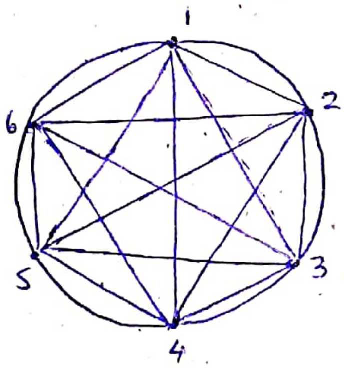
(P3) Figure shows a mechanism. Various dimensions are : $O_1O_2 = 150$ mm, $O_1Q = 85$ mm, $O_2P = 75$ mm, $PR = 405$ mm.

Using instantaneous centre of rotation method, find the velocity of the slider R at the crank position shown in the figure, if the crank is rotating at 175 rpm in the anticlockwise direction. Find the angular velocity of link PR at the same instant. (Safari 16)(Q 2b) (10) 8

Solution : Since there are 6 links in this mechanism,

$$N = \frac{n(n-1)}{2} = \frac{6(5)}{2} = 15$$

Hence, there are 15 Instantaneous centres in this mechanism.



$I_{12}, I_{23}, I_{34}, I_{14}, I_{45}, I_{56}, I_{16}$ are easily located.

links →	1	2	3	4	5	6
I.C.	✓12 ✓13 ✓14 ✓15 ✓16	✓23 ✓24 ✓25 ✓26	✓34 ✓35 ✓36	✓45 ✓46	✓56	

To locate I_{15} – Draw dotted line 15. I_{15} will lie on the intersection of lines passing through I_{16}, I_{56} and I_{14}, I_{45}. Thus, I_{15} can be located. Make the line 15 dark.

In a similar way, locate the other instantaneous centres of rotation.

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1) To find velocity of slider R (link 6). The angular velocity of crank O_1Q (link 2) is known. Hence consider the I centre I_{26}.

Consider I_{26} to be on link 2 and assume that link 2 is rotating about I_{12}.

$$\therefore V_{I_{26}} = \{l(I_{12} I_{26})\} \cdot \omega_2$$

$$\therefore V_{I_{26}} = (0.014)\left(\frac{2\pi(175)}{60}\right)$$

$$\therefore V_{I_{26}} = 0.257 \text{ m/s}$$

Now consider link 6 to be a disc containing I_{26} and rotating about I_{16}. (*)

Since I_{16} is at ∞, $l(I_{26} I_{16}) = l(R\, I_{16})$

Hence since point R and I_{26} are on the same link, they will have the same velocity due to their equal distance from I_{16}.

$$\therefore V_r = V_{I_{26}} = 0.257 \text{ m/s}$$

2) To find ω_5:

$$\frac{\omega_5}{\omega_2} = \frac{l(I_{25} I_{12})}{l(I_{25} I_{15})}$$

$$\therefore \omega_5 = \frac{2\pi(175)}{60} \cdot \frac{(12)}{(644)}$$

$$\therefore \omega_5 = 0.34 \text{ rad/s} \circlearrowleft$$

(The direction is same as that of ω_2, because ~~I_{25}~~ I_{12} and I_{15} lie on the same side of I_{25}).

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* All points on a sliding link have the same velocity. Hence if I_{26} is considered to be on link 6, velocity of link 6 will be equal to velocity of I_{26}. $\therefore V_r = V_{I_{26}} = 0.257$ m/s

