Title

KINEMATICS OF MACHINES

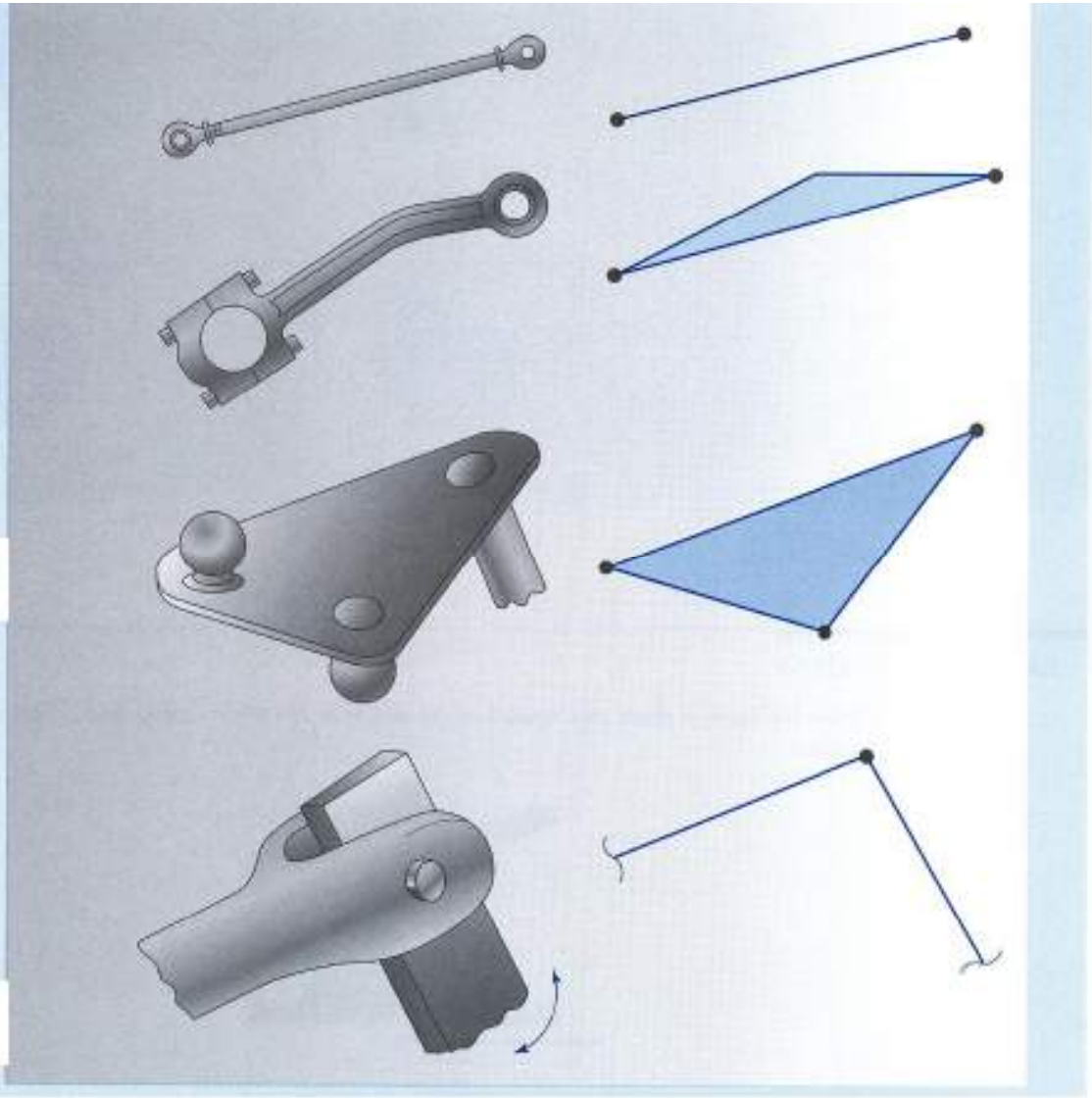
Sub-title

Velocity & Acceleration Analysis

BASICS OF KINEMATICS

- Kinematics
  - Deal with the way things move
- Kinematic analysis
  - Determine
    - Position, displacement, rotation, speed, velocity, acceleration
  - Provide
    - Geometry dimensions of the mechanism
    - Operation range
- Dynamic analysis
  - Power capacity, stability, member load
- Planar mechanism – motion in 2D space

