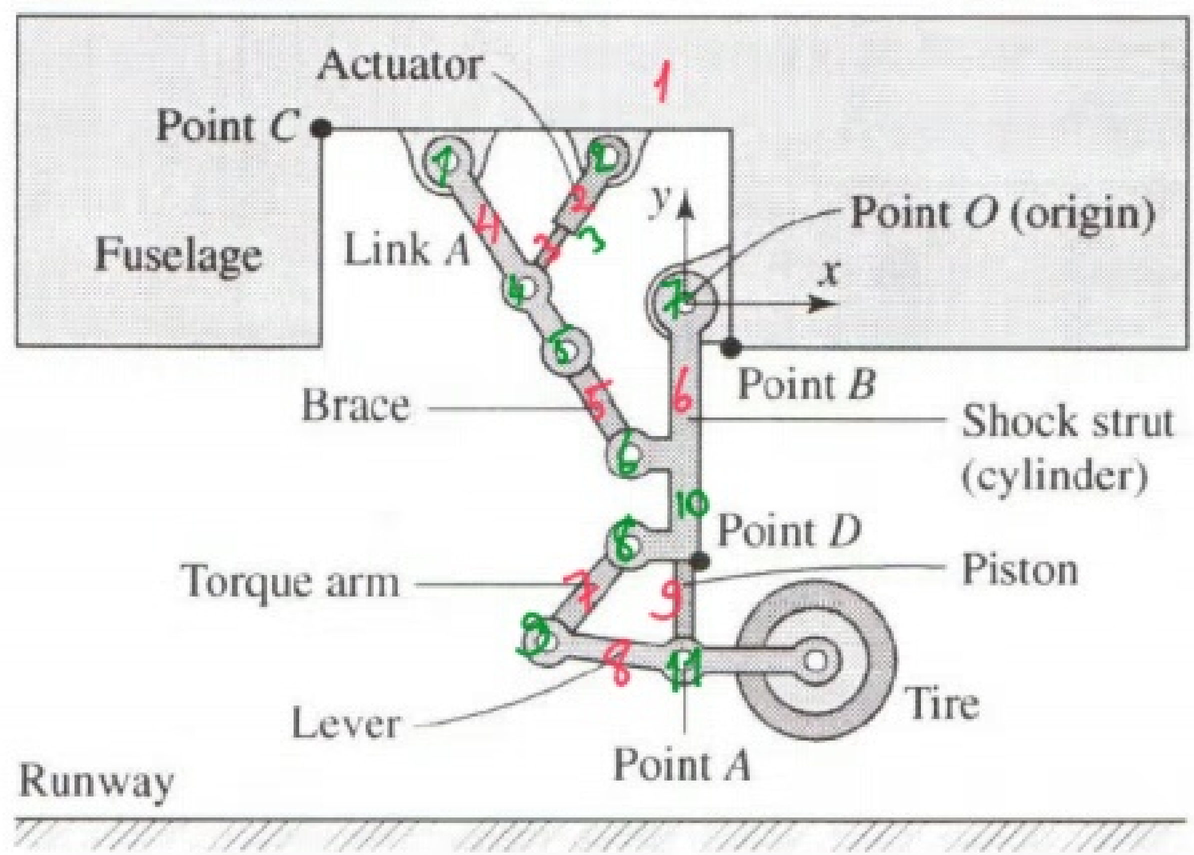
20151 / MT01

1st question



$n = 9$

$j = 11$

$$M = 3(n - j - 1) + \sum f_i = 3(9 - 11 - 1) + 11$$

$$= \underline{\underline{2}} \text{ DOF}$$

4th question

F.K.

$x = l\, C_\theta$

I.K.

$\theta = C^{-1} \dfrac{x}{l}$

If we think of a simple bar rotating around a point, θ is amount of rotation. The position eq. of the tip w.r.t. θ is forward kinematics, the equation calculating needed amount of rotation for required x, y position of the tip is inverse kinematics.

