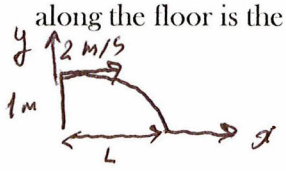
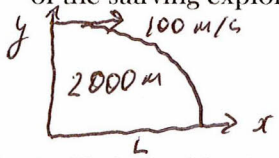
Projectile Motion Worksheet

1) A ball rolls with a speed of 2.0 m/s across a level table that is 1.0 m above the floor. Upon reaching the edge of the table, it follows a parabolic path to the floor. How far along the floor is the landing spot from the table?



$x = 2t$ $\quad y = 1 - \frac{gt^2}{2}$ $\quad 1 - \frac{gt^2}{2} = 0$ $\quad t = \sqrt{\frac{2}{g}} = 0.45\,s$ $\quad L = 2 \times 0.45 = 0.9\,m$

2) A rescue pilot drops a survival kit while her plane is flying at an altitude of 2000.0 m with a forward velocity of 100.0 m/s. If air friction is disregarded, how far in advance of the starving explorer's drop zone should she release the package?



$x = 100t$ $\quad y = 2000 - \frac{gt^2}{2}$ $\quad t = \sqrt{\frac{4000}{g}} = 20.2\,s$ $\quad L = 100 \times 20.2 = 2020\,m$

3) A rifle is fired horizontally and travels 200.0 m. The rifle barrel is 1.90 m from the ground. What speed must the bullet have been travelling at? Ignore friction.

$200 = Vt$ $\quad 1.9 = \frac{gt^2}{2}$ $\quad t = \sqrt{\frac{3.8}{g}} = 0.62\,s$ $\quad 200 = V \times 0.62$ $\quad V = \frac{200}{0.62} = 321.2\,m\,s^{-1}$

4) A skier leaves the horizontal end of a ramp with a velocity of 25.0 m/s [E] and lands 70.0 m from the base of the ramp. How high is the end of the ramp from the ground?

$70 = 25t$ $\quad t = \frac{70}{25} = 2.8\,s$ $\quad h = \frac{gt^2}{2}$ $\quad h = \frac{9.8 \times 2.8^2}{2} = 38.4\,m$

5) An astronaut stands on the edge of a lunar crater and throws a half-eaten Twinkie™ horizontally with a velocity of 5.00 m/s. The floor of the crater is 100.0 m below the astronaut. What horizontal distance will the Twinkie™ travel before hitting the floor of the crater? (The acceleration of gravity on the moon is 1/6th that of the Earth).

$h = \frac{g/6 \times t^2}{2} = \frac{gt^2}{12}$ $\quad t = \sqrt{\frac{100 \times 12}{9.8}} = 11.1\,s$ $\quad L = 5 \times 11.1 = 55.5\,m$

6) A baseball player leads off the game and hits a long home run. The ball leaves the bat at an angle of 30.0° from the horizontal with a velocity of 40.0 m/s. How far will it travel in the air?

$$L = \frac{4^2 \sin 2\theta}{g}$$

$$L = \frac{40^2 \sin 60^\circ}{9.8} = 141.4\,m$$

7) A golfer is teeing off on a 170.0 m long par 3 hole. The ball leaves with a velocity of 40.0 m/s at 50.0° to the horizontal. Assuming that she hits the ball on a direct path to the hole, how far from the hole will the ball land (no bounces or rolls)?

$L = \frac{u^2 \sin 2\theta}{g}$ $L = \frac{40^2 \sin 100^\circ}{9.8} = 160.78$ $170 - 160.78 = 9.22\ m$

8) A punter in a football game kicks a ball from the goal line at 60.0° from the horizontal at 25.0 m/s.

a) What is the hang time of the punt?

$t = \frac{2u \sin\theta}{g}$ $t = \frac{2 \times 25 \sin 60^\circ}{9.8} = 4.42\ s$

b) How far down field does the ball land?

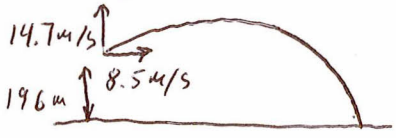
$L = \frac{u^2 \sin 2\theta}{g}$ $L = \frac{25^2 \sin 120^\circ}{9.8} = 55.2\ m$

9) A cannon fires a cannonball 500.0 m downrange when set at a 45.0° angle. At what velocity does the cannonball leave the cannon?

$L = \frac{u^2 \sin 2\theta}{g}$ $u = \sqrt{\frac{Lg}{\sin 2\theta}}$ $u = \sqrt{\frac{500 \times 9.8}{\sin 90^\circ}} = 70\ m\,s^{-1}$

10) You are piloting a helicopter which is rising vertically at a uniform velocity of 14.70 m/s. When you reach 196.00 m, you see Barney (Uh-oh). A large object is projected with a horizontal velocity of 8.50 m/s from the rising helicopter.

a) When does the ball reach Barney's head if he is standing in a hole with his head at ground level?



