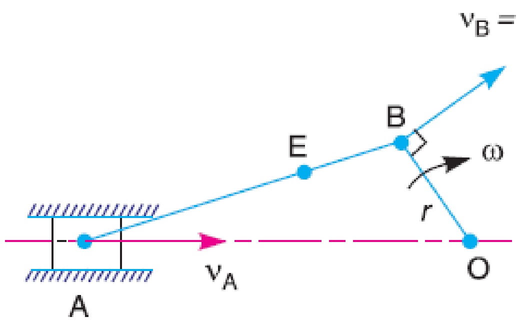
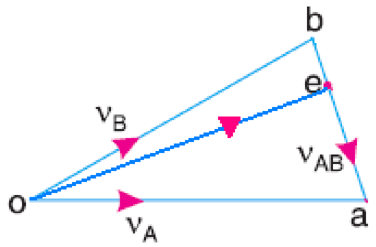
1. Velocities in Slider Crank Mechanism

The slider *A*, in Fig. 1(*a*) ,is attached to the connecting rod *AB*. v_B is known in magnitude and direction. The slider reciprocates along the line of stroke *AO*.

The velocity of the slider *A* (*i.e.* v_A) may be determined by follow:



(*a*) Slider crank mechanism.



(*b*) Velocity diagram.

Fig. 1

1. From any point *o*, draw vector *ob* parallel to the direction of v_B (or perpendicular to *OB*) such that $ob = v_B = \omega.r$, to some suitable scale, as shown in Fig. 1(*b*).
2. Draw vector *ba* perpendicular to *AB* to represent the velocity of *A* with respect to *B* *i.e.* v_{AB}.
3. From point *o*, draw vector *oa* parallel to the path of motion of the slider *A* (which is along *AO* only). The vectors *ba* and *oa* intersect at *a*. Now *oa* represents the velocity of the slider *A* *i.e.* v_A, to the scale.
4. To find velocity of point *E* $\frac{be}{BE} = \frac{ba}{BA}$ and then find point e in Fig. 1(*b*) and then v_E.

$$\omega_{AB} = \frac{v_{BA}}{AB} = \frac{ab}{AB} \qquad \text{(Anticlockwise about } A\text{)}$$

The angular velocity of the sliding member is zero.

2. Rubbing Velocity at a Pin Joint

Consider two links *OA* and *OB* connected by a pin joint at *O* as shown in Fig. 2.

Let ω_1 = Angular velocity of the link *OA* or the angular velocity of the point *A* with respect to *O*.

ω_2 = Angular velocity of the link *OB*,

r = Radius of the pin.

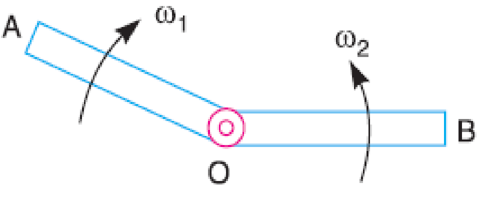


Fig. 2 . Links connected by pin joints.

Rubbing velocity at the pin joint *O*

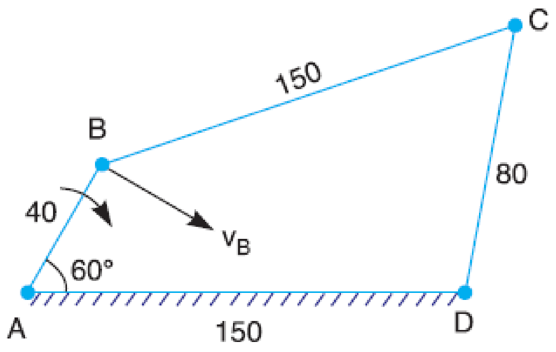
$= (\omega_1 - \omega_2)\, r$, if the links move in the same direction

$= (\omega_1 + \omega_2)\, r$, if the links move in the opposite direction

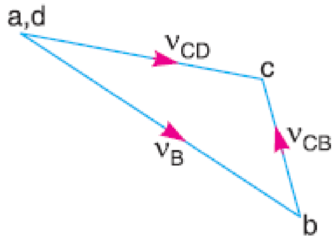
Example: 1

In a four bar chain *ABCD*, *AD* is fixed and is 150 mm long. The crank *AB* is 40 mm long and rotates at 120 r.p.m. clockwise, while the link *CD* = 80 mm oscillates about *D*. *BC* and *AD* are of equal length. Find the angular velocity of link *CD* when angle *BAD* = 60°.

