i) Relative velocity equations:

$$\overset{\times\checkmark}{V_C} = \overset{\checkmark\checkmark}{V_B} + \overset{\times\checkmark}{V_{CB}}$$

$$\overset{\times\checkmark}{V_E} = \overset{\checkmark\checkmark}{V_D} + \overset{\times\checkmark}{V_{ED}}$$

$$V_B = r_{O_2B} w_2 = 15(2)$$
$$= 30\,\text{mms}^{-1}$$

ii) See answer sheet below for the diagram.

$V_C = 22\,\text{mms}^{-1}$, $V_{CB} = 17.5\,\text{mms}^{-1}$

$$V_{CB} = r_{BC} w_3$$
$$17.5 = 40 w_3$$
$$w_3 = 0.4375\,\text{rads}^{-1}$$
$$\approx 0.44\,\text{rads}^{-1} \text{ (ccw)}$$

1ii) $V_C = r_{O_4C}\,\omega_4$

$22 = 15\,\omega_4$

$\omega_4 = 1.4\dot{6}\ \text{rads}^{-1}$ (cw)

From the diagram, $V_D = 53\ \text{mms}^{-1}$, $V_E = 46\ \text{mms}^{-1}$,

$V_{ED} = 9.5\ \text{mms}^{-1}$,

$V_{ED} = r_{ED}\,\omega_5$

$9.5 = 25\,\omega_5$

$\omega_5 = 0.38\ \text{rads}^{-1}$ (cw)

$V_E = r_{O_6E}\,\omega_6$

$46 = 15\,\omega_6$

$\omega_6 = 3.0\dot{6}\ \text{rads}^{-1}$ (cw)

1iii) Relative acceleration equations

$$\overset{\checkmark\checkmark}{A_C^n} + \overset{\times\checkmark}{A_C^t} = \overset{\checkmark\checkmark}{A_B^n} + \underset{(\text{zero})}{\overset{\checkmark\checkmark}{A_B^t}} + \overset{\checkmark\checkmark}{A_{CB}^n} + \overset{\times\checkmark}{A_{CB}^t}$$

All can find using $w^2 r$

$$A_C^n = w_4^2 r_{O_4C} = 1.4\dot{6}^2(15)$$
$$= 32.2\dot{6}\ mms^{-2}$$

$$A_{CB}^n = w_3^2 r_{CB} = 0.4375^2(40)$$
$$= 7.65625\ mms^{-2}$$

$$A_B^n = w_2^2 r_{O_2B} = 2^2(15)$$
$$= 60\ mms^{-2}$$

1iv) Refer to the answer sheet below for the diagram.

From the diagram, $A_C^t = 40.5\ mms^{-2}$, $A_{CB}^t = 81\ mms^{-2}$,

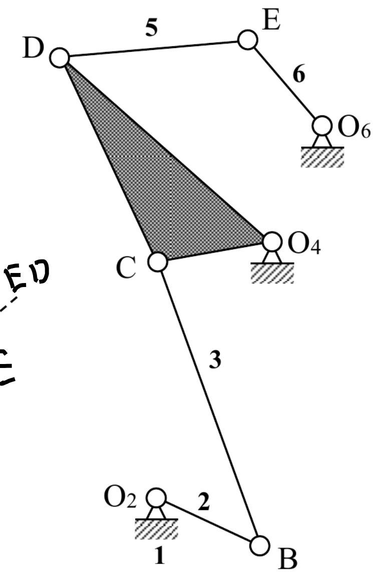
$$A_{CB}^t = r_{CB}\alpha_3$$
$$81 = 40\alpha_3$$
$$\alpha_3 = 2.025\ rads^{-2}\ (cw)$$

negative of w_3

$$A_C^t = r_{O_4C}\alpha_4$$
$$40.5 = 15\alpha_4$$
$$\alpha_4 = 2.7\ rads^{-2}\ (ccw)$$

