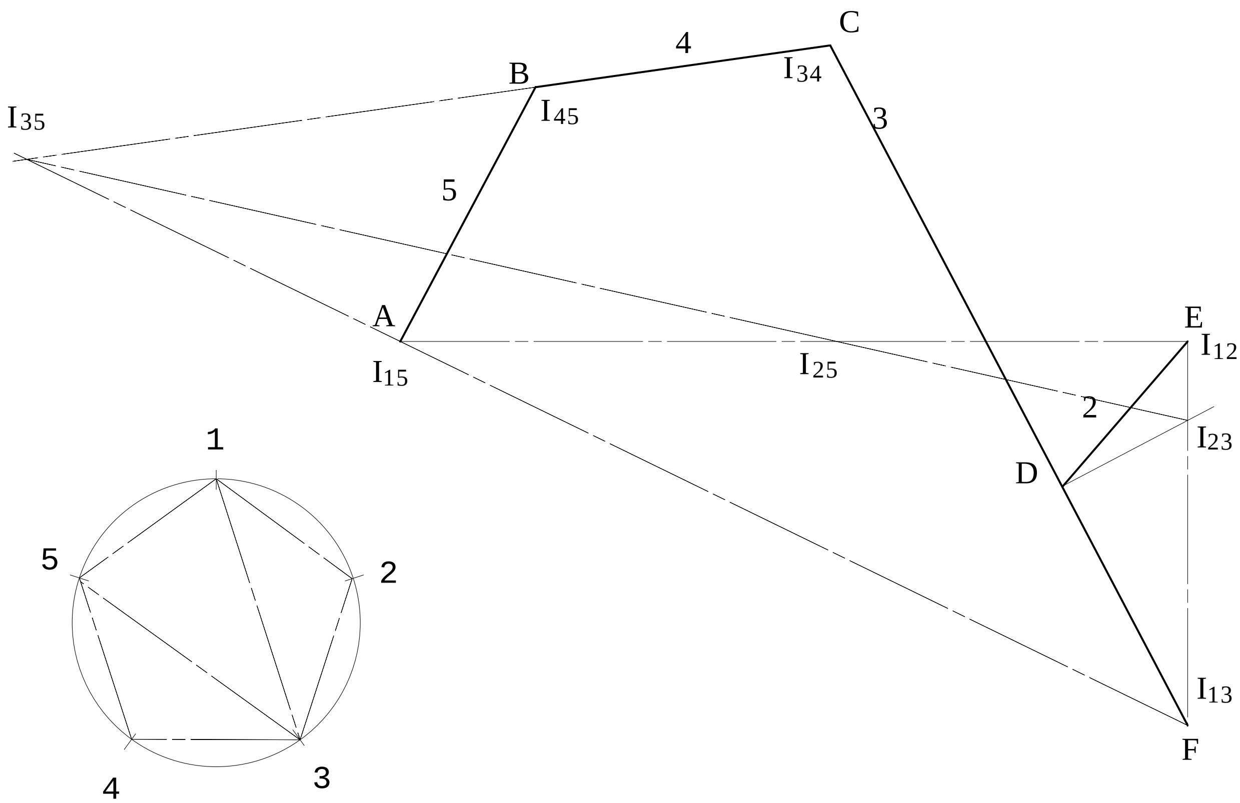
$$ {}^1\omega_2 \times r_{I_{25}/I_{12}} = {}^1\omega_5 \times r_{I_{25}/I_{15}} \tag{1}$$

Solve Eq. (1) for ${}^1\omega_5$,

$$ |{}^1\omega_5| = |{}^1\omega_2| \cdot \frac{|r_{I_{25}/I_{12}}|}{|r_{I_{25}/I_{15}}|} = 5 \cdot \frac{1.83}{2.27} = 4.03 \text{ rad/s} $$

