Part I

1. A ball is thrown straight up from height H while a second is thrown straight down. Neglect air resistance. After the balls have been released

   (a) the one thrown up has the greater acceleration.

   (b) the one thrown down has the greater acceleration.

   (c) the accelerations are the same.

   (d) neither ball accelerates after it has been released.

   Answer (c): When an object is acted on by gravity alone the acceleration is always constant and directed downward.

2. Two footballs are kicked at the same angle above the horizontal but one leaves the ground with twice the speed. The faster one will travel

   (a) twice as high and twice as far.

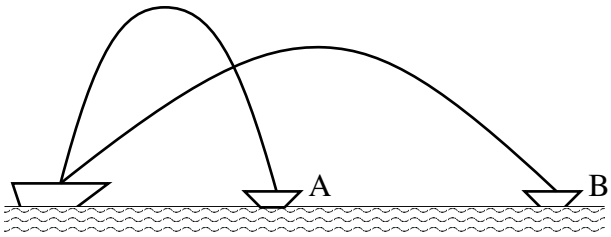
   (b) twice as high and four times as far.

   (c) four times as high and twice as far.

   (d) four times as high and four times as far.

   Answer: (d). The ball travels twice as fast in the vertical direction so it is in the air twice as long. Twice as fast and twice as long means that the ball travels four times as high and four times as far.

3. A ship simultaneously tosses two water balloons at enemy boats. If the balloons follow the parabolic trajectories shown, which boat gets hit first?



   (a) A; (b) B; (c) both at the same time; (d) need more information.

   Answer: (b). Balloon B travels higher and therefore is in the air longer.

4. A projectile is launched at an angle above the horizontal and follows a parabolic trajectory reaching a maximum height at point P. If air friction is negligible which of the following statements about point P is correct?

   (a) The horizontal component of both velocity and acceleration are zero.

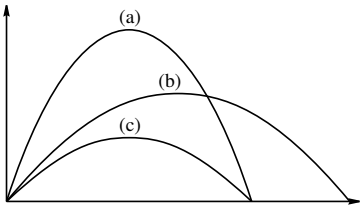
   (b) The vertical component of both velocity and acceleration are zero.

(c) The horizontal component of velocity and the vertical component of acceleration are zero.

(d) The vertical component of velocity and the horizontal component of acceleration are zero.

Answer: (d). The horizontal component of acceleration is zero since gravity acts in the vertical direction only. The horizontal component of velocity is constant and not zero, but at the maximum height the vertical component of velocity changes from up to down and so is momentarily zero.

5. Three projectiles (a) (b) and (c) are launched with the same speed. Rank the the projectiles in order of increasing horizontal velocity.



Answer: (a) then (b) then (c). Since the speed is the same then then the increasing horizontal component of velocity corresponds to decreasing launch angle.

Part II

1. Two stones are released from rest at a certain height, one slightly after the other. Answer the following questions regarding their motion as they fall through the air, with explanations.

   (a) will the difference in their speeds increase, decrease, or stay the same?
   The difference in their speeds will remain constant since the acceleration is constant, so their velocities increase by the same amount each second.)

   (b) will their distance between them increase, decrease, or stay the same?
   There distance apart will increase because the first stone is traveling faster than the second.

   (c) will the time interval between the instants at which they hit the ground be smaller than, equal to, or larger than the time interval between the instants of their release?
   The time interval will be equal to the initial time interval. Although the balls are further apart than at the beginning they are also traveling faster.

2. A physics text book is dropped from a height of 1.0 m onto a stationary cockroach.

   (a) How long does it take for the book to reach the ground?

   $\Delta y = \frac{1}{2}at^2 \;\Rightarrow\; -1.0 = \frac{1}{2}(-9.8)t^2 \;\Rightarrow\; t^2 = 1.0/4.9 \;\Rightarrow t = 0.45$ s

   (b) What will the velocity of the book be when it reaches the ground?