negative of w_4

From the diagram, $A_D = 127\ mms^{-2}$

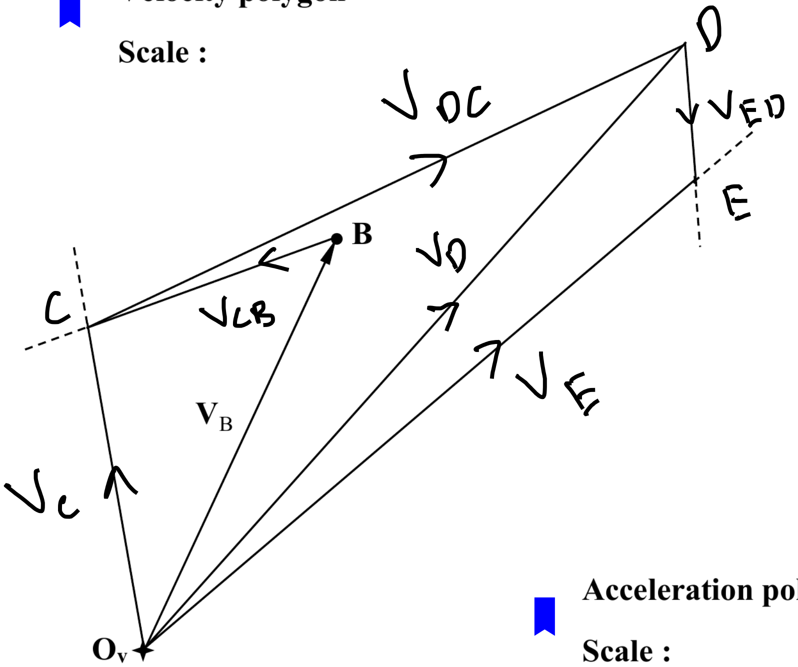


ω_2 = 2 rad/s (ccw)

O_2B = 15 mm
BC = 40 mm
CD = 30 mm
O_4C = 15 mm
O_4D = 37 mm
DE = 25 mm
O_6E = 15 mm

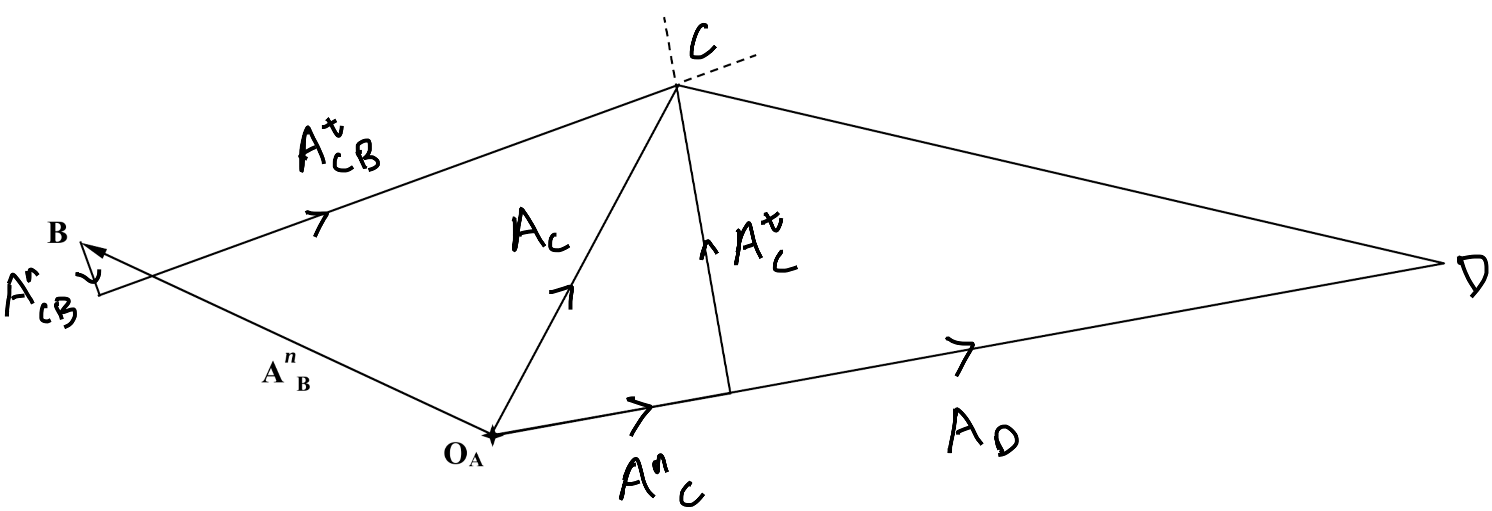
Velocity polygon

Scale :



