AP Physics Free Response Practice – Kinematics

1982B1. The first meters of a 100-meter dash are covered in 2 seconds by a sprinter who starts from rest and accelerates with a constant acceleration. The remaining 90 meters are run with the same velocity the sprinter had after 2 seconds.
a.   Determine the sprinter's constant acceleration during the first 2 seconds.
b.   Determine the sprinters velocity after 2 seconds have elapsed.
c.   Determine the total time needed to run the full 100 meters.
d.   On the axes provided below, draw the displacement vs time curve for the sprinter.
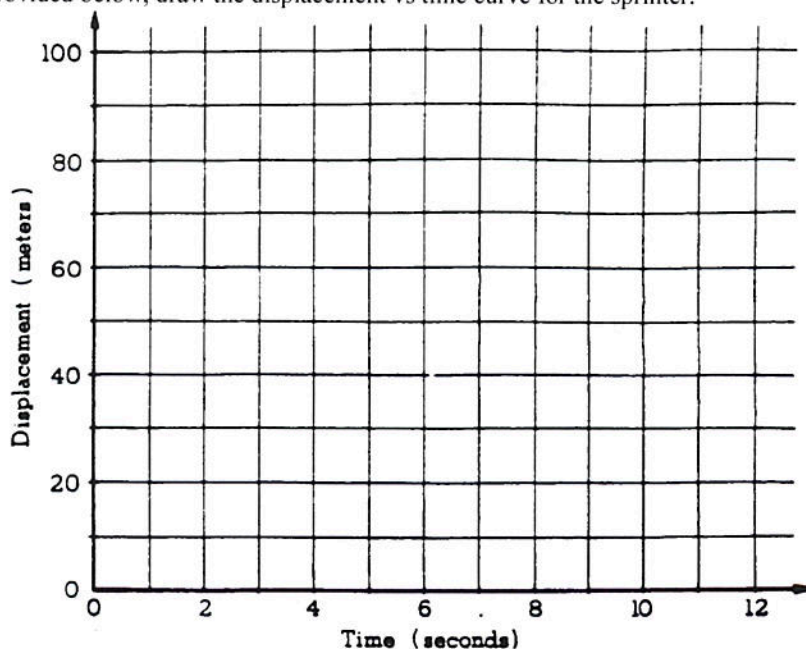
2006B2. A world-class runner can complete a 100 m dash in about 10 s. Past studies have shown that runners in such a race accelerate uniformly for a time t and then run at constant speed for the remainder of the race. A world-class runner is visiting your physics class. You are to develop a procedure that will allow you to determine the uniform acceleration a and an approximate value of t for the runner in a 100 m dash. By necessity your experiment will be done on a straight track and include your whole class of eleven students.

(a) By checking the line next to each appropriate item in the list below, select the equipment, other than the runner and the track, that your class will need to do the experiment.

_____Stopwatches   _____Tape measures   _____ Rulers   _____ Masking tape

_____Metersticks   _____ Starter's pistol   _____ String   _____ Chalk

(b) Outline the procedure that you would use to determine a and t, including a labeled diagram of the experimental setup. Use symbols to identify carefully what measurements you would make and include in your procedure how you would use each piece of the equipment you checked in part (a).

(c) Outline the process of data analysis, including how you will identify the portion of the race that has uniform acceleration, and how you would calculate the uniform acceleration.
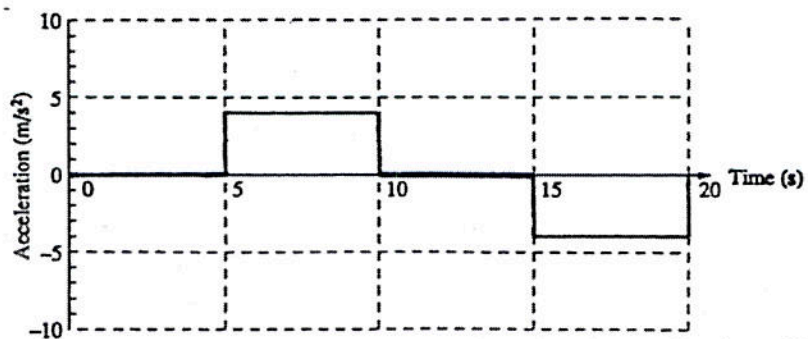
1993B1 (modified) A student stands in an elevator and records his acceleration as a function of time. The data are shown in the graph above. At time t = 0, the elevator is at displacement x = 0 with velocity v = 0. Assume that the positive directions for displacement, velocity, and acceleration are upward.

a. Determine the velocity v of the elevator at the end of each 5-second interval.
    i. Indicate your results by completing the following table.

