* امثلة تطبيقية على السرعة والتعجيل

* Example on Velocity and acceleration

1) Example (1) :

In four bar mechanism ABCD as shown in fig(1), AD is fixed and is (15 cm) Long, AD and BC are of equal length, the Crank AB is (4 cm) Long and rotates at (120) r.p.m in cloelcwise, while the link CD is (8 cm) oscillates about D. Determine the Followings when angle (BAD = 60°)

A- Draw space diagram with suitable scale,
B - Draw Velocity diagram with suitable scale,
C - Draw acceleration diagram with suitable Scale, and find the angular acceleration of the link (CD)

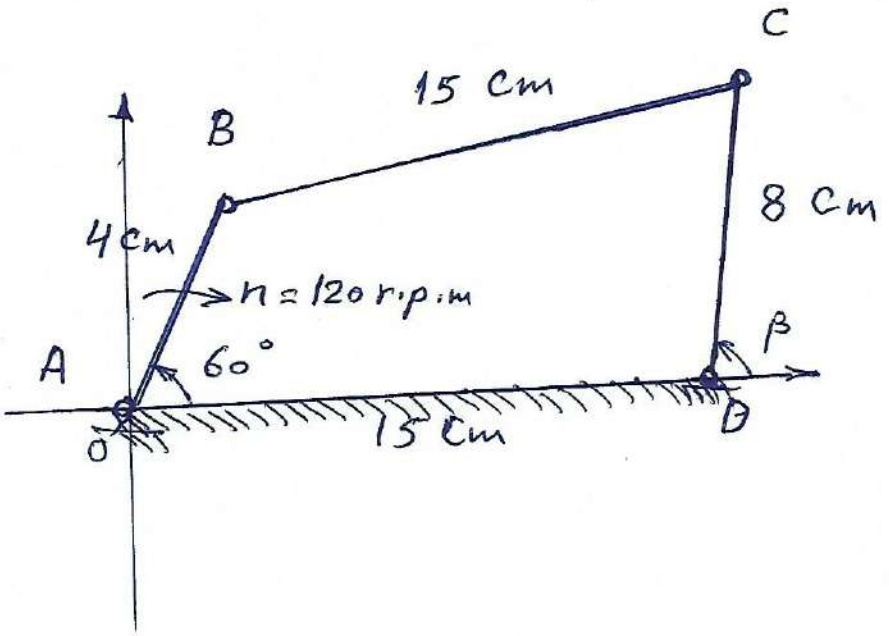


Fig (1)

Q1 : Answer

I) Draw Space diagram with Suitable scale.
Take Scale 1cm = 5 mm

$\therefore K_l = \frac{AB}{\bar{AB}} = \frac{4}{4*5} = \frac{1}{5}$

$\therefore$ | $\bar{AB} = 4 \times 5 = 20$ mm
| $BC = 15 * 5 = 75$ mm
| $CD = 8 * 5 = 40$ mm

II) Velocity diagram
By Calculating velocity of link AB

$V_{AB} = V^t_{AB} + V^r_{AB} = V_B = \omega_{AB} * AB$ ($V^t_{AB} = 0$) · $V = \omega * r$

$\omega_{AB} = \frac{2\pi n}{60} = \frac{2 * 3.14 * 120}{60} = 12.568$ rad/s

$\therefore V_B = 12.568 * 4 = 5,03$ Cm/s

Assume Scale for v
1 Cm/s = 10 mm

$\therefore K_v = \frac{V_P}{\bar{V_P}} = \frac{5,03}{5,03 * 10} = 0,1$

Draw V-D by taking pole $a \equiv d$
From A draw line // VB = 50,3 mm
then from b draw line ⊥ BC
and from d draw line ⊥ CD

X C < CB = VcB =
cd = VcD =

$\therefore$ | $V_{CB} = 22 * 0,1 = 2,2$ Cm/s
| $V_{CD} = 21 * 0,1 = 2,1$ Cm/s

* Angular velocity of link CD

$\omega_{CD} = \frac{V_{CD}}{CD} = \frac{2,2}{8} = 0,275$ rad/s

III - Acceleration diagram

$A^{BA}_{AB} = A^{r\,BA}_{AB} + A^{t=0\,BA}_{AB} = A^{r\,BA}_{AB}$ for fixed point A

$\therefore A^{BA}_{AB} = A^{r}_{AB\,BA} = \frac{(V^{BA}_{AB})^2}{AB_{BA}} = \frac{(5.3)^2}{4}$ cm/s^2 $= 6,25$ cm/s^2.

also $A^{r\,BA}_{AB} = \omega^2 * AB_{BA}$ cm

Assume Scale $1\ cm/s^2 = 10$ mm

$\therefore K_A = \frac{A_{AB}}{A\bar{A}B} = \frac{6.25}{6.25 \times 10} = \frac{6.25}{6.25 \times 10} = 0,1$

Take pole $A \equiv D$ and draw

A^{r}_{AB} from B to A $= 62.5$ mm

$A_{CB} = A^{r}_{CB} + A^{t}_{CB}$

$\therefore A^{r}_{CB} = \frac{(V_{CB})^2}{CB} = \frac{(2,2)^2}{15} = 0,322\ cm/s^2$

$\therefore A^{r}_{CB} = \frac{0,322}{0,1} = 3,22$ mm

and $A^{r}_{CD} = \frac{(V_{CD})^2}{CD} = \frac{2,1}{8} = 0,26\ cm/s^2$

$\therefore A^{r}_{CD} = \frac{0,26}{0,1} = 2,6$ mm

$\therefore \frac{A^{t}_{CB}}{A^{t}_{CD}} \times c <$ $xc = A^{t}_{CB} = 60 * 0,1 = 6\ cm/s^2$

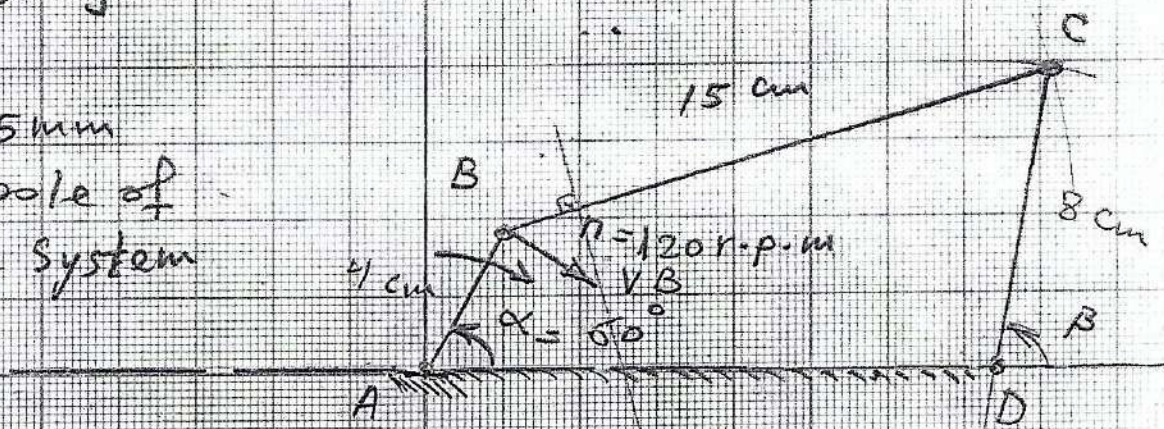
$yc = A^{t}_{CD} = 62 * 0,1 = 6,2\ cm/s^2$