Solution



(*a*) Space diagram (All dimensions in mm).



(*b*) Velocity diagram.

1. Draw the mechanism as shown in Fig. (*a*) by take suitable scale, let 20mm = 1 cm in paper
2. Find $v_{BA} = v_B = \omega_{BA} \times AB$

   N_{BA} = 120 r.p.m. , $\omega_{BA} = 2\pi \times 120/60 = 12.568$ rad/s

   $v_B = 12.568 \times 40 = 503$ mm/s
3. Draw the velocity diagram as shown in Fig. (*b*) by take suitable scale, let 503 mm/s = 4 cm in paper
4. From point *a,d* draw line *ab* = 4 cm ⊥ link *AB* (vector $ab = v_B$), Fig. (*b*).
5. From point *b* draw line *bc* ⊥ link *BC*.

6. From point a,d draw line $dc \perp$ link DC intersecting the line bc at c.
7. Measure dc from Fig. (b)

$$dc = 3 \text{ cm in paper}, \quad v_{CD} = v_C = \text{vector } dc$$

$$v_C = 3 \times \frac{503}{4} = 378 \text{ mm/s}$$

We know that $CD = 80$ mm

∴ Angular velocity of link CD, $\omega_{CD} = \frac{v_{CD}}{DC} = \frac{378}{80} = 4.72$ rad/s

(clockwise about D) **Ans.**

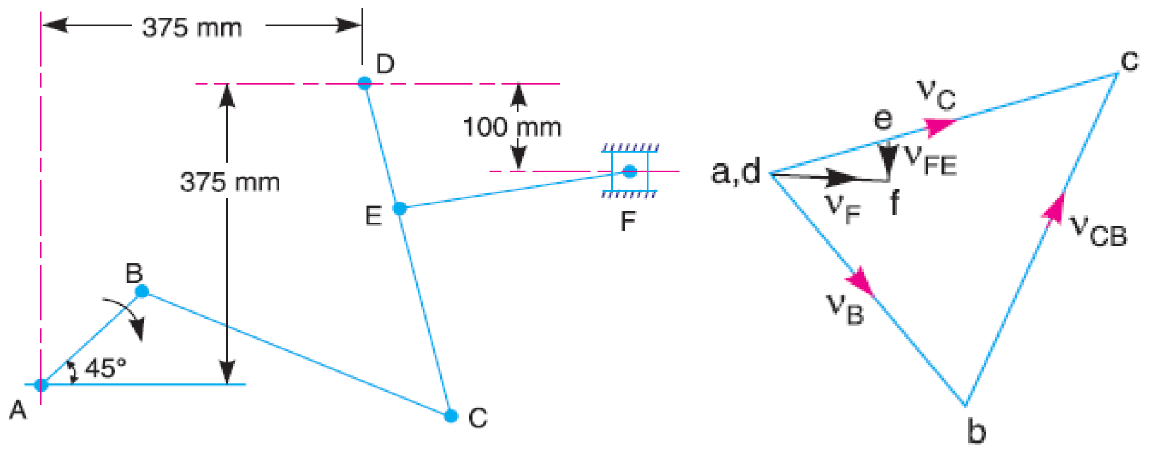
Example: 2

The mechanism, as shown in Figure below, has the dimensions of various links as follows :
$AB = DE = 150$ mm ; $BC = CD = 450$ mm ; $EF = 375$ mm.

The crank AB makes an angle of 45° with the horizontal and rotates about A in the clockwise direction at a uniform speed of 120 r.p.m. The lever DC oscillates about the fixed point D, which is connected to AB by the coupler BC. The block F moves in the horizontal guides, being driven by the link EF. Determine:

1. velocity of the block F,
2. angular velocity of DC, and
3. rubbing speed at the pin C which is 50 mm in diameter.

Solution:



(a) Mechansim (b) Velocity diagram.

