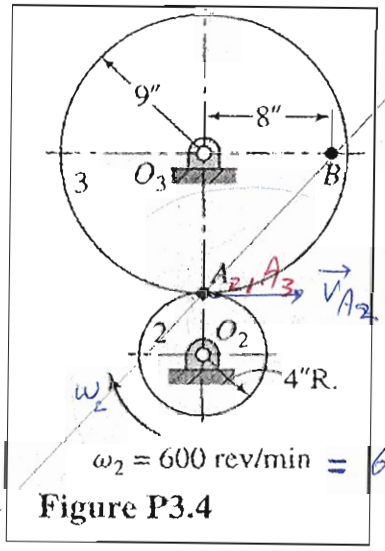
TUTORIAL 4: VELOCITY ANALYSIS (p158 in 4th ed.)

OCTOBER 5, 2009

PROBLEM 1: Problem 3.4 (p135)

Given:

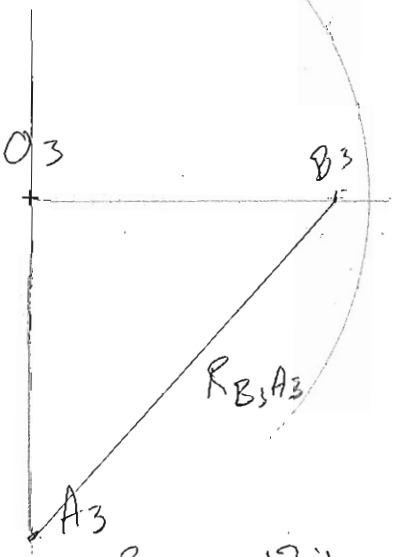
Q: $w_3, V_{B3} = ?$



$\omega_2 = 600$ rev/min = 62.8 rad/sec (C.W.)

Figure P3.4

$\vec{V}_{A_2} = \vec{V}_{A_3}$ (b/c no slip)



$R_{B_3A_3} = 12$ in

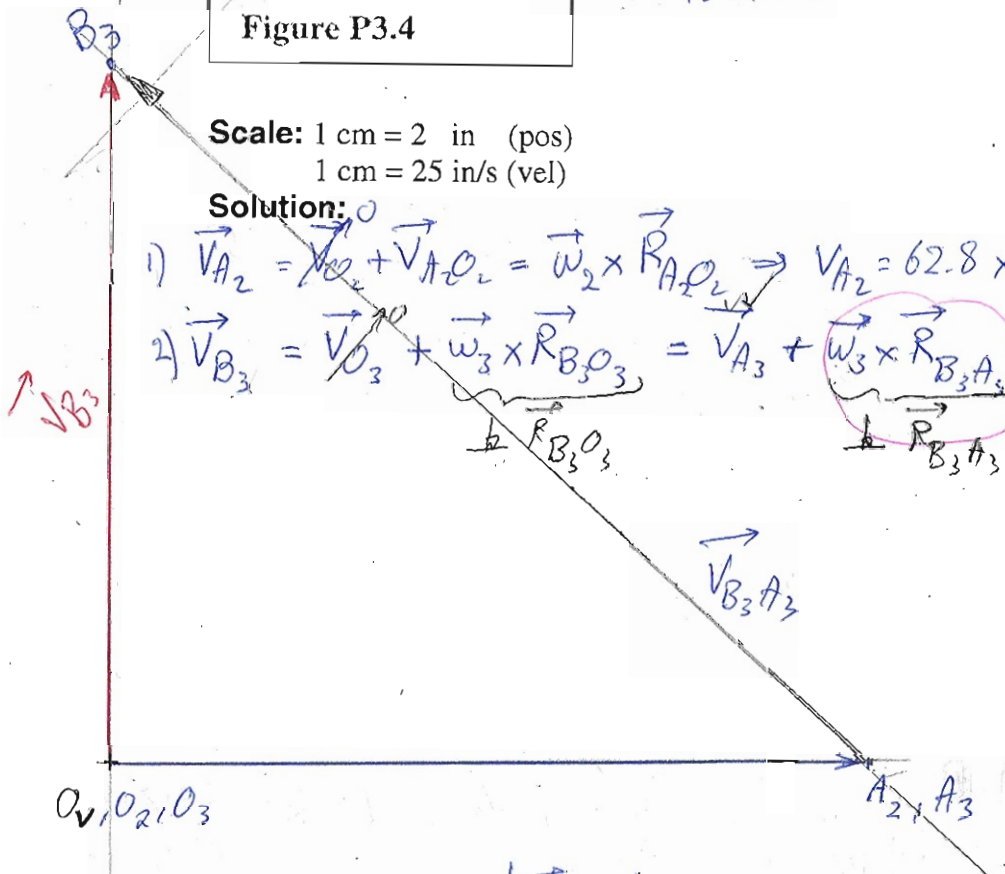
Scale: 1 cm = 2 in (pos)
1 cm = 25 in/s (vel)