Acceleration polygon

Scale :



2i) Relative velocity equations:

$$\overset{\times\checkmark}{V_B} = \overset{\checkmark\checkmark}{V_A} + \overset{\times\checkmark}{V_{B/A}}$$

$$\overset{\times\checkmark}{V_D} = \overset{\checkmark\checkmark}{V_C} + \overset{\times\checkmark}{V_{D/C}}$$

$V_A = r_{O_2A} w_2$

$= 15(2)$

$= 30\ mms^{-1}$

$V_C = r_{O_2C} w_2$

$= 30(2)$

$= 60\ mms^{-1}$

ii) Refer to the answer sheet below for the diagram.

$$\frac{r_{E/C}}{r_{C/D}} = \frac{V_{E/C}}{V_{C/D}}$$

From the diagram, $V_E = 92\ mms^{-1}$, $V_B = 32\ mms^{-1}$,

$V_{B/A} = 16\ mms^{-1}$

$V_{B/A} = r_{B/A} w_3$

$16 = 25 w_3$

$w_3 = 0.64\ rads^{-1}$ (cw)

From the diagram, $V_D = 54\ mms^{-1}$, $V_{D/C} = 57\ mms^{-2}$

$V_{D/C} = r_{D/C} w_5$

$57 = 40(w_5)$

$w_5 = 1.425\ rads^{-1}$ (cw)

$V_D = r_{D/O_6} w_6$

$54 = 50 w_6$

$w_6 = 1.08\ rads^{-1}$ (cw)

2iii)

$$A_D = A_C + A_{D/C}$$

$$\overset{\checkmark\checkmark}{A_D^n} + \overset{\times\checkmark}{A_D^t} = \overset{\checkmark\checkmark}{A_C^n} + \underset{\text{(zero)}}{\overset{\checkmark\checkmark}{A_C^t}} + \overset{\checkmark\checkmark}{A_{D/C}^n} + \overset{\times\checkmark}{A_{D/C}^t}$$

$$A_B = A_A + A_{B/A}$$

$$\underset{\text{(zero)}}{\overset{\checkmark\checkmark}{A_B^n}} + \overset{\times\checkmark}{A_B^t} = \overset{\checkmark\checkmark}{A_A^n} + \underset{\text{(zero)}}{\overset{\checkmark\checkmark}{A_A^t}} + \overset{\checkmark\checkmark}{A_{B/A}^n} + \overset{\times\checkmark}{A_{B/A}^t}$$

$$A_{D/C}^n = w_5^2 \, r_{D/C}$$
$$= 1.425^2(40)$$
$$= 81.225 \text{ mms}^{-2}$$

$$A_{B/A}^n = w_3^2(r_{B/A})$$
$$= 0.64^2(25)$$
$$= 10.24 \text{ mms}^{-2}$$

$$A_C^n = w_2^2(r_{O_2C})$$
$$= 2^2(30)$$
$$= 120 \text{ mms}^{-2}$$

$$A_A^n = w_2^2(r_{O_2A})$$
$$= 2^2(15)$$
$$= 60 \text{ mms}^{-2}$$

$$A_D^n = w_6^2(r_{O_6D})$$
$$= 1.08^2(50)$$
$$= 58.32 \text{ mms}^{-2}$$

2iv) Refer to the answer sheet below for the diagram.

