

Example 16

A ball is thrown from the top of a building is given an initial velocity of  $10.0 \text{ m s}^{-1}$  straight upward. The building is  $30.0 \text{ m}$  high and the ball just misses the edge of the roof on its way down, as shown in figure below. Calculate

a) The maximum height of the stone from point A. [Answer:  $5.19 \text{ m}$ ]  
b) The time taken from point A to C. [Answer:  $2.04 \text{ s}$ ]  
c) The time taken from point A to D. [Answer:  $2.69 \text{ s}$ ]  
d) the velocity of the stone when it reaches point D. [Answer:  $-26.20 \text{ ms}^{-1}$ ]

Handwritten notes:  
 $u = 10$   
 $a = -g$   
 $v^2 = u^2 + 2as$   
 $0 = 10^2 + 2(-g)s$   
 $s = 5.097$   
 $S = ut + \frac{1}{2}at^2$   
 $0 = 10t - \frac{1}{2}gt^2$   
 $t = 1.02$   
 $T = 2.04$   
 $S = 30 + 5.097 = 35.097$   
 $S = ut + \frac{1}{2}at^2$   
 $35.097 = 10t - \frac{1}{2}gt^2$   
 $t = 2.69$   
 $v = u + at$   
 $v = 10 - 9.8(2.69) = -26.20$

Example 17

A 32 caliber bullet fired from a revolver with a 3-inch-long barrel will have a relatively low muzzle speed of about  $200 \text{ m s}^{-1}$ . If it's shot straight up, neglecting air resistance,

a) What is the peak height the bullet will reach? [Answer:  $2038.74 \text{ m}$ ]  
b) How fast will it be moving (velocity) when it returns to the height of the gun? [Answer:  $-200 \text{ ms}^{-1}$ ]  
c) How long will the whole trip take? (What is the time of flight?) [Answer:  $40.77 \text{ s}$ ]

Handwritten notes:  
 $u = 200$   
 $a = -g$   
 $v = 0$   
 $v^2 = u^2 + 2as$   
 $0 = 200^2 + 2(-g)s$   
 $s = 2038.74$   
 $v = u + at$   
 $0 = 200 - gt$   
 $t = 20.387$   
 $T = 40.77$   
 $v = u + at$   
 $v = 200 - 9.8(40.77) = -200$

Example 18

A plane travelling at a constant velocity of  $50 \text{ m s}^{-1}$  at an altitude of  $300 \text{ m}$  releases a parcel directly above a point X on level ground. Calculate

a) The flight time of the parcel. [Answer:  $7.82 \text{ s}$ ]  
b) The velocity of impact of the parcel. [Answer:  $91.57 \text{ ms}^{-1}$  below positive x-axis]  
c) The distance from X to the point of impact. [Answer:  $391 \text{ m}$ ]

Handwritten notes:  
 $u_x = 50$   
 $u_y = 0$   
 $a_x = 0$   
 $a_y = -g$   
 $s_y = 300$   
 $v_y = 0$   
 $v_y^2 = u_y^2 + 2as$   
 $0 = 0 + 2(-g)s$   
 $s = 300$   
 $t = 7.82$   
 $s_x = ut$   
 $s_x = 50(7.82) = 391$   
 $v_x = u_x = 50$   
 $v_y = -76.714$   
 $v = \sqrt{50^2 + 76.714^2} = 91.57$   
 $\theta = \tan^{-1}(\frac{v_y}{v_x}) = 56.9^\circ$

Example 15

The person in the gondola throws a ball at  $40.0^\circ$  to the horizon at  $10 \text{ m s}^{-1}$ . If the ball is launched at a height of  $100 \text{ m}$ , where will it land? (Calculate the horizontal distance  $S_x$ ) [Answer:  $40 \text{ m}$ ]

Handwritten notes:  
 $u = 10$   
 $\theta = 40^\circ$   
 $u_x = 7.66$   
 $u_y = 6.43$   
 $a_x = 0$   
 $a_y = -g$   
 $s_y = 100$   
 $v_y^2 = u_y^2 + 2as$   
 $v_y^2 = 6.43^2 + 2(-g)(100)$   
 $v_y = -44.2$   
 $t = 8.82$   
 $s_x = u_x t$   
 $s_x = 7.66(8.82) = 67.6$

Example 16

Santa parked his sleigh  $5.0 \text{ m}$  from the edge of a  $20^\circ$  roof. Unfortunately, the parking brake failed. Santa's sleigh slid down the roof and landed on the ground  $6.0 \text{ m}$  from the wall of the house. Given that the velocity of the sleigh after sliding  $5.0 \text{ m}$  is  $5.11 \text{ ms}^{-1}$ . How high was the wall of the house? [ANSWER:  $9.85 \text{ m}$ ]

