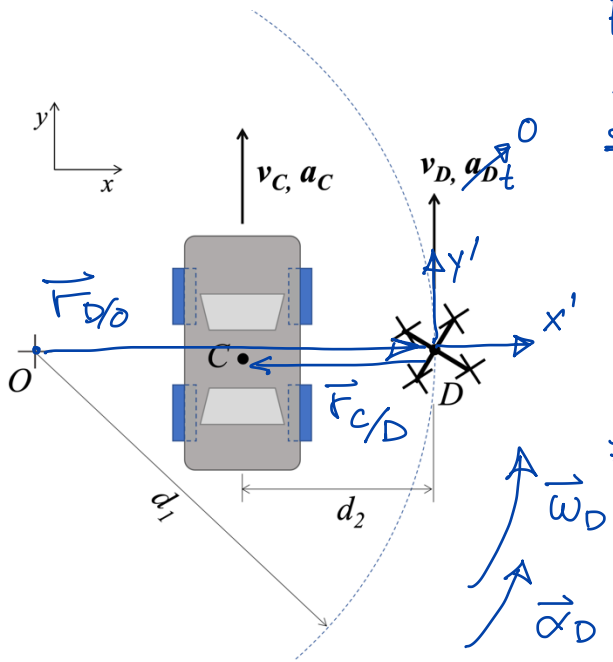A camera drone, D, flies over a car race in a curved trajectory (centre O) with a constant ground-speed velocity of $v_D = 9$ m/s. At the moment shown, car C is travelling with velocity of $v_C = 12$ m/s and an acceleration of $a_C = 2$ m/s² as shown. Assume $d_1 = 7.5$ m, $d_2 = 3$ m.

    a) Find the velocity of the car <u>as observed by the camera on drone D</u> at this instant.

    b) Find the acceleration of the car <u>as observed by the camera on drone D</u> at this instant.

Find $(\vec{v}_{C/D})_{rel}$ & $(\vec{a}_{C/D})_{rel}$

$\vec{\Omega}:$ $\vec{v}_D = \vec{v}_0^{\,\nearrow O} + \vec{\omega}_D \times \vec{r}_{D/O}$

$v_D \hat{j} = \omega_D \hat{k} \times d_1 \hat{i}$

$v_D \hat{j} = \omega_D d_1 \hat{j}$ $\Rightarrow$ $\omega_D = \dfrac{v_D}{d_1} = \dfrac{9 m/s}{7.5 m}$

$\omega_D = 1.2 \text{ rad/s} \,\hat{k} = \vec{\Omega}$

$\dot{\vec{\Omega}}:$ $\vec{a}_D = \vec{a}_0^{\,\nearrow O} + \vec{\alpha}_D \times \vec{r}_{D/O} - \omega_D^2 \vec{r}_{D/O}$

$\vec{a}_D = a_{Dx} \hat{i} + 0 \hat{j}$ $(\vec{a}_{Dt} = 0)$

$\Rightarrow$ $a_{Dx} \hat{i} = \underbrace{\alpha_D \hat{k} \times d_1 \hat{i}}_{\alpha_D d_1 \hat{j}} - \omega_D^2 d_1 \hat{i}$

$\hat{j}: 0 = \alpha_D d_1$ $\Rightarrow$ $\alpha_D = 0 = \dot{\vec{\Omega}}$

$\vec{v}_C = \vec{v}_D + \vec{\Omega} \times \vec{r}_{C/D} + (\vec{v}_{C/D})_{rel}$

$v_C \hat{j} = v_D \hat{j} + \omega_D \hat{k} \times d_2 (-\hat{i}) + (\vec{v}_{C/D})_{rel}$

$12 m/s \hat{j} = 9 m/s \hat{j} - (1.2 \text{ rad/s})(3m) \hat{j} + (\vec{v}_{C/D})_{rel}$

$\boxed{(\vec{v}_{C/D})_{rel} = 6.6 \text{ m/s} \,\hat{j}}$

$\vec{a}_C = \vec{a}_D + \dot{\vec{\Omega}}^{\,\nearrow O} \times \vec{r}_{C/D} - \Omega^2 \vec{r}_{C/D} + 2\vec{\Omega} \times (\vec{v}_{C/D})_{rel} + (\vec{a}_{C/D})_{rel}$

$2 m/s^2 \hat{j} = -\omega_D^2 \underset{\substack{\uparrow \\ 7.5m}}{d_1} \hat{i} - \omega_D^2 \underset{\substack{\uparrow \\ 3m}}{(-d_2 \hat{i})} + 2(\omega_D \hat{k}) \times (6.6 \hat{j}) + (\vec{a}_{C/D})_{rel}$

$2 m/s^2 \hat{j} = -10.8 m/s^2 \hat{i} + 4.32 m/s^2 \hat{i} - 15.84 m/s^2 \hat{i} + (\vec{a}_{C/D})_{rel}$

$\boxed{(\vec{a}_{C/D})_{rel} = (22.32 \hat{i} + 2 \hat{j}) \, m/s^2}$