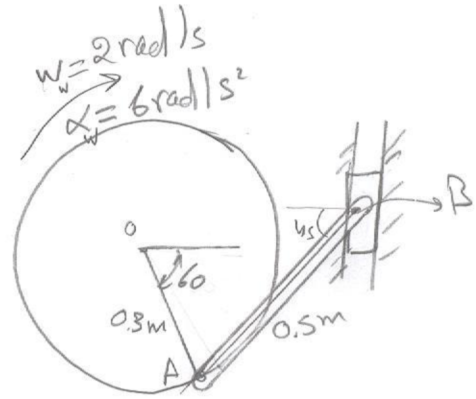
H.W 7

16-112



$$\vec{a}_A = \vec{a}_o + \vec{\alpha}_w \times \vec{r}_{A/o} - \omega_w^2 \vec{r}_{A/o}$$

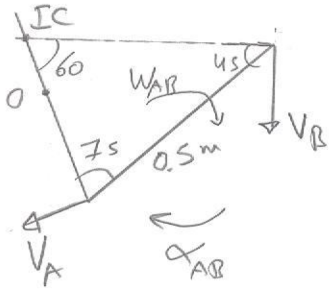
$$= 0 + (-6k)\times(0.3\cos 60 i - 0.3\sin 60 j)$$
$$- (2)^2 (0.3\cos 60 i - 0.3 \sin 60 j)$$

$$\vec{a}_A = -1.8\cos 60 j - 1.8 \sin 60 i - 1.2\cos 60 i + 1.2 \sin 60 j$$

$$\Rightarrow \vec{a}_A = (-2.159 i + 0.1392 j)\ m/s^2$$

To find $\vec{a}_B$; $\vec{w}_{AB}$ must be found first

Use the $\underline{Ic}$



$$\frac{0.5}{\sin 60} = \frac{r_{A/Ic}}{\sin 45} \Rightarrow r_{A/Ic} = 0.4082\ m$$

$$W_{AB} = \frac{V_A}{r_{A/Ic}} = \frac{0.3(2)}{0.4082} = 1.47\ rad/s$$

$$\vec{a}_B = -a_B j = \vec{a}_A + \vec{\alpha}_{AB} \times \vec{r}_{B/A} - \omega_{AB}^2 \vec{r}_{B/A}$$

$$-a_B j = -2.159 i + 0.1392 j + (-\alpha_{AB} k)\times(0.5\cos 45 i + 0.5 \sin 45 j)$$
$$- (1.47)^2 (0.5\cos 45 i + 0.5 \sin 45 j)$$

$$-a_B j = -2.159 i + 0.1392 - 0.5\alpha_{AB}\cos 45 j + 0.5\alpha_{AB}\sin 45 i - 1.08\cos 45 i - 1.08 \sin 45 j$$

