(P11) A crank OA, 100 mm long, rotates clockwise at 100 rev/min, as shown in the figure. Rod AC, 500 mm long, slides in a swivelling pin at B. The end C slides on a swinging link DE. When the angle BOA is 120°, find the angular velocity and angular acc^n of DE.

Solution:-

Velocity diagram -

1) $V_{ao} = l(AO)\,\omega_{oa} = (0.1) \times \frac{2\pi(100)}{60} = 1.05$ m/s

Draw V_{ao}.

2) Assume B' to be coincident with B, and to be on link AC.

$V_{b'a}$ will be ⊥ to AB. Through 'a', draw a line ⊥ to AB. $V_{b'b}$ will be ∥ to AB'. Through 'b', draw a line ∥ to AB'. The intersection of these two lines locates point 'b''.

3) Extend 'ab'' to 'c' such that $\frac{b'c}{ab'} = \frac{B'c}{AB'}$

$\therefore\ b'c = \left(\frac{\cancel{362.5}\ 137.5}{362.50}\right) \cdot (3.65)$ cm

$\therefore\ b'c = 1.38$ cm

Thus, 'c' can be located.

4) Assume c' to be coincident with c, but on ~~the~~ link DE. $V_{c'c}$ will be ∥ to Dc'. Through 'c' draw a line ∥ to Dc'. $V_{c'd}$ will be ⊥ to Dc'. Through 'd', draw a line ⊥ to Dc'. The intersection of these two lines locates point 'c''.

Thus, the velocity diagram can be completed.

From the velocity diagram

Ang. velocity of link DE

$= \omega_{de} = \frac{V_{c'd}}{l(C'D)}$ (∵ c' is on link DE)

$= \frac{0.576}{0.12}$

$\therefore\ \omega_{de} = 4.8$ rad/s ↻ $= \omega_{c'd}$

Acceleration diagram

Sr. No.	Vector	Magnitude	Direction	Sense
1	a^c_{ao}	$= \frac{V^2_{ao}}{l(AO)} = \frac{(1.05)^2}{(0.1)} = 11.03\ m/s^2$	$\parallel$ to OA	Towards O in config. diag.
2	a^t_{ao}	$= 0 \quad \because \alpha_{ao} = 0$	—	—
3	$a^c_{b'a}$	$= \frac{V^2_{b'a}}{l(B'A)} = \frac{(0.73)^2}{(0.3625)} = 1.47\ m/s^2$	$\parallel$ to B'A	Towards A in config. diagram
4	$a^t_{b'a}$	$= l(AB)\alpha_{ab} = 4.75\ m/s^2$ $\therefore \alpha_{ab} = \frac{4.75}{0.3625} = 13.10\ rad/s^2$	$\perp$ to $a^c_{b'a}$	—
5	$a^s_{b'b}$ (sliding)	$= 6.3\ m/s^2$	$\parallel$ to B'A	—
6	$a^{cor.}_{b'b}$ (Coriolis)	$= 2 V_{b'b}\, \omega_{b'a}$ $= 2(0.74)(2.01)$ $= 2.98\ m/s^2$ Now $\omega_{b'a} = \frac{V_{b'a}}{l(B'A)} = \frac{0.73}{(0.3625)} = 2.01\ rad/s$	As shown on config diag.	—
7	$a^c_{c'd}$	$= \frac{V^2_{c'd}}{l(C'D)} = \frac{(0.576)^2}{(0.12)} = 2.77\ m/s^2$	$\parallel$ to C'D	Towards D in config. diag
8	$a^t_{c'd}$	$= l(C'D)(\alpha_{c'd}) = 10\ m/s^2$ $\therefore \alpha_{c'd} = \frac{10}{0.12} = 83.33\ rad/s^2$	$\perp$ to $a^c_{c'd}$	—
9	$a^s_{c'c}$ (sliding)	$= 0.65\ m/s^2$	$\parallel$ to C'D	—
10	$a^{cor.}_{c'c}$ (Coriolis)	$= 2 V_{c'c}\, \omega_{c'd} = 2(0.54)(4.8)$ $= 5.18\ m/s^2$	As shown on config. diag.	—