Solution:

1) $\vec{V}_{A_2} = \vec{V}_{O_2} + \vec{V}_{A_2O_2} = \vec{\omega}_2 \times \vec{R}_{A_2O_2} \Rightarrow V_{A_2} = 62.8 \times 4 = 251.3$ in/s →

2) $\vec{V}_{B_3} = \vec{V}_{O_3} + \vec{\omega}_3 \times \vec{R}_{B_3O_3} = \vec{V}_{A_3} + \vec{\omega}_3 \times \vec{R}_{B_3A_3} \rightarrow \vec{V}_{B_3A_3}$

$\vec{R}_{B_3O_3}$ ⊥ $\vec{R}_{B_3A_3}$



$V_{B_3} = 9.3 \times 25 = 232.25$ in/s ↑

$w_3 = \frac{V_{B_3A_3}}{R_{B_3A_3}} = \frac{13.5 \times 25}{12} = 28.125$ rad/s (C.C.W.)

Or: $w_3 = \frac{|\vec{V}_{B_3O_3}|}{R_{B_3O_3}} = \frac{232.25}{8} = 29.03$ rad/s (C.C.W.)

(p158 in 4th ed.)

PROBLEM 2: Problem 3.8 (p136)

Given

V_B= 40 m/s

R_{AB} = 40 cm

Scale: 1 cm = 0.1 m (pos)

1 cm = 5 m/s (vel)

Q: w_3, V_A = ?

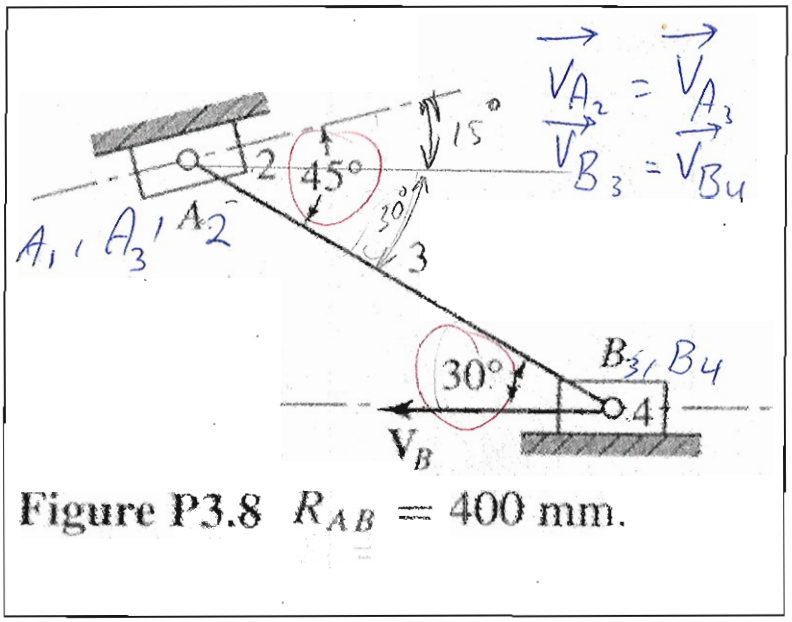
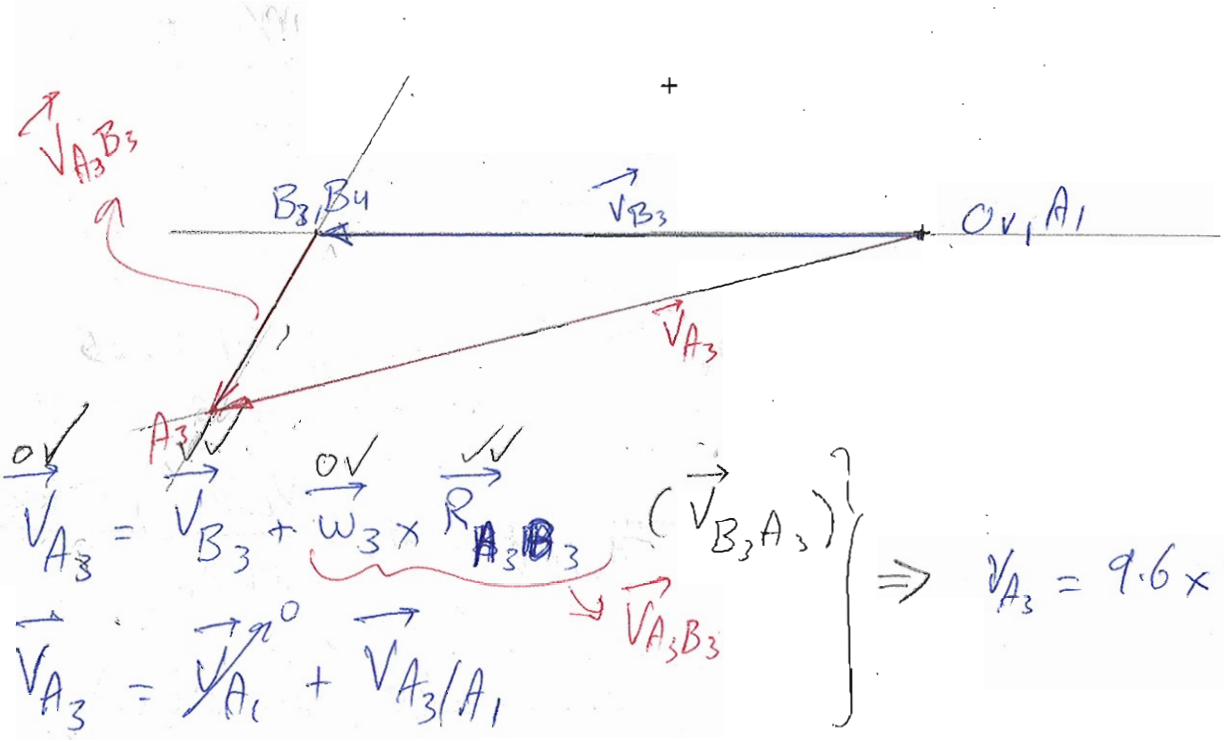


