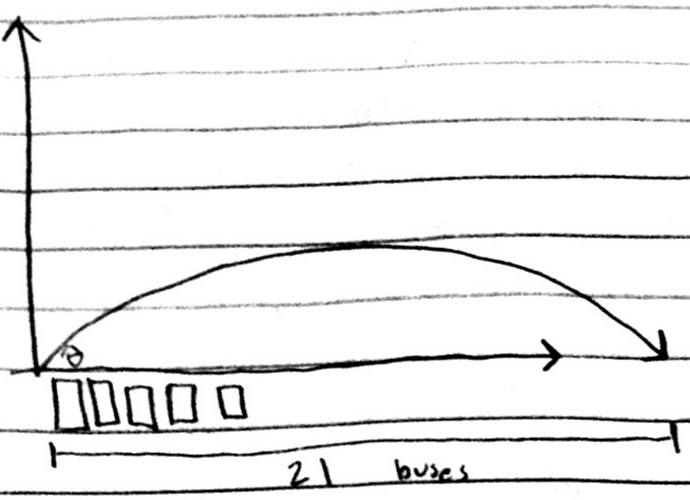
Jan. 23

1.



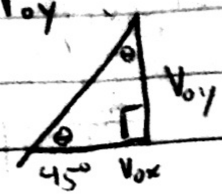
Known
$\theta = 45°$
$a_x = 0 \, m/s^2$
$a_y = -9.8 \, m/s^2$
$x - x_0 = 52.5 m$

Unknown
V_0

$(21 \text{ buses})(2.5 m) = 52.5 m$

How do we start?

$V_{ox} = V_{oy}$



remember also that if a projectile motion problem begins and ends on the same plane, then $V_{oy} = -V_y$

$X - X_0 = V_{ox} t$

$V_{ox} = \frac{X - X_0}{t}$

$V_{ox} = \frac{52.5m}{t} = V_{oy} = -V_y$

$V_{oy} = \frac{52.5m}{t}$

$V_y = -\frac{52.5m}{t}$

$V_y = V_{oy} + a_y t$

$-\frac{52.5m}{t} = \frac{52.5m}{t} + (-9.8 \, m/s^2) t$

$-52.5m = 52.5m + (-9.8 \, m/s^2) t^2$

$+105m = (+9.8 \, m/s^2) t^2$

$105m = (9.8 \, m/s^2) t^2$

$\frac{105m}{9.8 \, m/s^2} = t^2$

$t^2 = 10.71 s^2$

$\boxed{t = 3.27 s}$, $-3.\cancel{27} s$

$V_{ox} = \frac{X - X_0}{t}$

$V_{ox} = \frac{52.5m}{3.27s}$

$V_{ox} = 16.06 \, m/s$

$V_{oy} = 16.06 \, m/s$

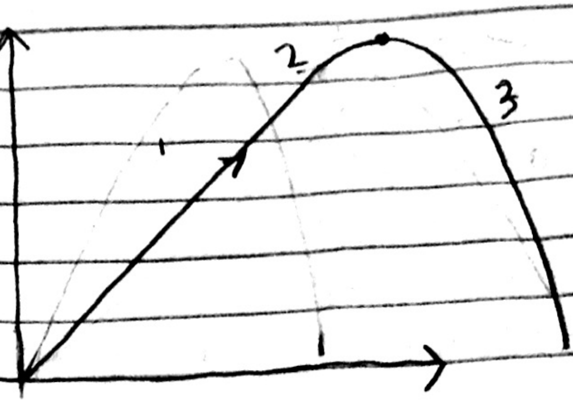
$V_0^2 = V_{ox}^2 + V_{oy}^2$

$V_0 = \sqrt{V_{ox}^2 + V_{oy}^2}$

$V_0 = \sqrt{515.8}$

$= 22.7 \, m/s$

2.



Known₁

$a_{x1} = 5.6\,m/s^2$

$a_{y1} = 7.8\,m/s^2$

$V_{ox1} = 0\,m/s$

$V_{oy1} = 0\,m/s$

$t_1 = 16\,s$

Unknown

$(x-x_o)_1$

V_{x1}

V_{y1}

$(y-y_o)_1$

$(x-x_o)_{total}$

t_{total}

Cut problem into 2 parts.