$$-a_B j = (-2.923 + 0.3536\alpha_{AB}) i + (-0.6245 - 0.3536\alpha_{AB}) j$$

$\underline{i\text{- component}}$

$$\Rightarrow \alpha_{AB} = \frac{2.923}{0.3536} = 8.266\ rad/s^2$$

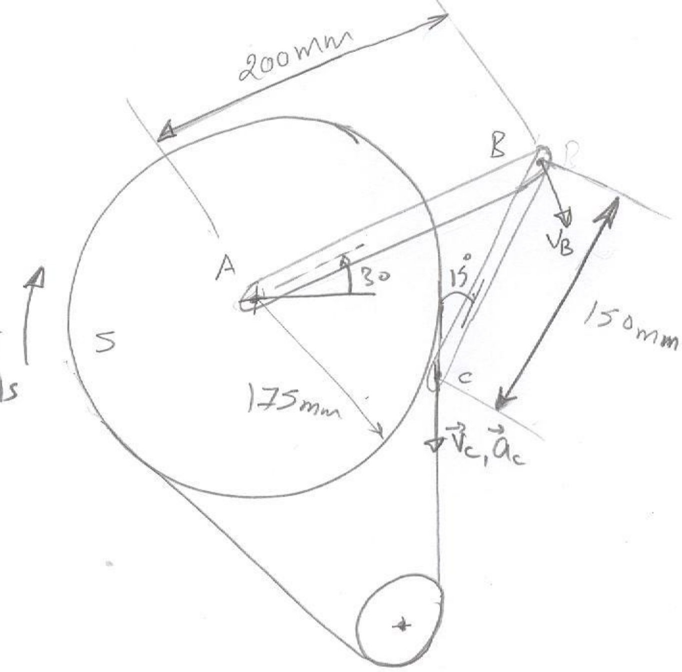
$\underline{j\text{-component}}$

$$a_B = 0.6245 + 0.3536 \times 8.266 = 3.547\ m/s^2$$

$$\vec{a}_B = (-3.547 j)\ m/s^2$$

16-130

Find $\vec{\omega}_{AB}$ & $\vec{\alpha}_{AB}$



$V_c = \omega_s r_s = 6 \times 0.175 = 1.05$ m/s ↓

$a_c = \alpha_s r_s = 2 \times 0.175 = 0.35$ m/s² ↓

$r_{B/Ic} = \dfrac{0.15}{\sin 30} \sin(105)$

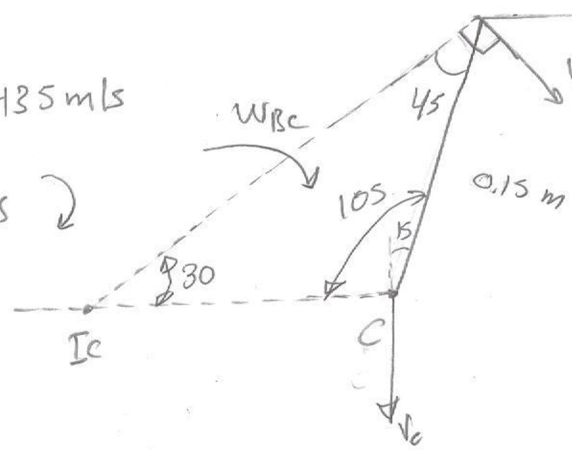
$= 0.2898$ m

$r_{c/Ic} = \dfrac{0.15}{\sin 30} \sin 45 = 0.2121$ m

$\omega_{BC} = \dfrac{V_c}{r_{c/Ic}} = \dfrac{1.05}{0.2121} = 4.95$ rad/s ↻

$V_B = \omega_{BC}(r_{B/Ic}) = 4.95(0.2898) = 1.435$ m/s

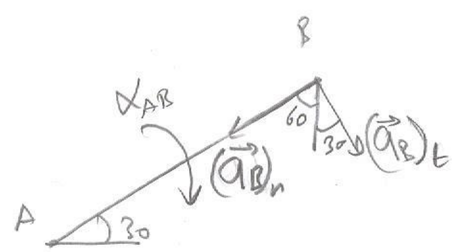
$\omega_{AB} = \dfrac{V_B}{r_{B/A}} = \dfrac{1.435}{0.2} = 7.173$ rad/s ↻



$\vec{a}_B = \vec{a}_c + (\vec{a}_{B/c})_t + (\vec{a}_{B/c})_n$

Point B makes rotation about fixed axis (A)

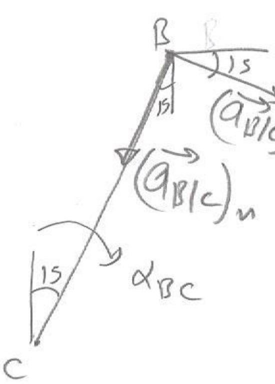
$(\vec{a}_B)_t + (\vec{a}_B)_n = \vec{a}_c + (\vec{a}_{B/c})_t + (\vec{a}_{B/c})_n$



$0.2\,\alpha_{AB}\ \underset{30}{\searrow} + (7.173)^2(0.2)\ \underset{60}{\swarrow} = 1.05\downarrow$

