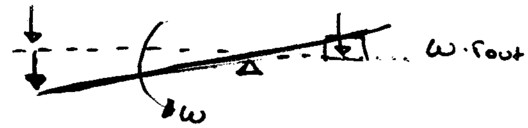
$$\frac{F_{out}}{F_{in}} = \frac{V_{in}}{V_{out}}$$

$F_{in}V_{in} = F_{out}V_{out}$



For press example:

$$M_A = \frac{F_{out}}{F_{in}} \quad ; \quad F_{out} = M_A \cdot F_{in} = \left(\frac{V_{in}}{V_{out}}\right) \cdot F_{in}$$

where ω_2 is given:

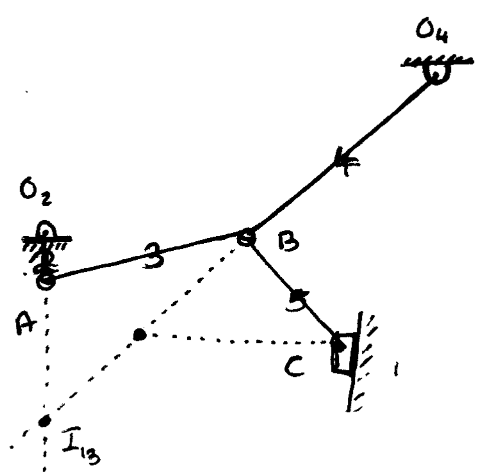
$V_{in} = O_2E \cdot \omega_2$

Given $F_{in} = 100$ lb, Find F_{out}

$O_2E = 21$mm

$V_{in} = \overline{O_2E} \cdot \omega_2$

$V_c = V_{out}$



IC. to find V_c

ω_3, I_{13}

$V_A = \overline{O_2A}\omega_2 = \overline{I_{13}A}\omega_3$

$$\omega_3 = \frac{\overline{O_2A}\,\omega_2}{\overline{I_{13}A}}$$

$V_B = \overline{I_{13}B} \cdot \omega_3 = \overline{I_{15}B} \cdot \omega_5$

$$\omega_5 = \frac{\overline{I_{13}B}}{\overline{I_{15}B}} \cdot \frac{\overline{O_2A}}{I_{13}A} \quad \omega_2$$

$V_c = I_{15}C \cdot \omega_5 = V_{out}$

$$F_{out} = \frac{O_2E\ \omega_c}{I_{15}C\,\omega_5}$$

$= 1.48(100) = 148$

$a, b, c, d, \theta_2, \omega_2$

Find ω_3, ω_4

1. Positional analysis to find θ_3, θ_4
2. $\hat{R}_2 + \hat{R}_3 - \hat{R}_4 - \hat{R}_1 = \emptyset$

   $ae^{j\theta_2} + be^{j\theta_3} - d - ce^{j\theta_4} = \emptyset$

3. Differentiate it:

$$aj\frac{d\theta_2}{dt}e^{j\theta_2} + bj\frac{d\theta_3}{dt}e^{j\theta_3} - \emptyset - cj\frac{d\theta_4}{dt}e^{j\theta_4} = \emptyset$$

$$\underbrace{aj\omega_2 e^{j\theta_2}}_{\hat{V}_A} + \underbrace{bj\omega_3 e^{j\theta_3}}_{\hat{V}_{B/A}} - \underbrace{cj\omega_4 e^{j\theta_4}}_{\hat{V}_C} = \emptyset$$

$$\therefore \hat{V}_C = \hat{V}_A + \hat{V}_{B/A}$$

2 scalar eq'ns:

$$a\omega_2 j(\cos\theta_2 + j\sin\theta_2) + b\omega_3 j(\cos\theta_3 + j\sin\theta_3) - c\omega_4(\cos\theta_4 + j\sin\theta_4) = \emptyset$$

$$ja\omega_2\cos\theta_2 - a\omega_2\sin\theta_2 + jb\omega_3\cos\theta_3 - b\omega_3\sin\theta_3 - jc\omega_4\cos\theta_4 + c\omega_4\sin\theta_4 = \emptyset$$

Real parts:

$$-a\omega_2\sin\theta_2 - b\omega_3\sin\theta_3 + c\omega_4\sin\theta_4 = \emptyset$$

Imaginary:

$j^2 = -1$

$$a\omega_2\cos\theta_2 + b\omega_3\cos\theta_3 - c\omega_4\cos\theta_4 = \emptyset$$

$$\underbrace{\begin{bmatrix} -b\sin\theta_3 & c\sin\theta_4 \\ b\cos\theta_3 & -c\cos\theta_4 \end{bmatrix}}_{A} \begin{bmatrix} \omega_3 \\ \omega_4 \end{bmatrix} = \underbrace{\begin{bmatrix} a\omega_2\sin\theta_2 \\ -a\omega\cos\theta_2 \end{bmatrix}}_{B}$$

$$\begin{bmatrix} \omega_3 \\ \omega_4 \end{bmatrix} = [A]^{-1}[B] \rightsquigarrow \text{ where } \begin{bmatrix} a & b \\ c & d \end{bmatrix}^{-1} = \frac{\begin{bmatrix} d & -b \\ -c & a \end{bmatrix}}{(ad - cb)}$$

or determinant

$$\omega_3 = \frac{ac(-\cos\theta_4\sin\theta_2 + \sin\theta_4\cos\theta_2)\omega_2}{bc(\sin\theta_3\cos\theta_4 - \cos\theta_3\sin\theta_4)}$$

$$= \sin(\theta_3 - \theta_4)$$

Example

(dimension in cm)

$d = 6$; $a = 2$; $b = 7$; $c = 9$; $p = 6$

$\delta_3 = 30°$; $\theta_2 = 30°$; $\omega_2 = 10$ rad/s

Find ω_3, ω_4, V_p

1. Position analysis

$\theta_3 = 88.8°$, $\theta_4 = 117.3°$

2. $$\omega_3 = \frac{2(10)}{7} \cdot \frac{\sin(117.3° - 30°)}{\sin(88.8° - 117.3°)} = -6 \text{ rad/s}$$

$$\omega_4 = \frac{2(10)}{9} \cdot \frac{\sin(30° - 88.8°)}{\sin(88.8° - 117.3°)} = -4 \text{ rad/s}$$

3. $$\hat{V}_p = \underbrace{j(2)(10)e^{j30°}}_{\hat{V}_A} + j(6)(-6)e^{j(88.8° + 30°)}$$

$$\hat{V}_A = 20(j\cos(118.8°) - \sin(118.8°))$$

$$= j\,17.34 + 31.55$$

$$V_p = 21.55 + j\,34.66$$

$$|\hat{V}_p| = \sqrt{21.55^2 + 34.66^2} = 40.8 \text{ cm/s}$$

$$\theta = \tan^{-1}\left(\frac{34.66}{21.55}\right) = 58°$$

Example

Point A

$$\hat{R}_2 - \hat{R}_1 - \hat{R}_4 - \hat{R}_3 = 0$$

$$ae^{j\theta_2} - de^{j0} - ce^{j90°} - be^{j\theta_3} = 0$$

$$aj\omega_2 e^{j\theta_2} - d - 0 - bj\omega_3 e^{j\theta_3} = 0$$

$$\hat{V}_A - \hat{V}_B - \hat{V}_{AB} = 0$$

$$\hat{V}_A = \hat{V}_B + \hat{V}_{B/A}$$

$\boxed{\text{Example } 6\text{-}8}$

$a = 40$ $\theta_2 = 60°$

$b = 120$ $\omega_2 = -30$ rad/s

$c = -20$

Find $\omega_3, \dot{d}$

1.) Find $\theta_3 = 152.9°$

2.) $\omega_3 = \frac{40}{120} \cdot \frac{\cos 60°}{\cos 152.9°} (-30) = 5.616$ rad

$\dot{d} = -40(-30) \sin 60° + 120(5.616) \sin(152.9°) = 1346$ mm/s

$\hat{V}_A = j a \omega_2 e^{j\theta_2} = a\omega_2 e^{j(\theta_2 + 90°)}$

$j = e^{j90°}$

$\hat{V}_A = 1039.23 - j600$

$\hat{V}_{AB} = j b \omega_3 e^{j\theta_3} = -306.86 - j600$

$\hat{V}_A = \hat{V}_B + \hat{V}_{B/A} \Rightarrow \hat{V}_B = \hat{V}_A - V_{AB} = 1346$ mm/s