$\therefore \alpha_{CD} = \frac{A^{t}_{CD}}{CD} = \frac{6,2}{8} = 0,775\ cm/s^2$

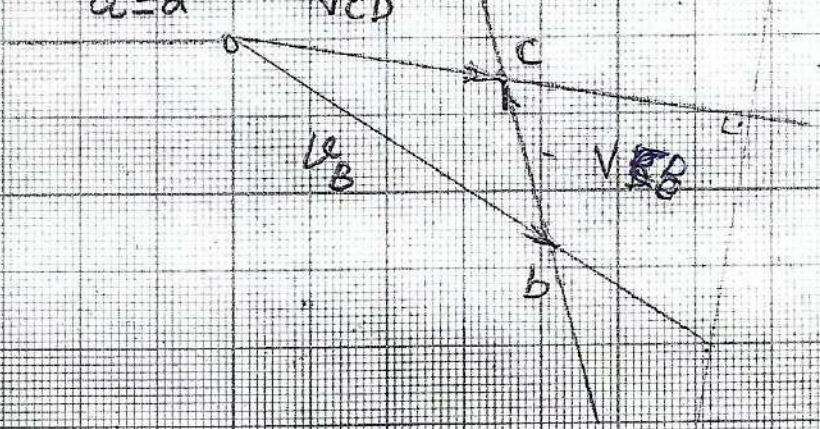
I- Space diagram
S - D

scale 1cm = 5mm

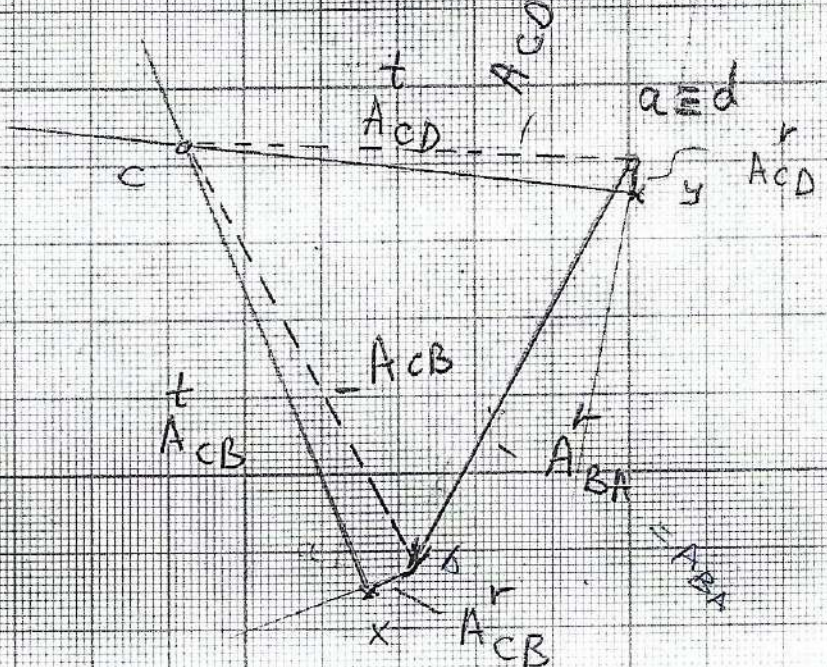
By taking pole of Coordinate System (A) ≡ D



II) V - D
with scale
1 cm/s = 10 mm
By taking Pole a ≡ d



III) A - D
with scale
$1 cm/s^2 = \frac{1}{10}$ mm
By taking pol a ≡ d



* 2) Example (2):

In the slider crank mechanism, as shown in fig (2), the crank (OB) rotates clock wise at a constant speed of (300) r.p.m, If the crank (OB) is (0,15) m long, and the connecting rod BA is (0,6) m long. Determine the followings:

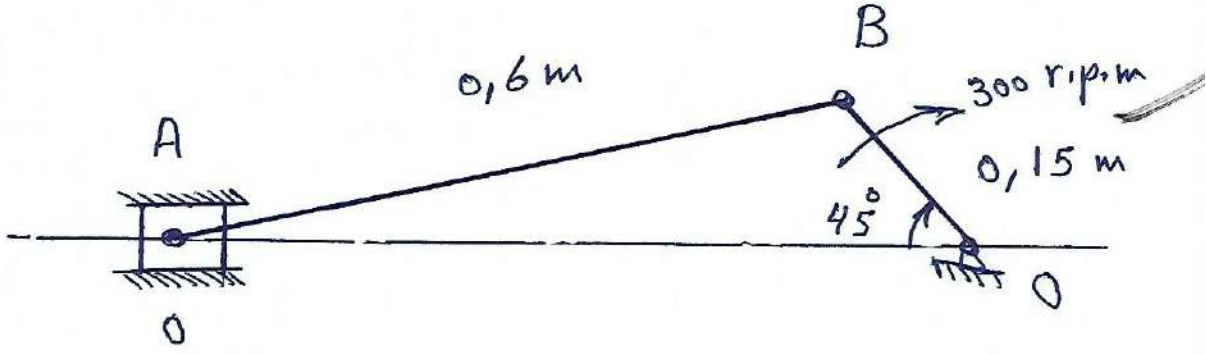
1 - Draw space diagram with suitable scale, when the angle (BOA = 45°).

2) Draw velocity diagram with suitable diagram.

3) Draw acceleration diagram with suitable scale.

4) Find the angular velocity and angular acceleration of Connecting rod (BA).

Fig (2)



Q 2 Solution

I) Draw space diagram with Suitable Scale:

i) Assume scale 1m = 100 mm for length.

$K_l = \frac{OB\ m}{OB\ mm} = \frac{0,15}{0,15 * 100} = 0,01\ \frac{m}{mm}$

$\therefore OB = \frac{0,15}{0,01} = 15\ mm$

$BA = \frac{0,6}{0,01} = 60\ mm$

II) Velocity diagram V-D

$V_{BO} = \omega_{BO} * OB = 31,42 * 0,15 = 4,713 m/s$

$\omega_{BO} = \frac{2\pi N}{60} = \frac{2 * 3,14 * 3000}{60} = 31,42\ rad/s$

i) Assume scal for v 1 m/s = 6,6 mm

$\therefore K_v = \frac{V_{BO}}{bo} = \frac{4,713}{4,713 * 6,6} = 0,134\ \frac{m/s}{mm}$

$\therefore V_{BO} = 4,713 m/s = 31,1 mm$

$V_{BA} = ba * K_v = 25 * 0,134 = 3,4 m/s$

$V_{AO} = AO * K_v = 30 * 0,134 = 4 m$

III) acceleration diagram A-D.