Time Interval (s)	0–5	5–10	10–15	15–20
v (m/s)	____	____	____	____
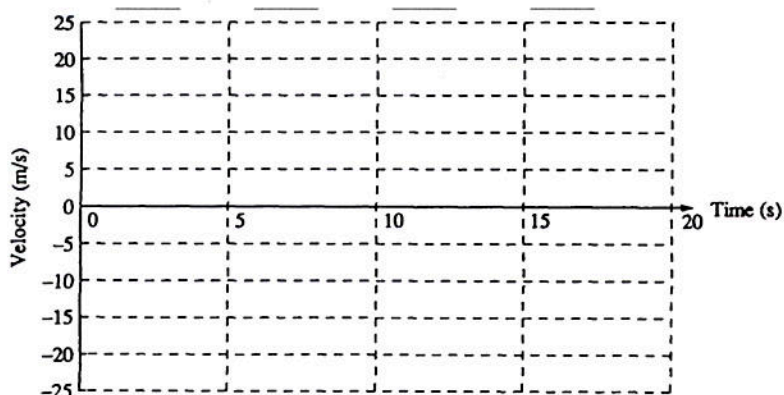
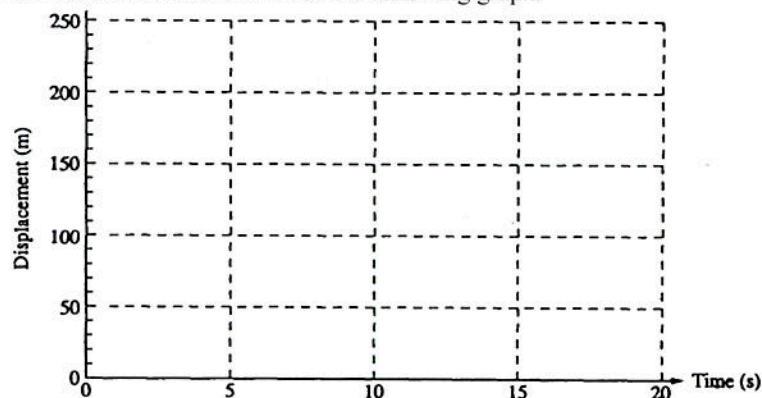   ii. Plot the velocity as a function of time on the following graph.

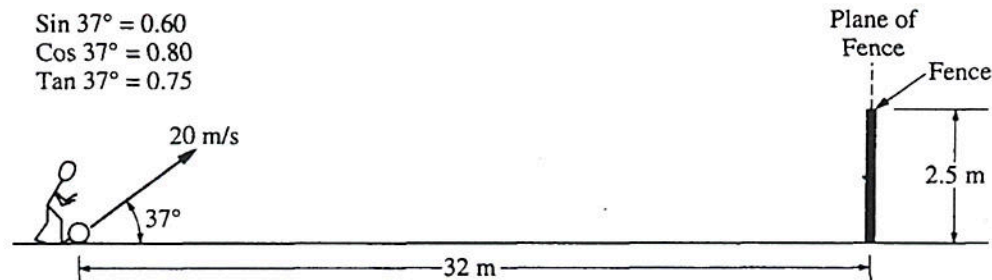b. Determine the displacement x of the elevator above the starting point at the end of each 5-second interval.
    i. Indicate your results by completing the following table.

Time Interval (s)	0–5	5–10	10–15	15–20
x (m)	____	____	____	____

    ii. Plot the displacement as a function of time on the following graph.

30

Sin 37° = 0.60
Cos 37° = 0.80
Tan 37° = 0.75

20 m/s

37°

Plane of
Fence

Fence

2.5 m

32 m

Note: Diagram not drawn to scale.

1994B1 (modified) A ball of mass 0.5 kilogram, initially at rest, is kicked directly toward a fence from a point 32 meters away, as shown above. The velocity of the ball as it leaves the kicker's foot is 20 meters per second at an angle of 37° above the horizontal. The top of the fence is 2.5 meters high. The ball hits nothing while in flight and air resistance is negligible.

a. Determine the time it takes for the ball to reach the plane of the fence.
b. Will the ball hit the fence? If so, how far below the top of the fence will it hit? If not, how far above the top of the fence will it pass?
c. On the axes below, sketch the horizontal and vertical components of the velocity of the ball as functions of time until the ball reaches the plane of the fence.
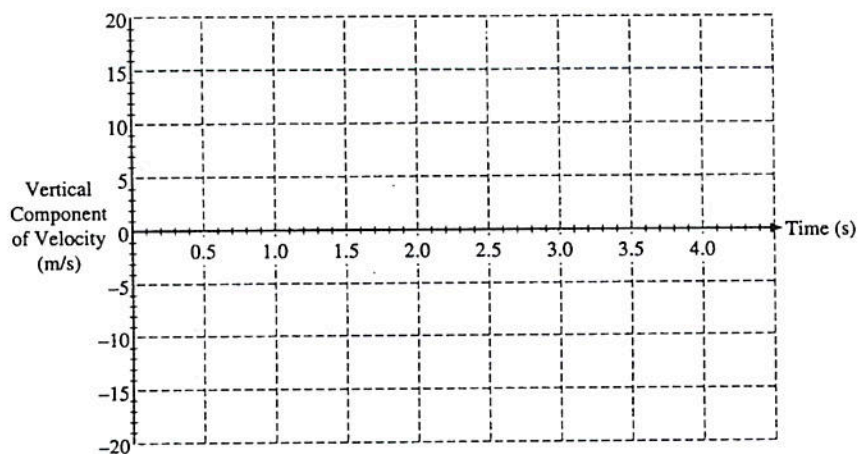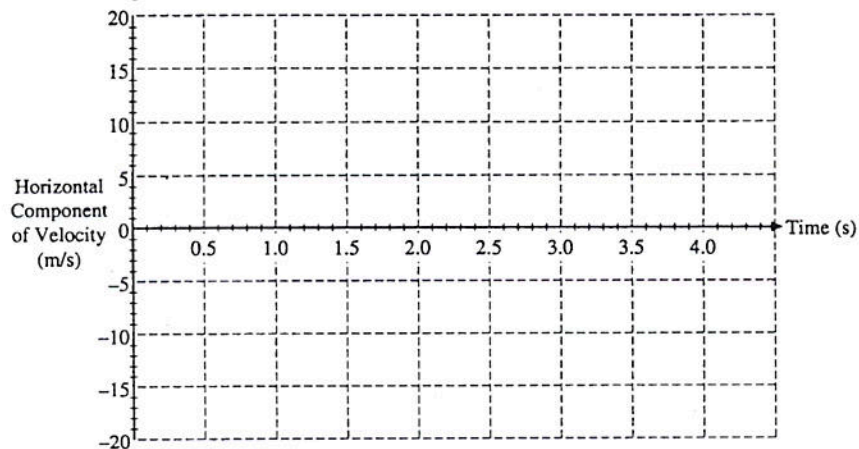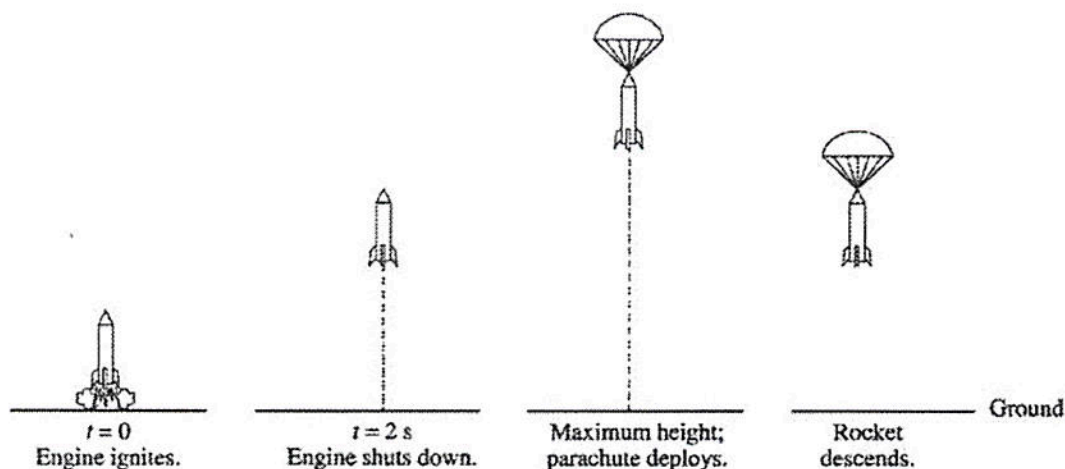
2000B1 (modified) A 0.50 kg cart moves on a straight horizontal track. The graph of velocity v versus time t for the cart is given below.
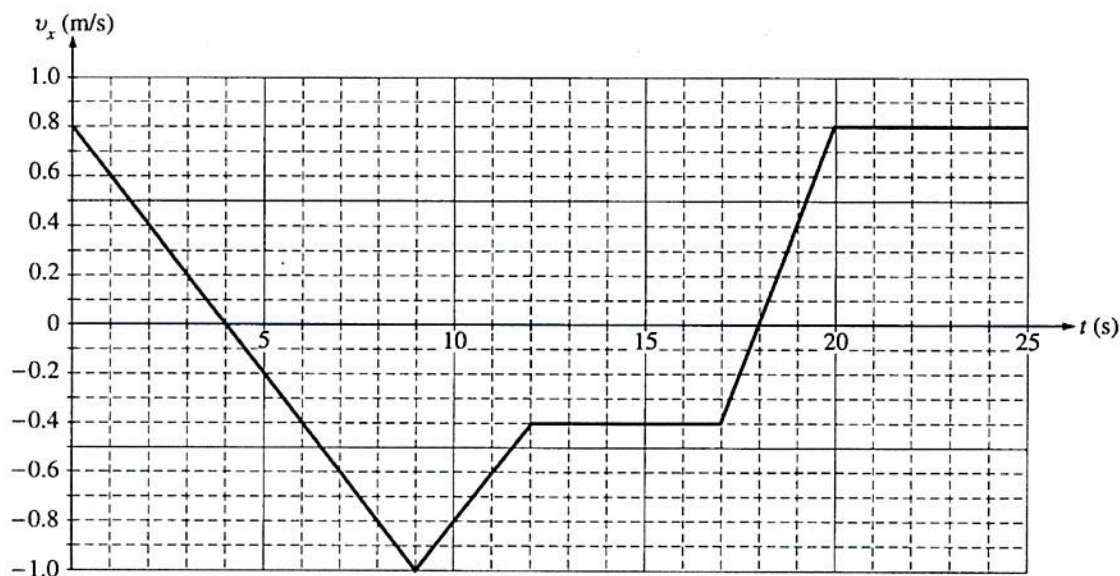
a. Indicate every time t for which the cart is at rest.
b. Indicate every time interval for which the speed (magnitude of velocity) of the cart is increasing.
c. Determine the horizontal position x of the cart at t = 9.0 s if the cart is located at x = 2.0 m at t = 0.
d. On the axes below, sketch the acceleration a versus time t graph for the motion of the cart from t = 0 to t = 25 s.
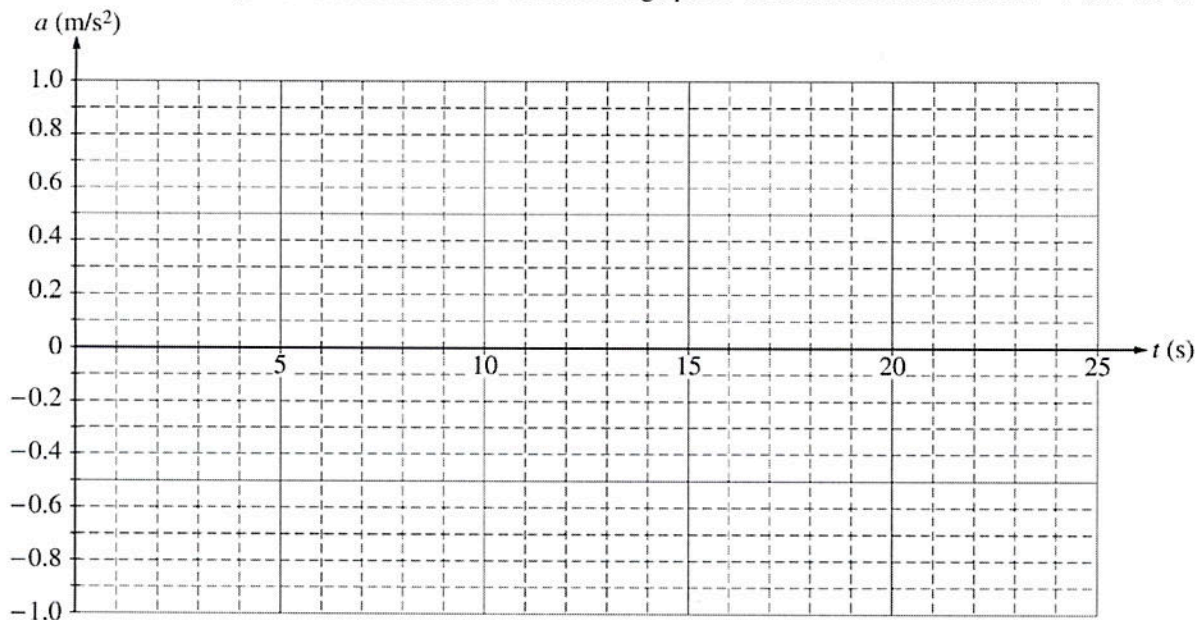

e. From t = 25 s until the cart reaches the end of the track, the cart continues with constant horizontal velocity. The cart leaves the end of the track and hits the floor, which is 0.40 m below the track. Neglecting air resistance, determine each of the following:
   i. The time from when the cart leaves the track until it first hits the floor
   ii. The horizontal distance from the end of the track to the point at which the cart first hits the floor

Ground

| $t = 0$ | $t = 2$ s | Maximum height; | Rocket |
| Engine ignites. | Engine shuts down. | parachute deploys. | descends. |

Note: Figures not drawn to scale.
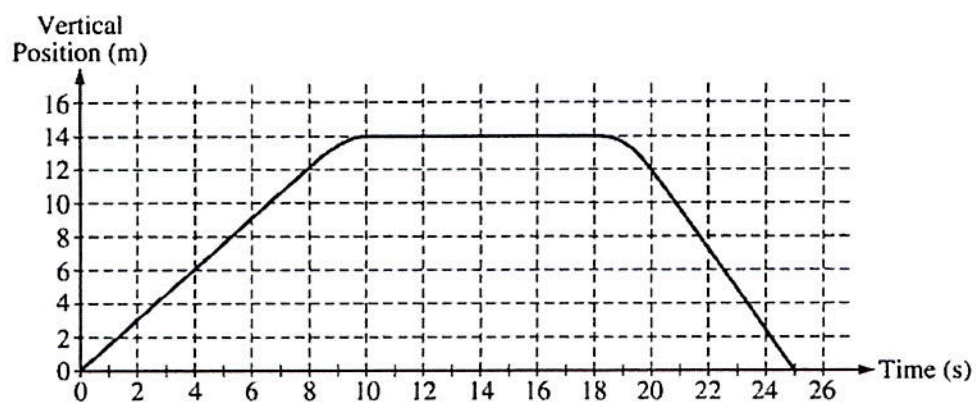
2002B1 (modified) A model rocket is launched vertically with an engine that is ignited at time t = 0, as shown above. The engine provides an upward acceleration of 30 m/s^2 for 2.0 s. Upon reaching its maximum height, the rocket deploys a parachute, and then descends vertically to the ground.

a. Determine the speed of the rocket after the 2 s firing of the engine.
b. What maximum height will the rocket reach?
c. At what time after t = 0 will the maximum height be reached?
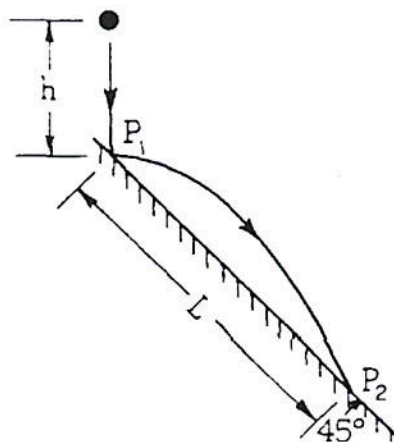

*1979M1 (modified) A ball of mass m is released from rest at a distance h above a frictionless plane inclined at an angle of 45° to the horizontal as shown above. The ball bounces horizontally off the plane at point P_1 with the same speed with which it struck the plane and strikes the plane again at point P_2. In terms of g and h determine each of the following quantities:

a. The speed of the ball just after it first bounces off the plane at P_1.
b. The time the ball is in flight between points P_1 and P_2.
c. The distance L along the plane from P_1 to P_2.
d. The speed of the ball just before it strikes the plane at P_2.

Vertical
Position (m)

```
16
14
12
10
8
6
4
2
0
   0  2  4  6  8  10 12 14 16 18 20 22 24 26   Time (s)
```

2005B1 (modified) The vertical position of an elevator as a function of time is shown above.

a. On the grid below, graph the velocity of the elevator as a function of time.

Velocity (m/s)

```
4
3
2
1
0
      2  4  6  8  10 12 14 16 18 20 22 24 26    Time (s)
-1
-2
-3
-4
```
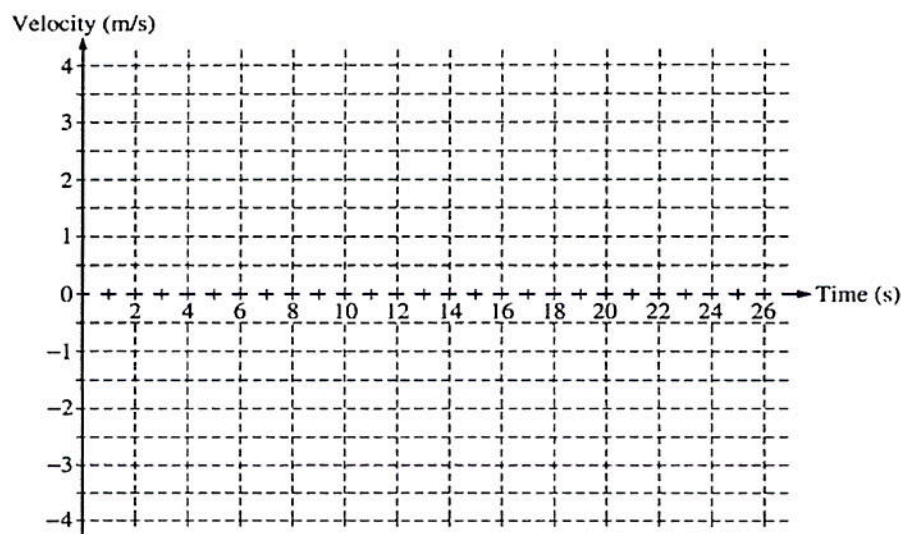
b. i.   Calculate the average acceleration for the time period t = 8 s to t = 10 s.
    ii. On the box below that represents the elevator, draw a vector to represent the direction of this average acceleration.

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Steel
Sphere

Recording
Plate

D
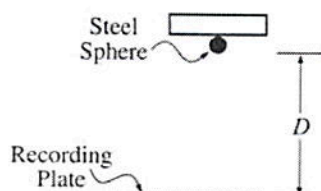
2006Bb1. A student wishing to determine experimentally the acceleration g due to gravity has an apparatus that holds a small steel sphere above a recording plate, as shown above. When the sphere is released, a timer automatically begins recording the time of fall. The timer automatically stops when the sphere strikes the recording plate.

The student measures the time of fall for different values of the distance D shown above and records the data in the table below. These data points are also plotted on the graph.

Distance of Fall (m)	0.10	0.50	1.00	1.70	2.00
Time of Fall (s)	0.14	0.32	0.46	0.59	0.63
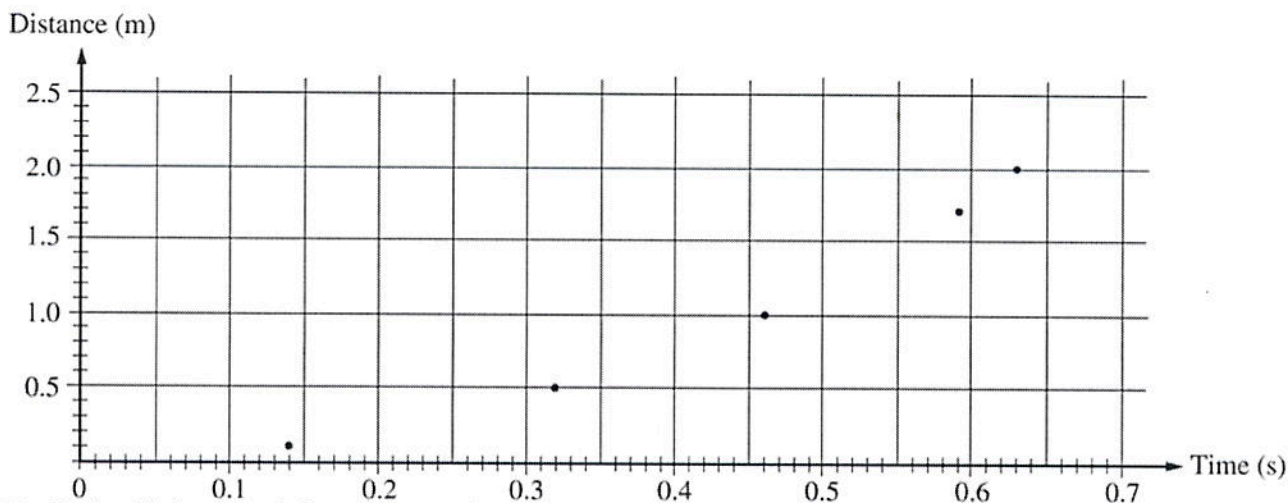
Distance (m)

(a) On the grid above, sketch the smooth curve that best represents the student's data

The student can use these data for distance D and time t to produce a second graph from which the acceleration g due to gravity can be determined.

(b) If only the variables D and t are used, what quantities should the student graph in order to produce a linear relationship between the two quantities?

(c) On the grid below, plot the data points for the quantities you have identified in part (b), and sketch the best straight-line fit to the points. Label your axes and show the scale that you have chosen for the graph.
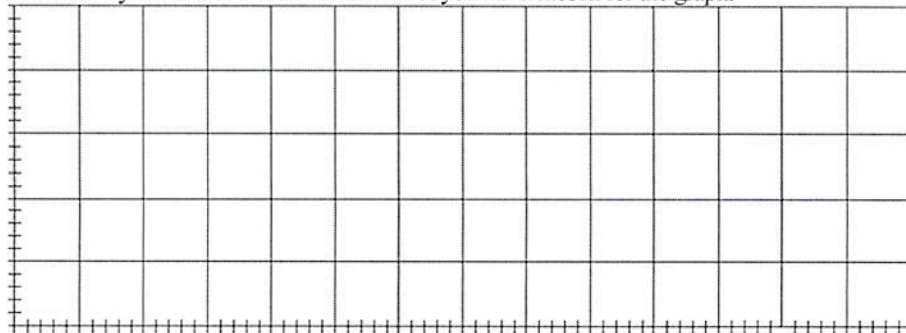
(d) Using the slope of your graph in part (c), calculate the acceleration g due to gravity in this experiment.

(e) State one way in which the student could improve the accuracy of the results if the experiment were to be performed again. Explain why this would improve the accuracy.