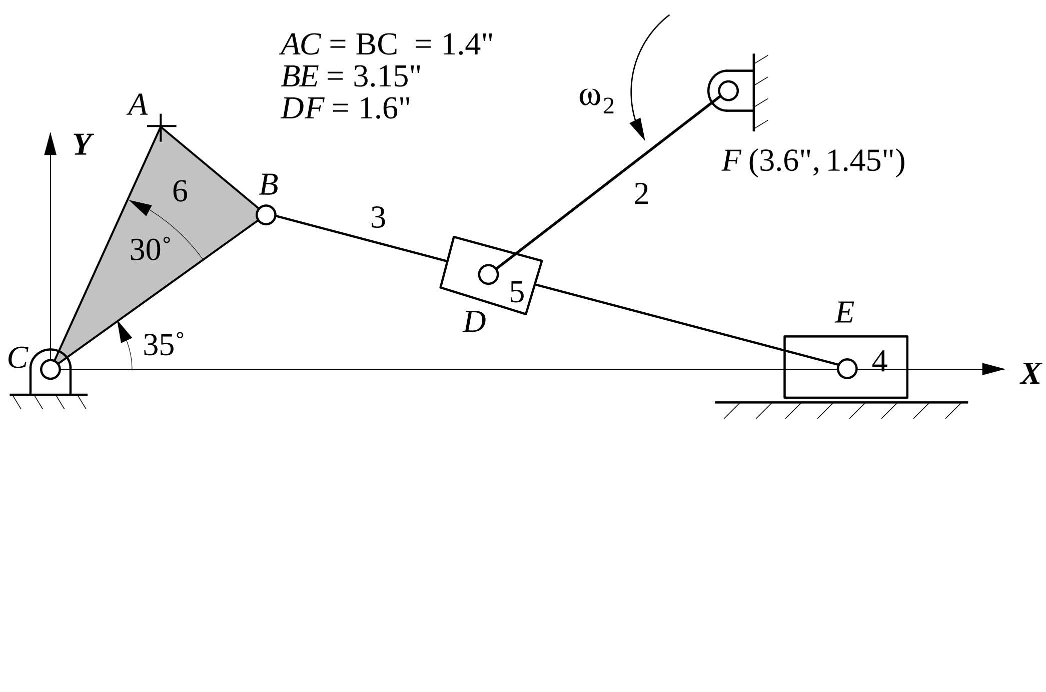
So,

$$ {}^1\omega_5 = 4.03 \text{ rad/s CW} $$

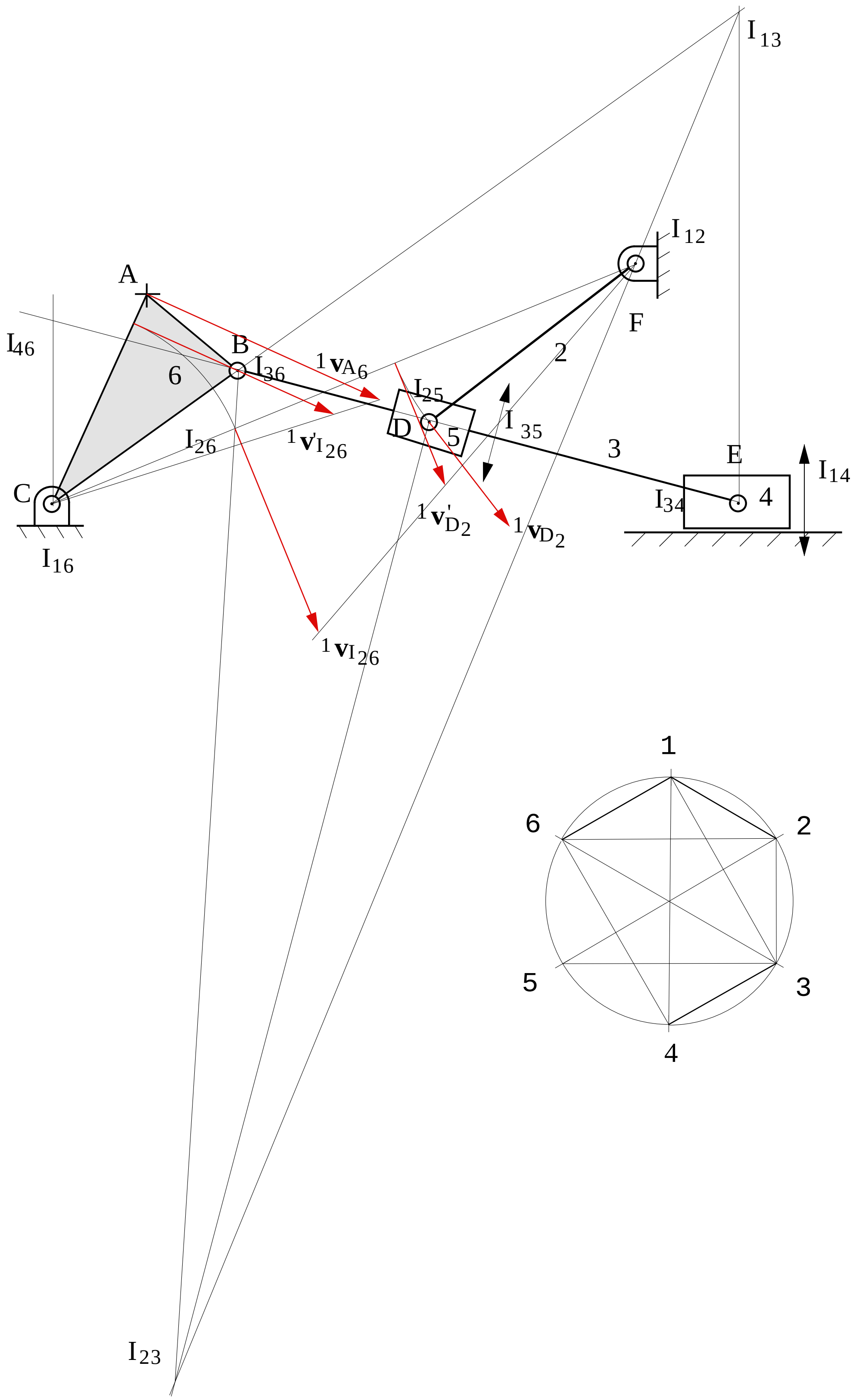


Problem 4.13

If ω_2 = 1 rad/s CCW, find the velocity of point A on link 6 using the instant center method. Show $\boldsymbol{v}_{A6}$ on the drawing.



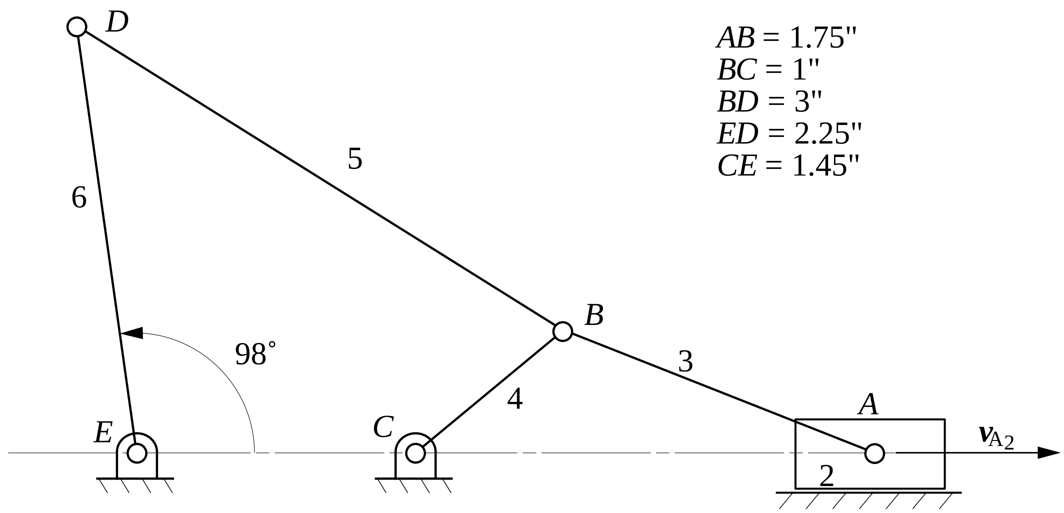
Solution:



Find necessary instant centers, i.e. I_{12}, I_{16}, and I_{26}, and the velocity of point D as

Problem 4.19

If the velocity of A_2 is 10 in/s to the right, find ω_6 using instant centers.



Solution:

Find necessary instant centers as shown in the sketch above, i.e. I_{12}, I_{16}, and I_{26}. All points in link 2 have the same velocity; therefore,

$$ {}^1\boldsymbol{v}_{A_2} = {}^1\boldsymbol{v}'_{A_2} = {}^1\boldsymbol{v}_{I_{26}} $$