$A_{BO} = A^r_{BO} + A^t_{BO} = A^r_{BO} = \frac{V^2_{BO}}{BO} = \frac{(4,713)^2}{0,15} = 148,1\ m/s^2$

assume Scale $1\ m/s^2 = 0,236$

$\therefore K_A = \frac{AB^r_O}{AB^r_O} = \frac{AB^r_O}{AB^r_O * 0,236} = \frac{148}{148 * 0,236} = 4,3\ \frac{m/s^2}{mm}$

$\therefore AB^r_O = \frac{148,1}{4,3} = 34,4\ mm$

Draw AB^r_O from B to O, = 34,4 mm

$A_{AB} \rightarrow A^r_{AB} = \frac{V^2_{AB}}{AB} = \frac{(3,4)^2}{0,6} = 19,3\ m/s^2$

$\rightarrow A^t_{AB}$

- 3 - تكملة اجوبة الامتحان النهائي ٢٠١٥ - ٢٠١٦ السنة الثالثة
المادة: تطبيقات ميكانيك نموذج (ب) المدرس: د. سامي محسن

Q1/ تكملة نموذج (ب)

$$A_{AO} = A^{t}_{AO} + A^{r}_{AO} = A^{t}_{AO} \qquad (A^{r}_{AO} = 0)$$

$$A^{t}_{AB} \times a \left\langle \begin{array}{l} oa = A_{AO} = oa * KA = \\ ax = A^{t}_{AB} = ax * KA = \end{array} \right.$$
A^{t}_{AO}

$$\therefore A^{t}_{AO} = 25 * 4,3 = 107.5 \ m/s^2$$

$$A^{t}_{AB} = 24 * 4,3 = 103,8 \ m/s^2$$

and $A_{AB\,total} = 28,6 * 4,3 = 122,8 \ m/s^2$

IV) 1) angular velocity of AB

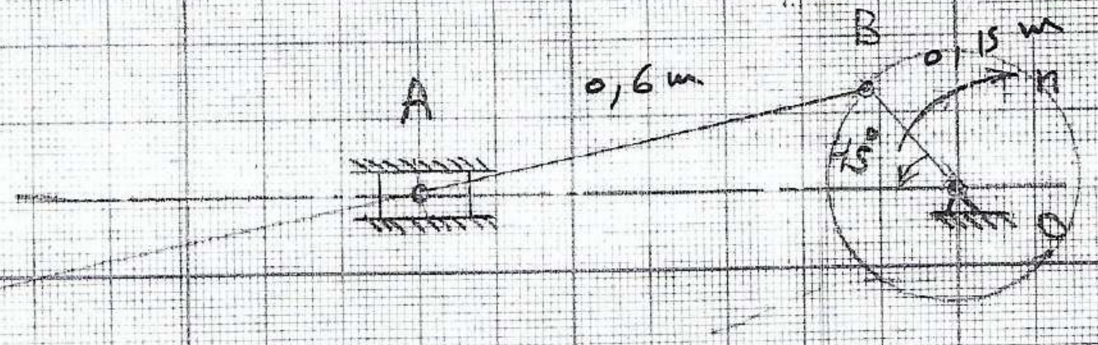
$$\omega_{AB} = \frac{V_{AB}}{AB} = \frac{3,4}{0,6} = 5,67 \ rad/s$$

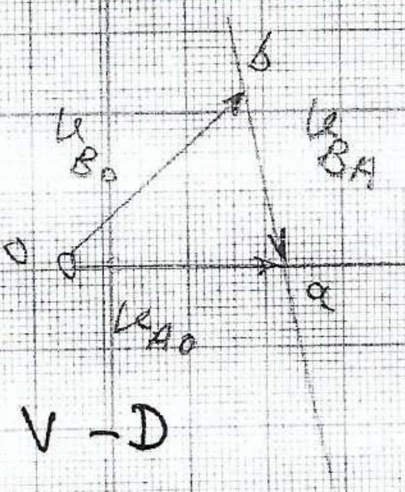
V) angular acceleration of AB

$$\alpha = \frac{a^{t}_{AB}}{AB} = \frac{103}{0,6} = 171,67 \ rad/s^2$$

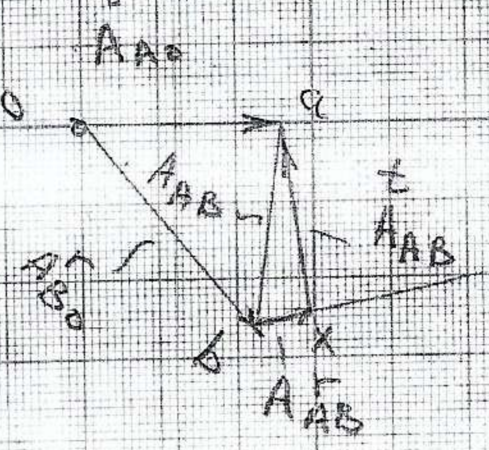
Q1 حل

I) Draw D-S-D





II - V - D



III) A - D

3) Example(3)

In the figure (3) as shown below, the Crank (OA) rotates at speed (20) r.p.m anticlockwise, and gives motion to the sliding blocks B and D. The dimensions of the various links are (OA = 0,3) m , (AB = 1,2) m , (Bc = 0,45) m and (CD = 0,45) m .

Determine the followings when the ang ($AOB = 30^\circ$)

1- Space diagram with suitable scale.
2) Velocity diagram with suitable scale,
3) linear acceleration of the slider D.

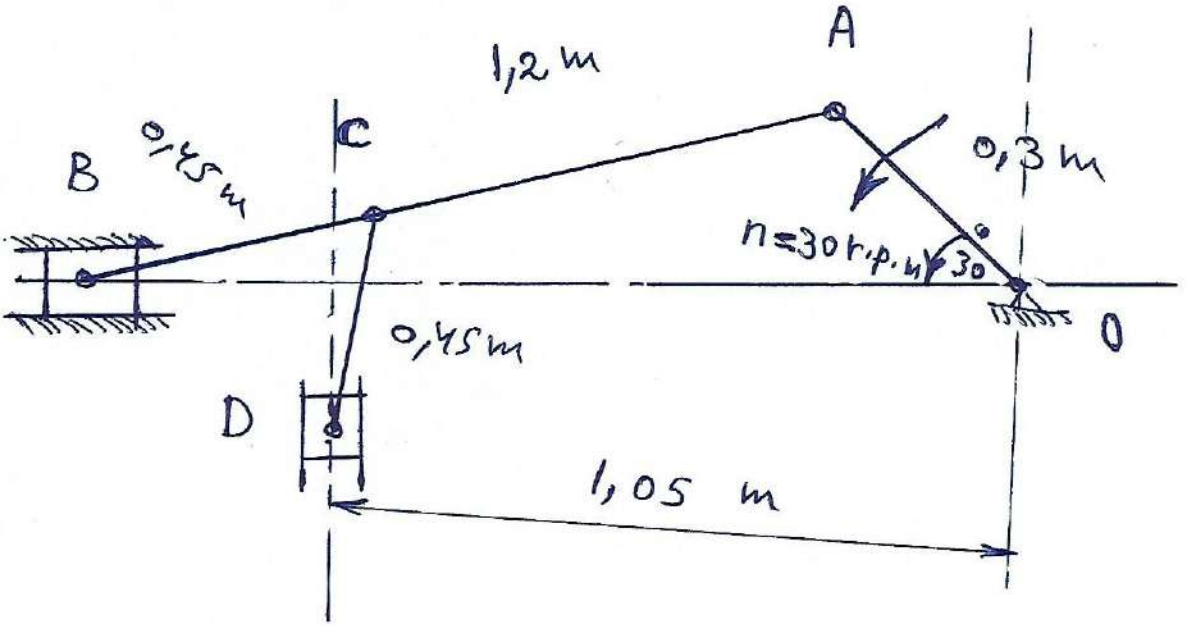


Fig (3)