$x = 8.5t$

$y = 196 + 14.7t - \frac{gt^2}{2}$

$t = 8\ s$

$y = 0$

$4.9t^2 - 14.7t - 196 = 0$

$t = \frac{14.7 + \sqrt{14.7^2 + 4 \times 4.9 \times 196}}{2 \times 4.9}$

b) Where does Barney have to be horizontally relative to the helicopter's position?

$x = 8.5t = 8.5 \times 8 = 68\ m$

c) What is the vertical velocity when it hits the ground?

$v_y = u_y - gt$

$v_y = 14.7 - 9.8 \times 8$

$= -63.7\ m\,s^{-1}$

$63.7\ m\,s^{-1}$ down

11) An object is punted at 25.0 m/s at 40.0° on G's home planet. What is the range of the object on level ground? (Use g = 18.0 m/s^2)

$L = \frac{u^2 \sin 2\theta}{g}$ $L = \frac{25^2 \sin 80^\circ}{18} = 34.2\ m$

12) An elastic loaded balloon launcher fires balloons at an angle of 38.0° from the surface of the ground. If the initial velocity is 25.0 m/s, find how far away the balloons are from the launcher when they hit the level ground again.

$L = \frac{u^2 \sin 2\theta}{g}$ $L = \frac{25^2 \sin 76^\circ}{9.8} = 61.9\ m$

13) A movie stunt driver on a motorcycle speeds horizontally off a 50.0 m high cliff. How fast (in km/h) must the motorcycle leave the cliff-top if it's to land on the level ground below at a distance of 90.0 m from the base of the cliff?

$x = ut$ $y = 0$ $t = \sqrt{\frac{100}{g}} = 3.19s$ $u = \frac{90}{3.19} = 28.2\ ms^{-1}$

$y = 50 - \frac{gt^2}{2}$ $\frac{gt^2}{2} = 50$ $90 = ut$ $u = 28.2 \times 3.6 = 101.6\ km/h$

14) A football is kicked at 37.0° to the horizontal at 20.0 m/s from the player's hand at 1.00 m from the ground. How far did the football travel before hitting the ground?

$x = 20 \cos 37^\circ t$

$y = 1 + 20 \sin 37^\circ t - 4.9t^2$

$4.9t^2 - \underbrace{20 \sin 37^\circ}_{12.04} t - 1 = 0$

$t = \frac{12.04 + \sqrt{12.04^2 + 4 \times 4.9}}{2 \times 4.9} = 2.54s$

$L = 20 \cos(37^\circ) \times 2.54$

$= 40.6\ m$

15) The same football in #14 is kicked from the ground instead.

a) Find the maximum height.

$$H = \frac{u^2 \sin^2\theta}{2g} = \frac{20^2 \sin^2(37^\circ)}{2\times 9.8} = 7.39\ m$$

b) Find the time of travel.

$$t = \frac{2u\sin\theta}{g} = \frac{2\times 20\sin(37^\circ)}{9.8} = 2.5\ s$$

c) How far away does it hit the ground?

$$L = \frac{u^2\sin(2\theta)}{g} = \frac{20^2\sin(74^\circ)}{9.8} = 39.24\ m$$

d) Find the velocity vector at maximum height.

$$v = u\cos\theta = 20\cos(37^\circ) = 15.97\ ms^{-1} \rightarrow$$

e) Find the acceleration vector at maximum height.

$$g = 9.8 \downarrow$$

16) The stone is thrown off the top of a building from a height of 45.0 m. The stone has a launch angle of 62.5° and a speed of 31.5 m/s.

a) How long is the stone in flight?

$$y = 45 + 31.5\sin(62.5)t - 4.9t^2$$

$$4.9t^2 - 31.5\sin(62.5^\circ)t - 45 = 0$$

$$t = \frac{31.5\sin(62.5^\circ) + \sqrt{(31.5\sin(62.5^\circ))^2 + 4\times 4.9\times 45}}{2\times 4.9}$$

$$= 7\ s$$

b) How far from the base of the building does it travel?

$$L = u\cos(\theta)t = 31.5\cos(62.5^\circ)\times 7$$

$$= 101.8\ m$$

c) What is its speed just before it hits the ground?]