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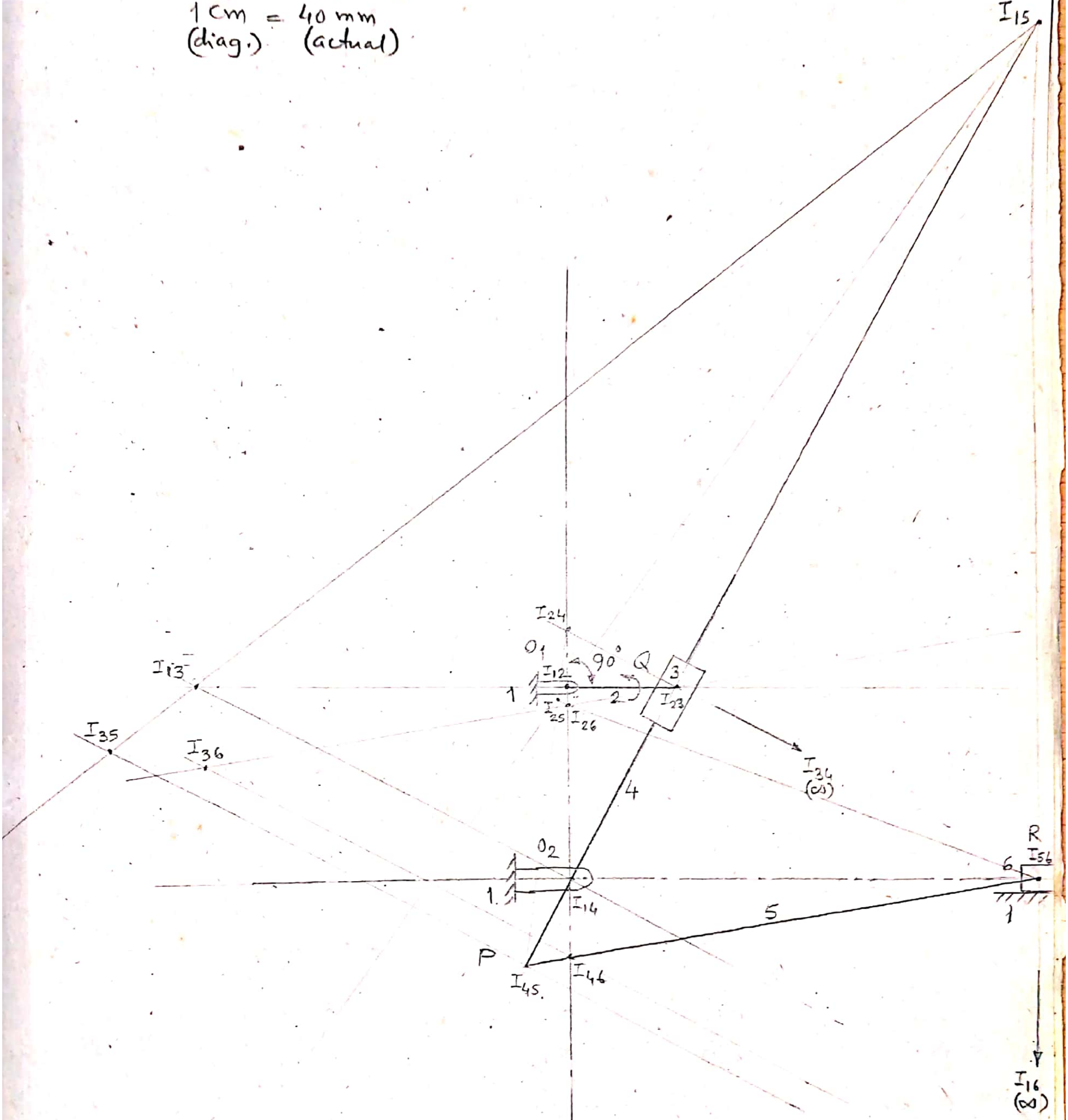
(P3)

1 cm = 40 mm
(diag.)   (actual)



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(P4) In the mechanism shown in the figure, O and Q are fixed centres. If the crank OC rotates at a uniform speed of 120 rpm in clockwise direction, find the angular velocity of links CP, PA and AQ and linear velocity of slider P by instantaneous centre method. Assume following data:

36 mm

May 99 (P97)

