2/16 Acceleration period:

$v = v_0 + at$: $\frac{22}{3.6} = 0 + \frac{9.81}{4} t_a$, $t_a = 2.49$ s

Note that The deceleration time $t_d = t_a$

$v^2 = v_0^2 + 2a\Delta s$: $\left(\frac{22}{3.6}\right)^2 = 0^2 + 2\,\frac{9.81}{4}\,\Delta s_a$

$\Delta s_a = 7.61\text{ m} = \Delta s_d$

Cruise period: $\Delta s_c = 350 - \Delta s_a - \Delta s_d = 335$ m

$\Delta s = v_c t_c$: $335 = \frac{22}{3.6} t_c$, $t_c = 54.8$ s

Total run time $t = t_c + t_a + t_d = \underline{59.8 \text{ s}}$

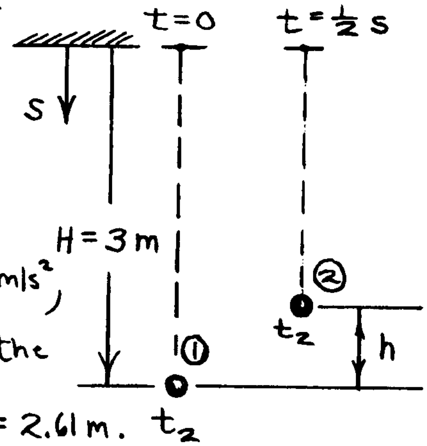
2/19 $s = s_0 + v_0 t + \frac{1}{2} g t^2$

Sphere ①: $H = \frac{1}{2} g t_2^2$

Sphere ②:

$(H-h) = \frac{1}{2} g \left(t_2 - \frac{1}{2}\right)^2$

With $H = 3$ m & $g = 9.81$ m/s^2, eliminate t_2 between the 2 equations & obtain $\underline{h = 2.61 \text{ m}}$.



2/23

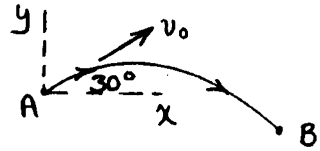
$$v^2 = v_0^2 + 2a(s - s_0)$$

$$0 = 4^2 + 2\left(-\frac{9.81}{4}\right)(s), \quad \underline{s = 3.26 \text{ m}}$$

$$v = v_0 + at : \quad 0 = 4 + \left(-\frac{9.81}{4}\right)t_{up}, \quad t_{up} = 1.631 \text{ s}$$

$$t = 2t_{up} = 2(1.631) = \underline{3.26 \text{ s}}$$

2/88 Set up x-y axes at A, target at B:



x-eq. : $x_B = (v_0 \cos 30°)t$

y-eq. : $y_B = (v_0 \sin 30°)t - \frac{1}{2}gt^2$

For $x_B = 12'$, $y_B = -0.333'$: $\begin{cases} v_0 = 20.6 \text{ ft/sec} \\ t = 0.672 \text{ sec} \end{cases}$

For $x_B = 14'$, $y_B = -0.333'$: $\begin{cases} v_0 = 22.4 \frac{\text{ft}}{\text{sec}} \\ t = 0.723 \text{ sec} \end{cases}$

So the range is $\underline{20.6 \leq v_0 \leq 22.4 \text{ ft/sec}}$

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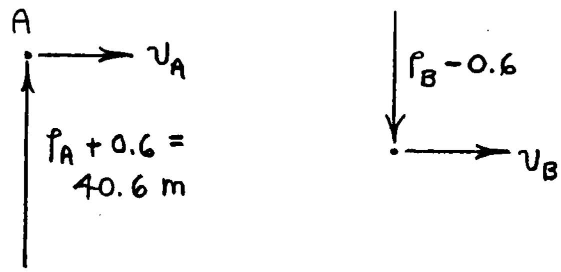