SIMPLE LINKS AND JOINTS



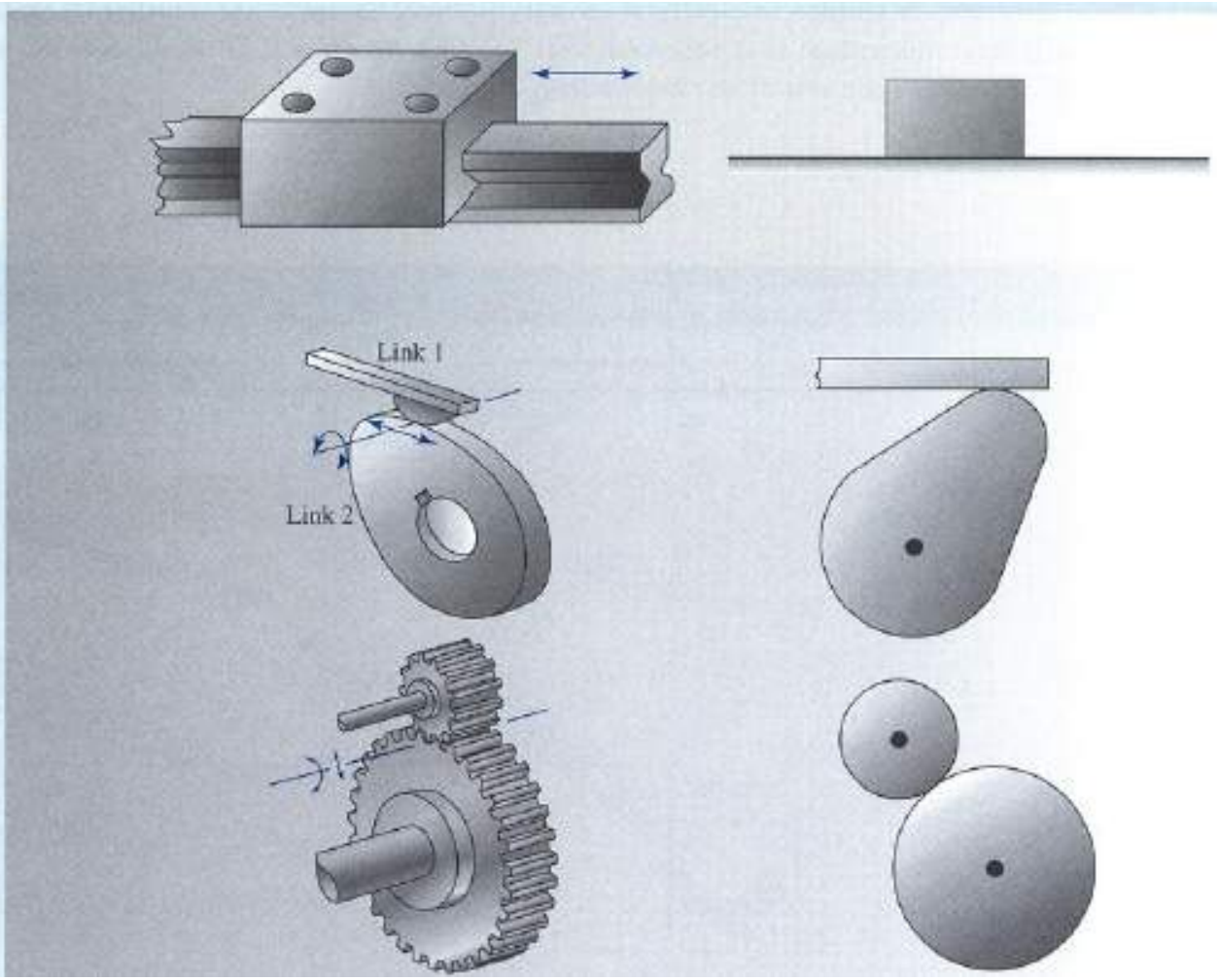
SIMPLE LINKS AND JOINTS

Slider Joint

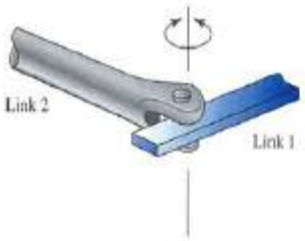
Translation Joint

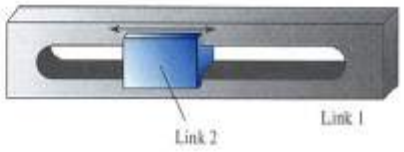
Cam Joint

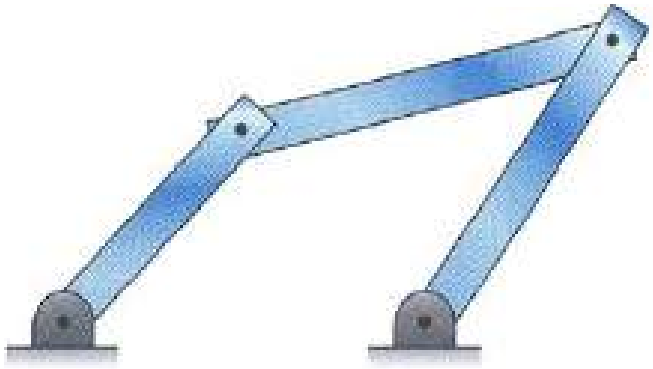
Gear Joint

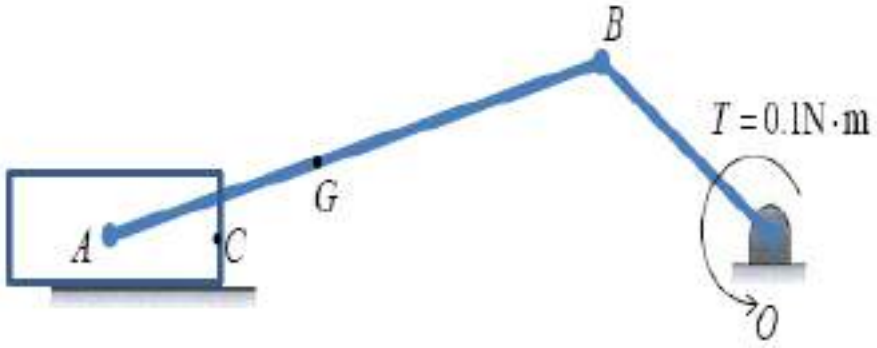


SIMPLE MECHANISMS









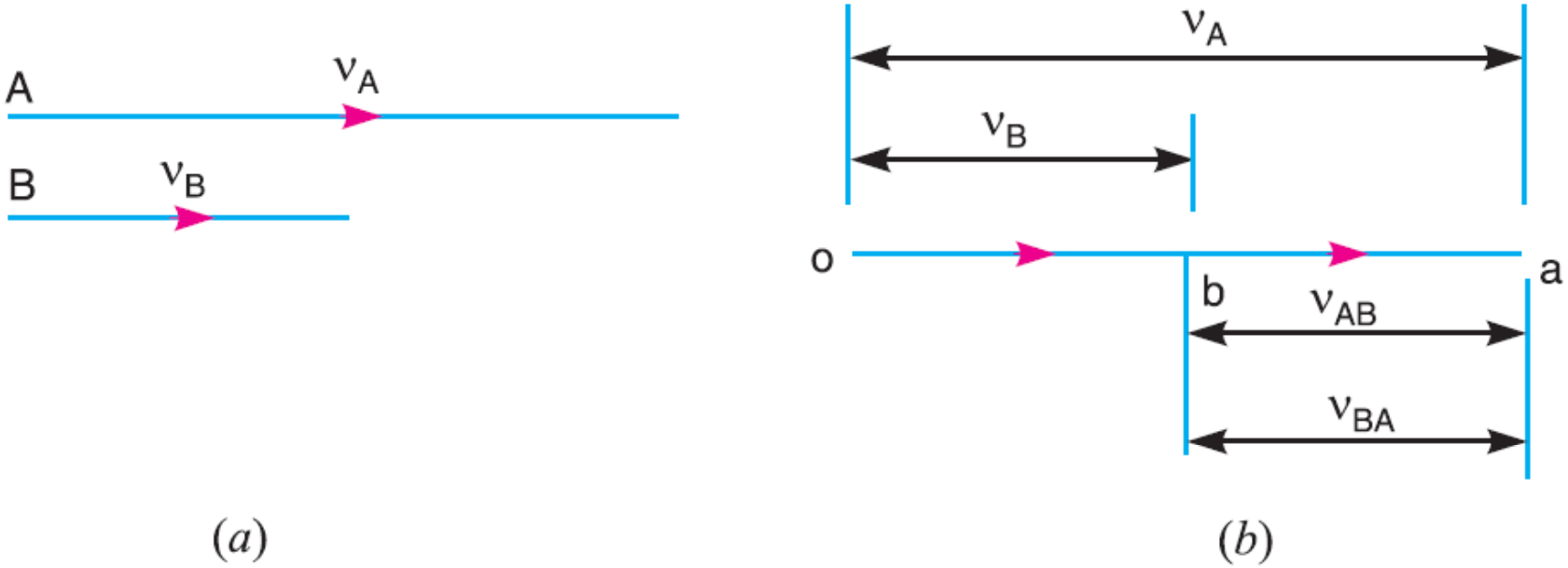
Velocity

Rate of change of displacement is called velocity

Absolute Velocity: Velocity of an object w.r.t a fixed point i.e. velocity of train wrt to a stationary object