Handwritten notes:  
 $u = 0$   
 $a = g \sin 20^\circ$   
 $s = 5$   
 $v^2 = u^2 + 2as$   
 $v = 5.11$   
 $v_y = v \sin 20^\circ = 1.75$   
 $v_x = v \cos 20^\circ = 4.82$   
 $s_y = 6$   
 $v_y^2 = u_y^2 + 2as$   
 $1.75^2 = 0 + 2(-g)s$   
 $s = 0.155$   
 $h = 6 + 0.155 = 6.155$

Example 19

A football is kicked at an angle  $\theta = 37^\circ$  with a velocity of  $20 \text{ m s}^{-1}$  as shown. Calculate

a) The maximum height H. [Answer:  $7.39 \text{ m}$ ]  
b) The time of travel before the football hits the ground. [Answer:  $2.45 \text{ s}$ ]  
c) How far away it hits the ground. [Answer:  $39.13 \text{ m}$ ]  
d) The velocity vector at maximum height. [Answer:  $v_x = 15.97 \text{ ms}^{-1}$ ,  $v_y = 0 \text{ ms}^{-1}$ ]  
e) The acceleration vector at maximum height. [Answer:  $a_x = 0 \text{ ms}^{-2}$ ,  $a_y = -9.81 \text{ ms}^{-2}$ ]

Handwritten notes:  
 $u = 20$   
 $\theta = 37^\circ$   
 $u_x = 16$   
 $u_y = 12$   
 $a_x = 0$   
 $a_y = -g$   
 $s_y = 0$   
 $v_y^2 = u_y^2 + 2as$   
 $0 = 12^2 + 2(-g)s$   
 $s = 7.39$   
 $t = 2.45$   
 $s_x = u_x t$   
 $s_x = 16(2.45) = 39.13$

Example 20

A car is traveling at a speed of  $72 \text{ km h}^{-1}$  when it reaches the highway. Calculate

a) The time taken for the car to reach the highway. [Answer:  $0.8 \text{ s}$ ]  
b) The height of the stage. [Answer:  $18.75 \text{ m}$ ]

Handwritten notes:  
 $u = 72$   
 $a = 0$   
 $s = 0$   
 $t = 0.8$   
 $s = ut + \frac{1}{2}at^2$   
 $0 = 72(0.8) + \frac{1}{2}(0)(0.8)^2$   
 $s = 57.6$

Matriculation Physics: Projectile Motion (Q6)

A screw falls from a hot air balloon  $200 \text{ m}$  above the ground. At the instance, the balloon is moving upwards with velocity of  $12 \text{ ms}^{-1}$  at an angle of  $30^\circ$  above the horizontal. What is the time taken for the screw to hit the ground?

Handwritten notes:  
 $u_x = 0$   
 $u_y = 12 \sin 30^\circ = 6$   
 $a_x = 0$   
 $a_y = -g$   
 $s_y = -200$   
 $v_y^2 = u_y^2 + 2as$   
 $v_y^2 = 6^2 + 2(-g)(-200)$   
 $v_y = 40.2$   
 $t = 7.03$

16) Free Fall.

a)  $u_y = 10$   
 $s_y = ?$   
 $a_y = -g$   
 $v_y = 0$

b)  $s_y = 0$   
 $u_y = 10$   
 $a_y = -g$   
 $t = ?$

Handwritten notes:  
 $v^2 = u^2 + 2as$   
 $0 = 10^2 + 2(-g)s$   
 $s = 5.097$   
 $S = ut + \frac{1}{2}at^2$   
 $0 = 10t - \frac{1}{2}gt^2$   
 $t = 1.02$   
 $T = 2.04$   
 $S = 30 + 5.097 = 35.097$   
 $S = ut + \frac{1}{2}at^2$   
 $35.097 = 10t - \frac{1}{2}gt^2$   
 $t = 2.69$   
 $v = u + at$   
 $v = 10 - 9.8(2.69) = -26.20$

17)  $t = 2.039 \text{ s}$

a)  $u_x = 200$   
 $u_y = 200$   
 $a_y = -g$

b)  $s = 0$   
 $a_y = -g$   
 $u_y = 200$

c)  $t = ?$   
 $s = 0$   
 $a = -g$   
 $u_y = 200$

$$s = ut + \frac{1}{2}at^2$$
$$-30 = 10t + \frac{1}{2}(-g)t^2$$
$$t = 3.694 \text{ s}$$

$$v_y = ?$$
$$u_y = 10$$
$$a_y = -g$$
$$v = -26.24 \text{ ms}^{-1}$$