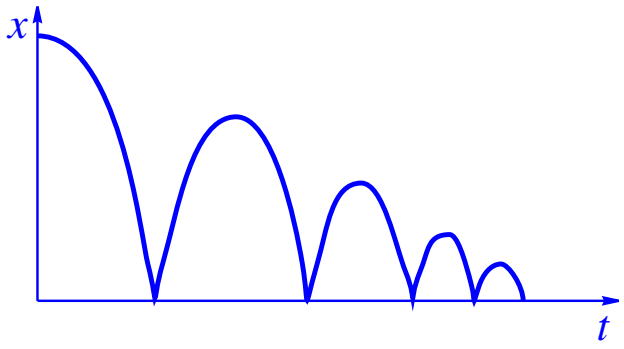
   $v = at = -9.8 \times 0.45 = -4.4$ m/s (ie 4.4 m/s downwards)

   (b) The cockroach sees the book the moment it is released and must move 10 cm to get out of the way. How fast must the cockroach move to avoid a sticky finish.

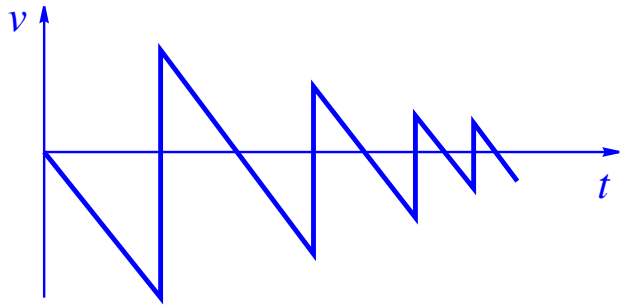
   $v = \Delta x/t = 0.1/45 = 0.22$ m/s

3. A ball is dropped from above the ground and bounces several times before coming to rest. Assuming the ground is the origin and the positive direction is upwards sketch graphs of

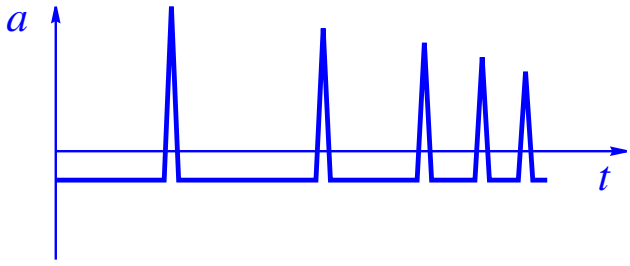
   (a) position vs. time



   (b) velocity vs. time

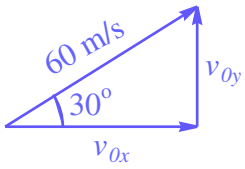


   (c) acceleration vs. time



4. A golf ball is hit and leaves the ground at a 30^o angle above the horizontal with a velocity of 60 m/s. Sadly the ball strikes a tree which is in its path 50 m away and drops straight to the ground.

   (a) Find the horizontal and vertical components of the initial velocity.



$v_{0x} = 60\cos 30 = 52$ m/s

$v_{0y} = 60\sin 30 = 30$ m/s

   (b) How long was the ball in the air before it hit the tree?

   In the horizontal direction there is uniform motion so $\Delta x = v_x t \Rightarrow t = 50/52 = 0.96$ s

   (c) How high up the tree did the ball hit?

   How high up the tree is a vertical displacement $\Delta y = v_{0y}t + \frac{1}{2}a_y t^2 = 30(0.96) - \frac{1}{2}(9.8)(0.96)^2 = 24m$

   So it hits the tree 24 m up the tree.

   (d) With speed did the ball hit the tree? (careful: speed is the magnitude of the velocity vector)

   $v = \sqrt{v_x^2 + v_y^2}$ The horizontal component of velocity is constant so $v_x = 52$ m/s. The vertical component of velocity changes according to $v_y = v_{0y} + a_y t = 30 - 9.8 \times 0.96 = 20.6$ m/s. So $v = \sqrt{(52)^2 + (20.6)^2} = 56$ m/s

   (e) How far would the ball have traveled if the tree had not been in the way?

   $\Delta x = v_x t$ where t is the time it takes the ball to go up and down – ie when vertical displacement is zero. So $\Delta y = v_{0y}t + \frac{1}{2}a_y t^2 \Rightarrow 0 = 30t + \frac{1}{2}(-9.8)t^2 = t(30 - 4.9t)$

   $\Rightarrow t = 30/4.9 = 6$ s $\Rightarrow \Delta x = 52 \times 6 = 320$ m. So the ball would have traveled 320 m.