Horizontal

① $(x-x_o)_1 = \cancel{V_{ox1}t_1} + \frac{1}{2}a_{x1}t_1^2$

$(y-y_o) = \frac{1}{2}a_{x1}t_1^2$

$\boxed{(y-y_o)_1 = 716.8\,m}$

$V_{x1} = \cancel{V_{ox1}} + a_{x1}t_1$

$V_{x1} = a_{x1}t_1$

$\boxed{V_{x1} = 89.6\,m/s}$

vertical

$V_{y1} = \cancel{V_{oy1}} + a_{y1}t_1$

$V_{y1} = a_{y1}t_1$

$\boxed{V_{y1} = 124.8\,m/s}$

$(y-y_o)_1 = \cancel{V_{oy1}t_1} + \frac{1}{2}a_{y1}t_1^2$

$(y-y_o)_1 = \frac{1}{2}a_{y1}t_1^2$

$\boxed{(y-y_o)_1 = 998.4\,m}$

vertical

② $\cancel{V_{y2}} = V_{oy2} + a_{y2}t_2$

$-V_{oy2} = a_{y2}t_2$

$t_2 = \frac{-V_{oy2}}{a_{y2}}$

$t_2 = \frac{-124.8\,m/s}{-9.8\,m/s^2}$

$\boxed{t_2 = 12.73\,s}$

Known₂

$V_{oy2} = 124.8\,m/s$

$V_{ox2} = 89.6\,m/s$

$a_{y2} = -9.8\,m/s^2$

$a_{x2} = 0\,m/s^2$

$V_{y2} = 0\,m/s$

Unknown

t_2

$(y-y_o)_2$

$(x-x_o)_2$

$(y-y_o)_2 = V_{oy2}t_2 + \frac{1}{2}a_{y2}t_2^2$

$(y-y_o)_2 = 1588.7\,m - (4.9\,m/s^2)(162.1\,s^2)$

$(y-y_o)_2 = 1588.7\,m - 794.1\,m$

$\boxed{(y-y_o)_2 = 794.6\,m}$

horizontal

$(x-x_o)_2 = V_{ox2}t_2 + \cancel{\frac{1}{2}a_{x2}t_2^2}$

$(x-x_o)_2 = V_{ox2}t_2$

$\boxed{(x-x_o)_2 = 1,140.6\,m}$

③ time

Can either do quadratic, or find V_{y3}.

$V_{y3}^2 = \cancel{V_{0y3}^2} + 2a_{y3}(y-y_0)_3$

$V_{y3}^2 = 2a_{y3}(y-y_0)_3$

$V_{y3} = \sqrt{2a_{y3}(y-y_0)_3}$

$= \sqrt{-19.6\,m/s^2 \cdot -1793\,m}$

$\boxed{V_{y3} = -187.46\,m/s}$

$V_{y3} = \cancel{V_{0y3}} + a_{y3}t_3$

$V_{y3} = a_{y3}t_3$

$t_3 = \frac{V_{y3}}{a_{y3}}$

$\boxed{t_3 = 19.13\,s}$

horizontal

$(x-x_0)_3 = V_{0x3}t_3 + \frac{1}{2}\cancel{a_{x3}t_3^2}$

$(x-x_0)_3 = V_{0x3}t_3$

$\boxed{(x-x_0)_3 = 1702.6\,m}$

Known

$V_{y2} = V_{0y3} = 0\,m/s$

$V_{0x3} = 89\,m/s$

$a_{y3} = -9.8\,m/s^2$

$a_{x3} = 0\,m/s^2$

$(y-y_0)_1 + (y-y_0)_2 = -(y-y_0)_3 = -1793\,m$

Unknown

t_3

$(x-x_0)$

V_{y3}

$(x-x_0)_1 = 716.8\,m$

$(x-x_0)_2 = 1{,}140.6\,m$

$(x-x_0)_3 = 1702.6\,m$ +

$\boxed{3560\,m}$

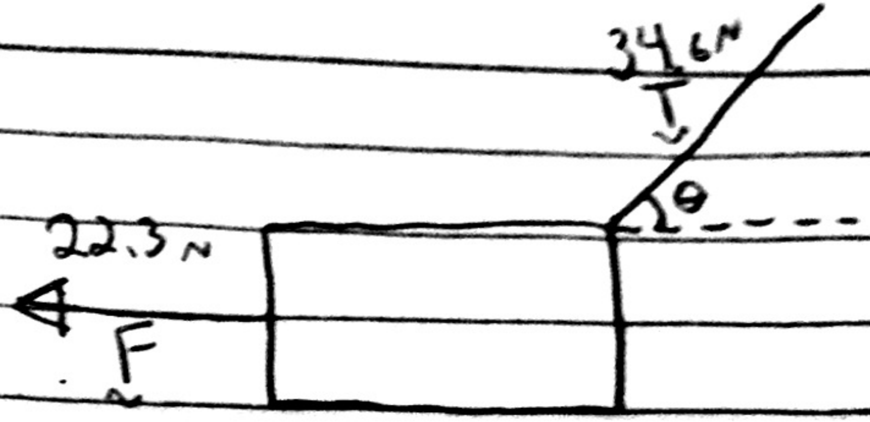
$t_1 = 16\,s$

$t_2 = 12.73\,s$

$t_3 = 19.13\,s$ +

$\boxed{47.86\,s}$

3.



To keep block at rest, T_x needs to be 22.3N.

$$\cos(\theta) = \frac{T_x}{T}$$

$$\theta = \cos^{-1}\left(\frac{T_x}{T}\right)$$

$$\boxed{\theta = 50.2^{\circ}}$$