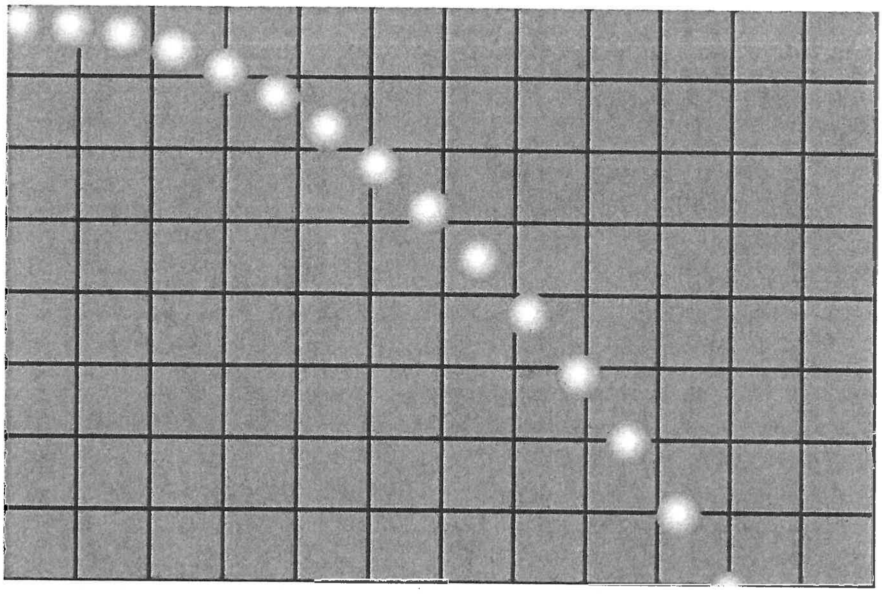
15 Projectile Motion Problems 4

Analysing projectile motion diagrams

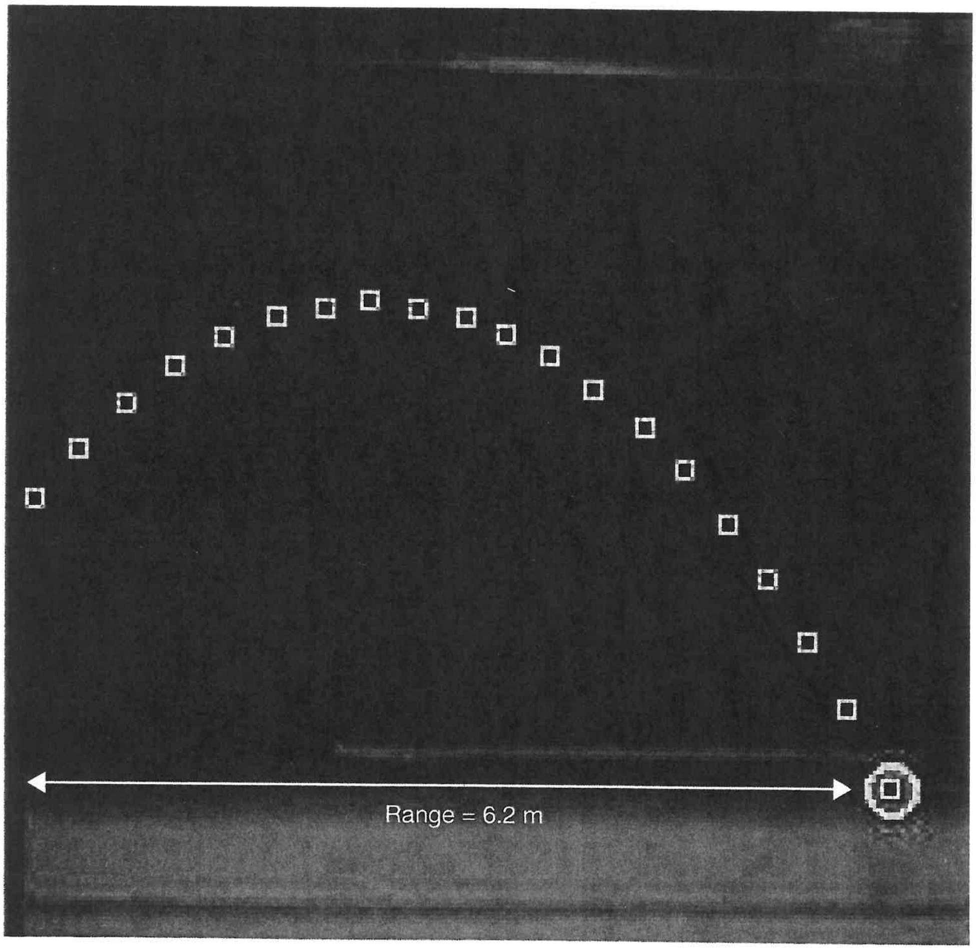
Q1 & 4 only

QUESTIONS

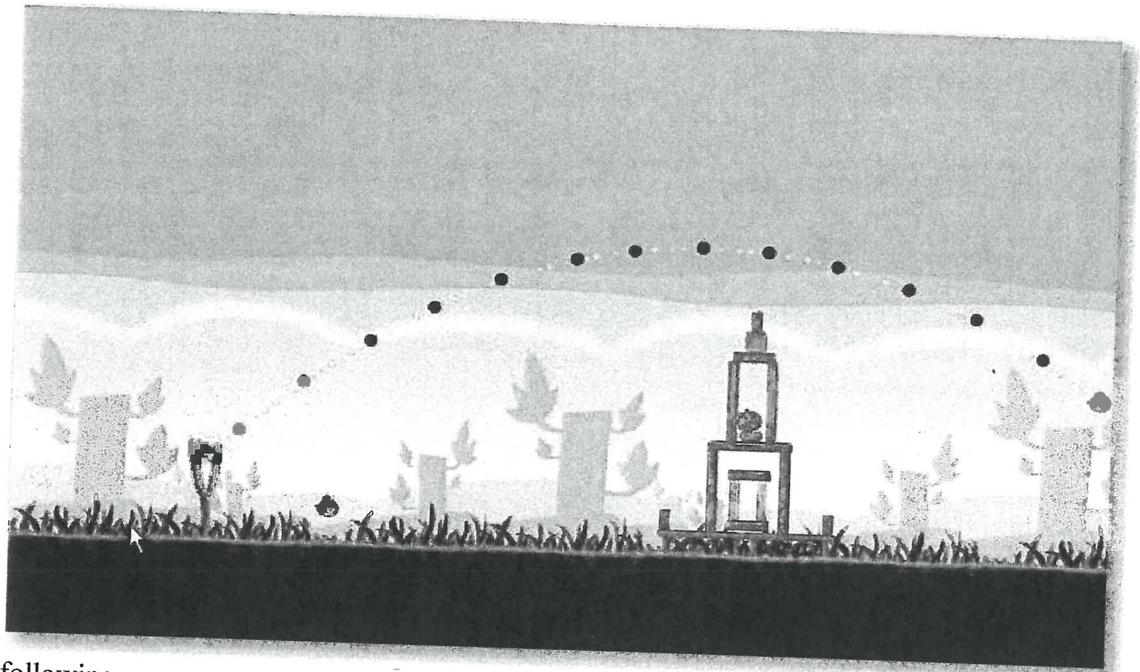
1. Analysis 1. The stroboscopic picture shows a projectile launched horizontally. If each grid square on the background sheet is 10 cm × 10 cm find:
   (a) The vertical displacement of the projectile.
   (b) Its time of flight.
   (c) The time interval between the flashes of the camera taking the picture.
   (d) The frequency of the stroboscope used.
   (e) The initial velocity of the projectile.



2. Analysis 2. The stroboscopic picture shows a projectile launched from a particular height above the floor in a high school gym, and landing on the floor. Find:
   (a) The angle at which the projectile was launched.
   (b) The vertical displacement of the projectile.
   (c) The maximum height above the launch position.
   (d) The initial vertical velocity of the projectile.
   (e) The time for the projectile to rise.
   (f) The time interval between the flashes of the camera.
   (g) The frequency of the stroboscope used to take the picture.
   (h) The horizontal velocity of the projectile.
   (i) The launch velocity of the projectile.