From the diagram, $A_E = 221 \text{ mms}^{-2}$, $A_B = 23 \text{ mms}^{-2}$,

$$A_{BA}^t = 51 \text{ mms}^{-2},$$

$$A_{BA}^t = r_{BA}\alpha_3$$
$$51 = 25\alpha_3$$
$$\alpha_3 = 2.04 \text{ mms}^{-2} \text{ (ccw)}$$

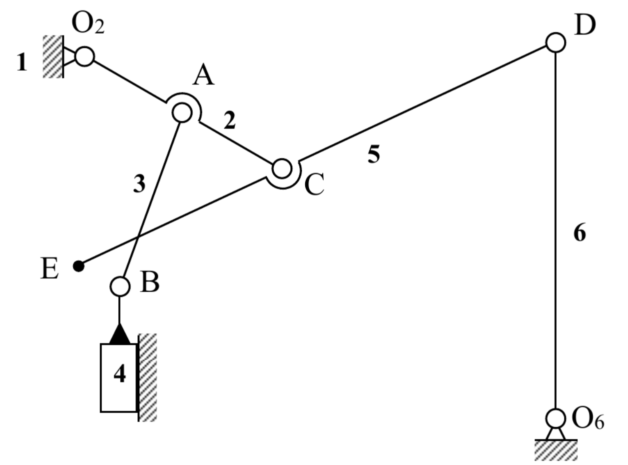
From the diagram, $A_D^t = 138 \text{ mms}^{-2}$, $A_{DC}^t = 96 \text{ mms}^{-2}$

$$A_{DC}^t = r_{DC}\alpha_5$$
$$96 = 40(\alpha_5)$$
$$\alpha_5 = 2.4 \text{ rads}^{-2} \text{ (cw)}$$

$$A_D^t = r_{O_6D}\alpha_6$$
$$138 = 50\alpha_6$$
$$\alpha_6 = 2.76 \text{ rads}^{-2} \text{ (ccw)}$$

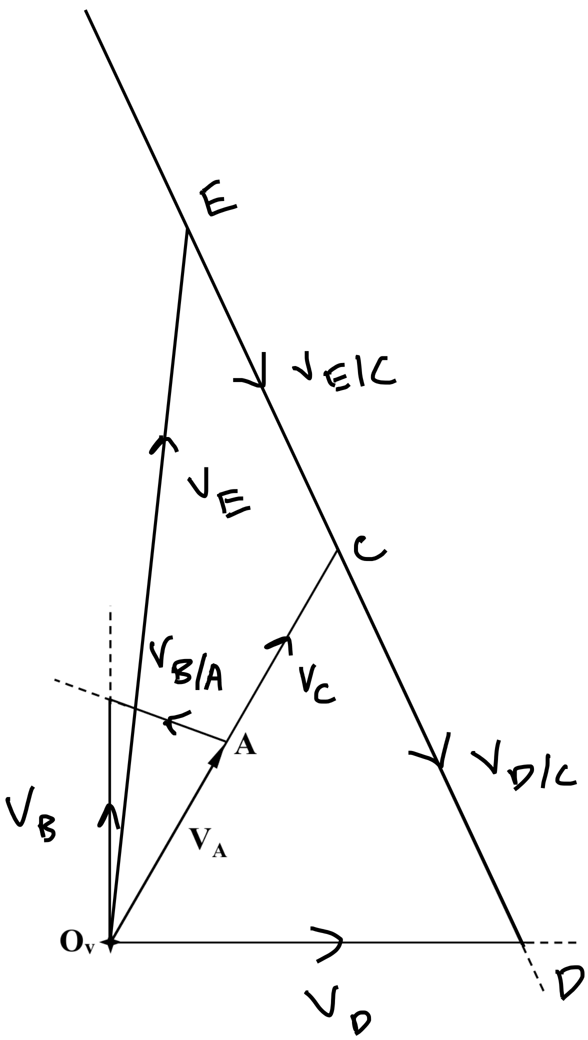
ω_2 = 2 rad/s (ccw)

