Question 1: (10 points)

For a Correct drawing of the situation - 3 Points

For showing correct vectors for velocity, with units . 1 Point

For showing component vectors of each velocity 1 Point

For indicating θ as the direction in which the dart Gun fires 1 Point

For correct Calculations - 6 Ponts

For any indication (stated or implied) that x-component velocities must be equal 2 Points

For stating: $\sin(\theta) = \frac{7\,\frac{m}{s}\cdot\sin(45)}{25\,\frac{m}{s}}$ or $\theta = \sin^{-1}\left(\frac{7\cdot\frac{m}{s}\cdot\sin(45)}{25\cdot\frac{m}{s}}\right)$ 2 Points

For an answer consistent with previous work 1 Point

For the correct numerical answer 1 Point

For correct units throughout the problem 1 Point

Question 2: (10 points)

Part A: 1 Point

For any indication of a parabola in the sketch of the graph 1 Point

Part B: 2 Points

For chosing a transformation that will linearize data (either t^2 or $\sqrt{h}$ 1 Point

For calculation of values consistent with the transformation chosen. 1 Point

Part C: 3 Points

For Labels and Units on both axes 1 Point

For a Graph consistent with calculated values 1 Point

For a Linear Graph 1 Point

Part D: 3 Points

For correctly calculating slope (linear regression or slope formula) 1 Point

For stating (or implying) that $m = \frac{g_m}{2}$ 1 Point

For a numerical answer consistent with previous work 1 Point

Throughout: For correct use of units throughout the problem 1 Point

Question 3: (10 points)

Part A: 4 Points

For showing a Positive Velocity of magnitude 1.5 m/s between 0s and 8 s, inclusive	1 Point
For showing zero velocity between 10s and 18s inclusive	1 Point
For showning a negative velocity of magnitude 2.4 m/s between 20s and 25s inclusive	1 Point
For showing two non-vertical transition regions for $8s < t < 10s$ and $18s < t < 20s$	1 Point

Part B: 5 Points

For a Definition or equation for average acceleration ie: $a_{avg} = \frac{\Delta v}{\Delta t}$ or $v_f = v_i + a \cdot t$	1 Point
For the correct substitution of numbers from part A	1 Point
For an answer consistent with previous work	1 Point
For the correct magnitude for the numerical answer (0.75)	1 Point
For correct units and sign: $a_{avg} = -0.75 \frac{m}{s^2}$	1 Point

Part C: 1 Point

For a correctly drawn vector, with or without a label, pointing downward.	1 Point

Question 4: (10 points) For this solution x is to the right, y is up in the second picture and z-is elevation. However, any coordinate system that obeys the right-hand rule is acceptable.

Part A: (3 Points)

For stating $\Delta d_x = \frac{1}{2}\cdot a_x\cdot\Delta t^2 + v_{ix}\cdot\Delta t$ or $v_x = \frac{\Delta d_x}{\Delta t}$ 1 Point

For stating (or implying) $\Delta t = \frac{\Delta d_x}{v_x}$ 1 Point

For a correct expression for time: $\Delta t = \frac{L}{2\cdot v_i\cdot\cos(\theta)}$ or equivalant. 1 Point

Part B: (3 Points)

For stating $\Delta d_z = \frac{1}{2}\cdot a_z\cdot\Delta t^2 + v_{iz}\cdot\Delta t$ or $v_z = \frac{\Delta d_z}{\Delta t}$ 1 Point

For stating (or implying) $\Delta t = \sqrt{\frac{2\Delta d_x}{a_z}}$ 1 Point

For a correct expression for time: $\Delta t = \sqrt{\frac{2\cdot l}{g}}$ 1 Point

Part C: (3 Points)

For stating (or implying) that the total time of flight is the sum of the times in parts A and B 1 Point

For a correct displacement vector of the following form (or equivalent) 2 Points

$$\vec{d} = \left(\frac{L}{2} + v_i\cdot\cos(\theta)\cdot\sqrt{\frac{2\cdot l}{g}}\right)\cdot\vec{i} + \left(\frac{L}{2}\cdot\tan(\theta) + v_i\cdot\sin(\theta)\cdot\sqrt{\frac{2\cdot l}{g}}\right)\vec{j} - L\cdot\vec{k}$$

Throughout: (1 Point)

For defining a coordinate system that obeys the right-hand rule 1 Point

Question 4: (10 points)

Part A: (3 Points)

For a correct diagram of the situation, including labels — 1 Point

For correctly stating $a = g \cdot \sin(25)$ — 1 Point

For an answer cosistent with previous work ($a = g \cdot \sin(25 \cdot deg) = 4.144 \frac{m}{s^2}$) — 1 Point

Part B: (3 Points)

For correctly stating a kinematic equation(s) to find final velocity — 1 Point

ie: $v_f^2 = v_i^2 + 2 \cdot a \cdot \Delta d$ or $\Delta d = \frac{1}{2} \cdot a \cdot \Delta t^2 + v_i \cdot \Delta t$ and $a = \frac{v_f - v_i}{\Delta t}$

For substitution of quantities correctly

ie: $v_f = \sqrt{0^2 + 2 \cdot \left(4.144 \cdot \frac{m}{s^2} \right) \cdot 3 \cdot m}$ — 1 Point

For an answer consistent with previous work , — 1 Point

ie: $v_f = 4.986 \frac{m}{s}$

Part C: (3 Points)

For correctly using the z-direction to calculate the time of fall — 1 Point

ie: $10 \cdot m = \frac{1}{2} \cdot (g) \cdot t^2 + \left(v_f \right) \cdot \sin(25 \cdot deg) \cdot t$ --> $t = 1.229 \cdot s$

For an answer cosistent with previous work — 1 Point

ie: $\vec{d} = 5.554 m \cdot \vec{i} - 10 \cdot m \cdot \vec{k}$

Part D: (1 Point)

Correctly answering "yes" with mathematical justification. — 1 point

Throughout: (1 Point)

For correct use of units — 1 Point