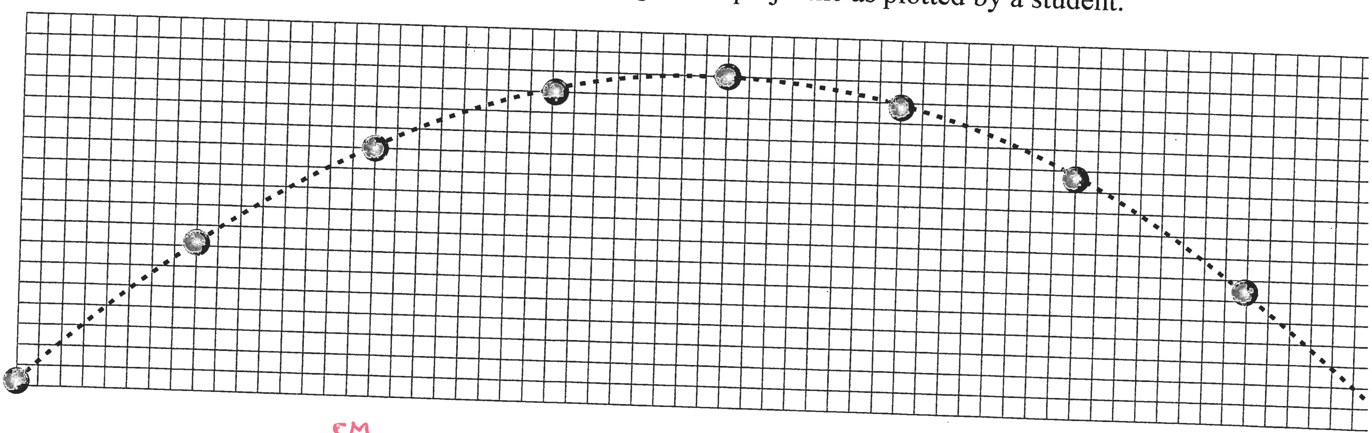
3. Analysis 3. The stroboscopic picture below shows an angry bird missing its target. The target tower is 30 m from the ground to the top of the highest block.



Find the following.

(a) The angle at which the angry bird was launched.
(b) The vertical displacement of the angry bird above its launch position.
(c) The initial vertical velocity of the angry bird.
(d) The initial velocity of the angry bird.
(e) The time for the angry bird to rise.
(f) The time interval between the flashes of the camera.
(g) The frequency of the stroboscope used to take the picture.
(h) The horizontal distance between the angry bird and the tower.
(i) The launch velocity of the angry bird.

4. Analysis 4. The stroboscopic graph shows the flight of a projectile as plotted by a student.



If the graph grid is a 10 ~~mm~~ cm grid, find:

(a) The maximum height of the projectile.
(b) The range of the projectile.
(c) The vertical component of the projectile's velocity.
(d) The time of flight of the projectile.
(e) The time interval between plot points.
(f) The horizontal component of the projectile's velocity.
(g) The initial velocity of the projectile.