Relative velocity: Velocity of an object w.r.t a moving object i.e. velocity of train wrt to other train moving on parallel railway line

Relative Velocity of Two Bodies Moving in Straight Lines



v_{AB}=Velocity of A wrt to B=ba

v_{BA}= Velocity of B wrt to A=ab

ba = - ab

Relative Velocity of Two Bodies Moving in Inclined Lines

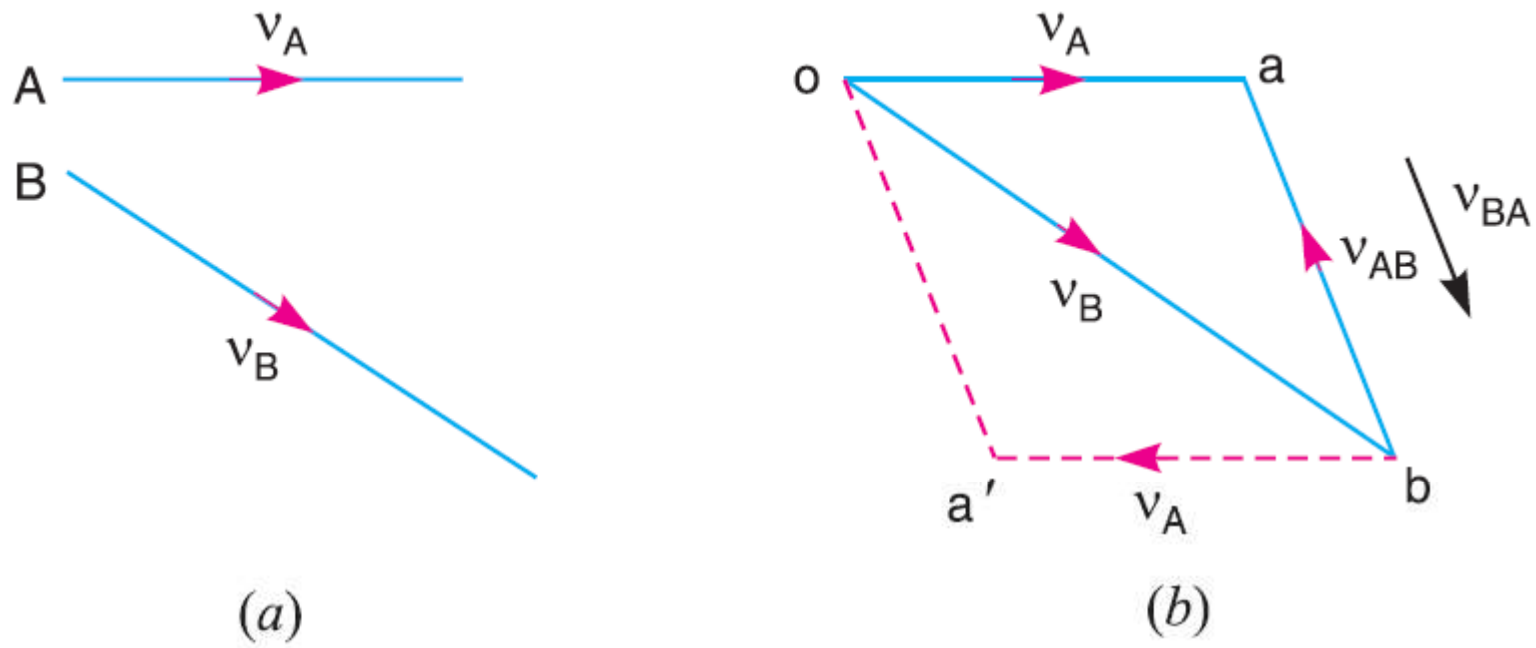


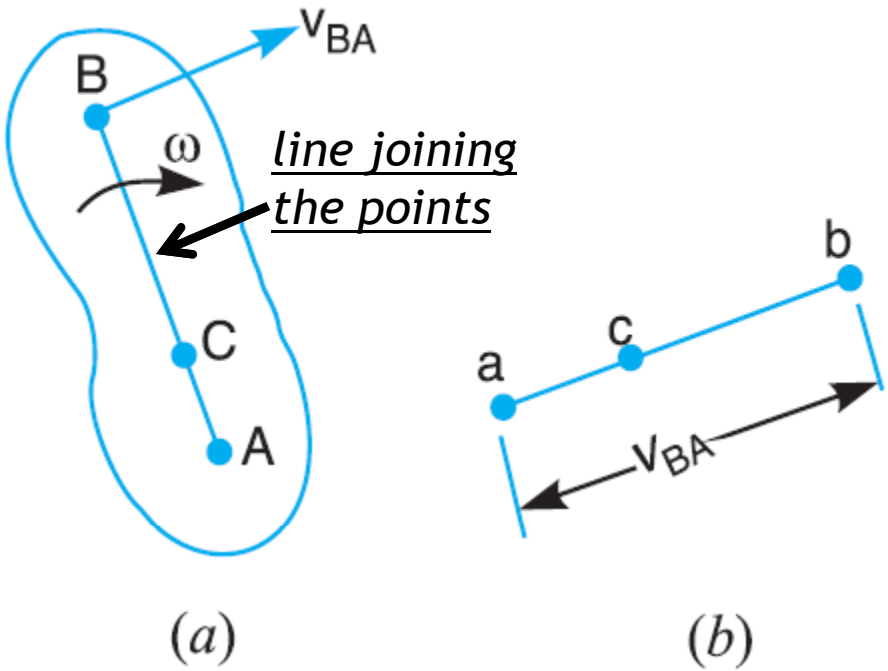
Fig. 7.2. Relative velocity of two bodies moving along inclined lines.

v_{BA} = Vector difference of v_B and $v_A = \overline{v_B} - \overline{v_A}$

v_{BA}= Velocity of B wrt to A=ab

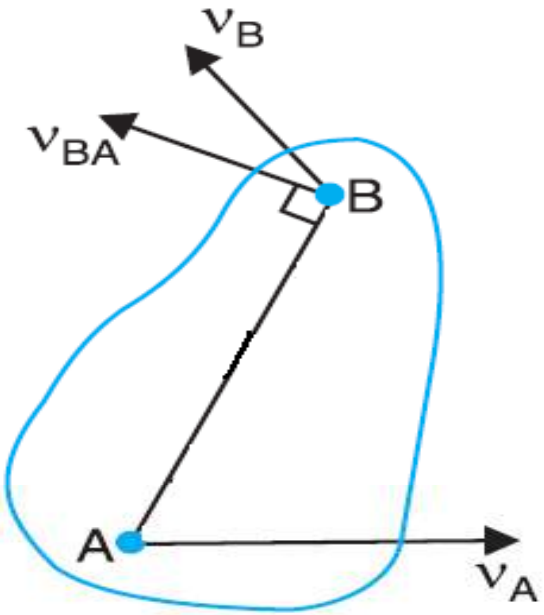
Motion of a Link

velocity of any point on a link with respect to another point on the same link is always perpendicular to the line joining these points on the configuration/line diagram