• The vectors are drawn serially as above.
~~The intersection~~
Sr. No. 1, 2, 3 are drawn. Sr. No. 4 is drawn in direction. Sr. No. 6 is drawn. Sr. No. 5 is drawn in direction. The intersection of Sr. No. 4 & 5 gives point 'b''.
'ab'' is now extended to give point 'c', such that

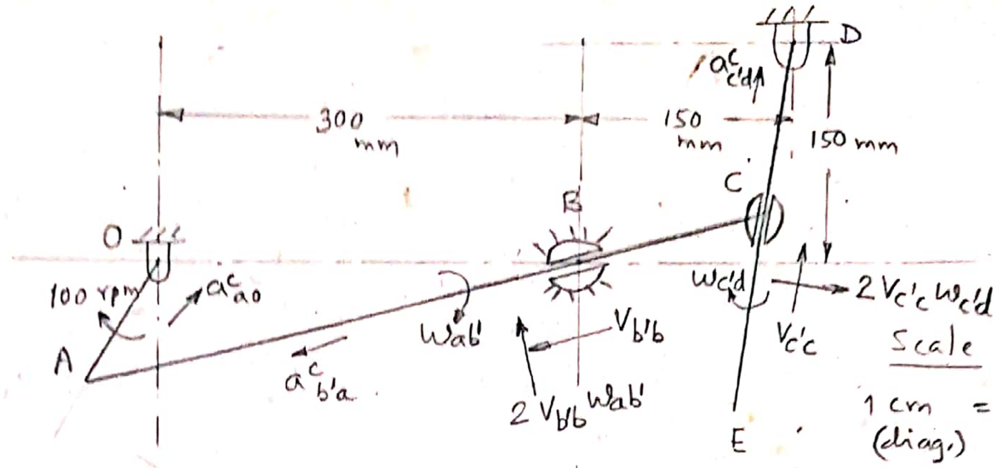
$\frac{b'c}{ab'} = \frac{B'C}{AB'} \quad \therefore b'c = (5\ cm)\left(\frac{137.5}{362.5}\right) \quad \therefore b'c = 1.9\ cm.$

Thus, point 'c' is located.

Then, Sr. No. 7 is drawn. Sr. No. 8 is drawn in direction. Then Sr. No. 10 is drawn. Sr. No. 9 is drawn in direction. The intersection of Sr. No. 8 & 9 gives point 'c''.

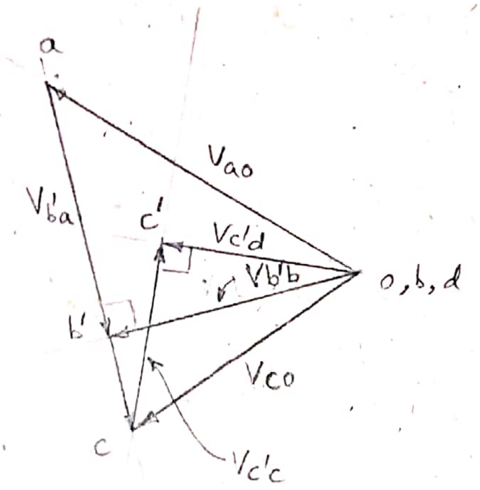
From Acc^n diagram, $\alpha_{de} = \alpha_{c'd} = 83.33\ rad/s^2$

P11



Scale

1 cm (diag.) = 50 mm (actual)