$v_A = \frac{50}{3.6} = 13.89$ m/s, $v_B = \frac{100}{3.6} = 27.8$ m/s

$v_B = v_A + a_t t$, $a_t = \frac{27.8 - 13.89}{10} = 1.389$ m/s^2

At A: $a_n = \frac{v^2}{\rho} = \frac{13.89^2}{40.6} = 4.75$ m/s^2

Total: $a_A = \sqrt{4.75^2 + 1.389^2} = 4.95$ m/s^2

At B: For $a_A = a_B = 4.95$ m/s^2,

$$4.95 = \sqrt{1.389^2 + a_n^2}$$

$$a_n = 4.75 = \frac{27.8^2}{\rho_B - 0.6}, \quad \underline{\rho_B = 163.0 \text{ m}}$$

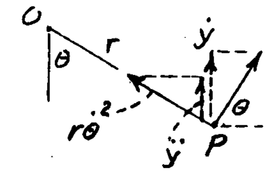
2/125 (a) $\dot{\theta} = \omega$, $\ddot{\theta} = 0$

$\dot{y} = r\dot{\theta}\sin\theta$

$= \underline{r\omega\sin\theta}$

$\ddot{y} = r\dot{\theta}^2\cos\theta$

$= \underline{r\omega^2\cos\theta}$



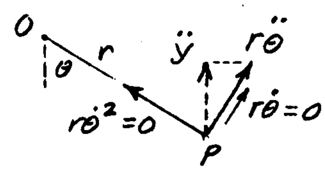
(b) $\dot{\theta} = 0$, $\ddot{\theta} = \alpha$

$\dot{y} = r\dot{\theta}\sin\theta$

$\underline{= 0}$

$\ddot{y} = r\ddot{\theta}\sin\theta$

$= \underline{r\alpha\sin\theta}$



$\boxed{2/126}$ $a_n = 0.8g = \frac{v^2}{\rho} \Rightarrow v = \sqrt{0.8g\rho}$

Car A : $v_A = \sqrt{0.8\,(9.81)(88)} = 26.3$ m/s

Car B : $v_B = \sqrt{(0.8)(9.81)\,72} = 23.8$ m/s

$t_A = \frac{s_A}{v_A} = \frac{\pi\,(88)}{26.3} = \underline{10.52 \text{ s}}$

$t_B = \frac{s_B}{v_A} = \frac{\pi\,(72) + 2(16)}{23.8} = \underline{10.86 \text{ s}}$

Car A will win the race!

2/133 $a_r = \ddot{r} - r\dot{\theta}^2 = 0 - 200(8^2) = -12\,800 \text{ mm/s}^2$

or $a_r = \underline{-12.80 \text{ m/s}^2}$

$a_\theta = r\ddot{\theta} + 2\dot{r}\dot{\theta} = 200(-20) + 2(-300)(8) = -8800 \text{ m/s}^2$

or $a_\theta = \underline{-8.80 \text{ m/s}^2}$

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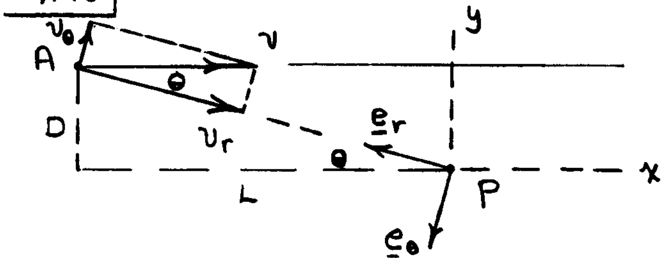
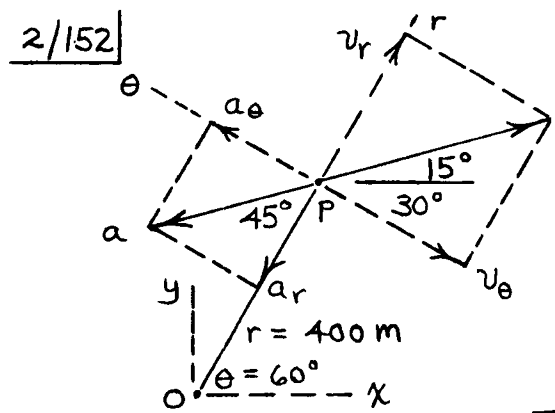


$$v' = |v_r| = v\cos\theta = \underline{v\frac{L}{\sqrt{L^2+D^2}}}$$

Numbers: $v' = 70 \dfrac{500}{\sqrt{500^2+20^2}} = \underline{69.9 \text{ mi/hr}}$