Q3: Solution: AB = 1,2 m , BC = 0,45 m ,
المعطى — CD = 0,45 m , OA = 0,3 m البعد الحقيقي

→ Draw S-D with Suitable Scale.

Assume Scale 1 m = 50 mm

$\therefore K_S = \frac{OA}{\bar{OA}} = \frac{0,3\ m}{0,3 * 50\ mm} = 0,02\ m/mm$

الرسم = على الورق البياض

$\therefore OA = \frac{0,3}{K_s} = \frac{0,3}{0,02} = 15\ mm$, $CD = BC = \frac{0,45}{0,02} = 22,5\ mm$

$AB = \frac{1,2}{0,02} = 60\ mm$ البعد على الورق.

II) Draw V-D with Suitable Scale

$V_{Ao} = v_A = \omega * OA \perp OA$ in direction of n

$= \frac{2\pi n}{60} * AO = \frac{2 * 3,14 * 20}{60} * 0,3 = 0,63\ m/s$

Assume Scale 1 m/s = 55 mm

$\therefore k_V = \frac{V_A}{\bar{V_A}} = \frac{0,63}{0,63 * 55} = 0,018$

$\therefore \bar{V_A} = 35\ mm$

V_{BA} [from a $\perp$ AB
V_{Bo} [from o // Bo ⨉ b [ab * k_V = V_{AB} = ; ob * k_V = V_{Bo} =

$\therefore$ [$30 * 0,018 = 0,54\ m/s$
[$22 * 0,018 = 0,4\ m/s$

For determining Vc by dividing in same ratio

$\frac{Bc}{BA} = \frac{bc}{ba} = \frac{22,5\ mm}{60\ mm} = \frac{bc}{30\ mm} \Rightarrow bc = \frac{22,5 * 30}{60} = 11,2$

$V_{CD} = \bar{Co} = 24\ mm * K_V = 24 \times 0,018 = 0,43\ m/s$

$V_{Do} = \bar{do} * K_V = 13,4\ mm * 0,018 = 0,24\ m/s$

V_{CD} → [from c $\perp$ CD
V_{Do} → [from o // Do ⨉ d [dc = V_{DC} = dc * k_V = ; od = V_{Do} = do * k_V =

Q1

I 2,c) III, Acceleration A-D

Acceleration of point A w.r.t o

$A_{Ao} = A^r_{Ao} + A^t_{Ao} = A^r_{Ao} = \frac{VA_o^2}{Ao} = \frac{(0,63)^2}{0,3\,m} = 1,3\ m/s^2$

also $A^r_{Ao} = \omega^2 * Ao$

Assume S. Scale for A $\Rightarrow 1\ m/s^2 = 27\ mm$

$K_A = \frac{A_A}{A\bar{A}} = \frac{1,3}{1,3*27} = \frac{1,3}{35} = 0,037$

∴ From $o = A_{Ao} \parallel Ao$

For $A_{BA} = A^r_{BA} + A^t_{BA}$

$A^r_{BA} = \frac{VBA^2}{BA} = \frac{(0,54)^2}{1,2} = 0,243\ m/s^2 = \frac{0,243}{0,037} = 6,6\ mm$

$A^t_{BA} \perp A^r_{BA}$ → from X

for $A_{Bo} = A^t_{Bo} + A^r_{Bo} = A^t_{Bo}$ → from o // Bo

$= A^t_{BA} = 17\ mm * K_A = 17 * 0,037 = 0,629\ m/s$

$= A^t_{Bo} = 35\ mm * K_A = 35 * 0,037 = 1,295\ m/s$

for Ac - by dividing in Same ratio:

$\frac{BC}{BA} = \frac{bc}{ba} = \frac{22,5\ mm}{60\ mm} = \frac{bc}{18\ mm} \Rightarrow b_c = \frac{22,5*18}{60} = 6,75\ mm$

∴ $A_c = C_o * K_V = 34\ mm * 0,037 = 1,26\ m/s^2$

for $A_{DC} = A^r_{DC} + A^t_{DC}$

$A^r_{DC} = \frac{(V_{DC})^2}{DC}$

$A^t_{DC} \perp DC$ from d

for $A_{Do} = A^t_{Do} + A^r_{Do} = A^t_{Do}$ → from o // Do

$= 34,6 * K_A = 34,6 * 0,037 = 1,28\ m/s^2$

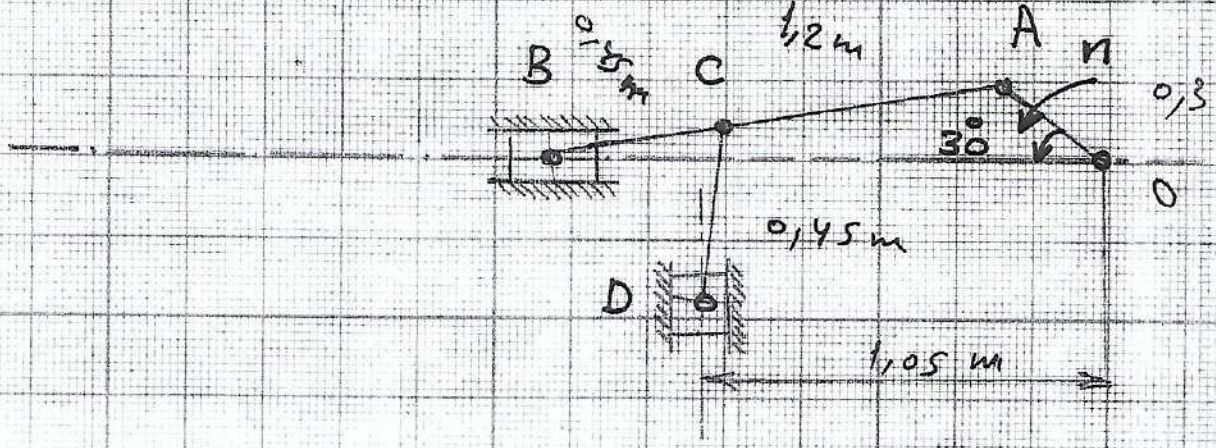
$= 4,5\ mm * K_A = 4,5\ mm * 0,037 = 0,16\ m/s^2$

∴ for Angular acceleration for p. @ point D → CD

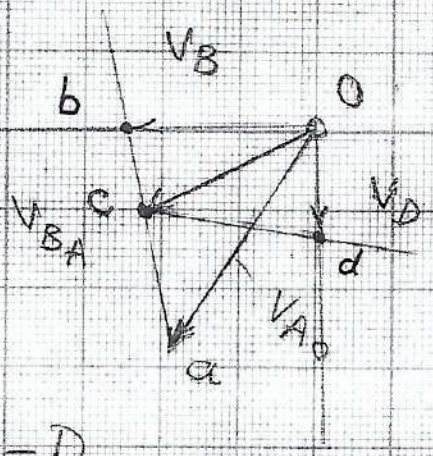
$1,28\ m/s^2$ → ou m/s^2 A.C.W

Q1 ; solution.

