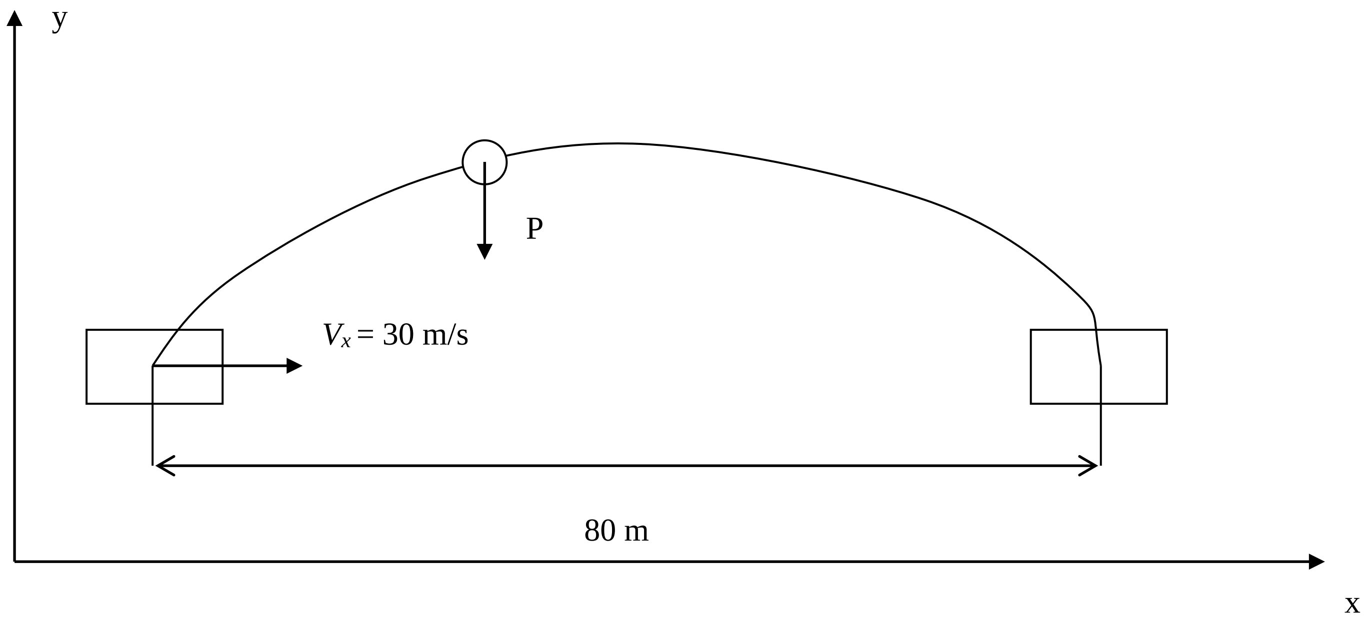



The cart is moving with a constant speed. The projectile in flight has only one force applied (weight), thus along x axis it is moving with a constant speed. Since the projectile returns to the cart, their horizontal speeds are equal. That means initial horizontal speed of the projectile relative to the cart is zero.

Time of flight:

$$\Delta t = \frac{\Delta x}{V_x};$$

$$\Delta t = \frac{80}{30} = 2.67 \text{ s}$$

Now let's consider vertical displacement of the projectile. During the time $t$ the projectile starts moving up with initial vertical speed $V_{y0}$, while moving up its speed is reduced by gravity force and reaches zero at the highest point. From the highest point the projectile accelerates down and at the moment of return to the cart the projectile's speed is equal to $-V_{y0}$. Let us make the equation of the projectile's vertical speed:

$$V_y = V_{y0} - gt;$$

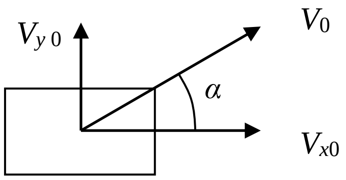
$$V_y(\Delta t) = V_{y0} - g\Delta t = -V_{y0};$$

$$V_{y0} = \frac{g\Delta t}{2};$$

$$V_{y0} = \frac{9.8 \times 2.67}{2} = 13.083 \text{ m/s}$$

Since initial horizontal speed of the projectile relative to the cart is zero, total initial speed of the projectile relative to the cart is 13.083 m/s.

To find angle at which the projectile is fired, let's consider its initial speed relative to the ground.




$V_{x0}$ = 30 m/s;

$V_{y0}$ = 13.083 m/s;

$$V_0 = \sqrt{V_{x0}^2 + V_{y0}^2}\ ;$$

$$V_0 = \sqrt{30^2 + 13.083^2}\ ;$$

$V_0$ = 32.73 m/s

$$\cos\alpha = \frac{V_{x0}}{V_0}\ ;$$

$$\cos\alpha = \frac{30}{32.73} = 0.92\,;$$

$\alpha$ = arccos(0.92) = 23°