$+ \alpha_{BC}(0.15)\ \underset{15}{\searrow}$

$+ (4.95)^2(0.15)\ \underset{15}{\swarrow}$



J - direction

$0.2\,\alpha_{AB}\cos 30 + (7.173)^2(0.2)\cos 60 = 1.05 + (0.15)(\alpha_{BC})\sin 15$
$+ (4.95)^2(0.15)\cos 15$

$\Rightarrow \alpha_{BC} = 4.461\,\alpha_{AB} + 32.07$

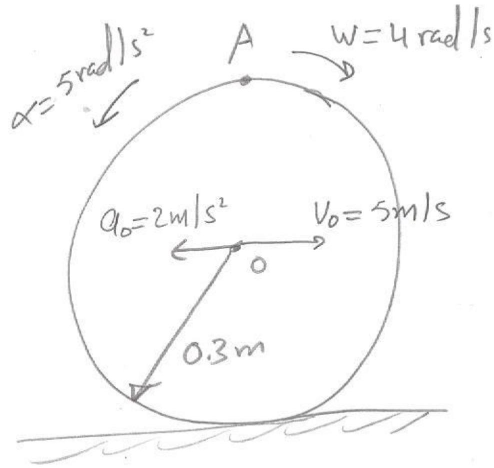
i- direction

$$0.2\,\alpha_{AB}\sin 30 - (7.173)^2(0.2)\sin 60 = 0.15(4.461\,\alpha_{AB} + 32.07)\cos 15 - (4.949)^2(0.15)\sin 15$$

$$\Rightarrow \alpha_{AB} = -23.07 \text{ rad/s}^2$$

$$= 23.07 \text{ rad/s}^2$$

16-115



Find $\vec{a}_A$?

$V_0 = 5\,m/s \neq \omega r = 4(0.3) = 1.2\,m/s$

⇒ slipping exists between the ground and the wheel

$$\vec{a}_A = \vec{a}_0 + (\vec{a}_{A/0})_t + (\vec{a}_{A/0})_n$$

$$\vec{a}_A = a_0 \leftarrow + (a_{A/0})_t \leftarrow + (a_{A/0})_n \downarrow$$

$$= -2i - \alpha(r_{A/0})\,i - w^2(r_{A/0})\,j$$

$$\Rightarrow \vec{a}_A = -2i - 5(0.3)i - (4)^2(0.3)\,j$$

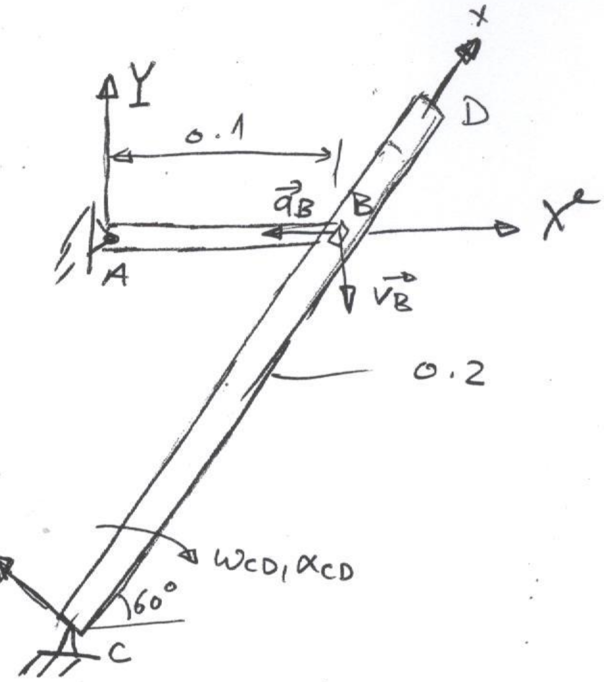
$$= (-3.5i - 4.8j)\ m/s^2$$

$$\vec{a}_A = \sqrt{(3.5)^2 + (4.8)^2} = 5.941\ m/s^2$$

$$\theta = 126.1^\circ$$

16-141

$\vec{\omega}_{AB} = -\omega_{AB}\vec{K}$



$V_B = \omega_{AB} r_{AB} = 3(0.1) = 0.3 \ m/s$

$\vec{V}_B = -0.3\vec{J}$

$\vec{a}_B = \vec{a}_A + \vec{\alpha}_{AB} \times \vec{r}_{B/A} - \omega_{AB}^2 \vec{r}_{B/A}$

