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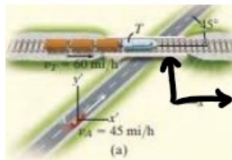
Example 1:

A train travels at a constant speed of 60 mph and crosses over a road. If automobile A is traveling at 45mph along the road, determine the magnitude and direction of the velocity of the train relative to the automobile



$$\bar{r}_{B/A} = \bar{r}_B - \bar{r}_A$$

$$\bar{V}_{B/A} = \bar{V}_B - V_A$$

$$\bar{A}_{B/A} = \bar{A}_B - \bar{A}_A$$

$$V_{T/A} = V_T - V_A$$

$$V_T = 60\hat{i}$$

$$V_A = 45\cos 45\hat{i} + 45\sin 45\hat{j}$$

$$= 60\hat{i} - (45\cos 45\hat{i} + 45\sin 45\hat{j})$$

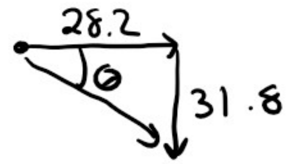
$$= 60\hat{i} - 31.8\hat{i} - 31.8\hat{j}$$

$$= (60 - 31.8)\hat{i} - (31.8)\hat{j}$$

$$= [28.2\hat{i} - 31.8\hat{j}]\text{ mph}$$ Vector form

$$|V_{T/A}| = \sqrt{(28.2)^2 + (-31.8)^2} = 42.5 \text{ mph } @ 48.43°$$

$$\theta = \tan^{-1}\left(\frac{31.8}{28.2}\right) = 48.43°$$



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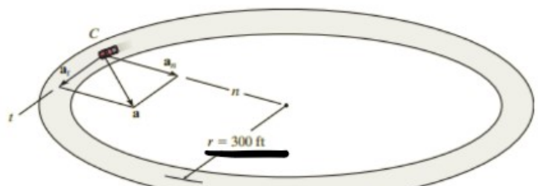
Example 2:

A car travels around the horizontal circular track that has a radius of 300ft. If the car increases its speed at a constant rate of 7 ft/s² and starts from rest, determine the time needed for it to reach an acceleration of 8ft/s². What is its speed at this instant?



$\rho = 300ft$

$a_t = 7ft/s^2$

$V_0 = 0$

$a_{TOTAL} = \underline{8 ft/s^2}$

$\bar{a}_{TOTAL} = \bar{a}_N + \bar{a}_T$

$V_f = \cancel{V_0} + a_t t$

$V_f = \underline{7t}$

$a_N = \frac{(7t)^2}{300} = 0.163t^2$

$a_{TOTAL} = \sqrt{a_t^2 + a_N^2}$

$8 = \sqrt{7^2 + (0.163t^2)^2}$

$8^2 = 7^2 + (0.163t^2)^2$

$15 = 0.026569t^4$

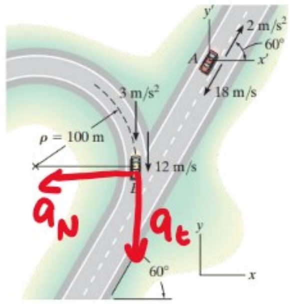
$t^4 = 564.57$

$t = \sqrt[4]{564.57} = 4.87s$

$V = 7(4.87) = 34.1 ft/s$

Example 3

Cars A and BV are traveling with speeds of 18 m/s and 12 m/s respectively. At this instant, A has a decrease in speed of 2 m/s^2 and B has an increase in speed of 3 m/s^2. Determine the velocity and acceleration of B with respect to A



$V_{B/A} = V_B - V_A$

$a_{B/A} = a_{B_{TOTAL}} - a_A$

$\bar{A}_A = 2\cos 60\hat{i} + 2\sin 60\hat{j}$

$\bar{a}_{Bt} = -3\hat{j}$

$a_{BN} = \frac{V^2}{\rho} = \frac{12^2}{100} = 1.44$ magnitude

$\overline{a_{BN}} = -1.44\hat{i}$

$V_B = -12\hat{j}$

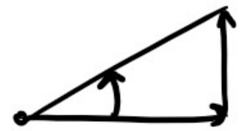
$V_A = -18\cos 60\hat{i} - 18\sin 60\hat{j}$

$V_{B/A} = -12\hat{j} - (-18\cos 60\hat{i} - 18\sin 60\hat{j})$

$= 9\hat{i} + 3.58\hat{j}$

$|V_{B/A}| = \sqrt{9^2 + 3.58^2} = 9.68\ m/s$

$\theta = \tan^{-1}(3.58/9) = 21.7°$

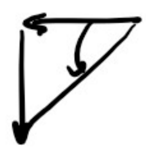


$\bar{a}_{B/A} = \bar{a}_{B_{TOTAL}} - \bar{a}_A$

$= \overline{a_{Bt}} + \overline{a_{BN}} - a_A$

$= -3\hat{j} - 1.44\hat{i} - (2\cos 60\hat{i} + 2\sin 60\hat{j})$

$= -2.44\hat{i} - 4.73\hat{j}\ m/s^2$



$|a_{B/A}| = \sqrt{(-2.44)^2 + (-4.73)^2} = 5.32\ m/s^2 \quad \theta = \tan^{-1}\left(\frac{4.73}{2.44}\right) = 62.7°$