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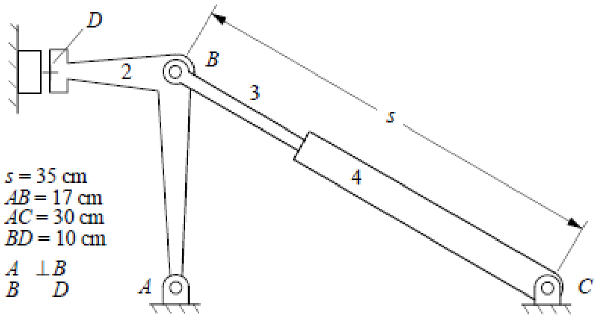
3. Velocity and acceleration polygons of printing mechanism is given below. Input velocity and acceleration of the piston is 5 cm/sec ve 2 cm/sec^2.
    a. Velocity and acceleration vectorial eq. are to be written based on the vector polygons.
    b. Angular velocity and acceleration of the rotating piece 2 is to be determined.
    c. Linear velocity and acceleration point D?

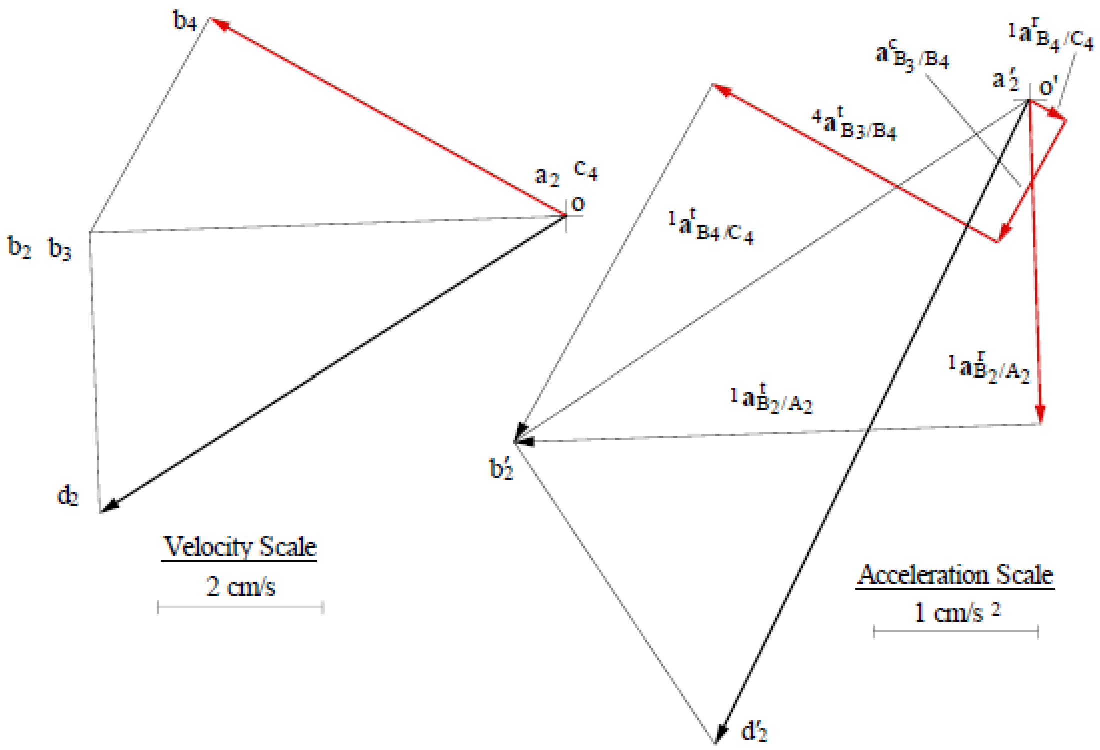
(Aşağıdaki baskı makinesinin hız ve ivme poligonları ölçekleri ile verilmiştir. Pistonun giriş hız ve ivmesi 5 cm/sn ve 2 cm/sn^2 olarak verilmiştir.

a. Sistemin hız ve ivme vektör eşitliklerini, vektör poligonlarından hareketle yazınız.

b. 2 elemanının açısal hız ve açısal ivmesini bulunuz.

c. D noktasının doğrusal hız ve ivmesini bulunuz.)