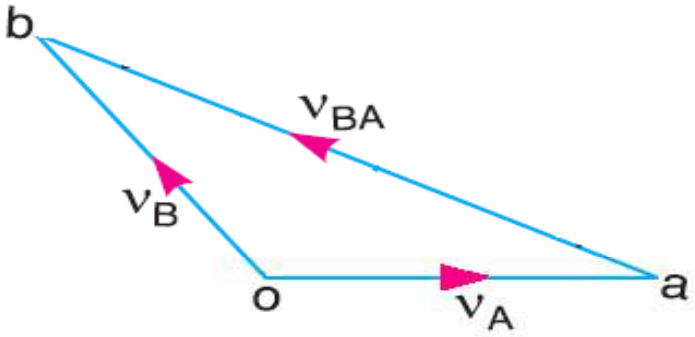


$$\frac{v_{CA}}{v_{BA}} = \frac{\overline{ac}}{\overline{ab}} = \frac{\omega.AC}{\omega.AB} = \frac{AC}{AB}$$

Velocity of a Point on a Link by Relative Velocity Method



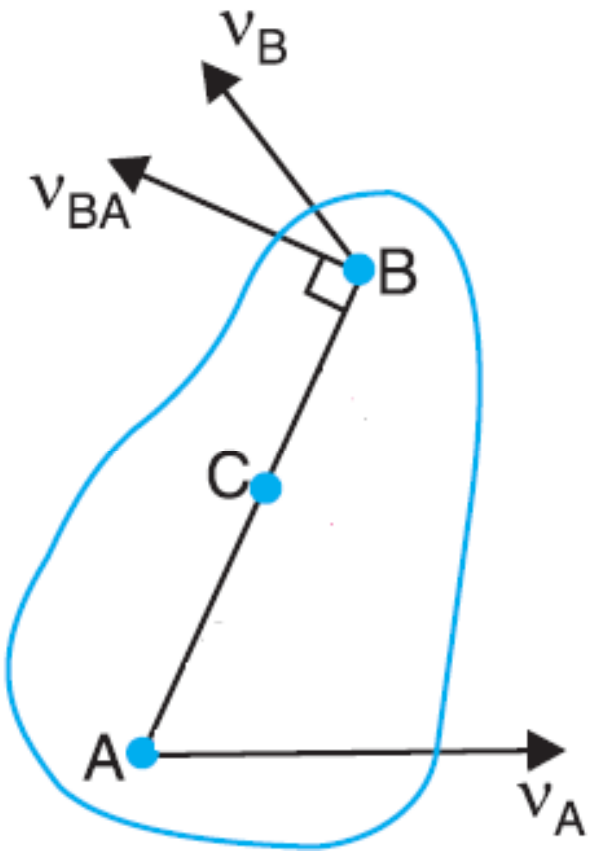
(a) Motion of points on a link.

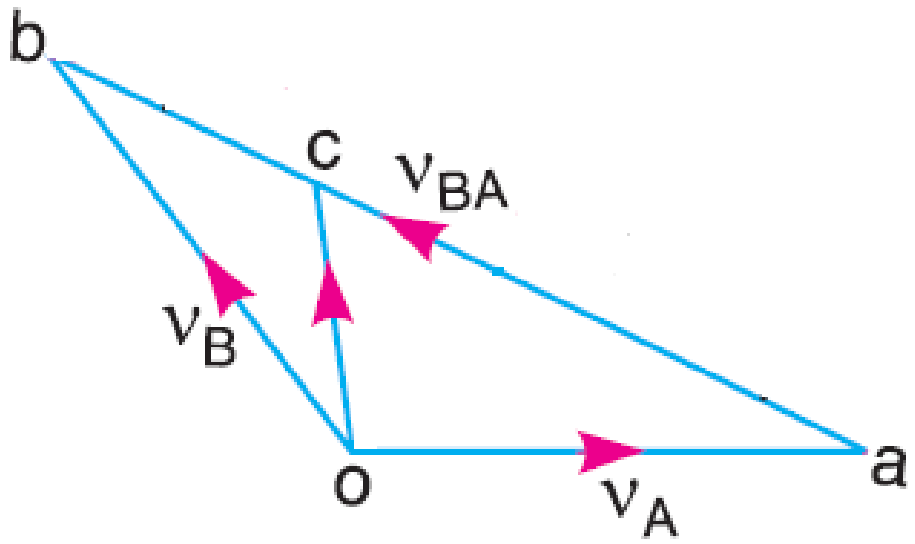


(b) Velocity diagram.

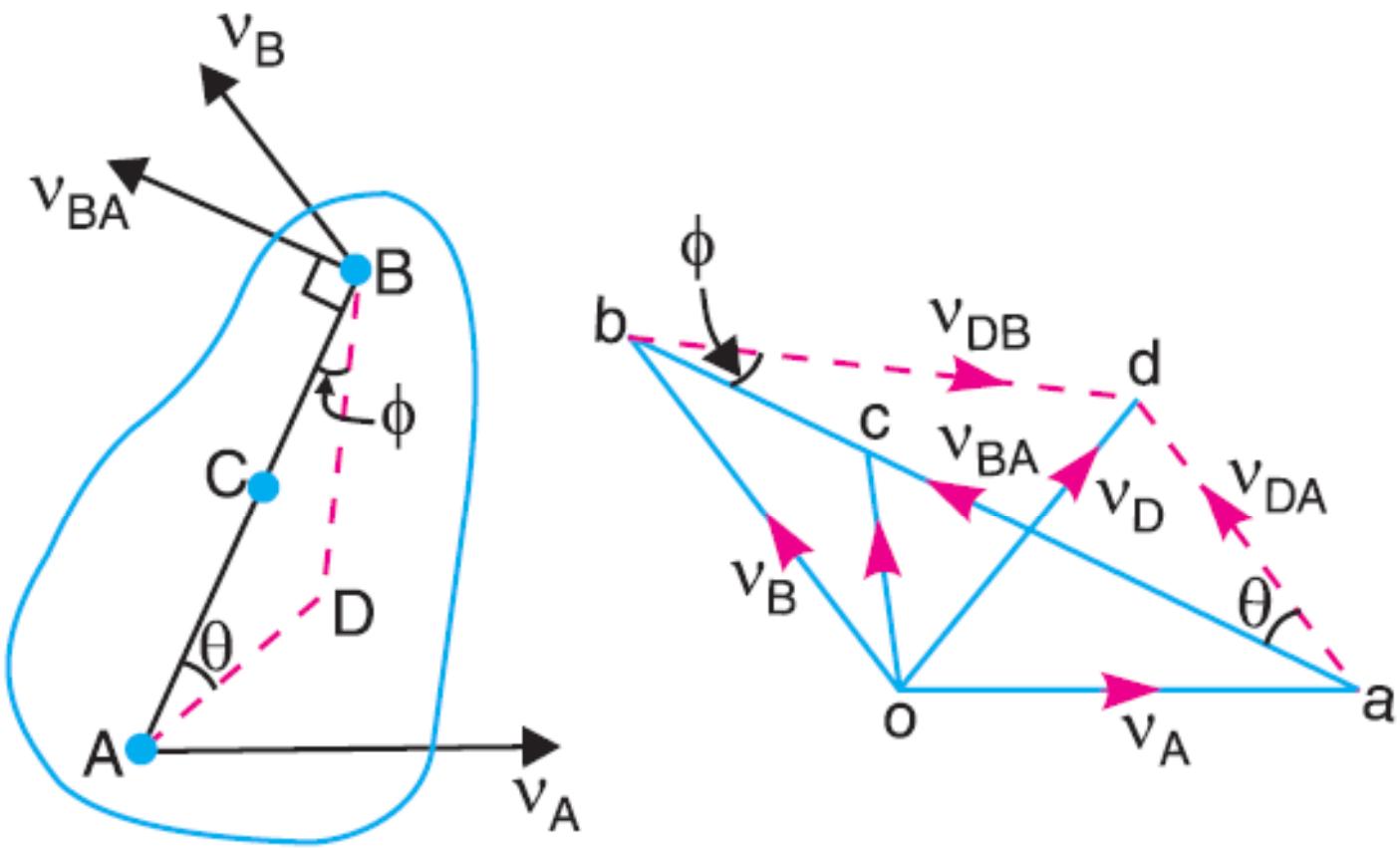
$$\omega_{AB} = \frac{v_{BA}}{AB} = \frac{ab}{AB}$$

