Theory of machinery

Chapter three

Velocity analysis

By

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Velocity analysis

As in position analysis, it is important in many cases to analyze the velocity of moving links.

Before start with velocity analysis, let us review some of the basic concepts we will need it in future. Let us assume a body rotating about certain axis. The angular velocity (ω) for this body is found by deriving the angular dimension ϴ with respect to time, mathematically:-

$$\omega = \frac{d\theta}{dt} = \dot{\theta}$$

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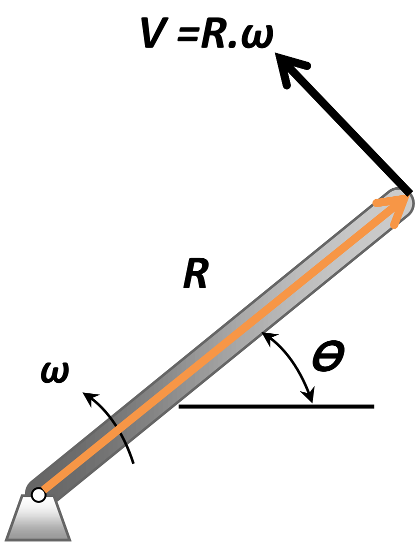
Due to the fixed links lengths, the velocity components is reduced from normal (radial) and tangential components to tangential component (**V_T**)only. As you remember, velocity is a vector quantity and **V_T** is perpendicular to **R** as shown

The relation between **V** and **ω** is : $V=R.\omega$.

This relation is for the magnitude.

The polygon method depends on this relation to find the angular velocity after finding the tangential one.

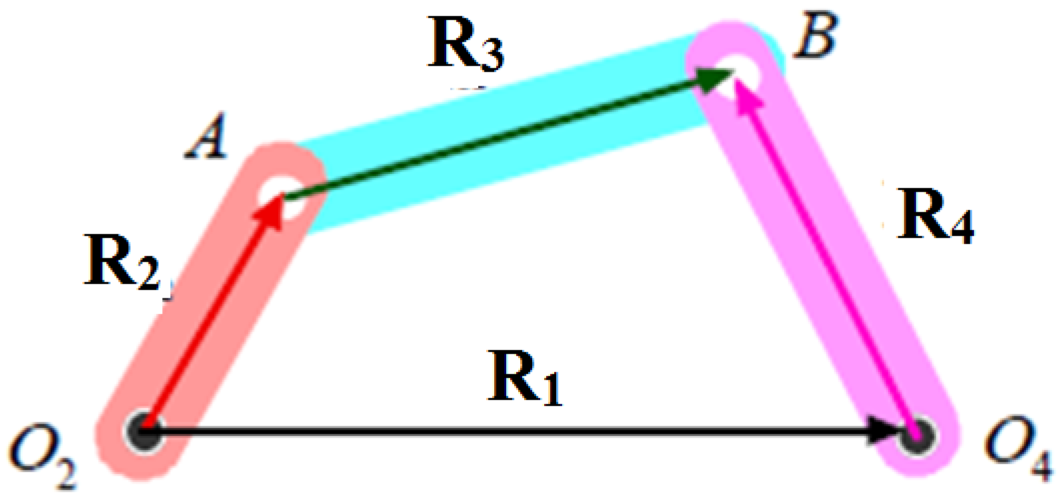


Velocity analysis

Velocity polygon method

4-bar mechanism

For a known four-bar mechanism, in a given configuration and for a known angular velocity of the crank, ω_2 , we want to determine ω_3 and ω_4 . In this example we assume ω_2 is CCW. For the position vector loop equation



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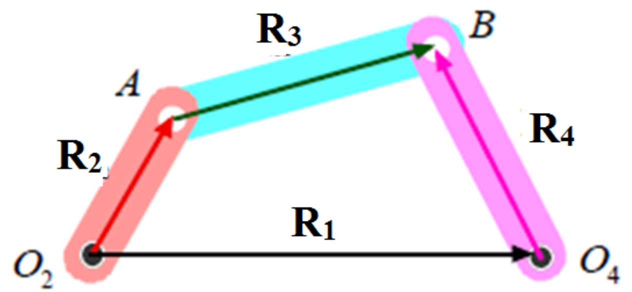
For the position vector loop equation:

$$R_2 + R_3 - R_4 - R_1 = 0 \text{ --- (1)}$$

the velocity equation is

$$V_2 + V_3 - V_4 = 0 \text{ --- (2)}$$



As mentioned before, the velocity component is tangential and Eq.2 becomes:

$$\omega_2 R_2 + \omega_3 R_3 - \omega_4 R_4 = 0 \text{ --- (3)}$$

Eq.1. is sometimes called **vector enclosure equation** because the velocity vector summation ends with **zero.**