$\omega_{AB} = \text{const.} \rightarrow \alpha_{AB} = 0$

$\vec{r}_{B/A} = 0.1\vec{I}$

$\vec{a}_B = 0 + 0 - \omega_{AB}^2 \vec{r}_{B/A}$

$\vec{a}_B = -0.9\vec{I}$

$\vec{V}_B = -0.3\vec{J} = -0.3(\cos 30\vec{i} + \sin 30\vec{j})$

$\vec{a}_B = -0.9\vec{I} = 0.9(-\cos 60\vec{i} + \sin 60\vec{j})$

Link CD

$\vec{V}_B = \vec{V}_C + \vec{\Omega} \times \vec{r}_{B/C} + (\vec{V}_{B/C})_{xy}$

$\vec{\Omega} = -\omega_{CD}\vec{k}$; $\vec{r}_{B/C} = 0.2\vec{i}$ $\quad (\vec{V}_{B/C})_{xy} = -(V_{B/C})_{xy}\vec{i}$

$-0.3(\cos 30\vec{i} + \sin 30\vec{j}) = 0 - \omega_{CD}\vec{k} \times (0.2)\vec{i} - (V_{B/C})_{xy}\vec{i}$

$= -0.2\,\omega_{CD}\vec{j} - (V_{B/C})_{xy}\vec{i}$

$i: \ (V_{B/C})_{xy} = 0.26 \ m/s$

$j: \ \omega_{CD} = 0.75 \ rad/s$

$\vec{a}_B = \vec{a}_C + \dot{\vec{\Omega}} \times \vec{r}_{B/C} + \vec{\Omega} \times (\vec{\Omega} \times \vec{r}_{B/C}) + 2\vec{\Omega} \times (\vec{V}_{B/A})_{xy} + (\vec{a}_{B/A})_{xy} \quad (*)$

$\vec{a}_C = 0$; $\vec{\Omega} = -0.75\vec{k}$ $\quad \dot{\vec{\Omega}} = -\alpha_{CD}\vec{k}$

$(\vec{V}_{B/A})_{xy} = -0.26\vec{i}$ $\qquad (\vec{a}_{B/A})_{xy} = (a_{B/A})_{xy}\vec{i}$

$$\dot{\vec{\Omega}} \times \vec{r}_{B/C} = -\alpha_{CD}\,\vec{k} \times 0.2\,\vec{i} = -0.2\,\alpha_{CD}\,\vec{j}$$

$$\vec{\Omega} \times (\vec{\Omega} \times \vec{r}_{B/C}) = -0.75\,\vec{k} \times (-0.75\,\vec{k} \times 0.2\,\vec{i}) = -0.1125\,\vec{i}$$

$$2\vec{\Omega} \times (\vec{v}_{B/C})_{xy} = 2(-0.75)\,\vec{k} \times (-0.26)\,\vec{i} = 0.39\,\vec{j}$$

Substituting into (*)

$$-0.9\cos 60\,\vec{i} + 0.9\sin 60\,\vec{j} = -0.2\,\alpha_{CD}\,\vec{j} - 0.1125\,\vec{i} + 0.39\,\vec{j} + (a_{B/C})_{xy}\,\vec{i}$$