O_2A = 15 mm
O_2C = 30 mm
AB = 25 mm
CD = 40 mm
DE = 70 mm
O_6D = 50 mm



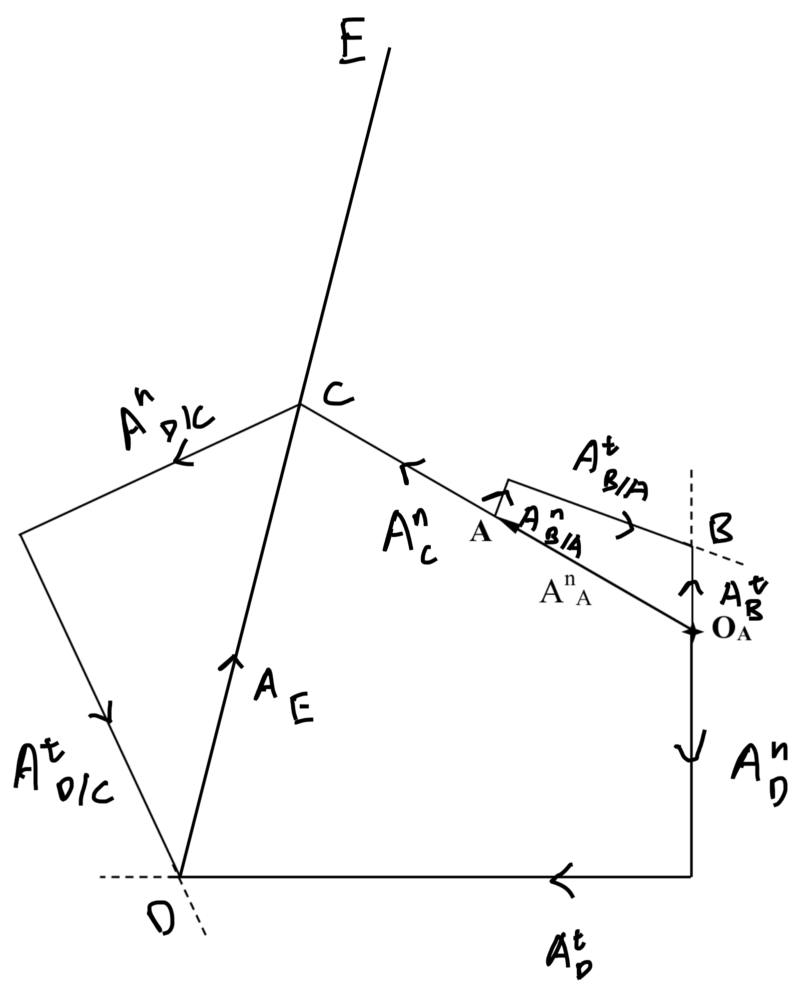
Velocity polygon

Scale :



Acceleration polygon

Scale :



3 i) Relative velocity equations:

$$\overset{\times\times}{V_C} = \overset{\checkmark\checkmark}{V_B} + \overset{\times\checkmark}{V_{C/B}}$$

$$\overset{\times\times}{V_C} = \overset{\checkmark\checkmark}{V_D} + \overset{\times\checkmark}{V_{C/D}} \quad (\perp CD)$$

$$\therefore \overset{\checkmark\checkmark}{V_B} + \overset{\times\checkmark}{V_{C/B}} = \overset{\checkmark\checkmark}{V_D} + \overset{\times\checkmark}{V_{C/D}}$$

ii) Refer to the answer sheet below for the diagram.

From the diagram, $V_{C/B} = 45\ mms^{-1}$, $V_{C/D} = 107\ mms^{-1}$, $V_C = 58\ mms^{-1}$

$$V_{C/B} = r_{CB} w_3$$

$$45 = 30 w_3$$

$$w_3 = 1.5\ rads^{-1}\ (cw)$$

$$V_{C/D} = r_{CD} w_4$$

$$107 = 25 w_4$$

$$w_4 = 4.28\ rads^{-1}$$

3iii) $A_C = A_B + A_{C/B}$

$$\overset{\times\times}{A_C} = \overset{\checkmark\checkmark}{A_B^n} + \overset{\checkmark\checkmark}{A_B^t} + \overset{\checkmark\checkmark}{A_{C/B}^n} + \overset{\times\checkmark}{A_{C/B}^t}$$

$$A_C = A_D + A_{C/D}$$

$$\overset{\times\times}{A_C} = \overset{\checkmark\checkmark}{A_D} + \overset{\checkmark\checkmark}{A_{C/D}^n} + \overset{\times\checkmark}{A_{C/D}^t} \ (\perp CD)$$