Velocity of a Intermediate Point on a Link

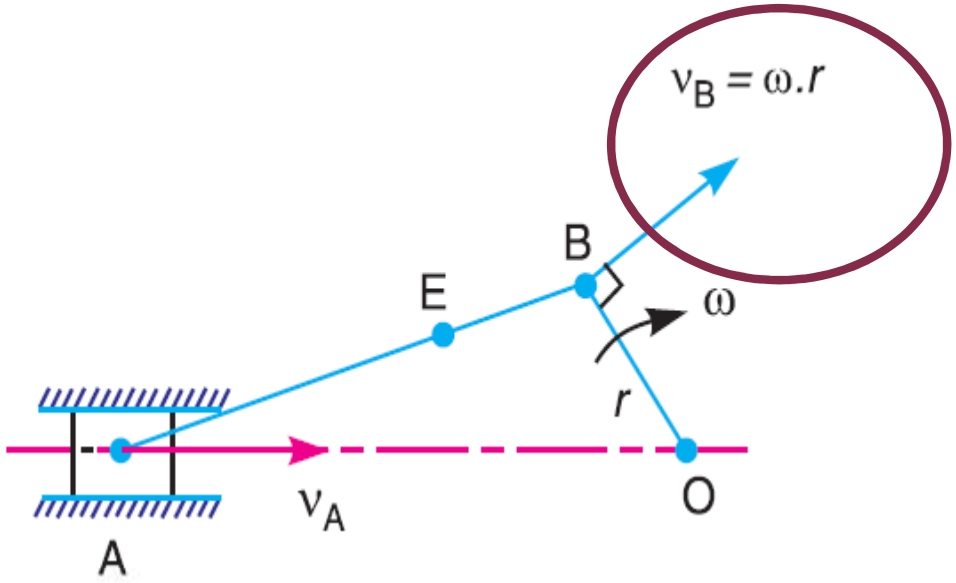




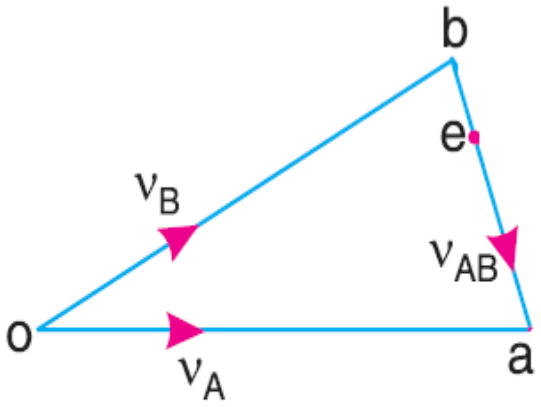
Velocity of an Offset Point on a Link



Velocities in Slider Crank Mechanism



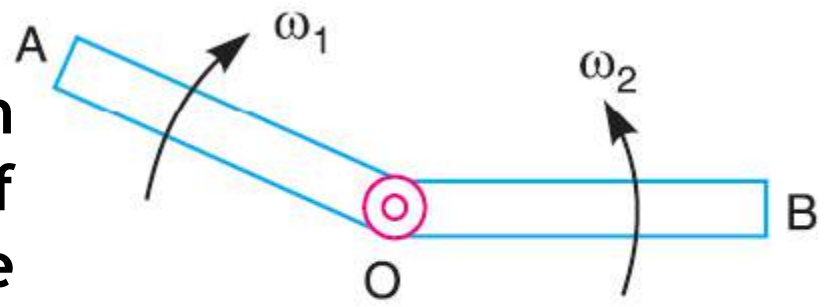
(*a*) Slider crank mechanism.



(*b*) Velocity diagram.

Rubbing Velocity at a Pin Joint

Rubbing velocity: **algebraic sum between angular velocities of two links which are connected by pin joints, multiplied by radius of the pin.**



Links connected by pin joints.