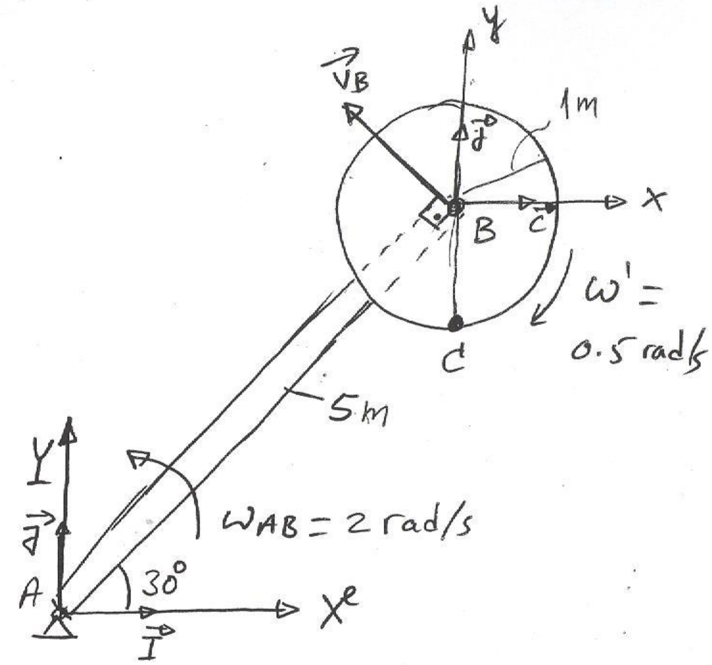
j: $0.9\sin 60 = 0.39 - 0.2\,\alpha_{CD}$

$\hookrightarrow$ $\alpha_{CD} = -1.947$ rad/s

i: $-0.9\cos 60 = -0.1125 + (a_{B/C})_{xy}$

$\hookrightarrow$ $(a_{B/C})_{xy} = -0.3375$ m/s

16-147



$\vec{V}_B = \vec{\omega}_{AB} \times \vec{r}_{B/A}$

$\vec{\omega}_{AB} = 2\vec{k}$

$\vec{r}_{B/A} = 5\cos 30\vec{I} + 5\sin 30\vec{J}$

$\vec{V}_B = 10\vec{k} \times (\cos 30\vec{I} + \sin 30\vec{J})$

$= 10(\cos 30\vec{J} - \sin 30\vec{I})$

$= -5\vec{I} + 8.66\vec{J}$

$\omega_{AB} = \text{const.}$

$\hookrightarrow \alpha_{AB} = 0 \qquad a_A = 0$

$\vec{a}_B = \vec{a}_A + \vec{\alpha}_{AB} \times \vec{r}_{B/A} - \omega_{AB}^2 \vec{r}_{B/A}$

$= 0 + 0 - (2)^2(5\cos 30\vec{I} + 5\sin 30\vec{J})$

$\vec{a}_B = -17.32\vec{I} - 10\vec{J}$

x, y are parall to X, Y $\Rightarrow$ at the instant!

since c is attached to the rigid disk

$\vec{V}_B = -5\vec{i} + 8.66\vec{j} \qquad \vec{a}_B = -17.32\vec{i} - 10\vec{j}$

x, y is attached to the disk $\rightarrow (\vec{V}_{C/B})_{xy} = (\vec{a}_{C/B})_{xy} = 0$

$\vec{\Omega} = (2 - 0.5)\vec{k} = 1.5\vec{k} \qquad \vec{r}_{C/B} = -\vec{j}$

$\vec{V}_C = \vec{V}_B + \vec{\Omega} \times \vec{r}_{C/B} + (\vec{V}_{C/B})_{xy}$

$= -5\vec{i} + 8.66\vec{j} + 1.5\vec{k} \times (-\vec{j}) + 0$

$\Omega = \text{const}$

$\dot{\vec{\Omega}} = 0$

$\vec{V}_C = -3.5\vec{i} + 8.66\vec{j}$

$\vec{a}_C = \vec{a}_B + \dot{\vec{\Omega}} \times \vec{r}_{C/B} + \vec{\Omega} \times (\vec{\Omega} \times \vec{r}_{C/B}) + 2\vec{\Omega} \times (\vec{V}_{C/B})_{xy} + (\vec{a}_{C/B})_{xy}$

$= -17.32\vec{i} - 10\vec{j} + 0 + 1.5\vec{k} \times [1.5\vec{k} \times (-\vec{j})] + 0 + 0$

$= -17.32\vec{i} - 10\vec{j} + 1.5\vec{i} + 1.5^2\vec{j}$

$\vec{a}_C = -17.32\vec{i} - 7.75\vec{j}$