The factor of $\cos\theta$ is the basis for the statement that, kinematically, radar can yield an accurate or low, but not high, speed measurement. As can be seen, however, adherence to the speed limit (not reliance upon $\cos\theta$) is the best policy!

2/152



$v = \frac{90}{3.6} = 25$ m/s

$a = 0.5$ m/s^2

$v_r = \dot{r} = v \sin 45° = 25 \frac{\sqrt{2}}{2} = \underline{17.68 \text{ m/s}}$

$v_\theta = r\dot{\theta}$: $-25 \cos 45° = 400\dot{\theta}$, $\underline{\dot{\theta} = -0.0442 \text{ rad/s}}$

$a_r = \ddot{r} - r\dot{\theta}^2$: $-0.5 \cos 45° = \ddot{r} - 400(-0.0442)^2$

$$\underline{\ddot{r} = 0.428 \text{ m/s}^2}$$

$a_\theta = r\ddot{\theta} + 2\dot{r}\dot{\theta}$: $0.5 \sin 45° = 400\ddot{\theta} + 2(17.68)(-0.0442)$

$$\underline{\ddot{\theta} = 0.00479 \text{ rad/s}^2}$$

2/178 $R = 0.75 + 0.5 = 1.25$ m, $\dot{R} = 0.2$ m/s, $\ddot{R} = -0.3\ \frac{m}{s^2}$

$\phi = 30°$, $\dot{\phi} = 10\left(\frac{\pi}{180}\right)$ rad/s, $\ddot{\phi} = 0$, $\dot{\theta} = 20\left(\frac{\pi}{180}\right)$ rad/s, $\ddot{\theta} = 0$

$$\begin{cases} v_R = \dot{R} = 0.2 \text{ m/s} \\ v_\theta = R\dot{\theta}\cos\phi = 1.25\left(20\frac{\pi}{180}\right)\cos 30° = 0.378\ \frac{m}{s} \\ v_\phi = R\dot{\phi} = 1.25\left(10\frac{\pi}{180}\right) = 0.218 \text{ m/s} \end{cases}$$

$$v = \sqrt{v_R^2 + v_\theta^2 + v_\phi^2} = \underline{0.480 \text{ m/s}}$$

$$a_R = \ddot{R} - R\dot{\phi}^2 - R\dot{\theta}^2\cos^2\phi$$
$$= -0.3 - 1.25\left(10\frac{\pi}{180}\right)^2 - 1.25\left(20\frac{\pi}{180}\right)^2\cos^2 30°$$
$$= -0.4523 \text{ m/s}^2$$

$$a_\theta = \cos\phi\left[2\dot{R}\dot{\theta} + R\ddot{\theta}\right] - 2R\dot{\theta}\dot{\phi}\sin\phi$$
$$= \cos 30°\left[2(0.2)\left(20\frac{\pi}{180}\right) + 1.25(0)\right]$$
$$- 2(1.25)\left(10\frac{\pi}{180}\right)\left(20\frac{\pi}{180}\right)\sin 30° = 0.0448\ \frac{m}{s^2}$$

$$a_\phi = 2\dot{R}\dot{\phi} + R\ddot{\phi} + R\dot{\theta}^2\sin\phi\cos\phi$$
$$= 2(0.2)\left(10\frac{\pi}{180}\right) + 1.25(0) + 1.25\left(20\frac{\pi}{180}\right)^2 0.5\ \frac{\sqrt{3}}{2}$$
$$= 0.1358 \text{ m/s}^2$$

$$a = \sqrt{a_R^2 + a_\theta^2 + a_\phi^2} = \underline{0.474 \text{ m/s}^2}$$