Figure P3.8 $R_{AB} = 400$ mm.

Solution:



$$w_3 = \frac{V_{A_3B_3}}{R_{A_3B_3}} = \frac{2.8 \times 5}{0.4} = 35 \text{ rad/s (CCW)}$$

(p159 in 4th ed.)

PROBLEM3: Problem 3.11 (p136)

Given

ω_2= 48 rad/s ccw

Scale: 1 cm = 20 in/s

Q: w_3, w_4, V_C = ?

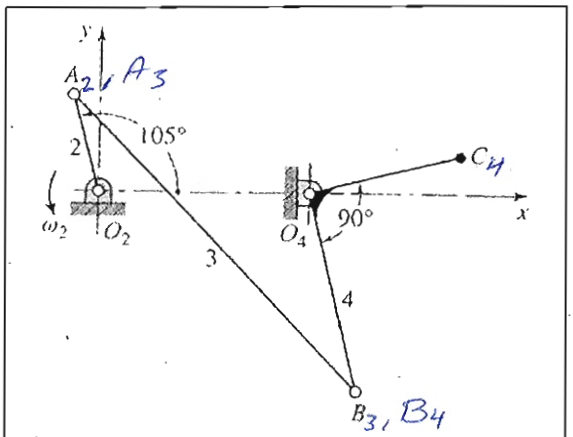


Figure P3.11 R_{AO_2} = 8 in, R_{BA} = 32 in, $R_{O_4O_2}$ = 16 in, R_{BO_4} = 16 in, R_{CO_4} = 12 in

Solution:

$\vec{V}_{A_2} = \vec{V}^{\,0}_{O_2} + \vec{\omega}_2 \times \vec{R}_{A_2O_2} \Rightarrow V_{A_2} = 48 \times 8 = 384$ in/s

$\vec{\omega}_2 \perp \vec{R}_{A_2O_2}$

$\left\{ \vec{V}_{B_3} = \vec{V}_{A_3} + \vec{\omega}_3 \times \vec{R}_{B_3A_3} \right\} = \left\{ \vec{V}_{B_4} = \vec{V}^{\,0}_{O_4} + \vec{\omega}_4 \times \vec{R}_{B_4O_4} \right\}$ (1) (2)

$\vec{R}_{B_3A_3} \perp$, $\vec{R}_{B_4O_4} \perp$

* Because of revolute joints at A & B:
- $\vec{V}_{A_2} = \vec{V}_{A_3}$
- $\vec{V}_{B_3} = \vec{V}_{B_4}$

$\Rightarrow w_3 = \frac{V_{B_3A_3}}{R_{B_3A_3}} = \frac{0.65 \times 20}{32} = 0.31$ rad/s (i.e. C.C.W)

$w_4 = \frac{V_{B_4O_4}}{R_{B_4O_4}} = \frac{18.65 \times 20}{16} = 23.31$ rad/s

* for $\vec{V}_C$: $\vec{V}_{C_4} = \vec{V}^{\,0}_{O_4} + \vec{\omega}_4 \times \vec{R}_{C_4O_4} = \vec{V}_{B_4} + \vec{\omega}_4 \times \vec{R}_{C_4B_4}$ → can be solved graphically

length can be determined graphically or by: $R_{C_4B_4} = \sqrt{R_{B_4O_4}^2 + R_{C_4O_4}^2}$

Or: $\vec{V}_{C_4} = \vec{V}^{\,0}_{O_4} + \vec{w}_4 \times \vec{R}_{C_4O_4}$

$\Rightarrow V_{C_4} = 23.31 \times 12 = 279.75$ in/s

& $\vec{V}_{C_4} \perp \vec{R}_{C_4O_4}$: