Answer on Question 70874, Physics, Mechanics, Relativity

Question:

A cannonball is fired from a cliff top horizontally out to sea with a speed of $74\ m/s$. The cliff is $320\ m$ above sea level. Calculate the speed of impact of the cannonball with the water.

Solution:

Let's first calculate the time taken by the cannonball to hit the water at the ground level:

$$h = v_{0y}t + \frac{1}{2}gt^2,$$

here, $h = 320\ m$ is the height of the cliff, $v_{0y} = 0$ is the vertical component of the initial velocity of the cannonball, $g = 9.8\ \frac{m}{s^2}$ is the acceleration due to gravity (we choose the downwards as the positive direction, so the acceleration due to gravity will be with sign plus) and t is time.

Then, we get:

$$t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2 \cdot 320\ m}{9.8\ \frac{m}{s^2}}} = 8.1\ s.$$

Then, we can find the x- and y-components of the impact velocity of the cannonball.

Since $g = 9.8\ \frac{m}{s^2}$ in the y-direction and 0 in the x-direction, we get:

$$v_{impact,x} = v_{0x} + gt = 74\ \frac{m}{s},$$

$$v_{impact,y} = v_{0y} + gt = 9.8\ \frac{m}{s^2} \cdot 8.1\ s = 79.4\ \frac{m}{s}.$$

Finally, we can find the resulting impact velocity from the Pythagorean theorem:

$$v_{impact} = \sqrt{\left(v_{impact,x}\right)^2 + \left(v_{impact,y}\right)^2} = \sqrt{\left(74\ \frac{m}{s}\right)^2 + \left(79.4\ \frac{m}{s}\right)^2} = 108.5\ \frac{m}{s}.$$

Answer:

$v_{impact} = 108.5\ \frac{m}{s}$.