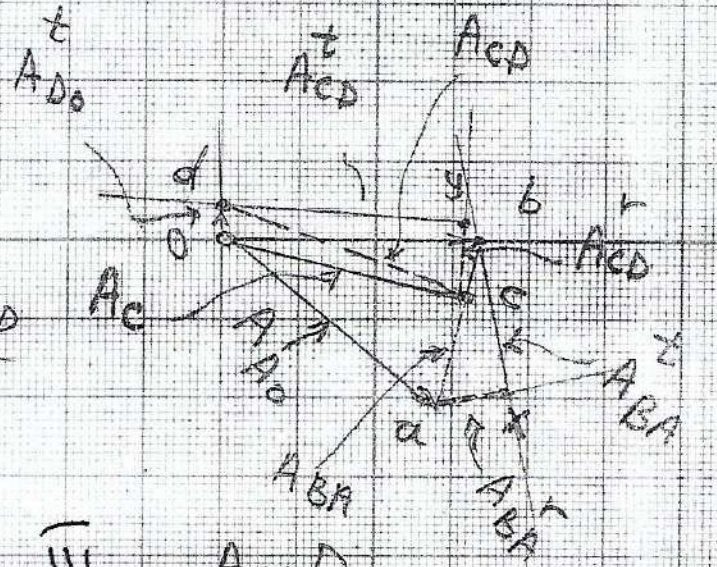
I) S-D



II) V-D



III) A-D



$\therefore A_{D_0} = 4,5\ mm * 1_A = 4,5 * 0,037 = 0,16\ m/s^2$

4) Example (4)

In the figure (4) as shown below, a toggle mechanism in which the crank op rotates at uniform Speed of (120) r.p.m in a clockwise direction. The lengths of the various links are as follow: (OP = 8 cm, (PR = 18) cm, (QR = 24) cm) and (SR = 27) cm. Determine the followings, when the ang (OPo = 45°).

1, Space diagram with suitable scale,
2, Velocity diagram with suitable scale,
3) Linear acceleration of the slider (S).

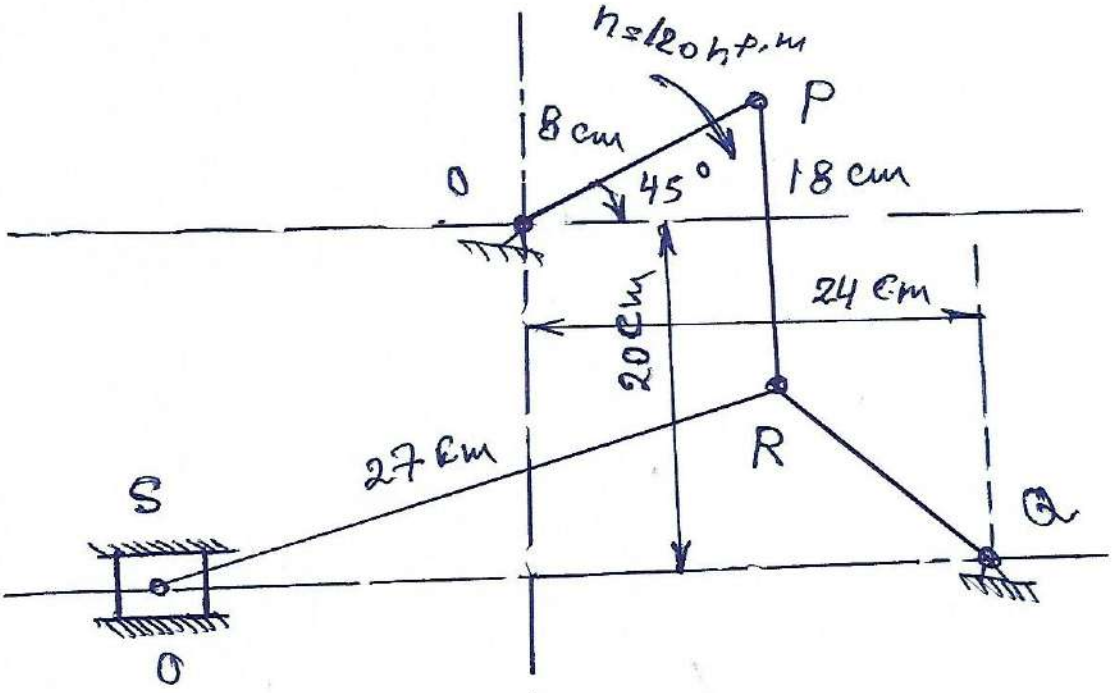


fig (4)

Q4 : Solution

I) Draw space diagram with suitable scale

assume scale 1 cm = 2mm

$\therefore k_\ell = \frac{OP}{\overline{op}} = \frac{8}{8*2} = 0,5 \frac{cm}{mm}$

$\therefore$
$OP = \frac{8\ cm}{k\ell} = 16\ mm$
$PR = \frac{18\ cm}{k\ell} = 36\ mm$
$QR = \frac{24\ cm}{k\ell} = 48\ mm$
$SR = \frac{27}{k\ell} = 54\ mm$

II) Velocity diagram

$V_{PO} = \omega * PO = \frac{2\pi n}{60} * PO = \frac{2*3,14*120}{60} * 8 =$

$\therefore V_{PO} = 100,5\ cm/s$

Assume scale ; $1\ cm/s = \frac{1}{5}\ mm$

$\therefore k_v = \frac{VP}{\overline{Vp}} = \frac{100,5}{100,5 * \frac{1}{5}} = .5\ cm/s/mm$

$\therefore \overline{Vpo} = \frac{100,5}{5} = 20,1\ mm$

Draw $V_{po} \perp op = 20,1\ mm$ from o.