1. Draw the mechanism, to some suitable scale, as shown in Fig.(*a*). let 100 mm = 1 cm in paper
2. Find $v_{BA} = v_B = \omega_{BA} \times AB$

   $N_{BA} = 120$ r.p.m. , $\omega_{BA} = 2\pi \times 120/60 = 12.568$ rad/s

   $v_{BA} = v_B = 12.568 \times 150 = 1.885$ m/s
3. Draw the velocity diagram, as shown in Fig. (*b*), since the points *A* and *D* are fixed. Now from point *a*, draw vector $ab \perp AB$, to some suitable scale.

let 1.885 m/s = 3 cm in paper

vector $ab = v_B$

4. From point *b* draw vector $bc \perp BC$ to represent v_{CB}, and from point *d*, draw vector $dc \perp DC$ to represent $v_{CD} = v_C$. The vectors *bc* and *dc* intersect at *c*.
5. Since the point *E* lies on *DC*,

$$\frac{dc}{DC} = \frac{de}{DE}$$

From Fig. (*b*) measure *dc* = 3.6 cm in paper

$$de = 3.6 \times \frac{150}{450} = 1.2 \text{ cm}$$

6. From point *e*, draw vector $ef \perp EF$ to represent v_{FE}, and from point *d* draw vector *df* // to the path of motion of *F*, which is horizontal, to represent v_F. The vectors *ef* and *df* intersect at *f*.

From Fig. (*b*) measure *df* = 1.1 cm in paper

$$v_F = \text{vector } df = 1.1 \times \frac{1.885}{3} = 0.7 \text{ m/s}$$ **Ans.**

7. $v_{CD} = \text{vector } dc = 3.6 \times \frac{1.885}{3} = 2.26$ m/s

$$\omega_{DC} = \frac{v_{CD}}{DC} = \frac{2.26}{0.45} = 5 \text{ rad/s}$$ ….. (Anticlockwise about *D*) **Ans.**

8. From velocity diagram, we find that v_{CB} ,

   By measurement *bc* = 3.6 cm in paper

$$v_{CB} = \text{vector } bc = 3.6 \times \frac{1.885}{3} = 2.26 \text{ m/s}$$

$$\omega_{CB} = \frac{v_{CB}}{BC} = \frac{2.26}{0.45} = 5 \text{ rad/s}$$ ….. (Anticlockwise about *B*)

We know that rubbing speed at the pin *C*

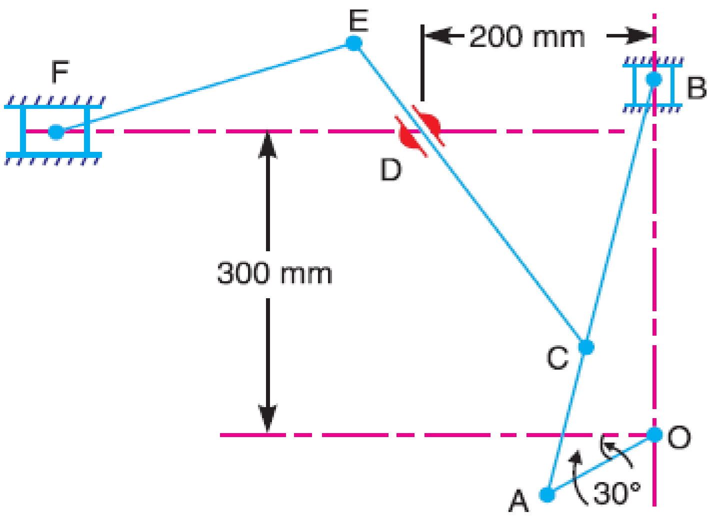
$$= (\omega_{CB} - \omega_{CD})\, r_C = (5 - 5)\, 0.025 = 0$$ **Ans.**

Home work

In a mechanism shown in Figure below, the crank *OA* is 100 mm long and rotates clockwise about *O* at 120 r.p.m. The connecting rod *AB* is 400mm long.

At a point *C* on *AB*, 150 mm from A, the rod *CE* 350 mm long is attached. This rod *CE* slides in a slot in a trunnion at *D*. The end *E* is connected by a link *EF*, 300 mm long to the horizontally moving slider *F*.

For the mechanism in the position shown, find **1.** velocity of F, **2.** velocity of sliding of *CE* in the trunnion, and **3.** angular velocity of *CE*.



Answers

1. v_f = 0.53 m/s.
2. Velocity of sliding of *CE* in the trunnion = v_D = 1.08 m/s.
3. ω_{CE} = 1.26 rad/s.