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Position Analysis

Draw the linkage to scale. Start by locating the pivots A and C. Then locate point B

Velocity Analysis

Consider the points at location B.

$$ {}^1v_{B_2} = {}^1v_{B_3} = {}^1v_{B_2/A_2} $$

$$ {}^1v_{B_3} = {}^1v_{B_4} + {}^1v_{B_3/B_4} $$

Where

$$ {}^1v_{B_2/A_2} = {}^1\omega_2 \times r_{B/A} \ (\perp \text{ to } r_{B/A}) $$

$$ {}^1v_{B_4} = {}^1v_{B_4/C_4} = {}^1\omega_4 \times r_{B/C} \ (\perp \text{ to } r_{B/C}) $$

$$ \left|{}^1v_{B_3/B_4}\right| = 5 \ \text{cm/s along } r_{B/C} $$

Solve Eq. (1) using a velocity polygon, and determine the velocity of D_2 by image.

$$ {}^1v_{D_2} = 5.79 \ \text{cm/s} $$

$$ \left|{}^1\omega_2\right| = \frac{\left|{}^1v_{B_2/A_2}\right|}{\left|r_{B/A}\right|} = \frac{5.81}{17} = 0.342 \ \text{rad/s CCW} $$

and

$$ \left|{}^1\omega_4\right| = \frac{\left|{}^1v_{B_4/C_4}\right|}{\left|r_{B/C}\right|} = \frac{3.018}{35} = 0.0862 \ \text{rad/s CCW} $$

Acceleration Analysis

Again, consider the points at location B.

$$ {}^1\alpha_{B_2} = {}^1\alpha_{B_3} = {}^1\alpha_{B_2/A_2} = {}^1\alpha^r_{B_2/A_2} + {}^1\alpha^t_{B_2/A_2} $$

$$ {}^1\alpha_{B_3} = {}^1\alpha_{B_4/A_4} + {}^1\alpha_{B_3/B_4} = {}^1\alpha^r_{B_4/A_4} + {}^1\alpha^t_{B_4/A_4} + {}^4\alpha^t_{B_3/B_4} + {}^4\alpha^n_{B_3/B_4} + {}^1\alpha^c_{B_3/B_4} $$

Combining the equations,

$$ {}^1\alpha^r_{B_2/A_2} + {}^1\alpha^t_{B_2/A_2} = {}^1\alpha^r_{B_4/A_4} + {}^1\alpha^t_{B_4/A_4} + {}^4\alpha^t_{B_3/B_4} + {}^4\alpha^n_{B_3/B_4} + {}^1\alpha^c_{B_3/B_4} $$

Where

$$ \left|{}^1\alpha^r_{B_2/A_2}\right| = \left|{}^1\omega_2\right|^2 \left|r_{B/A}\right| = 0.342^2(17) = 1.99 \ \text{cm/s}^2 \ (\text{opposite to } r_{B/A}) $$

$$ {}^1\alpha^t_{B_2/A_2} = {}^1\alpha_2 \times r_{B/A} \ (\perp \text{ to } r_{B/A}) $$

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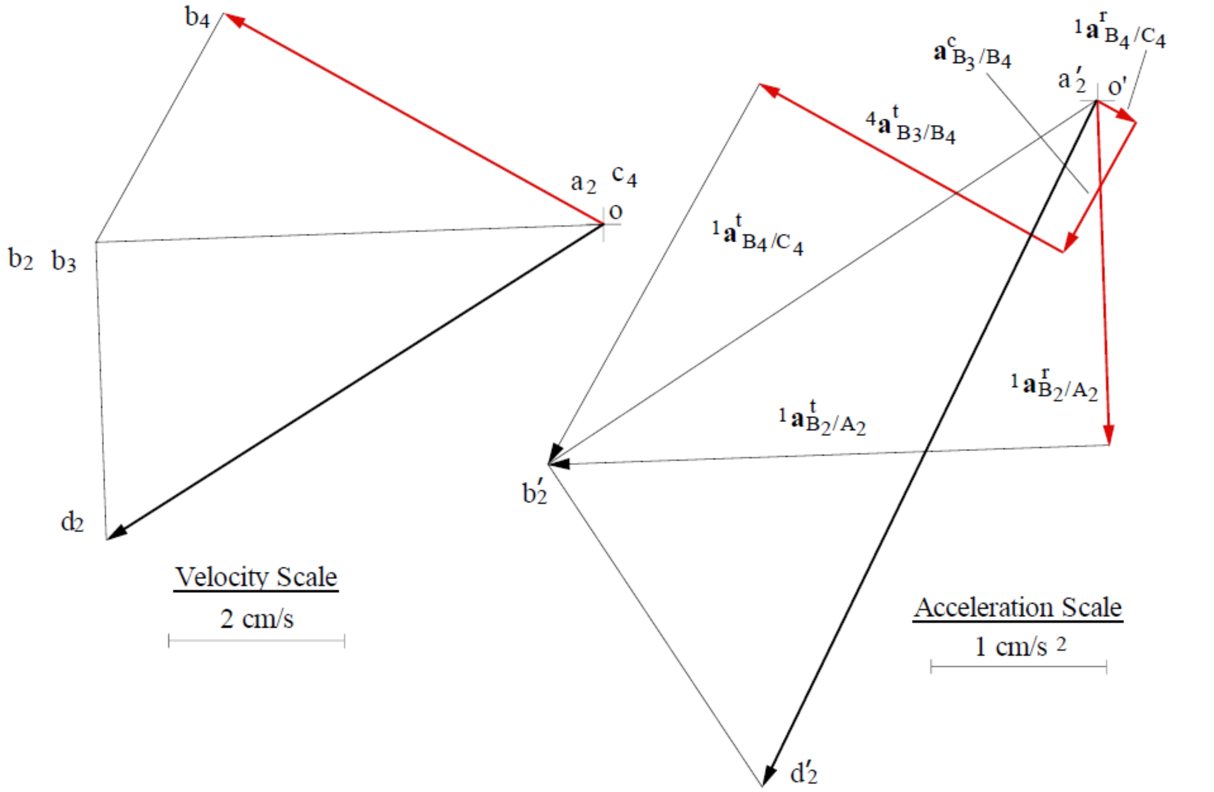