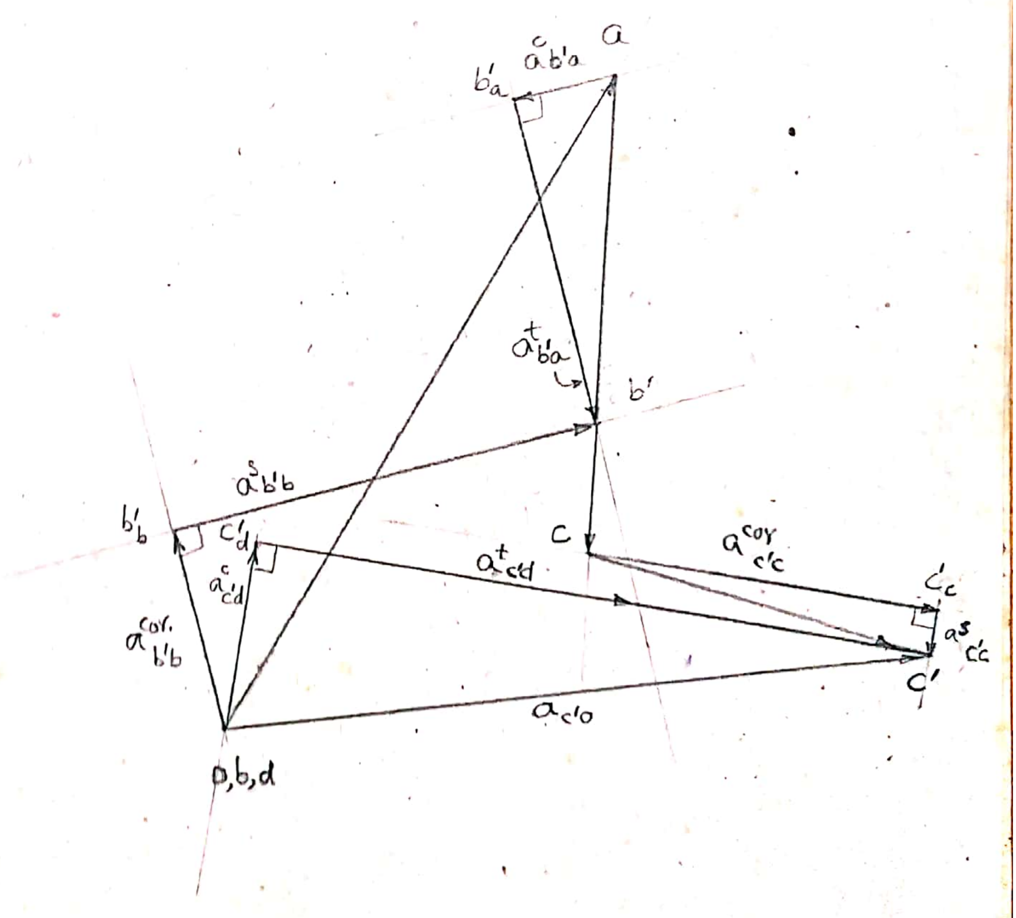


Vel. diagram

1 cm (diag.) = 0.2 m/s (actual)

Acc^n diagram

1 cm (diag.) = 1 m/s^2 (actual)



(P12) The fig. shows a quick return mechanism, in which the driving crank OA rotates at 120 rpm in a clockwise direction. For the position shown, determine the magnitude and direction of

a) The accⁿ of block D.

b) The angular accⁿ of the slotted bar QB.

Solution -

Velocity diagram

1) $V_{ao} = l(OA)\left(\frac{2\pi(120)}{60}\right) = 2.51$ m/s.

Draw V_{ao}. $\underset{(diag.)}{1 \text{ cm}} = \underset{(actual)}{1 \text{ m/s}}$

2) Assume A_1 to be coincident with A, but on link BC.

~~V_{a_1q} will be ⊥ to QA_1. Through~~

V_{a_1a} will be ∥ to A_1Q. Through 'a', draw a line ∥ to A_1Q. V_{a_1q} will be ⊥ to A_1Q. Through 'q', draw a line ⊥ to A_1Q. The intersection locates point 'a_1'.

3) Extend a_1q to point 'c', such that

$$\frac{qc}{a_1q} = \frac{QC}{A_1Q} \quad \therefore qc = (2.45 \text{ cm})\left(\frac{150}{262.5}\right) = 1.4 \text{ cm}.$$

Thus, 'c' can be marked.

4) V_{dc} will be ⊥ to CD. Through 'c', a line ⊥ to CD is drawn. V_{do} will be ∥ to the path of motion of D. Through 'o', a line ∥ to the path of motion of D is drawn. The intersection of these lines locates 'd'.

From the vel. diagram, $\omega_{qc} = \frac{V_{cq}}{l(QC)} = \frac{1.4}{0.15}$

$\therefore \omega_{qc} = 9.33$ rad/s ↻

Acceleration diagram

Sr. No.	Vector	Magnitude	Direction	Sense
1	a^c_{ao}	$= \frac{V_{ao}^2}{l(AO)} = \frac{(2.51)^2}{(0.2)} = 31.5\ m/s^2$	// to OA	Towards O in config. diag.
2	a^t_{ao}	$= 0 \because \alpha_{ao} = 0$	—	—
3	$a^{cor}_{a_1a}$	$= (2 V_{a_1a}\,\omega_{qc}) = 2(0.85)(9.33)$ $= 15.86\ m/s^2$	As shown in fig. ($\perp$ to BC)	—
4	$a^s_{a_1a}$	$= 6.9\ m/s^2$	// to BC	—
5	a^c_{dc}	$= \frac{V_{dc}^2}{l(CD)} = \frac{(0.95)^2}{(0.5)} = 1.81\ m/s^2$	// to CD	Towards C in fig.
6	a^t_{dc}	$= l(CD)\,\alpha_{dc} = 11.75\ m/s^2$ $\therefore \alpha_{dc} = \frac{11.75}{0.5} = 23.5\ rad/s^2$	$\perp$ to a^c_{dc}.	—
7	a_{do}	$= 6.75\ m/s^2$	// to path of motion of D	—
8	$a^c_{a_1q}$	$= \frac{V_{a_1q}^2}{l(A_1Q)} = \frac{(2.45)^2}{(0.2625)} = 22.87\ m/s^2$	// to A_1Q	Towards Q in fig.
9	$a^t_{a_1q}$	$= l(A_1Q)\,\alpha_{a_1q} = 5.65\ m/s^2$ $\therefore \alpha_{a_1q} = \frac{5.65}{(0.2625)} = 21.52\ rad/s^2$	$\perp$ to $a^c_{a_1q}$	—

1) a^c_{ao} is drawn. a^t_{ao} is zero. Thus, 'a' is located.

2) $a^{cor}_{a_1a}$ is drawn. $a^s_{a_1a}$ will be $\perp$ to $a^{cor}_{a_1a}$. Through 'a_1a', a line $\perp$ to $a^{cor}_{a_1a}$ is drawn. (line 1).

3) $a^c_{a_1q}$ is drawn. $a^t_{a_1q}$ will be $\perp$ to $a^c_{a_1q}$. Through 'a_1q', a line $\perp$ to $a^c_{a_1q}$ is drawn. (line 2)

The intersection of these two lines locates point 'a_1'.

4) 'a_1q' is extended to point 'c', such that

$$\frac{qc}{a_1q} = \frac{QC}{A_1Q} \quad \therefore qc = (4.75\ cm)\left(\frac{150}{262.5}\right)$$

$$\therefore qc = 2.71\ cm$$

Thus, 'c' can be marked.

5) a^c_{dc} is drawn. a^t_{dc} will be $\perp$ to a^c_{dc}. Through 'dc', a line $\perp$ to a^c_{dc} is drawn. (line 1)

9a)

6) a_{do} will be $\parallel$ to the path of motion of D.
Through 'o', a line $\parallel$ to the path of motion of D is drawn. (line 2).
The intersection of these two lines locates point 'd'.

From the acc^n diagram

1) Acc^n of block D = $a_{do} = 6.75 \ m/s^2$

2) Angular acc^n of slotted bar QB

$= \alpha_{qb}$

$= \alpha_{a_1q} = 21.52 \ rad/s^2$ ↺.

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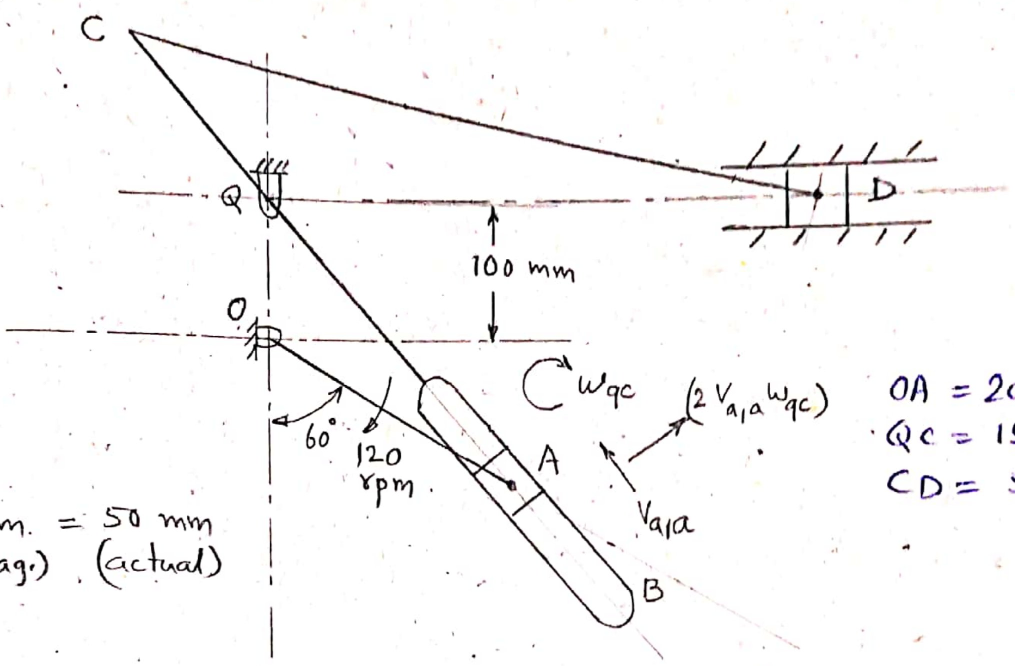
P12

2b mom ...