V_{RP} | From $P \perp RP$
V_{RQ} | From $q \perp RQ$
$\times r \rightarrow \begin{cases} rp * k_v = V_{RP} \\ rq * k_v = V_{RQ} \end{cases}$

$\therefore$
$V_{RP} = 18,4 * 5 = 92\ cm/s$ relative velocity
$V_{RQ} = 10,8 * 5 = 54\ cm/s$

V_{SR} | From $r \perp SR$
V_{SQ} | From $q \parallel SQ$
$\times s \rightarrow \begin{cases} sr * k_v = V_{SR} \\ sq * k_v = V_{Sq} \end{cases}$

$\therefore$
$V_{SR} = 10,8 * 5 = 54\ cm/s$
$V_{Sq} = 7,2 * 5 = 36\ cm/s$

Q_1 ; Solution

III) Acceleration diagram

$A_{po} = A^r_{po} + A^t_{po}$ // $= A_{po}$

$\therefore A^r_{po} = \frac{V^2_{po}}{po} = \frac{100,5}{8} = 1262,5 \text{ cm/s}^2$

Assume Scale: $1 \text{ cm/s}^2 = \frac{1}{40} \text{ mm}$

$\therefore K_A = \frac{OP}{@P} = \frac{1262,5}{1262,5 * \frac{1}{40}} = 40,7 \frac{\text{cm/s}^2}{\text{mm}}$

$\therefore$ for A_{po} draw $op // op$ from $o = \frac{1262,5}{K_A} = \frac{1263,5}{40,7} = 3$

* a_{rp} $\begin{cases} a^r_{rp} = \frac{V^2_{RP}}{RP} = \frac{(92)^2}{18} = 470,2 \text{ cm/s}^2 \\ \therefore a^r_{rp} = \frac{470,2}{K_A} = \frac{470,2}{40,7} = 11,5 \text{ mm, from R} \rightarrow \end{cases}$

* a_{rQ} $\begin{cases} a^r_{rQ} = \frac{V_{RQ}}{RQ} = \frac{54^2}{24} = 121,5 \frac{\text{cm}}{\text{s}^2} * \frac{1}{40,7} = 2 \\ \text{draw from R} \rightarrow Q \end{cases}$

and $\begin{bmatrix} a^t_{RP} \\ a^t_{RQ} \end{bmatrix} \times r \begin{bmatrix} xr = a^t_{RP} = \\ yr = a^t_{RQ} = \end{bmatrix}$

by joing rp $\rightarrow a_{RP}$ total, rq $\rightarrow a_{RQ}$ total

and * a_{SR} $\begin{cases} a^r_{sR} = \frac{V^2_{SR}}{L_{SR}} = \frac{54^2}{27} = 108 \text{ cm/s}^2 * \frac{1}{40,7} = 2,65 \\ a^t_{sR} + A_{SR} \rightarrow \text{from} \end{cases}$

and a_{SQ} $\begin{cases} a^r_{sQ} = 0 \\ a^t_{sQ} = SQ \end{cases}$

$\therefore \begin{bmatrix} a^t_{sR} \\ a^t_{sQ} \end{bmatrix} \times S - \begin{bmatrix} Zs = a_{sR} = \\ Sq = a^t_{sQ} = aS = 4.42 \text{ mm} * \frac{1}{40,7} = 18 \end{bmatrix}$

