

## Elementary Dynamics Example #31: (Rigid Body Kinematics – Relative Velocity)

Given:  $r, \omega$

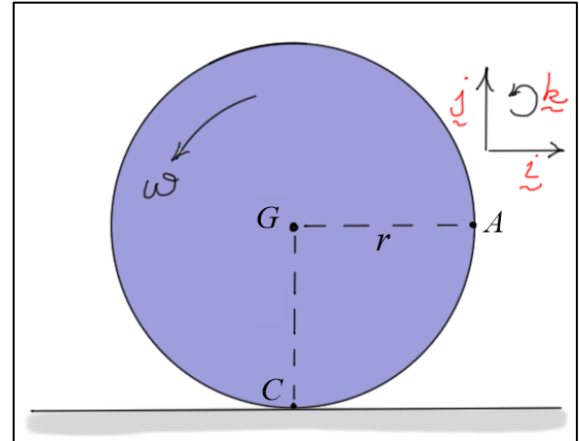
wheel rolls without slipping ( $v_C = 0$ ).

Find: a)  $v_G$  the velocity of  $G$

b)  $v_A$  the velocity of  $A$

Solution:

a) Using the relative velocity equation for two points fixed on a rigid body,



$$v_G = v_C + v_{G/C} = \underset{\text{zero}}{v_C} + v_{G/C} = [\omega \times r_{G/C}] = \omega k \times r j$$

$$\Rightarrow \boxed{v_G = -r\omega i}$$

b) Again, using the relative velocity equation,

$$v_A = v_C + v_{A/C} = \underset{\text{zero}}{v_C} + v_{A/C} = [\omega \times r_{A/C}] = \omega k \times (r i + r j)$$

$$\Rightarrow \boxed{v_A = -r\omega i + r\omega j}$$

or,

$$v_A = v_G + v_{A/G} = -r\omega i + v_{A/G} = -r\omega i + [\omega \times r_{A/G}] = -r\omega i + [\omega k \times r i]$$

$$\Rightarrow \boxed{v_A = -r\omega i + r\omega j} \quad \dots \quad \text{same result}$$

Notes:

1. Because the wheel **rolls without slipping**, the contact point has the **same velocity** as the contacting surface which, in this case, is **zero**.
2. In the above form, the relative velocity equation can be used to relate the velocities of **any two points** on a rigid body in terms of its **angular velocity**.
3. **Velocity** is a **property** that applies to the **points** of a body, whereas **angular velocity** is a **property** that applies to an **entire body**, not the individual points of that body.