15 Projectile Motion Problems 4

1. (a) From the grid, vertical displacement = about 7.8 squares = 0.78 m
   (b) From $\Delta y = u_y t_{fall} + \frac{1}{2}gt^2$
   $0.78 = 0 + 4.9t^2$
   Therefore $t = 0.4$ s (rounded)
   (c) Time between flashes = time/number of time intervals
   Number of time spaces (do not count dots because the first dot is at time zero – count spaces between dots = 14
   Therefore, time between flashes = time/14 = 0.0286 s
   (d) Frequency = (time between flashes = period)$^{-1}$ = $(0.0286)^{-1}$ = 35 Hz
   (e) Initial velocity = u_x (remember $u_y = 0$) = range (count the squares again)/time taken = about 0.98/0.4 = 2.45 m s^{-1}
2. (a) Measuring from the diagram, about 50° to the horizontal
   (b) By measuring the horizontal and vertical displacements as in the diagram, then applying the scale for the horizontal displacement, vertical displacement = about 1.92 m
   (c) Again, by measuring and applying the scale = 1.44 m
   (d) From $(v_y)_{top}{}^2 = u_y + 2g\Delta y$, we get $u_y = 5.3$ m s^{-1}
   (e) From $v_y = u_y + gt_{rise}$, $t_{rise} = 0.54$ s
   (f) From the diagram. It takes 7 time intervals to reach maximum height = 0.54 s
   Therefore each time interval = period of the stroboscope = 0.077 s
   (g) Frequency of stroboscope = (period)$^{-1}$ = $(0.077)^{-1}$ = 12.9 Hz
   (h) Total time of flight = number of time intervals × 0.077 = 19 × 0.077 = 1.463 s
   Therefore, horizontal velocity = range/total time = 6.2/1.463 = 4.24 m s^{-1}
   (i) From $u_x = u \cos \theta$, $4.24 = u \cos 50°$
   Therefore $u = 6.6$ m s^{-1} at 50° to the horizontal
3. (a) Using a protractor and appropriately drawn reference lines on the diagram, $\theta = 35°$
   (b) By scale, knowing the height of the tower = 30 m, height above launch = 27 m
   (c) From $(v_{top})^2 = 0 = u_y{}^2 + 2g\Delta y = u_y{}^2 + 2 \times 9.8 \times 27$
   Therefore, $u_y = 23$ m s^{-1}
   (d) From $u_y = u \sin \theta$, $u = u_y/\sin 35° = 40.01$ m s^{-1}
   (e) From $v_{top} = 0 = u_y + at_{rise}$, $t_{rise} = 23/9.8 = 2.35$ s
   (f) From the diagram, 2.35 s = 8 time intervals
   Therefore the time interval between flashes = period of the stroboscope = 2.35/8 = 0.293 s
   (g) Frequency = 0.293^{-1} = 3.4 Hz
   (h) From a scale calculation = 72 m, or
   From the diagram, time to reach level with the side of the tower horizontally from the launch position = 8 time intervals = 8 × 0.293 = 2.35 s
   And $u_x = u \cos 35° = 40 \times \cos 35° = 32.7$ m s^{-1}
   So, distance between angry bird launch and tower = $u_x \times t = 32.7 \times 2.35 = 77$ m (note scale errors apply)
   (i) Launch velocity = vector sum of u_x and u_y = $\sqrt{(40^2 + 23^2)}$ = 46.1 m s^{-1} at 30° to the horizontal (compared to 40.1 m s^{-1} in part (d) above – note estimating and rounding off errors apply here)
4. (a) By counting vertical grid = 16 squares = 160 cm = 1.6 m
   (b) Horizontal distance between plot points = 8 grid lines × 8 intervals = 64 grid lines = 6.4 m
   (c) From $(v_y)_{top}{}^2 = 0 = u_y{}^2 + 2g\Delta y$
   $u_y{}^2 = 2 \times 9.8 \times 1.6$
   Therefore $u_y = 5.6$ m s^{-1}
   (d) From $(v_y)_{top} = 0 = u_y + gt$
   We get $t_{rise} = 0.57$ s
   Therefore $t_{flight} = 2 \times 0.57 = 1.14$ s
   (e) There are 4 time intervals to rise, therefore 1 time interval = 0.57/4 = 0.143 s
   (f) From range = $u_x \times t_{flight}$
   $6.4 = u_x \times 1.14$
   Therefore $u_x = 5.6$ m s^{-1}
   (g) Since magnitude of $u_x = u_y$, angle of launch = 45°
   Therefore from $u_x = u \cos 45° = 5.6$
   We get $u = 7.92$ m s^{-1} at 45° to the horizontal

16 Circular Motion

1. (a) 1799 N towards centre of the Earth
   (b) 9.0 m s^{-2} towards centre of Earth
2. (a) 1920 N to the centre
   (b) 0.96 m s^{-2} to centre
3. (a) 22.6 m s^{-1}
   (b) 426.4 m s^{-2} to centre
   (c) 640 N to centre
4. P = 5.27 N to centre
   Q = 10.5 N to centre
   R = 15.8 N to centre
5. (a) 1 : 2 : 3
   (b) 1 : 2 : 3
   (c) 1 : 2 : 3