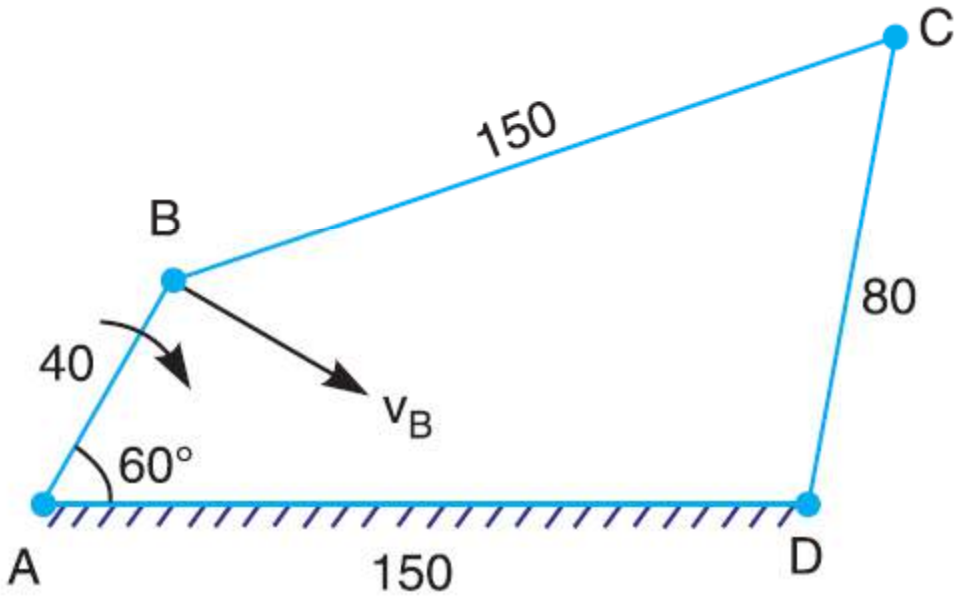
Rubbing velocity at the pin joint O

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

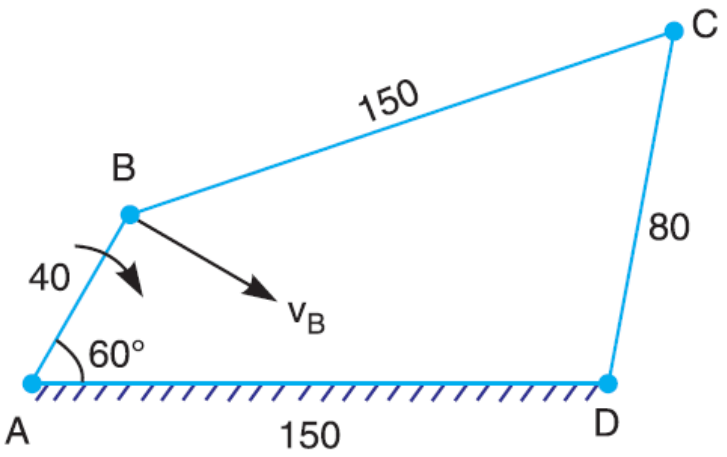
$= (\omega_1 + \omega_2)\, r$, if the links move in the opposite direction

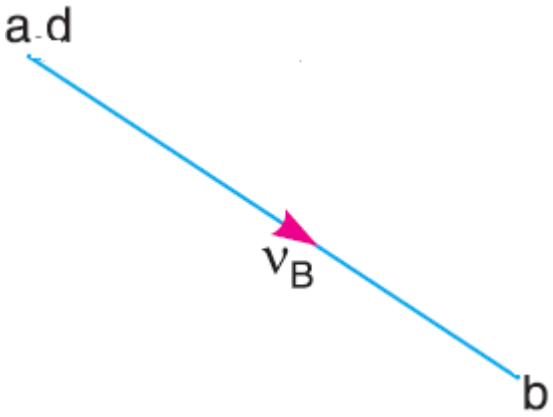
Example 1

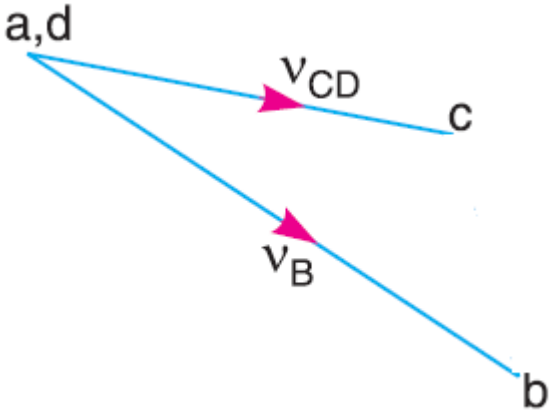
In a four bar chain ABCD, AD is fixed and is 150 mm long. The crank AB is 40 mm long and rotates at 120 rpm cw, while link CD = 80 mm oscillates about D. BC and AD are of equal length. Find the angular velocity of link CD when angle BAD = 60°.

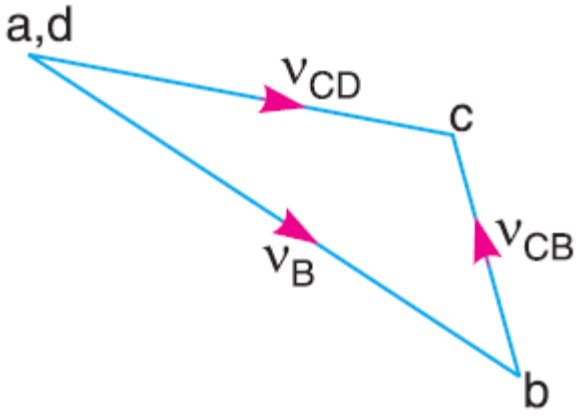


(*a*) Space diagram (All dimensions in mm).


C
150
B
80
40
v_B
60°
A
150
D


a,d
v_B
b


a,d
v_{CD}
c
v_B
b


a,d
v_{CD}
c
v_{CB}
v_B
b

Example 2

The crank and connecting rod of a theoretical steam engine are 0.5 m and 2 m long respectively. The crank makes 180 rpm in the cw direction. When it has turned 45° from the inner dead center position, determine :