by Joing $Sp \Rightarrow a_{sR}$ total

I, S-D

OP = 16 mm

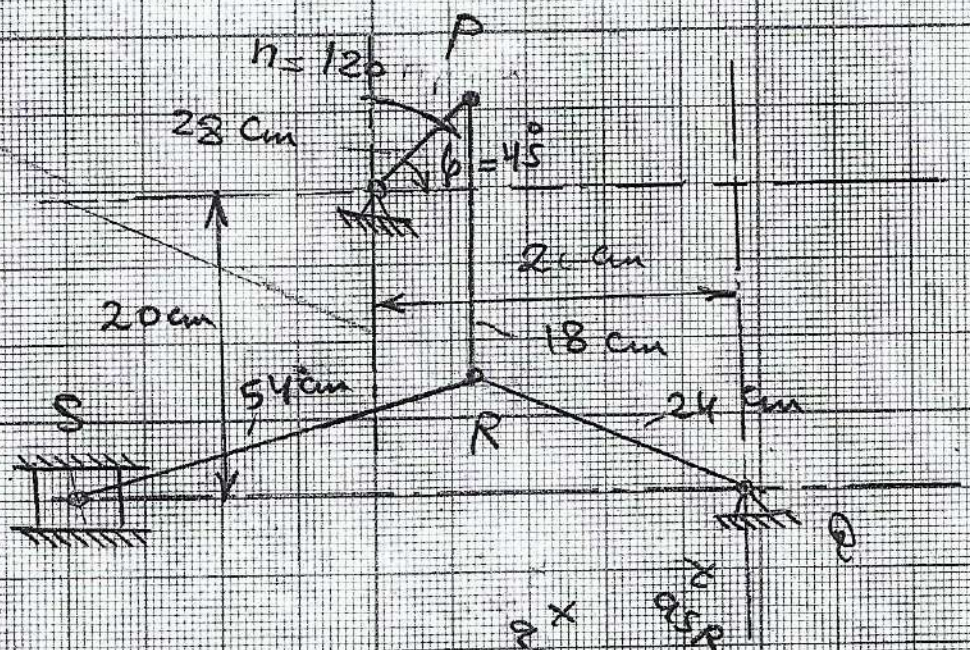
PR = 36 mm

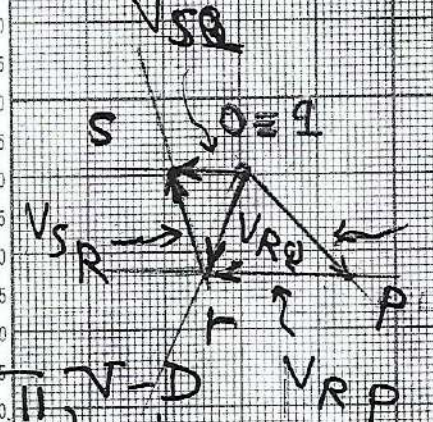
QR = 48 mm

SR = 54 mm

$\varphi_S = 45^\circ$ ↷

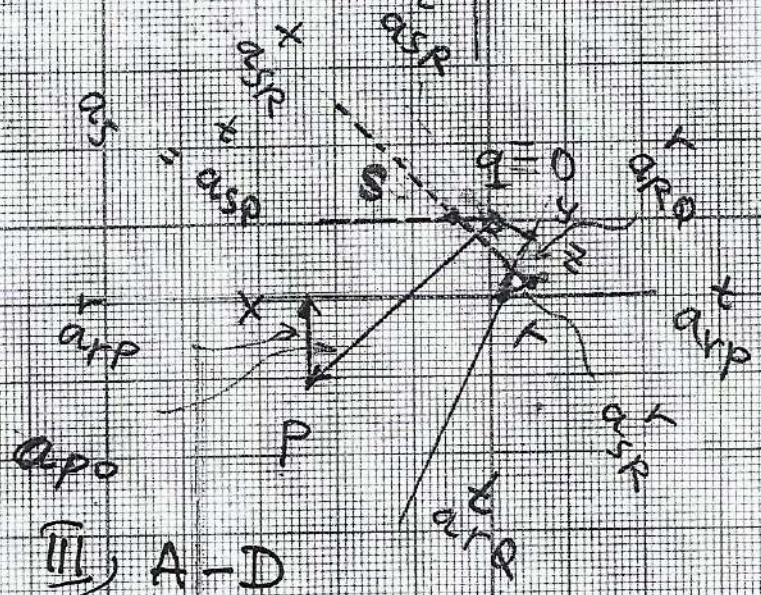
n = 120 r.p.m





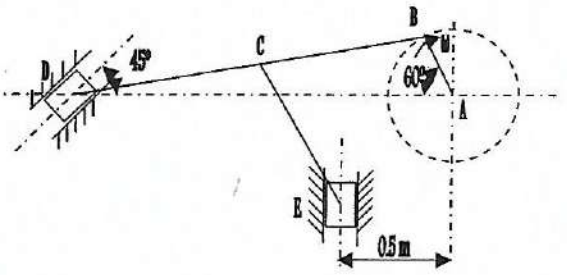
II) V-D

$\therefore a_{SQ} = a_S = 4\,mm * K_A = 4,4 \times 40,7 = 180\ Cm/s^2$

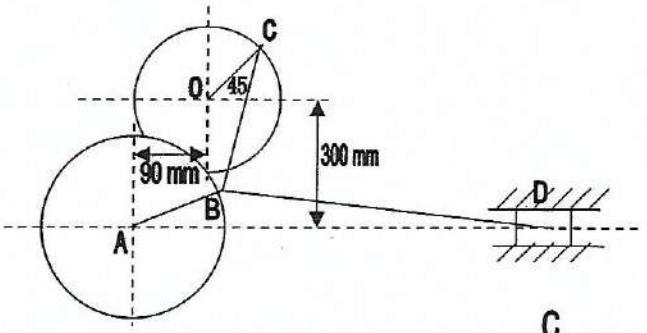


(Home works)

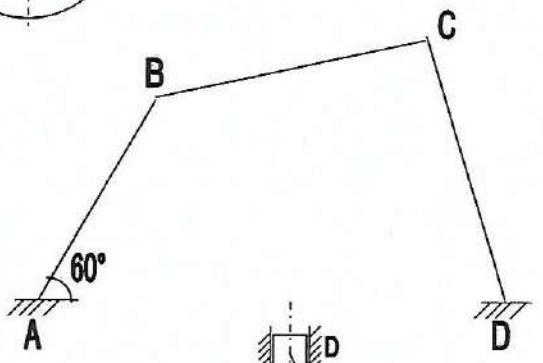
Q1/ The dimensions of the mechanism shown are as follows:
AB = 0.45 m; BD = 1.5 m; BC = CE = 0.9 m. The crank AB turns uniformly at 180 rpm in the clockwise direction and the blocks at D and E are working in frictionless guides. Draw the velocity diagram for the mechanism and find the velocities of the sliders D and E in their guides.



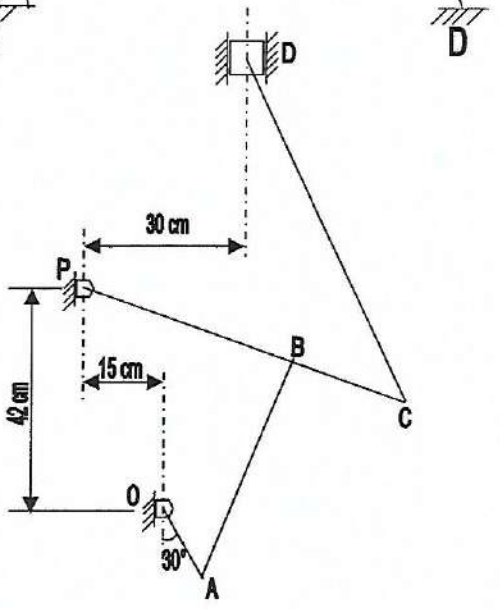
Q2/ In the toggle mechanism shown in figure below, D is constrained to move on a horizontal path. The dimensions of various links are as follows:
AB = 200 mm; BC = 300 mm; OC = 150 mm; and BD = 450 mm.
The crank OC is rotating in a counter clockwise direction at a speed of 180 rpm. Find the velocity of D, and angular velocity of BD.



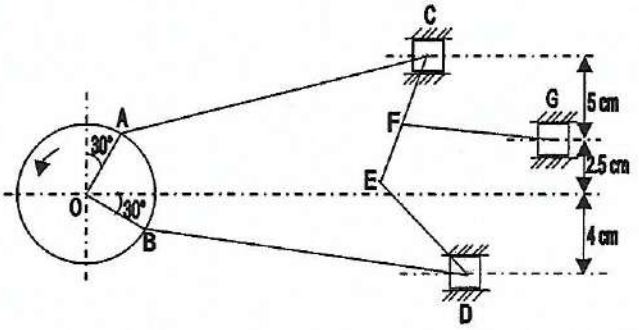
Q3/ The dimensions and configuration of the four bar mechanism shown in figure are as follows:
AB = 30 cm, CD = 36 cm, BC = 36 cm and AD = 60 cm. The crank AB has an angular velocity of 10 rad/sec clockwise. Determine the angular velocity of DB and BC and velocity of the joint C.



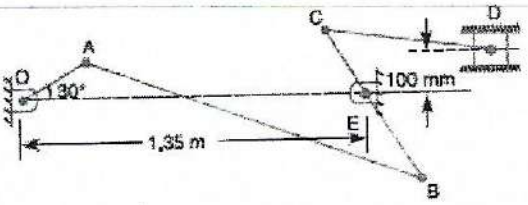
Q4/ Find out the velocity of the slider D and the angular velocity of link CD for the engine mechanism shown in figure. The dimensions of the various links are
OA = 15 cm; AB = 45 cm; PB = 24 cm; BC = 21 cm; CD = 66 cm and N_{OA} = 180 rpm.



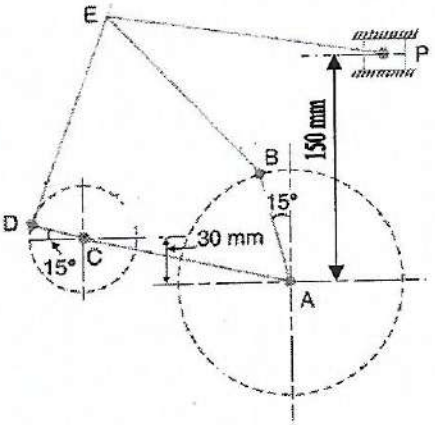
Q5/ In the mechanism shown in figure OA and OB are two equal cranks at right angle rotating about O at a speed of 40 rpm anticlockwise. The dimensions of the various links as follows:
OA = OB = 5 cm; AC = BD = 17.5 cm; DE = CE = 7.5 cm; FG = 11.5 cm and EF = FC. Find the velocity of the slider G.



