By measurement, we find that velocity of piston P,

v_P = *vector op = 8.15 m/s* ***Answer.***

2. Angular velocity of connecting rod

From the velocity diagram, we find that the velocity of P with respect to B,

v_{PB} = *vector bp = 6.8 m/s*

Since the length of connecting rod PB is 2 m, therefore angular velocity of the connecting rod,

$$\omega_{PB} = \frac{v_{PB}}{PB} = \frac{6.8}{2} = 3.4 \text{ rad/s (Anticlockwise)}$$ ***Answer.***

3. ***Velocity of point E on the connecting rod***

The velocity of point *E* on the connecting rod 1.5 m from the gudgeon pin (*i.e.* *PE* = 1.5 m) is determined by dividing the vector *bp* at *e* in the same ratio as *E* divides *PB* in Figure 2 (*a*). This is done in the similar way as discussed in Art 7.6. Join *oe*. The vector *oe* represents the velocity of *E*. By measurement, we find that velocity of point *E*,

v_E = vector *oe* = 8.5 m/s **Answer.**

Note : The point *e* on the vector *bp* may also be obtained as follows :

$$\frac{BE}{BP} = \frac{be}{bp} \quad \text{or} \quad be = \frac{BE \times bp}{BP}$$

4. ***Velocity of rubbing***

We know that diameter of crank-shaft pin at *O*,

d_O = 50 mm = 0.05 m

Diameter of crank-pin at *B*,

d_B = 60 mm = 0.06 m

and diameter of cross-head pin,

d_C = 30 mm = 0.03 m

We know that velocity of rubbing at the pin of crank-shaft

$$= \frac{d_O}{2} \times \omega_{BO} = \frac{0.05}{2} \times 18.85 = 0.47 \text{ m/s} \quad \textbf{Ans.}$$

Velocity of rubbing at the pin of crank

$$= \frac{d_B}{2} (\omega_{BO} + \omega_{PB}) = \frac{0.06}{2} (18.85 + 3.4) = 0.6675 \text{ m/s} \quad \textbf{Ans.}$$

...($\because$ ω_{BO} is clockwise and ω_{PB} is anticlockwise.)

and velocity of rubbing at the pin of cross-head

$$= \frac{d_C}{2} \times \omega_{PB} = \frac{0.03}{2} \times 3.4 = 0.051 \text{ m/s} \quad \textbf{Ans.}$$

...($\because$ At the cross-head, the slider does not rotate and only the connecting rod has angular motion.)

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

The position of point *G* on the connecting rod which has the least velocity relative to crankshaft is determined by drawing perpendicular from *o* to vector *bp*. Since the length of *og* will be the least, therefore the point *g* represents the required position of *G* on the connecting rod.

By measurement, we find that

vector *bg* = 5 m/s

The position of point *G* on the connecting rod is obtained as follows:

$$\frac{bg}{bp} = \frac{BG}{BP} \quad \text{or} \quad BG = \frac{bg}{bp} \times BP = \frac{5}{6.8} \times 2 = 1.47 \text{ m} \quad \textbf{Ans.}$$

By measurement, we find that the linear velocity of point *G*,

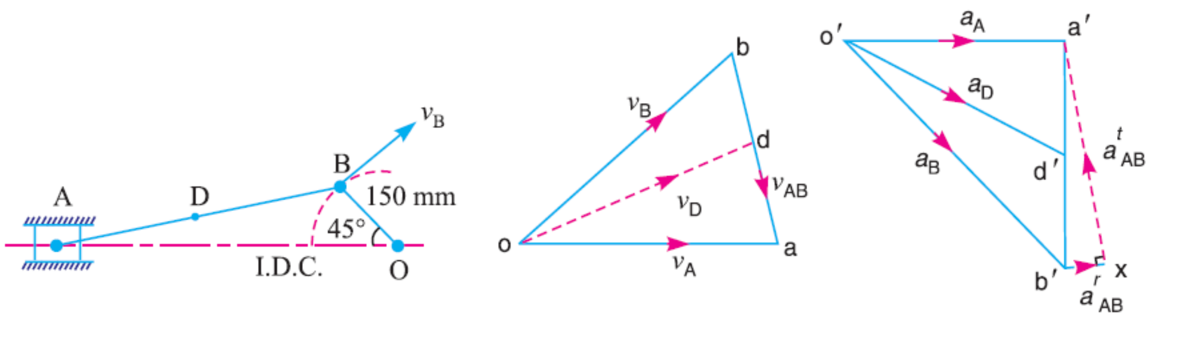
$$v_G = \text{vector } og = 8 \text{ m/s} \quad \textbf{Ans.}$$

Example 3. *The crank of a slider crank mechanism rotates clockwise at a constant speed of 300 r.p.m. The crank is 150 mm and the connecting rod is 600 mm long. Determine:* **1.** *Linear velocity and acceleration of the midpoint of the connecting rod, and* **2.** *angular velocity and angular acceleration of the connecting rod, at a crank angle of 45° from inner dead centre position.*

Solution. *Given :* $N_{BO} = 300$ *r.p.m. or* $\omega_{BO} = 2\pi \times 300/60 = 31.42$ *rad/s; OB = 150 mm = 0.15 m ; BA = 600 mm = 0.6 m*

We know that linear velocity of B with respect to O or velocity of B,

$v_{BO} = v_B = \omega_{BO} \times OB = 31.42 \times 0.15 = 4.713$ *m/s... (Perpendicular to BO)*



(*a*) Space diagram. (*b*) Velocity diagram. (*c*) Acceleration diagram.