$$v_x = u\cos(\theta) = 31.5\cos(62.5) = 14.55\ ms^{-1}$$

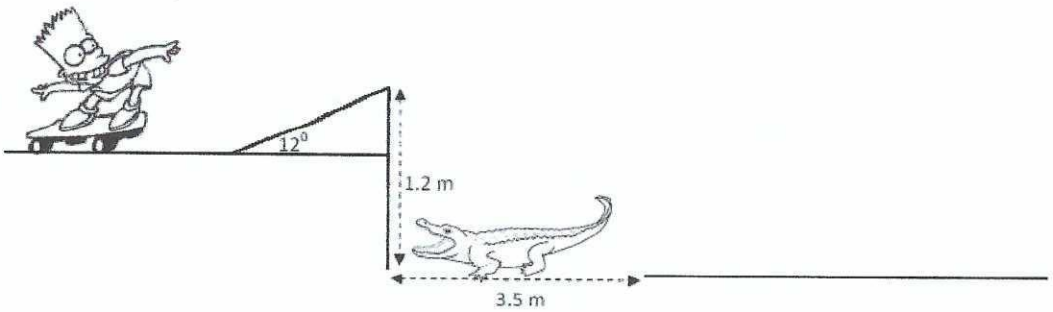
$$v_y = 31.5\sin(62.5^\circ) - 9.8\times 7 = -40.66\ m/s$$

$$v = \sqrt{v_x^2 + v_y^2} = 43.2\ ms^{-1}$$

Or $\frac{mv^2}{2} = mgh + \frac{mu^2}{2}$

$$v = \sqrt{2gh + u^2} = \sqrt{2\times 9.8\times 45 + 31.5^2} = 43.3\ ms^{-1}$$

17) Student is attempting to jump an alligator on his skateboard as in figure below.



W hat is the minimum speed student must leave the ramp in order to make the jump?

$y = 1.2 + u\sin(12°)t - 4.9t^2$

$4.9t^2 - u\sin(12°)t - 1.2 = 0$

$x = u\cos\theta\, t$

$u\cos(12°)t = 3.5$

$t = \frac{3.5}{u\cos(12°)}$

$4.9\frac{3.5^2}{u^2\cos^2(12°)} - 3.5\tan(12°) - 1.2 = 0$

$\frac{62.74}{u^2} - 1.94 = 0$

$u = \sqrt{\frac{62.74}{1.94}} = 5.7\,m\,s^{-1}$

18) Student is playing golf. H e is hitting golf balls from the top of a cliff into the water below. O ne ball is hit with an initial speed of 65 m/s at an angle of 45° to the horizontal. T he ball takes 12.5 s from the time it is hit until it lands in the water. W hat is the height of the cliff? H ow high above the top of the cliff does the ball rise?

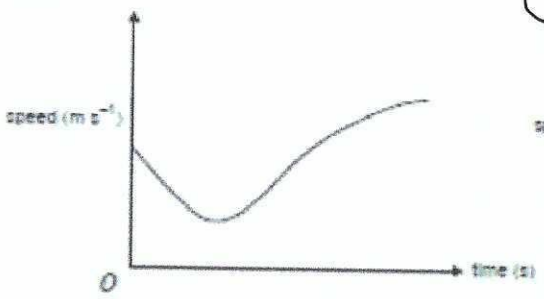
$H = \frac{u^2\sin^2\theta}{2g} = \frac{65^2\times\sin^2(45)}{19.6} = 107.8\,m$

$y = h + 65\sin(45°)t - 4.9t^2$

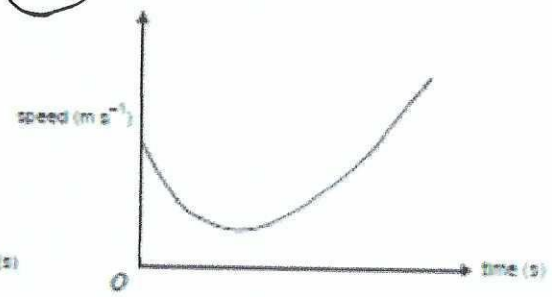
$h = 4.9\times 12.5^2 - 65\sin(45°)\times 12.5 = 191.1\,m$

19) W hich of the following graphs below best represents students speed as a function of time whilst airborne?

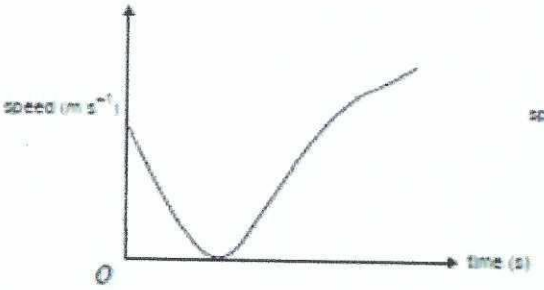
A.



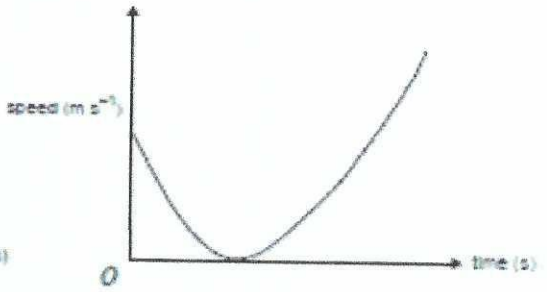
B.



C.



D.



At the top speed $\neq 0$.
On the way down it is accelerating all time.