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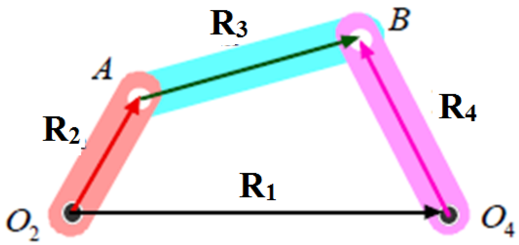
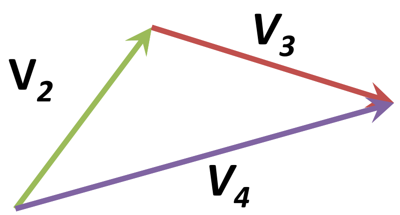
Velocity polygon method:-

As illustrated in Eq.2, the velocity enclosure equation

Can be represented in the following vector diagram





$$V_2+V_3 - V_4 = 0 \text{ --- } (2)$$

So, our task is to draw this diagram or **polygon.**

Remember, the velocities vectors are perpendicular to the position vectors.

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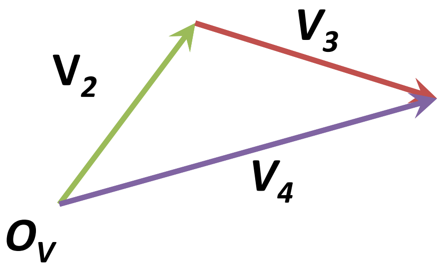
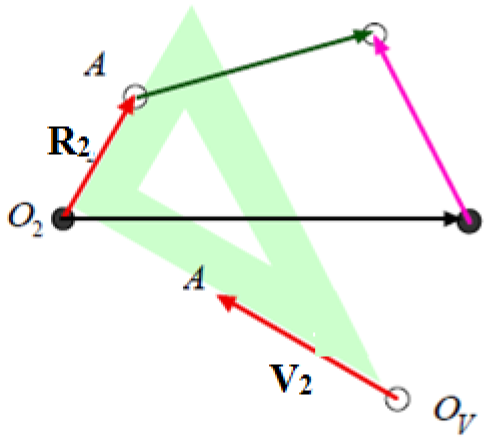


- To start, select a reference zero velocity point (O_V)
- Draw a perpendicular line to vector R_2 from O_V as shown in the next figure. Note that vector V_2 can be drawn directly because its angle is determined by the line drawn previously and its magnitude is $\boldsymbol{\omega_2 R_2}$
- Note that the direction of $\mathbf{V_2}$ is determined by rotating R_2 in the same direction of ω_2.



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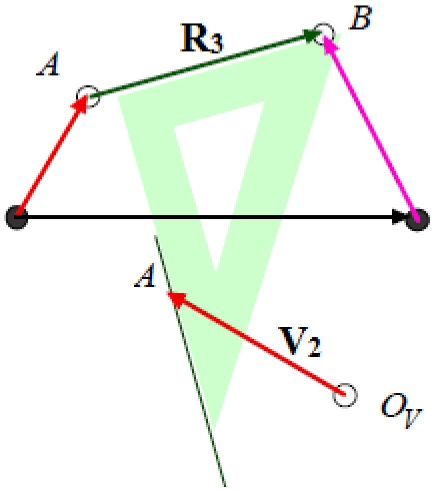
From *A draw a line perpendicular to* $\boldsymbol{R_3}$. $\boldsymbol{V_3}$ must reside on this line.