Figure. 3

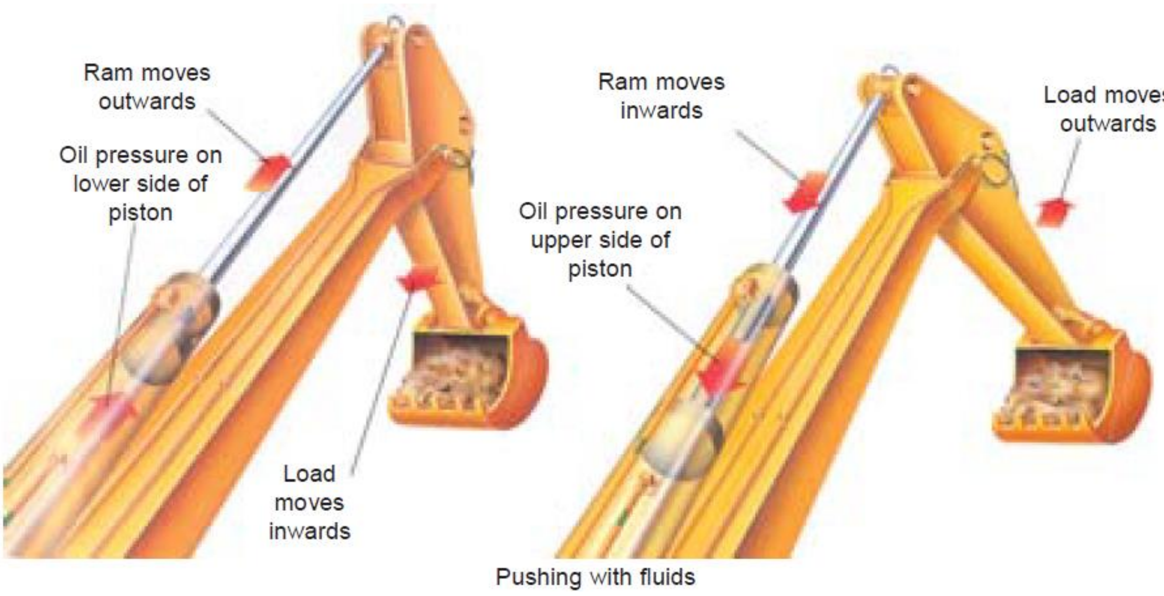


Figure. 4

1. ***Linear velocity of the midpoint of the connecting rod***

First of all, draw the space diagram, to some suitable scale; as shown in Figure 3 (*a*). Now the velocity diagram, as shown in Figure 3 (*b*), is drawn as discussed below:

1. Draw vector *ob* perpendicular to *BO*, to some suitable scale, to represent the velocity of

B with respect to *O* or simply velocity of *B i.e.* v_{BO} or v_B, such that

vector *ob* = $v_{BO} = v_B = 4.713$ m/s

2. From point *b*, draw vector *ba* perpendicular to *BA* to represent the velocity of *A* with respect to *B i.e.* v_{AB} , and from point *o* draw vector *oa* parallel to the motion of *A* (which is along *AO*) to represent the velocity of *A i.e.* v_A. The vectors *ba* and *oa* intersect at *a*.

By measurement, we find that velocity of *A* with respect to *B*,

$$v_{AB} = \text{vector } ba = 3.4 \text{ m/s}$$

and

$$\text{Velocity of } A,\ v_A = \text{vector } oa = 4 \text{ m/s}$$

3. In order to find the velocity of the midpoint *D* of the connecting rod *AB*, divide the vector *ba* at *d* in the same ratio as *D* divides *AB*, in the space diagram. In other words,

$$bd/ba = BD/BA$$

Note: Since *D* is the midpoint of *AB*, therefore *d* is also midpoint of vector *ba*.

4. Join *od*. Now the vector *od* represents the velocity of the midpoint *D* of the connecting rod *i.e.* v_D.

By measurement, we find that

$$v_D = \text{vector } od = 4.1 \text{ m/s} \quad \textbf{Ans.}$$

Acceleration of the midpoint of the connecting rod

We know that the radial component of the acceleration of *B* with respect to *O* or the acceleration of *B*,

$$a^r_{BO} = a_B = \frac{v^2_{BO}}{OB} = \frac{(4.713)^2}{0.15} = 148.1 \text{ m/s}^2$$

and the radial component of the acceleraiton of *A* with respect to *B*,

$$a^r_{AB} = \frac{v^2_{AB}}{BA} = \frac{(3.4)^2}{0.6} = 19.3 \text{ m/s}^2$$

Now the acceleration diagram, as shown in Fig. 8.4 (*c*) is drawn as discussed below:

1. Draw vector *o′b′* parallel to *BO*, to some suitable scale, to represent the radial component of the acceleration of *B* with respect to *O* or simply acceleration of *B i.e.* a^r_{BO} or a_B, such that

$$\text{vector } o'b' = a^r_{BO} = a_B = 148.1 \text{ m/s}^2$$

Note: Since the crank *OB* rotates at a constant speed, therefore there will be no tangential component of the acceleration of *B* with respect to *O*.

2. The acceleration of *A* with respect to *B* has the following two components:

(*a*) The radial component of the acceleration of *A* with respect to *B i.e.* a^r_{AB}, and

(*b*) The tangential component of the acceleration of *A* with respect to *B i.e.* a^t_{AB}. These two components are mutually perpendicular.

Therefore from point *b′*, draw vector *b′x* parallel to *AB* to represent $a^r_{AB} = 19.3 \text{ m/s}^2$ and from point *x* draw vector *xa′* perpendicular to vector *b′x* whose magnitude is yet unknown.

3. Now from *o′*, draw vector *o′a′* parallel to the path of motion of *A* (which is along *AO*) to represent the acceleration of *A i.e.* a_A . The vectors *xa′* and *o′a′* intersect at *a′*. Join *a′b′*.