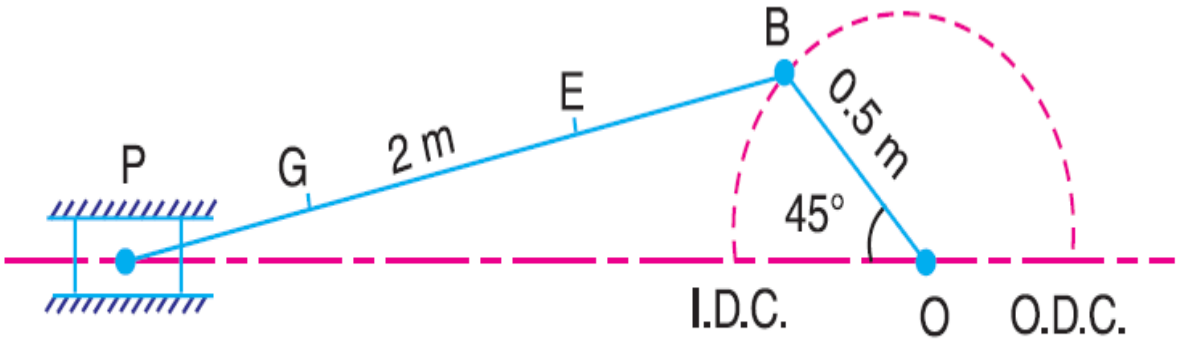
1. Velocity of piston

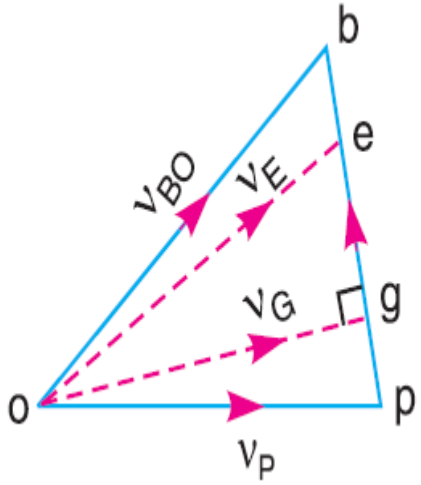
2. Angular velocity of connecting rod

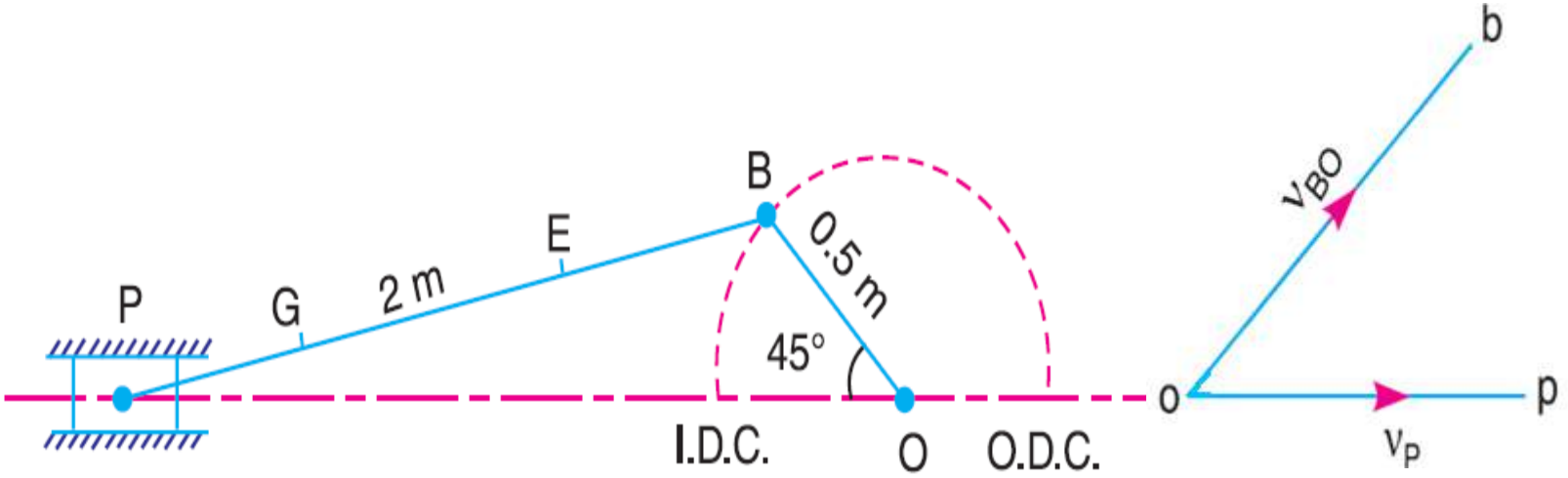
3. Velocity of point E on the connecting rod 1.5 m from the gudgeon pin

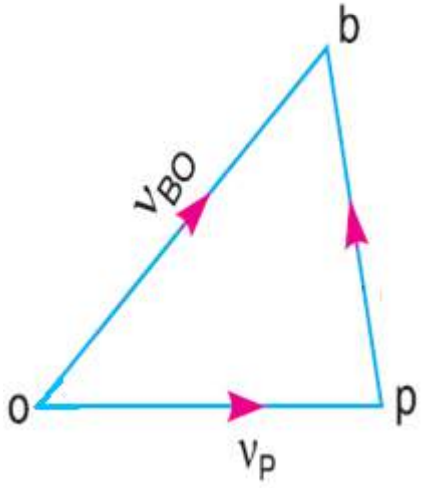
4. Velocities of rubbing at the pins of the crank shaft, crank and crosshead when the diameters of their pins are 50 mm, 60 mm and 30 mm respectively

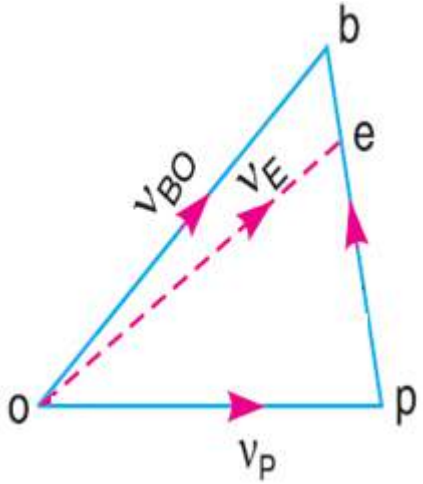
5. Position and linear velocity of any point G on the connecting rod which has the least velocity relative to crank shaft.