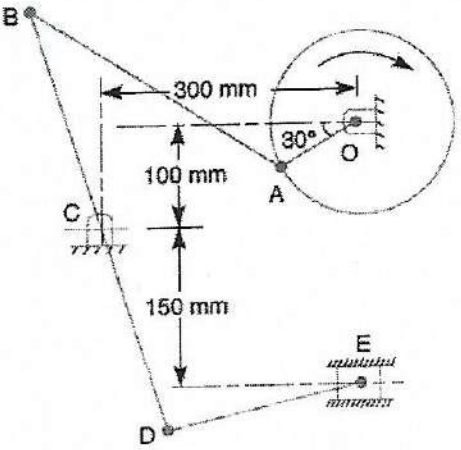
Q6/ A mechanism, as shown in figure, have the following dimensions:
OA = 200 mm; AB = 1.5 m; BC = 600 mm; CD = 500 mm and BE = 400 mm. If crank OA rotates uniformly at 120 rpm clockwise, find (1) the velocity of B, C and D (2) the angular velocity of the links AB, BC and CD.



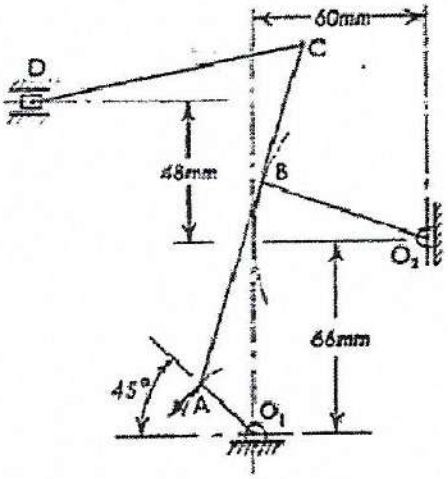
Q7/ In a mechanism shown in figure, the dimensions are as follows: AB = 80 mm; CD = 40 mm; BE = DE = 150 mm; AC =150 mm; and EP = 200 mm. The speed of the crank CD is 1140 rpm and of the crank AB is 570 rpm clockwise. Determine the velocity of the piston P for the given configuration.



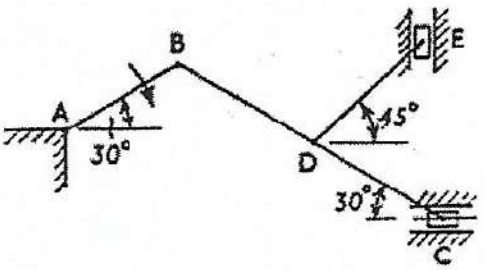
Q8/ In a mechanism as shown in figure, the crank OA is 100 mm long and rotates in a clockwise direction at a speed of 100 rpm. The straight rod BCD rocks on a fixed point at C. The links BC and CD are each 200 mm long and the link AB is 300 mm long. The slider E, which is driven by the rod DE is 250 mm long. Find the velocity of E.



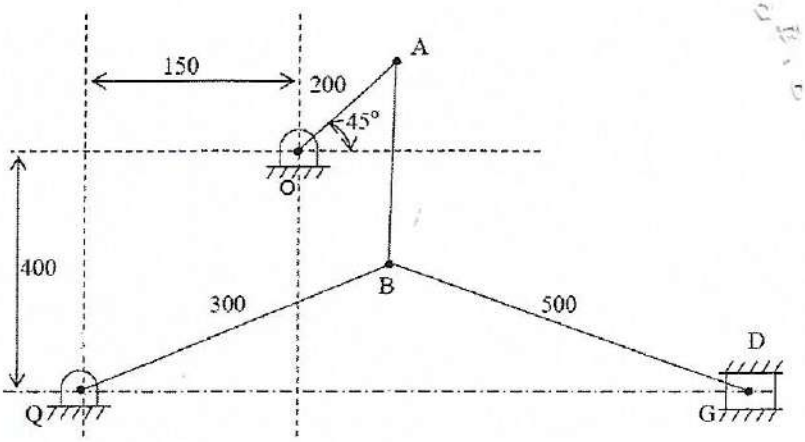
Q9/ The diagram of a linkage is given in Fig. below. Find the velocity of the slider D and the angular velocity of DC, when the crank O1A is in the given position and the speed of rotation is 90 rev/min anticlockwise. O1A = 24 mm, O2B = 60 mm, CD = 96 mm, AB = 72 mm, CB = 48 mm.



Q10/ In the mechanism shown in Fig., the crank AB is 75 mm long and rotate uniformly clockwise at 8 rad/sec. Given that BD = DC = DE; BC = 300 mm, draw the velocity diagrams, and find the velocity of the pistons at C and E.



Q11/ In a toggle mechanism shown in figure the crank OA rotates at 210 rpm counter clockwise. Determine the velocity of slider D and angular velocity of link BD.



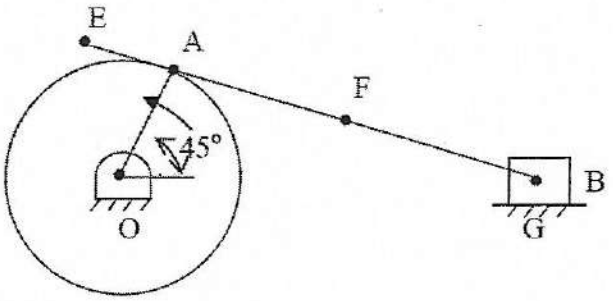
Q12/ In a slider crank mechanism the crank OA is 200 mm long and rotates at 40 rad/sec in a counter clockwise direction. The length of the connecting rod AB is 800 mm. Determine,

i) The velocity of the slider B.

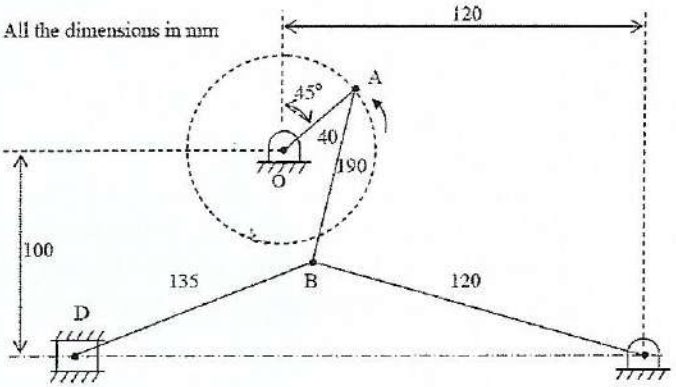
ii) Velocity of point E located at a distance of 200 mm on the connecting rod extended.

iii) The position and velocity of point F on the connecting rod having the least absolute velocity.

iv) The angular velocity of connecting rod.



Q13/ Figure below shows a toggle mechanisms in which the crank OA rotates at 120 rpm. Find the velocity of the slider D.



Q14/ A toggle mechanism is shown in figure along with the diagrams of the links in mm. find the velocities of the points B and C and the angular velocities of links AB. The crank rotates at 50 rpm in the clockwise direction.