$$\left|{}^1\alpha^r_{B_4/C_4}\right| = \left|{}^1\omega_4\right|^2 \left|r_{B/C}\right| = 0.0862^2(35) = 0.260 \text{ cm/s}^2 \text{ (opposite to } r_{B/C})$$

$${}^1\alpha^t_{B_4/A_4} = {}^1\alpha_4 \times r_{B/C} \;(\perp \text{ to } r_{B/C})$$

$$\left|{}^4\alpha^t_{B_3/B_4}\right| = 10 \text{ cm/s}^2 \text{ (along } r_{B/C})$$

$$\left|{}^4\alpha^n_{B_3/B_4}\right| = \frac{\left|{}^1v_{B_3/B_4}\right|^2}{\infty} = 0$$

$${}^1\alpha^c_{B_3/B_4} = 2 \cdot {}^1\omega_4 \times {}^4v_{B_3/B_4} \Rightarrow \left|{}^1\alpha^c_{B_3/B_4}\right| = 2\left|{}^1\omega_4\right|\left|{}^4v_{B_3/B_4}\right| = 2(0.0862)(5) = 0.862$$

The direction for ${}^1\alpha^c_{B_3/B_4}$ is perpendicular to BC and in the direction defined by rotating ${}^4v_{B_3/B_4}$ 90° in the direction of ${}^1\omega_4$. This direction is generally down and to the left.

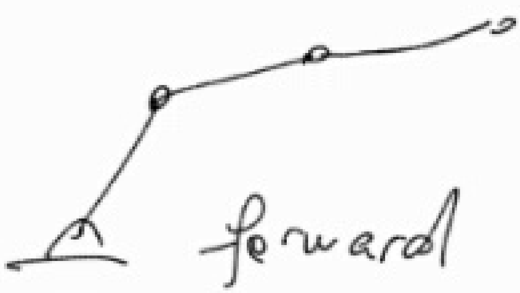
Solve Eq. (2) using an acceleration polygon, and determine the acceleration of D_2 by image.

$${}^1a_{D_2} = 4.39 \; cm/s^2$$

$$\left|{}^1\alpha_2\right| = \frac{\left|{}^1\alpha^t_{B_2/A_2}\right|}{\left|r_{B/A}\right|} = \frac{3.23}{17} = 0.190 \text{ rad/s}^2 \text{ CCW}$$

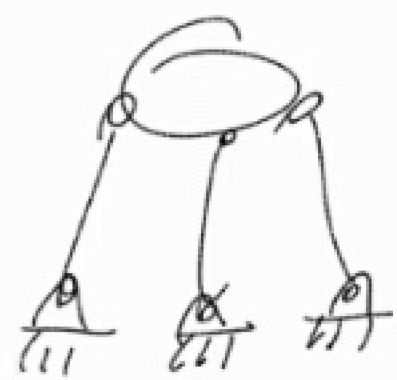
5th question

SERIAL



forward
inverse

PARALLEL



	serial	parallel
F	Easy	Hard
I	Hard	Easy