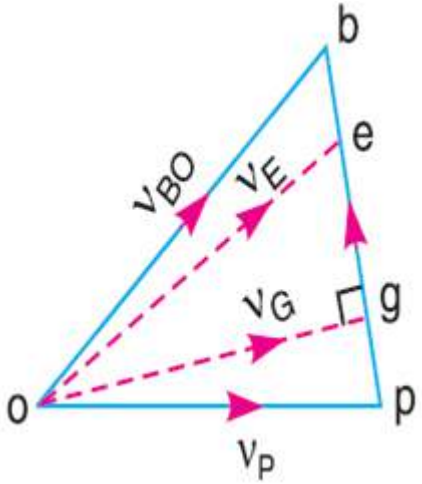





P
G
2 m
E
B
0.5 m
45°
I.D.C.
O
O.D.C.
b
v_{BO}
o
p
v_P

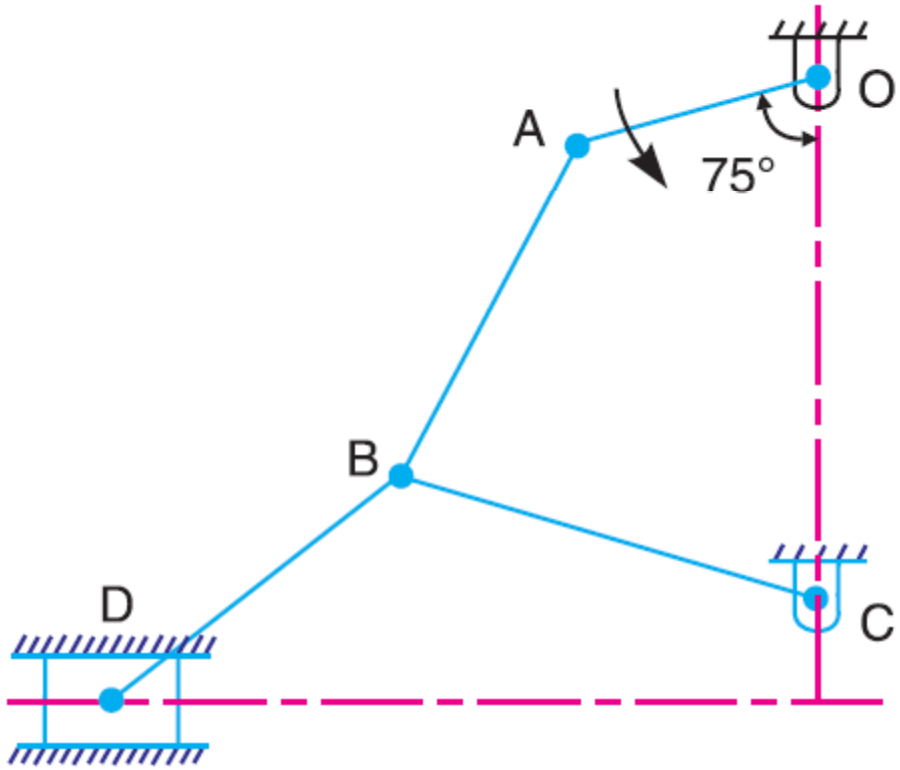

b
v_{BO}
o
p
v_P

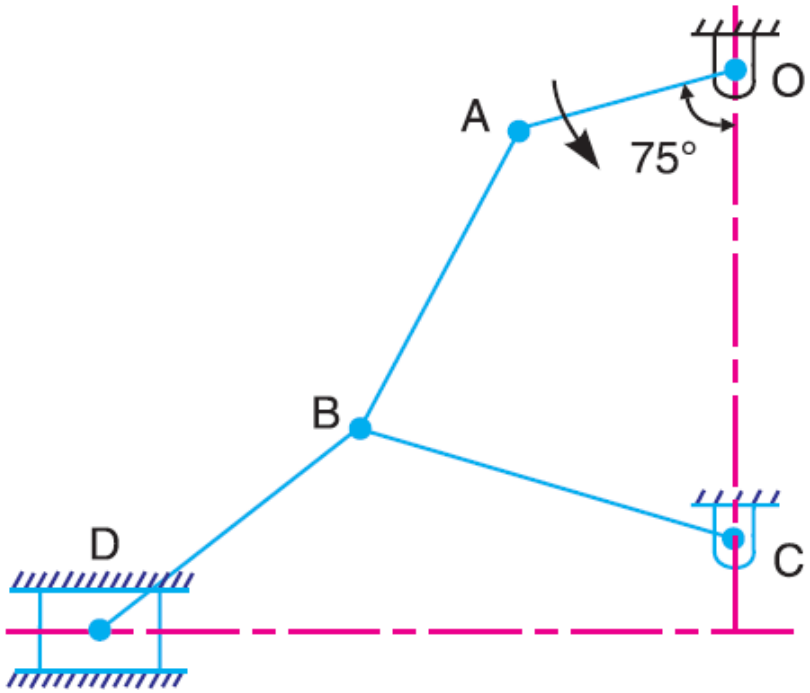

b
v_{BO}
v_E
e
o
p
v_P


b
v_{BO}
v_E
e
v_G
g
o
p
v_P

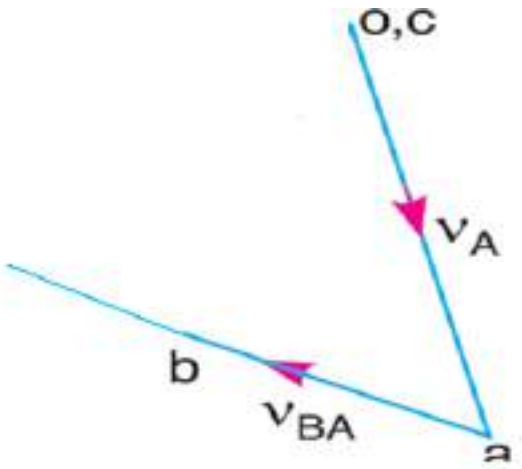
Example 3

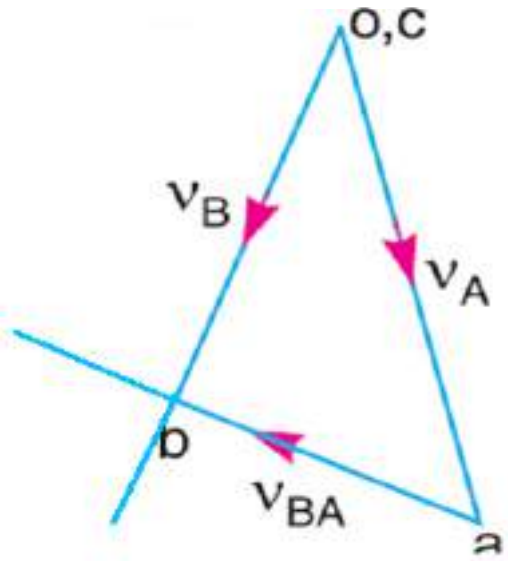
In the Figure, the angular velocity of crank OA is 600 rpm. Determine the linear velocity of slider D and angular velocity of link BD, when the crank is inclined at an angle of 75° to the vertical. The dimensions of various links are: OA = 28 mm ; AB = 44 mm ; BC 49 mm ; and BD = 46 mm. The center distance between the centers of rotation O and C is 65 mm. The path of travel of the slider is 11 mm below the fixed point C. The slider moves along a horizontal path and OC is vertical.

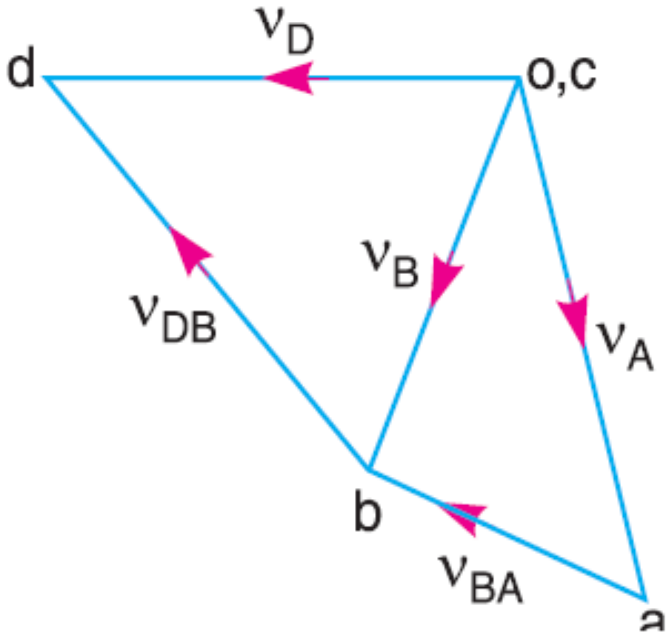



A
O
75°
B
D
C


o,c
v_A
a


o,c
v_A
b
v_{BA}
a


o,c
v_B
v_A
b
v_{BA}
a


d
v_D
o,c
v_B
v_{DB}
v_A
b
v_{BA}
a