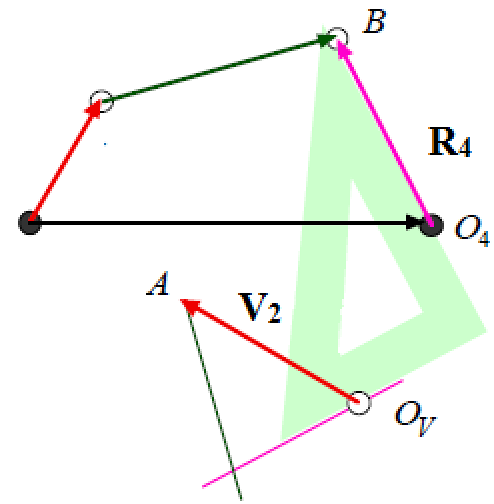


From O_V *draw a line perpendicular to* $\boldsymbol{R_4}$. $\boldsymbol{V_4}$ must reside on this line.

Construct vectors $\mathbf{V_3}$ and $\boldsymbol{V_4}$.

Determine the magnitude of **V3** ***from the polygon.***

Compute $\omega_3 = V_3 / R_3$. *Determine the direction of* ω_3. In this example it is CW since $\mathbf{R_3}$ ***must rotate 90º CW*** to line up with $\mathbf{V_3}$



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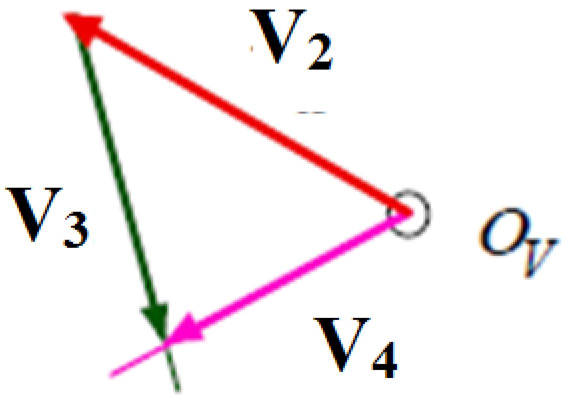
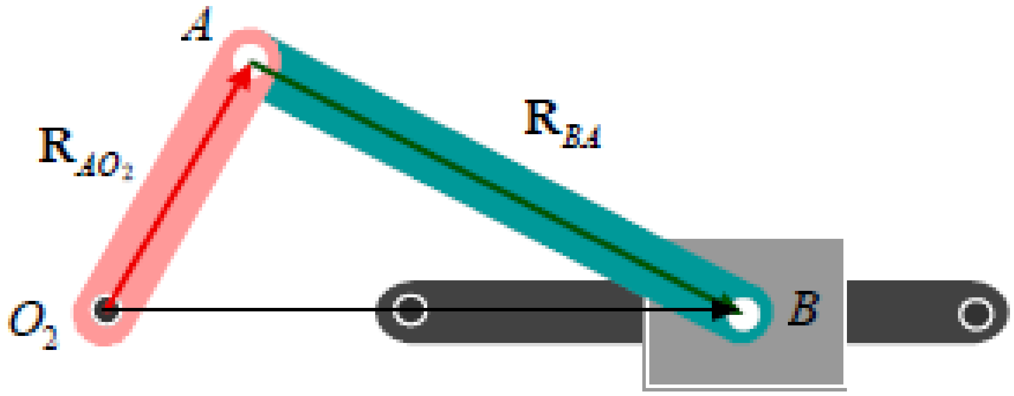
Determine the magnitude of VB from the polygon. Compute $\omega_4 = V_4 / R_4$. Determine the direction of ω_4 . In this example it is CCW since R_4 must rotate 90^o CCW to line up with V_4 .



Velocity analysis

Slider crank mechanism

This slider-crank mechanism in the given configuration has a known angular velocity of the crank, ω_2 . We want to determine ω_3 and the velocity of the slider block. In this example we assume ω_2 is CCW.