OC = 125 mm

CP = 500 mm

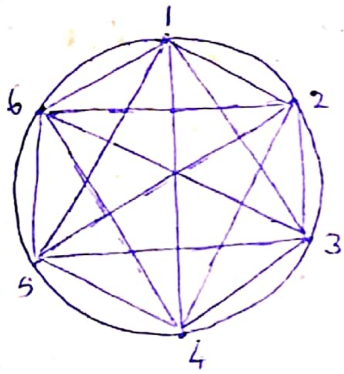
AQ = 250 mm

AP = 125 mm

(Nov. 93) (Q1) (16)

Solution: Locate all the I centres first.

$$N = \frac{n(n-1)}{2} = \frac{6(5)}{2} = 15$$



Links →	1	2	3	4	5	6
	12	23	34	45	56	
	13	24	35	46		
	14	25	36			
	15	26				
	16					

Thus, all the I centres can be located.

ω_2 is known. We have to find ω_3, ω_5, and ω_6.

1) $$\frac{\omega_3}{\omega_2} = \frac{l(I_{23}\,I_{12})}{l(I_{23}\cdot I_{13})} = \frac{0.125}{0.695}$$

$$\therefore \omega_3 = \frac{0.125}{0.695}\left(\frac{2\pi(120)}{60}\right)$$

$$\therefore \underline{\omega_3 = 2.26 \text{ rad/s}}$$

(I_{12} and I_{13} lie on opposite sides of I_{23}).

2) $$\frac{\omega_5}{\omega_2} = \frac{l(I_{25}\,I_{12})}{l(I_{25}\cdot I_{15})} = \frac{\cancel{0.925}}{\cancel{0.610}} = \frac{0.918}{1.525}$$

$$\therefore \omega_5 = \frac{\cancel{0.925}(0.918)\,2\pi(120)}{\cancel{0.610}(1.525)\;60} = \underline{\overset{7.57}{\cancel{19.06}} \text{ rad/s}}$$

(I_{12} and I_{15} lie on the same side of I_{25})

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3) $\frac{\omega_6}{\omega_2} = \frac{l(I_{26} \cdot I_{12})}{l(I_{26} \cdot I_{16})} = \frac{0.110}{0.230}$.

$\therefore \omega_6 = \frac{0.110}{0.230} \times \frac{2\pi(120)}{60}$

$\therefore \underline{\omega_6 = 6.01 \text{ rad/s}} \circlearrowleft$

4) To find linear velocity of slider P is that of link 4, when angular velocity of link 2 is known:

Consider their common instant centre, I_{24}.

Consider link 2 to be a disc, containing I_{24} and rotating about I_{12}.

$\therefore V_{I_{24}} = l(I_{24} \cdot I_{12})(\omega_2)$

$\therefore V_{I_{24}} = \frac{2\pi(120)}{60} \times (0.110)$

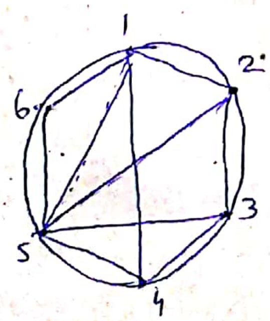
$\therefore \underline{V_{I_{24}} = 1.38 \text{ m/s}}$

Now consider link 4 to be a disc, containing I_{24} and rotating about I_{14}. I_{14} is at ∞, and hence $\cancel{V}$ $l(I_{14} \cdot P) = l(I_{14} \cdot I_{24})$.

Hence, the velocity of the slider will be equal to that of I_{24}.

$\therefore \underline{V_P = V_{I_{24}} = 1.38 \text{ m/s}}$.

———— x ———— x ————



We can obtain V_P also by the following ways -

1) Point P lies on ~~link~~ link 3. Link 3 can be assumed to be having a purely rotary motion about the frame link 1, about I_{13}.

$$\therefore V_P = l(I_{13} \cdot P) \cdot (\omega_3)$$
$$= (0.61)(2.26)$$
$$= 1.38 \text{ m/s.}$$

2) Point P also lies on link 5. Link 5 can be assumed to be having a purely rotary motion about the frame link 1, about I_{15}.

$$\therefore V_P = l(I_{15} \cdot P)(\omega_5)$$
$$= (0.18)(7.57)$$
$$= 1.36 \text{ m/s.}$$

3) V_P can be also obtained by knowing ω_6 (any link for that matter)

Consider I_{46} is common Icenter of link 4 & 6.

