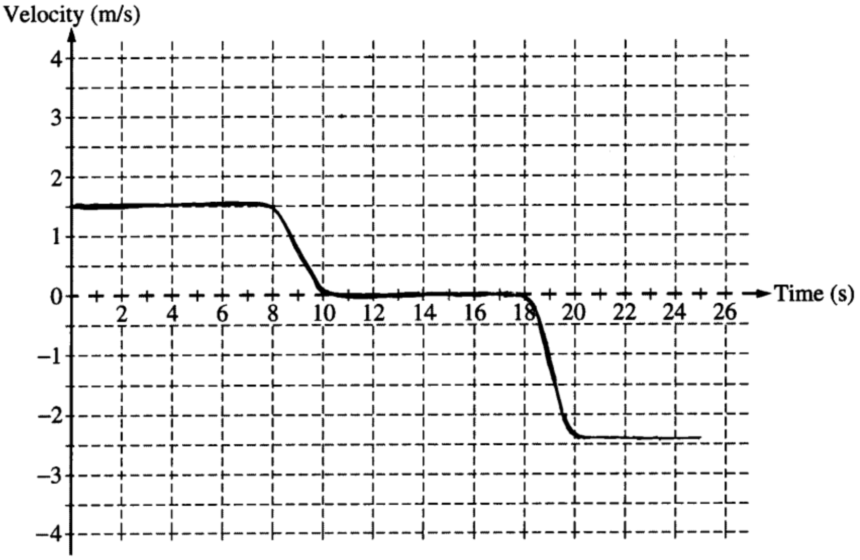
Ans. To Homework for Chapter 1

1. **10 points total** **Distribution of points**

(a) 4 points



The velocities can be found from the slope of the position graph.

For showing a positive velocity of magnitude 1.5 m/s (i.e., 12 m/8 s) between 0 s and 8 s inclusive — 1 point

For showing zero velocity between 10 s and 18 s inclusive — 1 point

For showing a negative velocity of magnitude 2.4 m/s (i.e., 12 m/5 s) between 20 s and 25 s inclusive — 1 point

For showing two nonvertical transition regions; between $t = 8$ s and 10 s and between $t = 18$ s and 20 s — 1 point

(b)

(i) 3 points

For a definition or equation for average acceleration — 1 point

$a_{avg} = \Delta v/\Delta t$ OR $v = v_0 + at$

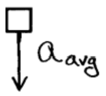
For the correct substitution from part (a) — 1 point

$a_{avg} = (0 - 1.5\ \text{m/s})/2\ \text{s}$

For the correct answer including units and sign — 1 point

$a_{avg} = -0.75\ \text{m/s}^2$

(ii) 1 point



For a correctly drawn vector, with or without a label — 1 point

(c) 2 points

The acceleration is zero, so the normal force (apparent weight) is equal to the gravitational force.

For a correct relationship leading to a calculation of apparent weight — 1 point

$N = W = mg$ OR $N - W = ma$

$W_{app} = (70\ \text{kg})(9.8\ \text{m/s}^2)$

For the correct answer with units — 1 point

$W_{app} = 686\ \text{N}$ (or 700 N using $g = 10\ \text{m/s}^2$)

2.

15 points total **Distribution of points**

Two general approaches were used by most of the students.

Approach A: Spread the students out every 10 meters or so. The students each start their stopwatches as the runner starts and measure the time for the runner to reach their positions.

Analysis variant 1: Make a position vs. time graph. Fit the parabolic and linear parts of the graph and establish the position and time at which the parabola makes the transition to the straight line.

Analysis variant 2: Use the position and time measurements to determine a series of average velocities ($\upsilon_{avg} = \Delta x/\Delta t$) for the intervals. Graph these velocities vs. time to obtain a horizontal line and a line with positive slope. Establish the position and time at which the sloped and horizontal lines intersect.

Analysis variant 3: Use the position and time measurements to determine a series of average accelerations $\left(\Delta x = \upsilon_0 t - at^2/2\right)$. Graph these accelerations vs. time to obtain two horizontal lines, one with a nonzero value and one at zero acceleration. Establish the position and time at which the acceleration drops to zero.

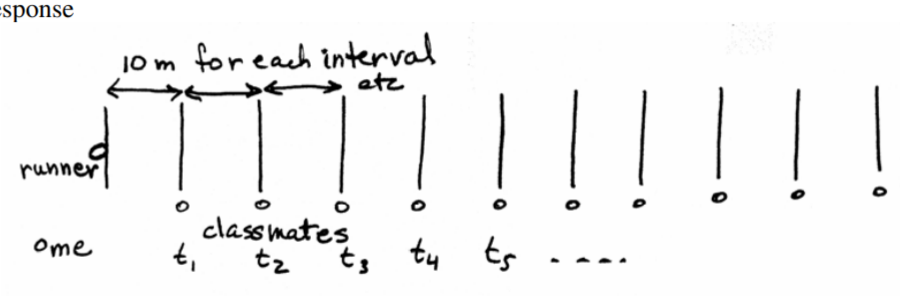
Approach B: Concentrate the students at intervals at the end of the run, in order to get a very precise value of the constant speed υ_f, or at the beginning in order to get a precise value for a_u. The total distance D is given by $D = \left(a_u t_u^2/2\right) + \upsilon_f\left(T - t_u\right)$, where T is the total measured run time. In addition, $\upsilon_f = a_u t_u$. These equations can be solved for a_u and t_u (if υ_f is measured directly) or υ_f and t_u (if a_u is measured directly). Students may have also defined and used distances, speeds, and times for the accelerated and constant-speed portions of the run in deriving these relationships.

(a) 2 points

For checking off a distance-measuring device and describing its use in part (b)	1 point
For checking off a stopwatch and describing its use in part (b)	1 point

(b) 6 points

Sample response



Use the tape measure and chalk to mark off the 100 meters in 10 meter lengths. Set a classmate with a stopwatch at marks as shown. Use the starter's pistol to signal the runner to run and the classmates to start their stopwatches. Each person turns off the stopwatch when the runner reaches his or her mark. You then have measurements of the time to reach each increment of 10 meters.

For taking distance measurements for 8 to 11 distinct fixed positions per run	1 point
For measuring time for the same 8 to 11 distinct fixed positions, consistent with the description of the experimental setup	1 point
For an experimental technique consistent with being able to determine the requested quantities	2 points
For a diagram of the experimental setup with clear labels and consistent with the technique described (awarded even if the technique is wrong)	1 point
For a technique that allows data for all positions to be taken in a single run	1 point

(c) 7 points

Approach A

For a clear and detailed explanation of the data analysis process	3 points

Note: This part of the solution was graded holistically and students could earn between 0 and 3 points depending on the clarity and completeness of their explanation.

For equations or clear prose and use of the data to identify the two distinct regions of motion (constant acceleration and constant velocity)	1 point
For clearly and correctly identifying t_u	1 point
For clearly and correctly identifying a_u	1 point
For having the final answers correct and no incorrect statements or calculations among the correct ones	1 point

Approach B

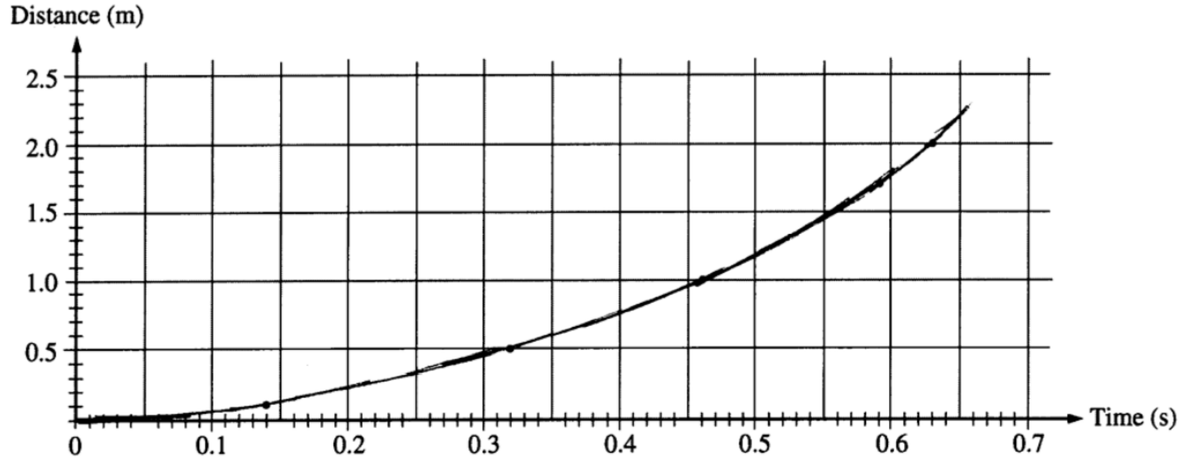
Students needed to clearly indicate which variable was used (acceleration or final velocity) by including the following.

For a description or diagram that clearly defines all the variables being used	1 point
For a description or diagram showing how the needed variable (acceleration or final velocity) will be determined	1 point
For a successful transformation of the above description into equation form	2 points
For correctly solving the equations obtained	1 point
For work that would determine a correct value of a_u	1 point
For work that would determine a correct value of t_u	1 point

3.

15 points total **Distribution of points**

(a) 3 points



For a line that is close to all of the data points — 1 point
For a smooth curve — 1 point
For a nonlinear curve that is concave up — 1 point

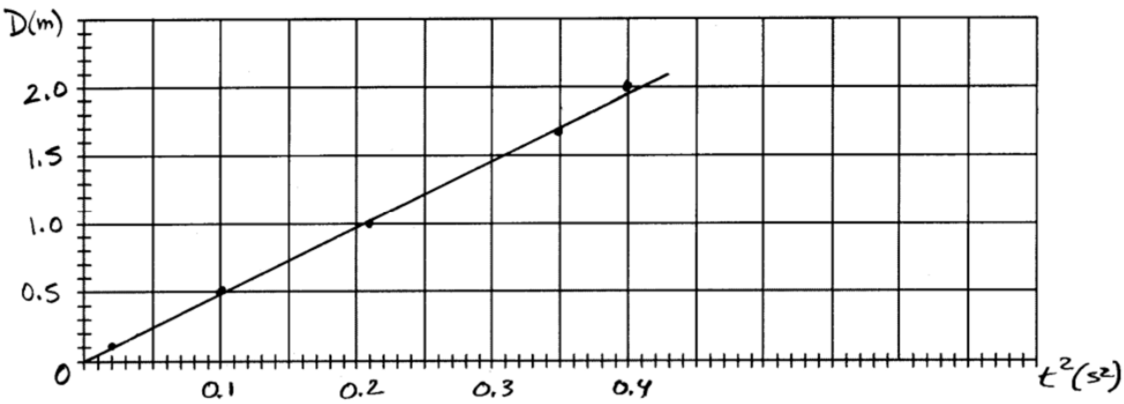
(b) 2 points

Distance and time are related by the equation $D = \frac{1}{2}gt^2$

For a correct pair of quantities, expressed in terms of D and t, that will yield a straight line — 2 points
Examples: D and t^2 OR $\sqrt{D}$ and t

(c) 4 points

For correctly scaling and labeling the horizontal axis for a quantity cited in part (b) — 1 point
For correctly scaling and labeling the vertical axis for a quantity cited in part (b) — 1 point
For a reasonably correct plotting of the data — 1 point
For a reasonably straight line through the data points — 1 point
Example graphing D versus t^2:



Note: If part (b) contains incorrect variables and they are correctly graphed in part (c), a maximum of 2 points could be earned.

(d) 3 points

For determining the slope of the line drawn on the graph — 1 point

Using the example graph above, slope $= \dfrac{(2.0 - 0.1)\ \text{m}}{(0.41 - 0.02)\ \text{s}^2} = \dfrac{1.9\ \text{m}}{0.39\ \text{s}^2} = 4.9\ \text{m/s}^2$

For an expression relating g to the slope — 1 point

In the example given, $D = \frac{1}{2}gt^2$, so $\frac{1}{2}g =$ slope

For a value of g in the range $9\text{-}11\ \text{m/s}^2$ — 1 point

In the example given, $g = 2\left(4.9\ \text{m/s}^2\right) = 9.8\ \text{m/s}^2$

(e) 3 points

For a good, specific improvement — 2 points
For an explanation of how this would improve accuracy — 1 point
Example: Do several trials for each value of D and take averages. This reduces personal and random error.
One point could be earned for less appropriate or less specific answers, for example "do trials in a vacuum" or "cut down on air resistance."