Velocity analysis

Slider crank mechanism

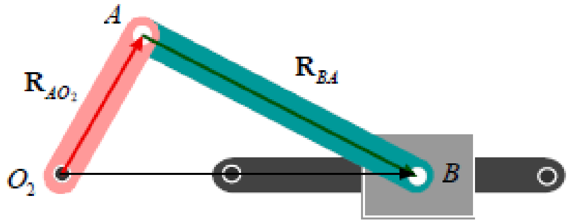
The position vector loop equation is:

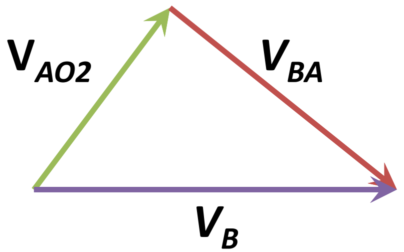
$$R_{AO2}+R_{BA} - R_{BO2} = 0$$

The velocity (loop) equation is expressed as

$$V_A+V_{BA} - V_B = 0$$

$$\omega_2 R_{AO2} + \omega_3 R_{BA} - \omega_4 V_B = 0$$





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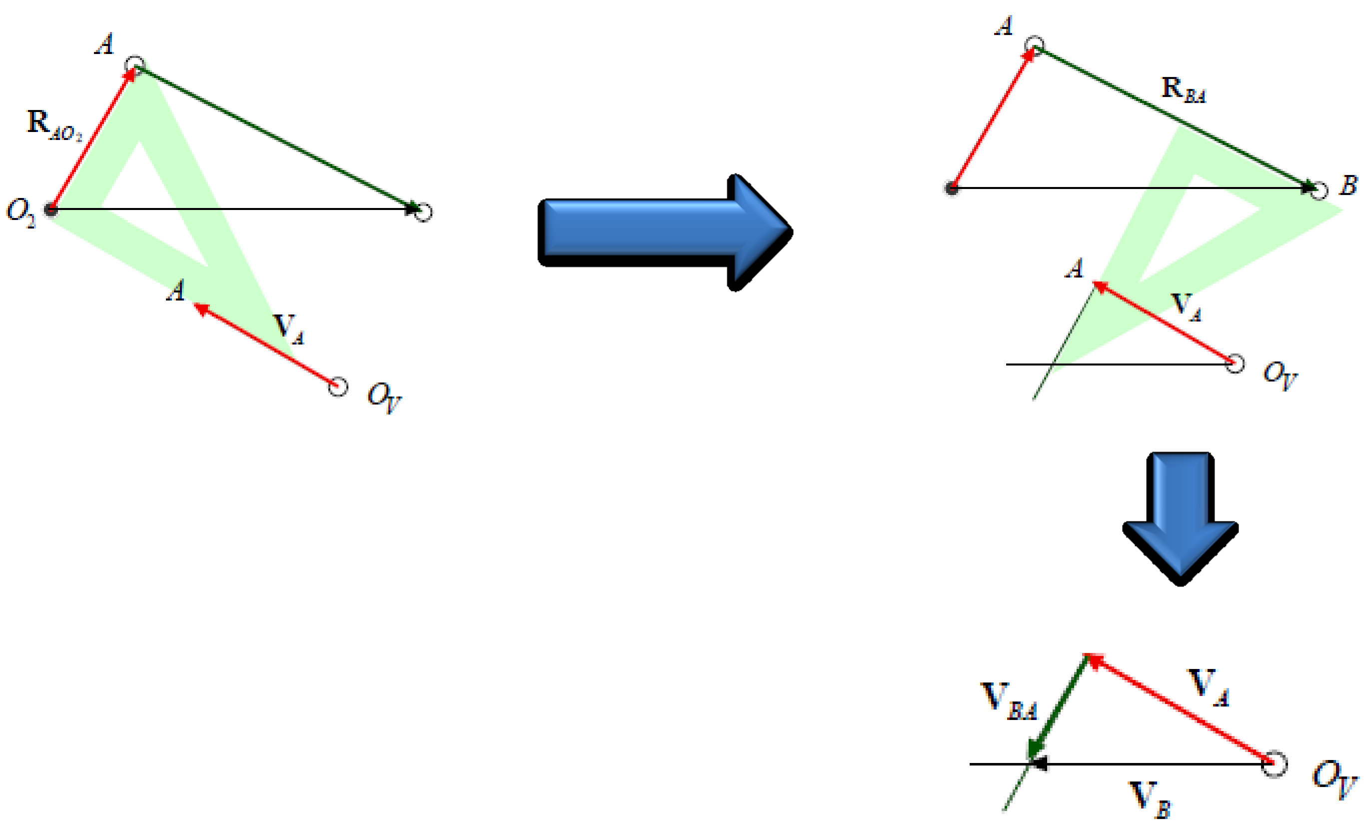
Slider crank mechanism



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