Consider I_{46} to be on link 6 and link 6 to be rotating about I_{16}.

$$\therefore V_{I46} = l(I_{46} \cdot I_{16})(\omega_6)$$
$$= (0.23)(6.01)$$
$$= 1.38 \text{ m/s.}$$

Now consider I_{46} to be on link 4, and link 4 to be rotating about I_{14}.

Since $l(I_{46} \cdot I_{14}) = l(I_{14} \cdot P)$, velocity of link 4 (ie. point P) will be the same as that of I_{46}.

$$\therefore V_P = V_{I46} = 1.38 \text{ m/s.}$$

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$V_{I_{46}} = \omega_6 \times l(I_{46} \cdot I_{16}) = 6.01 \times 0.23 = 1.38 \text{ m/s.}$

$V_{I_{34}} = \omega_3 \times l(I_{34} - I_{13}) = \cancel{2.26} \times \cancel{0.825} = 1.38 \text{ m/s}$
2.26×0.61

$V_{I_{45}} = \omega_5 \times l(I_{45}\, I_{15}) = 7.57 \times 0.185 = 1.40 \text{ m/s}$

$V_{I_{24}} = \omega_2 \times l(I_{24}\, I_{12}) = \cancel{0.110} \times 0.11 = 1.38 \text{ m/s}$
12.57

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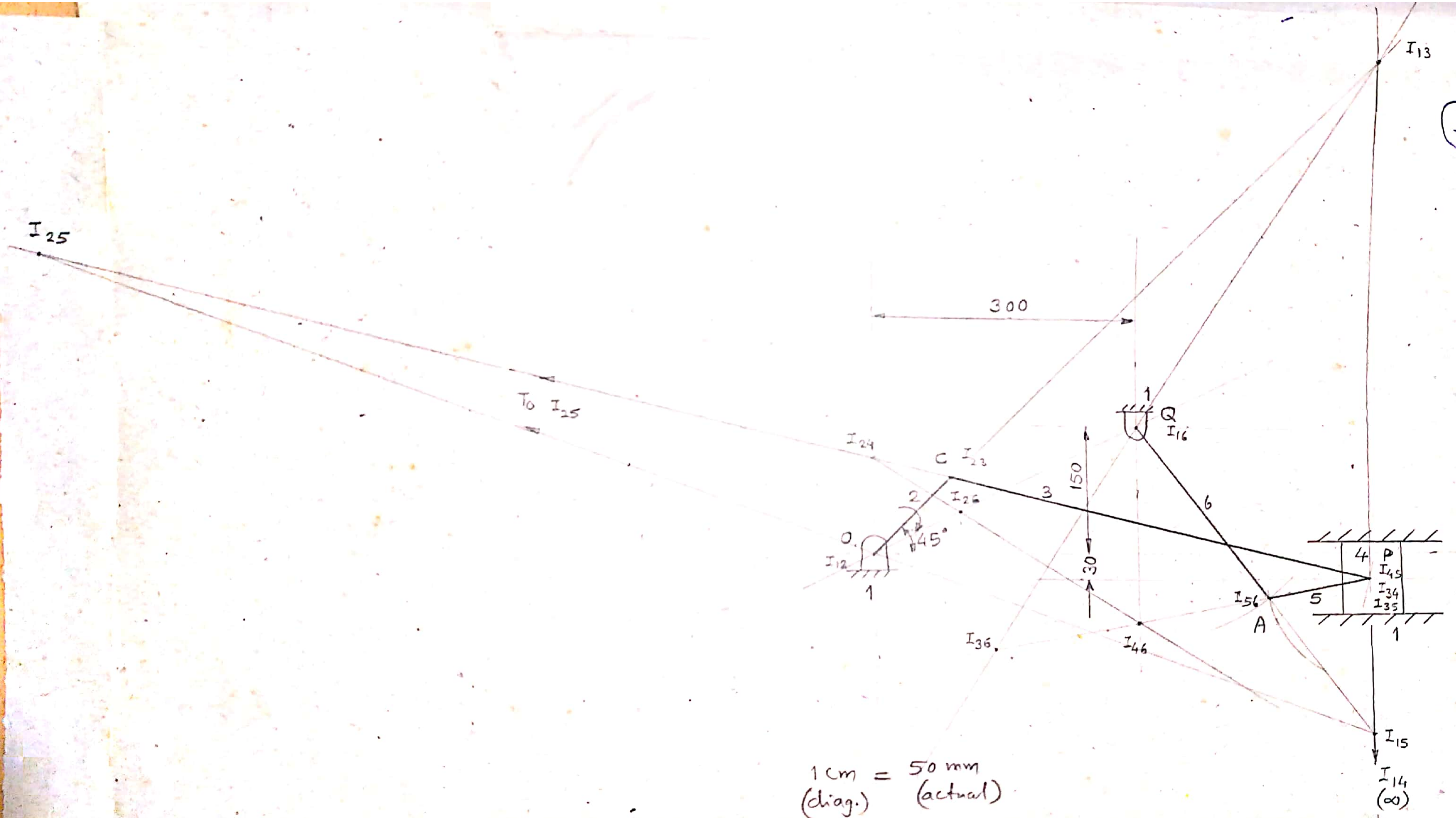
(P4)