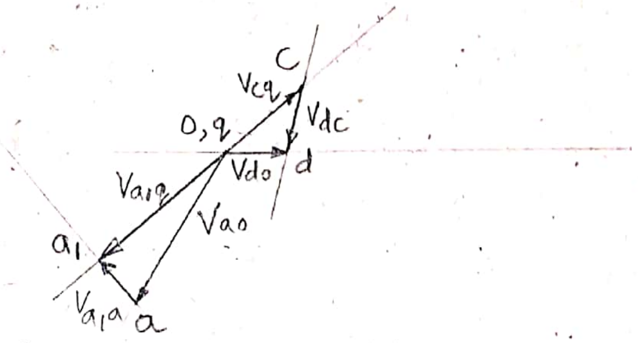


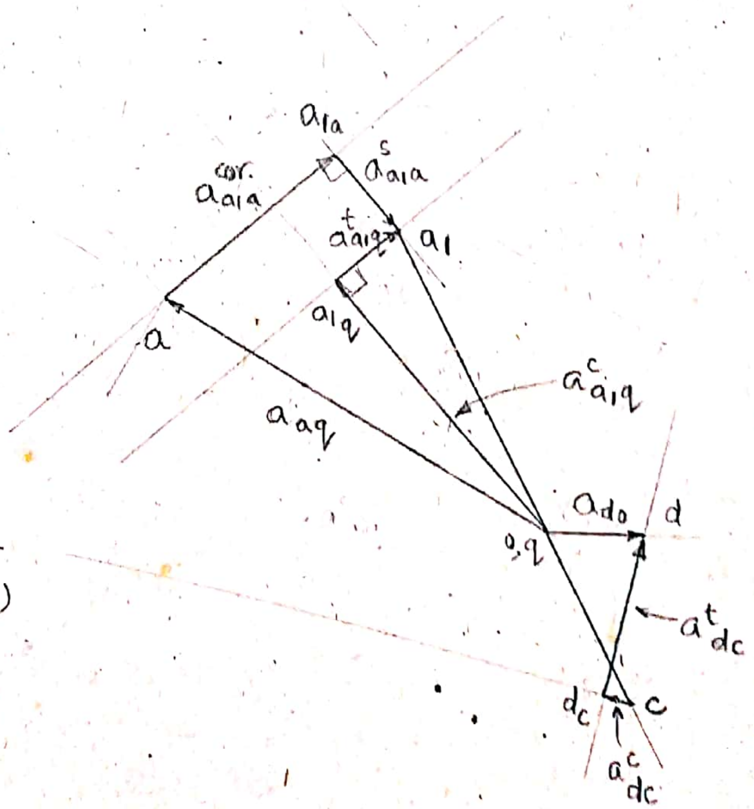
OA = 200 mm
QC = 150 mm
CD = 500 mm

1 cm. = 50 mm
(diag.) (actual)

Vel. diagram

1 cm = 1 m/s
(diag.) (actual)





Acc^n diagram

1 cm = 5 m/s^2
(diag.) (actual)

(P13) In the mechanism shown in the figure, the crank AB, 70 mm long, rotates clockwise at 110 rpm. CD is 140 mm long. Link BD is 260 mm long, and slides through a swivelling pin E at the lower end of rod EF. EF slides in vertical guides as shown.

For the position shown, find the angular velocity and angular acceleration of DB, and linear velocity and linear acceleration of F.

Solution - Velocity diagram -

1) $V_{ba} = l(AB) \frac{2\pi(110)}{60} = (0.07)\frac{2\pi(110)}{60} = 0.81$ m/s.

2) Draw V_{ba}.

3) V_{db} will be ⊥ to BD. Through 'b', draw a line ⊥ to DB. V_{dc} will be ⊥ to CD. Through 'c' draw a line ⊥ to CD. The intersection locates 'd'.

4) On 'bd' mark 'e₁' such that $\frac{de_1}{db} = \frac{DE_1}{DB}$

$\therefore de_1 = (3.75\text{ cm})\left(\frac{76}{260}\right) = 1.1$ cm.

Thus 'e₁' can be marked.

{E_1 is a point coincident with E, but on link BD}

5) V_{ee_1} will be ∥ to DB. Through 'e₁', draw a line ∥ to BD. V_{eo} will be ∥ to the path of F. Through 'a', draw a line ∥ to the path of F. The intersection locates point 'e'.

From the velocity diagram,

1) Angular velocity of link DB

$= \omega_{db} = \frac{V_{db}}{l(BD)} = \frac{0.375}{(0.26)} = 1.44$ rad/s ↻

2) Linear velocity of F

$= V_f = V_{ea} = 0.45$ m/s

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Acceleration diagram

Sr. No.	Vector	Magnitude	Direction	Sense
1	a^c_{ba}	$= \frac{V^2_{ba}}{l(BA)} = \frac{(0.81)^2}{(0.07)} = 9.37\ m/s^2$	$\parallel$ to AB	Towards A in config. diag.
2	a^t_{ba}	$= 0 \quad \because \alpha_{ab} = 0$	—	—
3	a^c_{db}	$= \frac{V^2_{db}}{l(DB)} = \frac{(0.375)^2}{(0.26)} = 0.54\ m/s^2$	$\parallel$ to DB	Towards B in config. diag.
4	a^t_{db}	$= l(DB)\alpha_{db} = 8.1\ m/s^2$ $\therefore \alpha_{db} = \frac{8.1}{0.26} = 31.15\ rad/s^2$	$\perp$ to a^c_{db}	—
5	$a^{cor.}_{ee_1}$	$= 2(V_{ee_1})\omega_{db} = 2(0.53)(1.44)$ $= 1.53\ m/s^2$	As shown in fig. ($\perp$ to BD)	—
6	$a^s_{ee_1}$	$= 8.3\ m/s^2$	$\perp$ to $a^{cor.}_{ee_1}$	—
7	a_{ea}	$= 2.55\ m/s^2$	$\parallel$ to path of F.	—
8	a^c_{dc}	$= \frac{V^2_{dc}}{l(DC)} = \frac{(0.53)^2}{(0.14)} = 2.01\ m/s^2$	$\parallel$ to CD	Towards C in config. diag.
9	a^t_{dc}	$= l(DC)\alpha_{dc} = 8\ m/s^2$ $\therefore \alpha_{dc} = \frac{8}{0.14} = 57.14\ rad/s^2$	$\perp$ to a^c_{dc}	—

