

Homework 5 - 2D Motion

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4 April 2023

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1 Book

1.1 3.38

$$\Delta x_{B,A} = 1500 \text{ m} = 1.5 \text{ km}$$

$$v_{\frac{b}{w}} = 4.00 \text{ km h}^{-1}$$

$$v_{\frac{p}{w}} = 4.00 \text{ km h}^{-1}$$

$$a = 0$$

$$v_w = 2.80 \text{ km h}^{-1}$$

$$\Delta x = v_f t_{b_0} - \frac{1}{2} a t_{b_0}^2$$

$$1.5 \text{ km} = (4.00 \text{ km h}^{-1} + 2.80 \text{ km h}^{-1})t - \frac{1}{2}(0)t^2$$

$$t_{b_0} = 0.221 \text{ h}$$

$$\Delta x = v_f t_{b_1} - \frac{1}{2} a t_{b_1}^2$$

$$1.5 \text{ km} = (4.00 \text{ km h}^{-1} - 2.80 \text{ km h}^{-1})t - \frac{1}{2}(0)t^2$$

$$t_{b_1} = 1.25 \text{ h}$$

$$t_b = 0.221 \text{ h} + 1.25 \text{ h}$$

$$t_b = 1.471 \text{ h}$$

$$2\Delta x = v_f t_{p_1} - \frac{1}{2} a t_{p_1}^2$$

$$2(1.5 \text{ km}) = (4.00 \text{ km h}^{-1}) t_{p_1} - \frac{1}{2} (0) t_{p_1}^2$$

$$t_p = 0.75 \text{ h}$$

$t_b = 1.471 \text{ h}, t_p = 0.75 \text{ h}$

1.2 3.41

$$\Delta x_r = 500 \text{ m}$$

$$v_{w/e} = 0\hat{x} + 2.0 \text{ m s}^{-1}\hat{y}$$

$$v_{b/r} = 4.2 \text{ m s}^{-1}\hat{x} + 0\hat{y}$$

$$v_{b/e} = 4.2 \text{ m s}^{-1}\hat{x} + 2.0 \text{ m s}^{-1}\hat{y}$$

(a)

$$v_{b/e} = \sqrt{(v_{r_x} + v_{b_x})^2 + (v_{r_y} + v_{b_y})^2}$$

$$= \sqrt{(0 + 4.2 \text{ m s}^{-1})^2 + (2.0 \text{ m s}^{-1} + 0)^2}$$

$$v_{b/e} = 4.652 \text{ m s}^{-1}$$

$$\tan(\theta) = \frac{v_{b/e_y}}{v_{b/e_x}}$$

$$\theta = \arctan\left(\frac{v_{b/e_y}}{v_{b/e_x}}\right)$$

$$\theta = \arctan\left(\frac{2.0 \text{ m s}^{-1}}{4.2 \text{ m s}^{-1}}\right)$$

$$\theta = 25.46^\circ$$

$v_{b/e} = 4.652 \text{ m s}^{-1}, \theta = 25.46^\circ \text{ S of E}$

(b)

$$\Delta x_r = v_{b/e_x} t - \frac{1}{2} a t^2$$

$$500 \text{ m} = (4.2 \text{ m s}^{-1}) t - \frac{1}{2} (0) t^2$$

$$t = 119.0 \text{ s}$$

$t = 119.0 \text{ s}$

(c)

$$y_0 = 0$$

$$\Delta y = v_{b/e_y} t - \frac{1}{2} a t^2$$

$$y_1 - 0 = (2.0 \text{ m s}^{-1})(119.0 \text{ s}) - \frac{1}{2}(0)(119.0 \text{ s})$$

$$y_1 = 238.0 \text{ m}$$

$$\boxed{\Delta y = 238.0 \text{ m}}$$

1.3 3.42

(a)

$$\sin(\theta) = \frac{v_{w/e}}{v_{b/w}}$$

$$\theta = \arcsin\left(\frac{v_{w/e}}{v_{b/w}}\right)$$

$$\theta = \arcsin\left(\frac{2.0 \text{ m s}^{-1}}{4.2 \text{ m s}^{-1}}\right)$$

$$\theta = 28.44^\circ \text{ N of E}$$

$$\boxed{\theta = 28.44^\circ \text{ N of E}}$$

(b)

$$v_{b/e} = \sqrt{(v_{b/w_x} + v_{w/e_x})^2 + (v_{b/w_y} + v_{w/e_y})^2}$$

$$v_{b/e} = \sqrt{((4.2 \text{ m s}^{-1}) \cos(28.44^\circ) + 0)^2 + ((4.2 \text{ m s}^{-1}) \sin(28.44^\circ) + 2.0 \text{ m s}^{-1})^2}$$

$$v_{b/e} = 3.693 \text{ m s}^{-1}$$

$$\boxed{v_{b/e} = 3.693 \text{ m s}^{-1}}$$

(c)

$$\Delta x_r = v_{b/e} t - \frac{1}{2} a t^2$$

$$500 \text{ m} = (3.693 \text{ m s}^{-1})t - \frac{1}{2}(0)t^2$$

$$t = 135.4 \text{ s}$$

$$\boxed{t = 135.4 \text{ s}}$$

1.4 3.43

(a)