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

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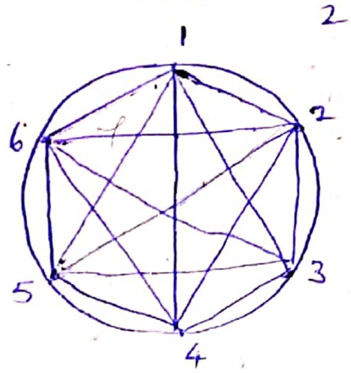
(P5.) For the configuration shown in the figure, with the particulars given below, enumerate and locate all the I centers of velocity and hence find the velocity of slider D and the angular velocity of CD.

OQ = 100 mm, OA = 200 mm, QC = 150 mm, CD = 500 mm, ω_{OA} about O = 120 rpm

(सांदर्भ 72)(Q 5b) (10)

Solution

$$N = \frac{6(5)}{2} = 15$$



Links	1	2	3	4	5	6
	12	23	34	45	56	
	13	24	35	46		
	14	25	36			
	15	26				
	16					

Thus, all the I centers can be located.

1) To find V_d :— i.e. to find velocity of slider 6.

$$V_d = V_6.$$

$$\omega_{OA} = \frac{2\pi(120)}{60} = 12.57 \text{ rad/s} = \omega_2$$

Now, Consider I_{26}: Consider link 2 to be containing I_{26} and rotating about I_{12}.

$$\therefore V_{I_{26}} = l(I_{26} I_{12})(\omega_2)$$

$$= 0.82 \text{ m/s.}$$

Now consider link 6 to be containing I_{26} and rotating about I_{16}. Since I_{16} is at ∞,

$$l(I_{16} I_{26}) = l(I_{16} \cdot 6)$$

$\therefore$ Velocity of slider 6 will be the same as that of I_{26}. $\therefore$ $V_d = V_6 = 0.82$ m/s.

2) To find angular velocity of link CD i.e link 5.

$$\frac{\omega_5}{\omega_2} = \frac{l(I_{25} \cdot I_{12})}{l(I_{25} \cdot I_{15})}$$

$$\therefore \omega_5 = (12.57)\left(\frac{0.0875}{0.605}\right)$$

$$\therefore \underline{\omega_5 = 1.82 \text{ rad/s}}$$

(Both I_{12} and I_{15} lie on the same side of I_{25}).