1) Draw a_{ba}.
2) Draw a^c_{db}. a^t_{db} will be $\perp$ to a^c_{db}. Through 'd_b', a line $\perp$ to a^c_{db} is drawn. (line 1)
3) Draw a^c_{dc}. The a^t_{dc} will be $\perp$ to CD. Through 'd_c', a line $\perp$ to a^c_{dc} is drawn (line 2)
   The intersection of these lines locates 'd'.
4) On 'db', a point 'e_1' is marked such that

$$\frac{de_1}{db} = \frac{DE_1}{DB}. \quad \therefore de_1 = (8.1\ cm)\left(\frac{76}{260}\right) = 2.37\ cm.$$

   Hence 'e_1' is marked.
5) Draw $a^{cor}_{ee_1}$. $a^s_{ee_1}$ will be $\perp$ to $a^{cor}_{ee_1}$. Through 'e_{e_1}', a line $\perp$ to $a^{cor}_{ee_1}$ is drawn. (line 1)
6) a_{ea} will be $\parallel$ to path of F. Through 'a' a line $\parallel$ to path of F is drawn. (line 2)

1a) The intersection of these lines locates point

From the acc^n diagram,

1) Ang. acc^n of link DB

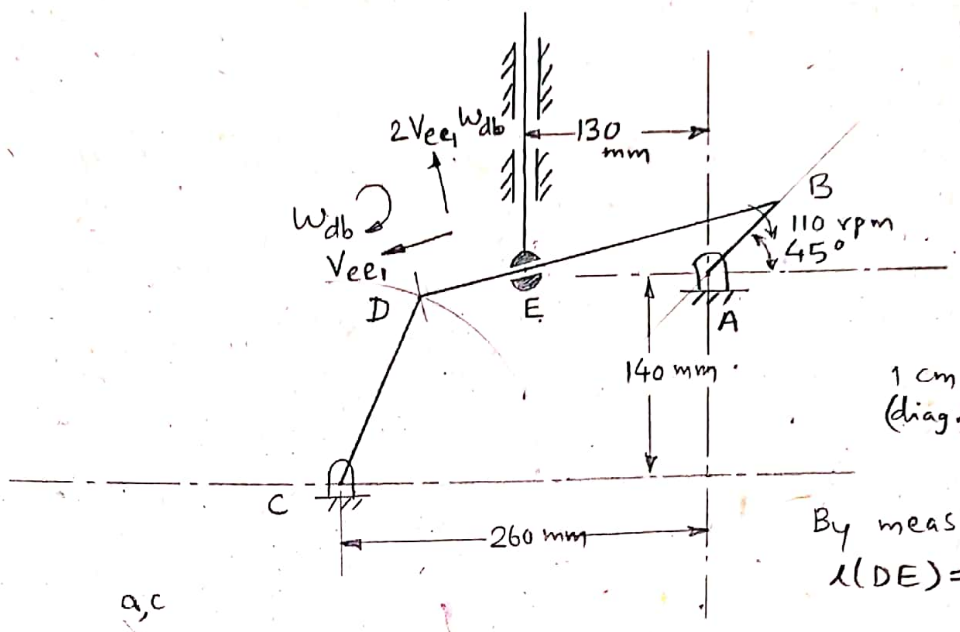
$= \alpha_{db} = 31.15 \text{ rad/s}^2$

2) Linear acc^n of F

$= a_{fa}$

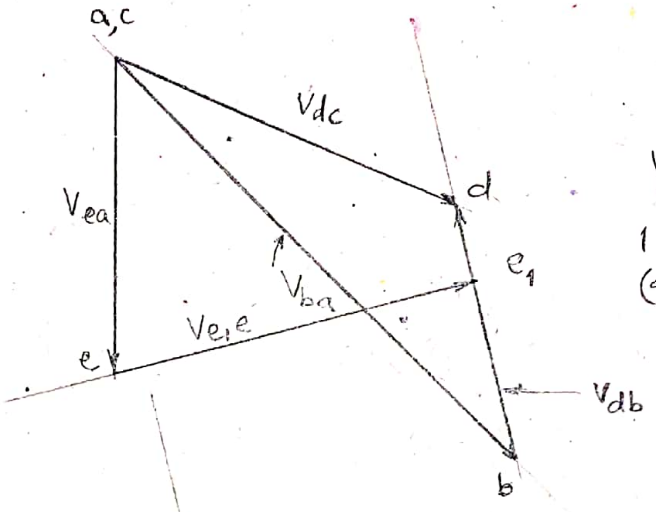
$= a_{ea} = 2.55 \text{ m/s}^2$

P13



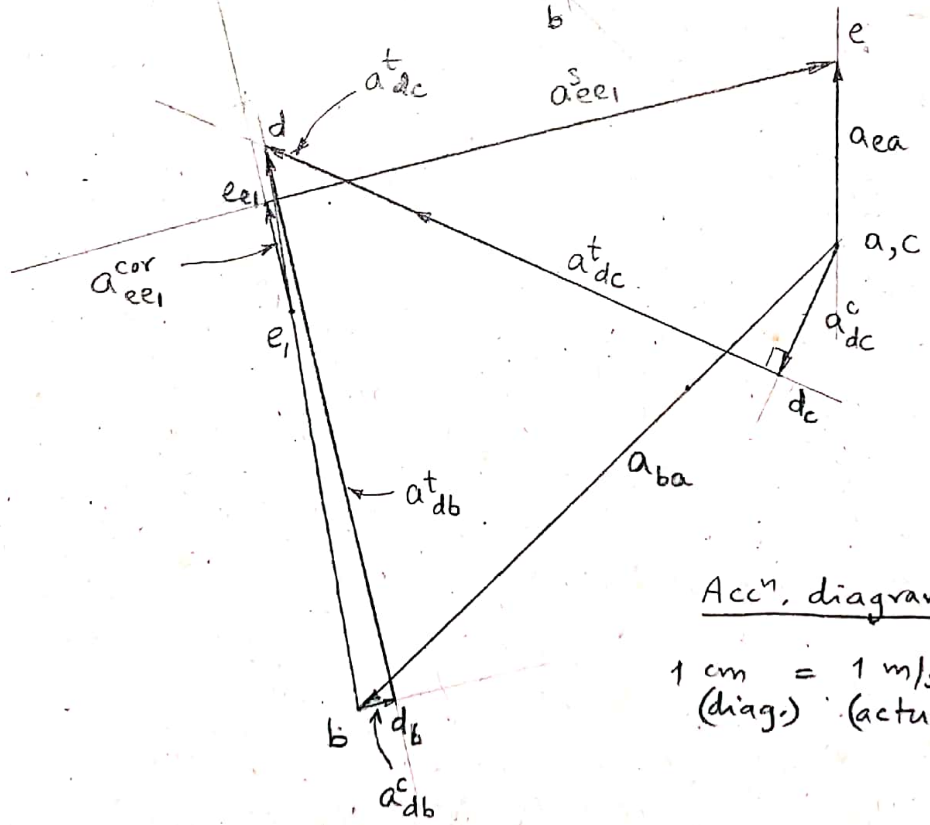
1 cm (diag.) = 50 mm (actual)

By measurement,
$l(DE) = 76$ mm



<u>Vel. diagram</u>

1 cm (diag.) = 0.1 m/s (actual)



<u>Accn. diagram</u>

1 cm (diag.) = 1 m/s^2 (actual)