Using the rotating radius method,

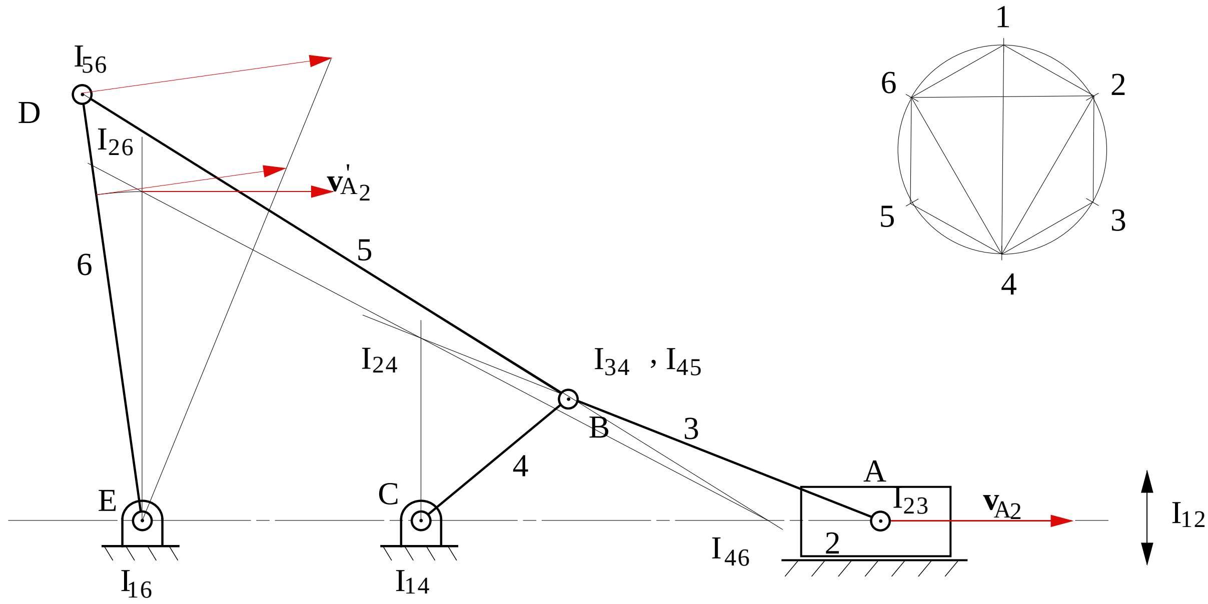
$$ {}^1\boldsymbol{v}_{D_6} = {}^1\boldsymbol{v}_{D_6/E_6} = 13.2 \text{ in/s} $$

Now,

$$ {}^1\boldsymbol{v}_{D_6/E_6} = {}^1\omega_6 \times \boldsymbol{r}_{D_6/E_6} \Rightarrow \left|{}^1\omega_6\right| = \frac{\left|{}^1\boldsymbol{v}_{D_6/E_6}\right|}{\left|\boldsymbol{r}_{D_6/E_6}\right|} = \frac{13.2}{2.25} = 5.87 \text{ rad/s} $$

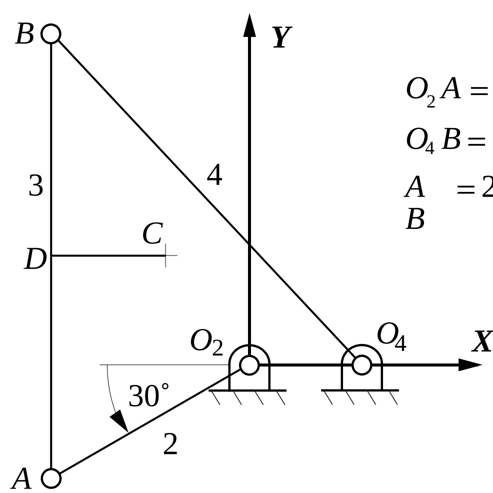
Therefore,

$$ \left|{}^1\omega_6\right| = 5.87 \text{ rad/s CW} $$



Problem 4.20

Crank 2 of the push-link mechanism shown in the figure is driven at ω_2 =60 rad/s (CW). Find the velocity of points B and C and the angular velocity of links 3 and 4 using the instant center method.



$O_2A = 15$ cm

$O_4B = 30.1$ cm

$AB = 29.5$ cm

$AD = 14.75$ cm

$DC = 7.5$ cm

$O_2O_4 = 7.5$ cm

Solution:

Find all instant centers and velocity of point A

$${}^1\mathbf{v}_{A2} = {}^1\boldsymbol{\omega}_2 \times \mathbf{r}_{A2/O2} \Rightarrow |{}^1\mathbf{v}_{A2}| = |{}^1\boldsymbol{\omega}_2| \times |\mathbf{r}_{A2/O2}| = 60 \cdot 0.015 = 0.9\ m/s$$

Using rotating radius method,

$${}^1\mathbf{v}_{B3} = 1.15\ \mathrm{m/s}$$