$$v_{w/e} = (0)\hat{x} + (80.0 \text{ km h}^{-1})\hat{y}$$

$$v_{a/w} = 320.0 \text{ km h}^{-1}$$

$$\sin(\theta) = \frac{v_{w/e,y}}{v_{a/w}}$$

$$\theta = \arcsin\left(\frac{80.0 \text{ km h}^{-1}}{320.0 \text{ km h}^{-1}}\right)$$

$$\theta = 14.48^\circ \text{ N of W}$$

$$\boxed{\theta = 14.48^\circ \text{ N of W}}$$

(b)

$$\cos(\theta) = \frac{v_{a/e}}{v_{a/w}}$$

$$v_{a/e} = (v_{a/w}) \cos(\theta)$$

$$v_{a/e} = (320.0 \text{ km h}^{-1}) \cos(14.48^\circ)$$

$$v_{a/e} = 309.8 \text{ km h}^{-1}$$

$$\boxed{v_{a/e} = 309.8 \text{ km h}^{-1}}$$

2 Lab Manual

2.1 473

$$v_{r/b} = v$$

$$d_A = d$$

$$v_{A/r} = c$$

$$a_A = 0$$

$$d_B = d$$

$$v_{B/r} = c$$

$$a_B = 0$$

(a) First find t_A . Subscripts 0, 1 denote the first and second trip (0-indexed).

$$\Delta x_0 = v_{A/r} t_0 + \frac{1}{2} a_A t_0^2$$

$$d_A = (c - v) t_0 + \frac{1}{2} (0) t_0^2$$

$$t_0 = \frac{d_A}{c - v}$$

$$\Delta x_0 = v_{A/r} t_0 + \frac{1}{2} a_A t_0^2$$

$$d_A = (c + v) t_1 + \frac{1}{2} (0) t_1^2$$

$$t_1 = \frac{d_A}{c + v}$$

$$t_A = t_0 + t_1$$

$$t_A = \frac{d_A}{c - v} + \frac{d_A}{c + v}$$

$$t_A = d_A \left(\frac{1}{c \left(1 - \frac{v}{c}\right)} + \frac{1}{c \left(1 + \frac{v}{c}\right)} \right)$$

$$t_A = \frac{d_A}{c} \left(\frac{1}{1 - \frac{v}{c}} + \frac{1}{1 + \frac{v}{c}} \right)$$

$$t_A = \frac{d_A}{c} \left(\frac{1 + \frac{v}{c}}{\left(1 - \frac{v}{c}\right)\left(1 + \frac{v}{c}\right)} + \frac{1 - \frac{v}{c}}{\left(1 + \frac{v}{c}\right)\left(1 - \frac{v}{c}\right)} \right)$$

$$t_A = \frac{2 \frac{d_A}{c}}{-\left(\frac{v}{c}\right)\left(\frac{v}{c}\right) + \frac{v}{c} - \frac{v}{c} + 1}$$

$$t_A = \frac{2 \frac{d_A}{c}}{1 - \left(\frac{v}{c}\right)^2}$$

$$\boxed{t_A = \frac{2 \frac{d}{c}}{1 - \left(\frac{v}{c}\right)^2}}$$

Find t_B . Subscripts 0, 1 denote the first and second trip (0-indexed).

$$v_{B/r}^2 - v_{r/b}^2 = v_{B/b}^2$$

$$v_{B/b} = \sqrt{c^2 - v^2}$$

$$2\Delta x = v_{B/b} t_B + \frac{1}{2} a_B t_B^2$$

$$2d_B = \left(\sqrt{c^2 - v^2} \right) t_B + \frac{1}{2} (0) t_B^2$$

$$t_B = \frac{2d_B}{\sqrt{c^2 \left(1 - \frac{v^2}{c^2}\right)}}$$

$$t_B = \frac{2d_B}{c \sqrt{1 - \frac{v^2}{c^2}}}$$

$$t_B = \frac{2 \frac{d_B}{c}}{\sqrt{1 - \left(\frac{v}{c}\right)^2}}$$

$$t_B = \frac{2\frac{d}{c}}{\sqrt{1 - \left(\frac{v}{c}\right)^2}}$$

- (b) Utilize the negative binomial series $(x+1)^{-n} = 1 - nx + \frac{1}{2}n(n+1)x^2 - \dots$ as the prompt states that $\frac{v}{c} < 1$.

$$\begin{aligned} t_A - t_B &\approx \frac{v^2 d}{c^3} \\ 2\frac{d}{c} \left(1 - \left(\frac{v}{c}\right)^2\right)^{-1} - 2\frac{d}{c} \left(1 - \left(\frac{v}{c}\right)^2\right)^{-1/2} &\approx \frac{v^2 d}{c^3} \\ 2\frac{d}{c} \left(\left(1 + \left(\frac{v}{c}\right)^2\right) - \left(1 + \frac{1}{2}\left(\frac{v}{c}\right)^2\right)\right) &\approx \frac{v^2 d}{c^3} \\ \frac{v^2 d}{c^3} &\approx \frac{v^2 d}{c^3} \end{aligned}$$

$$t_A - t_B \approx \frac{v^2 d}{c^3}$$

2.2 475

2.3 477

2.4 670

2.5 672

2.6 676

2.7 678