Answer on Question #41218-Physics-Mechanics- Kinematics-Dynamics

A cart is moving horizontally along a straight line with constant speed of 30 m/s. A projectile is fired from the moving cart in such a way that it will return to the cart after the cart has moved 80 m. At what speed (relative to the cart) and at what angle (to the horizontal) must the projectile be fired?

Solution:

According to Galilean relativity:

$$\overrightarrow{v_{\text{projectile-ground}}} = \overrightarrow{v_{\text{car-ground}}} + \overrightarrow{v_{\text{car-projectile}}}$$

In projection on horizontal OX axis:

$$v_{\text{projectile-ground}_X} = v_{\text{car-ground}_X} + v_{\text{car-projectile}_X}$$

Equation of motion in projection on OX:

For projectile:

$$x = x_0 + v_{\text{projectile-ground}_X} * t$$

For car:

$$x = x_0 + v_{\text{car-ground}_X} * t$$

So:

$$v_{\text{projectile-ground}_X} = v_{\text{car-ground}_X}$$

Thus:

$$v_{\text{car-projectile}_X} = 0\ m/s$$

In projection on vertical OY axis:

$$v_{\text{projectile-ground}_Y} = v_{\text{car-ground}_Y} + v_{\text{car-projectile}_Y}$$

As car is moving horizontally:

$$v_{\text{car-ground}_Y} = 0\ m/s$$

Thus:

$$v_{\text{projectile-ground}_Y} = v_{\text{car-projectile}_Y}$$

Equation of motion in projection on OX:

For projectile:

$$y = v_{\text{projectile-ground}_y} * t - \frac{gt^2}{2}$$

For car:

$$y = 0$$

Time of collision:

$$t = \frac{x}{v_{\text{car}-\text{ground}_\text{X}}} = \frac{80}{30} = 2.667\ s$$

Thus:

$$0 = v_{\text{projectile}-\text{ground}_y} * t - \frac{gt^2}{2}$$

$$v_{\text{projectile}-\text{ground}_y} = \frac{gt}{2} = \frac{9.8 * 2.667}{2} = \mathbf{13.0683}\,\boldsymbol{\frac{m}{s}}$$

Answer: $\mathbf{13.0683}\,\frac{\boldsymbol{m}}{\boldsymbol{s}}$, **90** °to the horizontal