---x---x---

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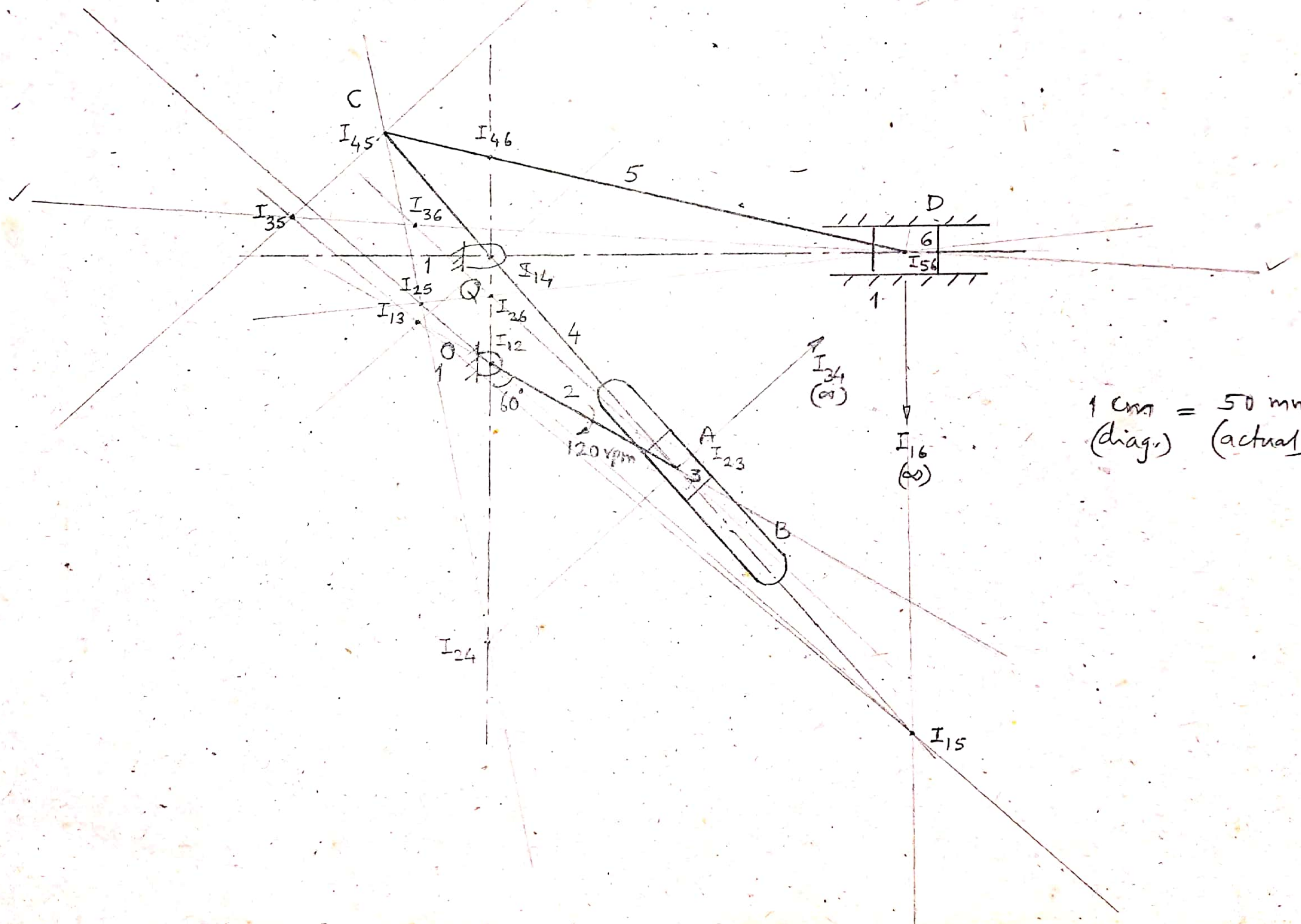
P.5



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