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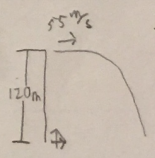
PHY 1110 - Summer 2020 - Study Guide #4 - Projectile Motion

A cannon is fired horizontally from the edge of a 120 m high cliff which overlooks a flat and level plain. The muzzle velocity of the cannon is 55 m/s and the ball move frictionlessly through the air.

1. Make a sketch of the situation. Let the +y axis lies in the vertical upward direction and the +x axis lie in the horizontal direction parallel to the initial velocity vector of the cannon ball. Place the origin of this coordinate system at the bottom of the cliff just below the end of the cannon barrel. Specify in proper mathematical form all that is known about the cannon ball. Let $t_0 = 0$ s.



$v_{x_0} = 55\ m/s$
$v_{y_0} = 0\ m/s$
$a_{x_0} = 0\ m/s^2$
$a_{y_0} = -9.8\ m/s^2$

$d = d_0 + v_0 t + \frac{1}{2} a t^2$
$0 = 120 + \frac{1}{2}(-9.8) t^2$
$t^2 = \frac{-120}{-4.9}$
$t = 4.955$

2. The horizontal component of the ball's velocity (a)decreases, (b)remains constant, or (c)increases as time progresses.

3. The vertical component of the ball's velocity (a)decreases, (b)remains constant, or (c)increases as time progresses.

4. The magnitude of the ball's velocity (a)decreases, (b)remains constant, or (c)increases as time progresses.

5. The acceleration of the ball (a) increases, (b)remains constant, or (c)decreases as time progresses.

6. The time after firing when the cannon ball to strike the flat, level plane below the cliff is 4.95 s.

$d = d_0 + v_0 t + \frac{1}{2} a t^2$
$0 = 120 + \frac{1}{2}(-9.8) t^2$
$t^2 = \frac{-120}{-4.9}$
$t = 4.95$

7. An identical cannon ball is dropped over the side of the cliff with no initial velocity at the exact instant the cannon is fired. The dropped ball will strike the ground (a)earlier than, (b)at the same time as, or (c)later than the fired cannon ball.

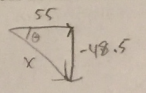
8. The horizontal distance traveled by the cannon ball before striking the ground is 272. m.

$d = d_0 + \frac{1}{2}(v_0 + v) t$
$= 0 + \frac{1}{2}(55 + 55) 4.95$
$= 55(4.95)$
$= 272.25\ m$

9. Just as the cannon ball is about to strike the ground, v_x = 55 m/s and v_y = -48.5 m/s.

$v = 0 + (-9.8)4.95$
$= -48.5$ m/s

10. The velocity of the cannon ball as it strikes the ground is 73.3 m/s which is directed at an angle of 41.4 ° below the horizontal.

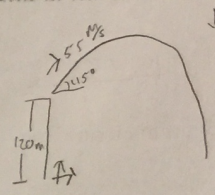


$x = \sqrt{55^2 + (-48.5)^2}$
$= 73.3$ m/s

$\tan\theta = \frac{48.5}{55}$
$\theta = \tan^{-1}\left(\frac{48.5}{55}\right)$
$= 41.4°$

The cannon barrel is now raised so the initial velocity of the cannon ball is directed at 45° above the horizontal.

11. Make a sketch of the situation. Include the same x and y axes as used previously. Specify in proper mathematical form all that is known about the cannon ball. (Assume the end of the barrel of the cannon is the same distance above the plane as previously.)



$\downarrow 9.8\ m/s^2$

$v_{x_0} = \cos(45)\,55$
$= 38.9$ m/s

$v_{y_0} = \sin(45)\,55$
$= 38.9$

$a_{x_0} = 0\ m/s^2$

$a_{y_0} = -9.8\ m/s^2$

12. The horizontal component of the ball's velocity (a)decreases, (b)remains constant, (c)increases, or (d) both decreases and increases as time progresses.

13. The vertical component of the ball's velocity (a)decreases, (b)remains constant, (c)increases, or (d) both decreases and increases as time progresses.

14. The magnitude of the ball's velocity (a)decreases, (b)remains constant, (c)increases, or (d) both decreases and increases as time progresses.

15. The acceleration of the ball (a) increases, (b)remains constant, (c)decreases, or (d) both decreases and increases as time progresses.

16. The time after firing when the ball strikes the ground is 10.3 s. This time is (a)less than, (b)the same as, or (c)greater than the time when the ball strikes the ground in the horizontally fired frictionless case.

$d = d_0 + v_0 t + \frac{1}{2} a t^2$

$0 = 120 + 38.9t + \frac{1}{2}(-9.8)t^2$

$0 = -4.9t^2 + 38.9t + 120$

$\frac{-38.9 \pm \sqrt{38.9^2 - 4(-4.9)(120)}}{2(-4.9)} = \frac{38.9 \pm \sqrt{3865.21}}{9.8} = -2.37, 10.3s$

17. When the cannon ball is just about to strike the ground, the forward distance the ball traveled is 401. m. This distance is (a)less than, (b)the same as, or (c)greater than the forward distance traveled by the ball in the horizontally fired frictionless case.

$d = d_0 + v_0 t + \frac{1}{2} a t^2$

$= 0 + 38.9(10.3) + \frac{1}{2}(-9.8)(10.3)^2$

$= 401.$

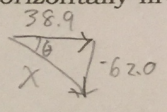
18. When the cannon ball is just about to strike the ground, v_x = 38.9 and v_y = −62.0. V_x is (a)less than, (b)the same as, or (c)greater than v_x in the frictionless case. V_y is (a)less than, (b)the same as, or (c)greater than v_y in the horizontally fired frictionless case.

$v = v_0 + at$

$= 38.9 + (-9.8)10.3$

$= -62.0$

19 When the cannon ball is just about to strike the ground, its velocity is 73.2 m/s which is directed at an angle of 57.9 ° below the horizontal. This angle is (a)smaller than, (b)the same as, or (c)greater than the angle in the horizontally-fired frictionless case.



$x = \sqrt{38.9^2 + (-62)^2}$

$= 73.2 \text{ m/s}$

$\theta = \tan^{-1}\left(\frac{62}{38.9}\right)$

$= 57.9°$

20. The maximum height above the flat and level plane reached by the cannon ball is 197. m. This height is reached 3.97 s after firing.

$v = v_0 + at$

$0 = 38.9 - 9.8t$

$t = 3.97 s$

$d = d_0 + v_0 t + \frac{1}{2} a t^2$

$= 120 + 38.9(3.97) + \frac{1}{2}(-9.8)(3.97)^2$

$= 197.2 m$