$$A_B^n = w_2^2 r_{O_2B}$$
$$= 1^2(50)$$
$$= 50 \text{ mms}^{-2}$$

$$A_D = 50 \text{ mms}^{-2}$$

$$A_{C/D} = r_{CD}(w_4)^2$$
$$= 25(4.28)^2$$
$$= 457.96 \text{ mms}^{-2}$$

$$A_B^t = r_{O_2B}\,\alpha_2$$
$$= 50(1)$$
$$= 50 \text{ mms}^{-2}$$

$$A_{C/B}^n = w_3^2 r_{CB}$$
$$= 1.5^2(30)$$
$$= 67.5 \text{ mms}^{-2}$$

iv) Refer to the answer sheet below for the diagram.

From the diagram, $A_{C/B}^t = 475 \text{ mms}^{-2}$, $A_{C/D}^t = 300 \text{ mms}^{-2}$,

$$A_C = 535 \text{ mms}^{-2},$$

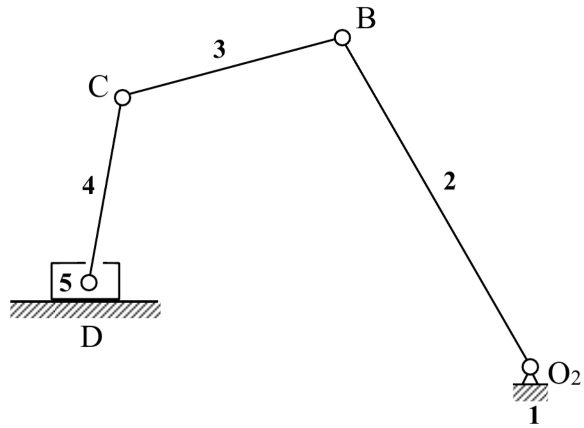
$$A^t_{C/B} = r_{C/B}(\alpha_3)$$
$$475 = 30\alpha_3$$
$$\alpha_3 = 15.8 \text{ rads}^{-2} \text{ (ccw)}$$

$$A^t_{C/D} = r_{C/D}(\alpha_4)$$
$$300 = 25\alpha_4$$
$$\alpha_4 = 12 \text{ rads}^{-2} \text{ (cw)}$$

Answer Sheet MA2002

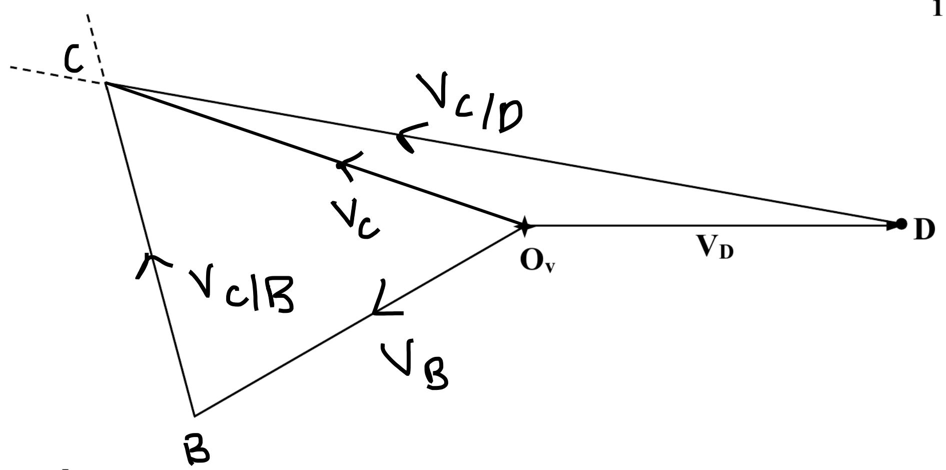
ω_2 = 1 rad/s (ccw)
α_2 = 1 rad/s^2 (ccw)
V_D = 50 mm/s (to the right)
A_D = 50 mm/s^2 (to the left)

O_2B = 50 mm
BC = 30 mm
CD = 25 mm



Velocity polygon

Scale :



Acceleration polygon

Scale :