AP® PHYSICS B
2006 SCORING GUIDELINES (Form B)

General Notes About 2006 AP Physics Scoring Guidelines

1. The solutions contain the most common method of solving the free-response questions and the allocation of points for this solution. Some also contain a common alternate solution. Other methods of solution also receive appropriate credit for correct work.

2. Generally, double penalty for errors is avoided. For example, if an incorrect answer to part (a) is correctly substituted into an otherwise correct solution to part (b), full credit will usually be awarded. One exception to this may be cases when the numerical answer to a later part should be easily recognized as wrong, e.g., a speed faster than the speed of light in vacuum.

3. Implicit statements of concepts normally receive credit. For example, if use of the equation expressing a particular concept is worth 1 point, and a student's solution contains the application of that equation to the problem but the student does not write the basic equation, the point is still awarded. However, when students are asked to derive an expression, it is normally expected that they will begin by writing one or more fundamental equations, such as those given on the AP Physics exam equation sheet. See pages 21–22 of the *AP Physics Course Description* for a description of the use of such terms as "derive" and "calculate" on the exams, and what is expected for each.

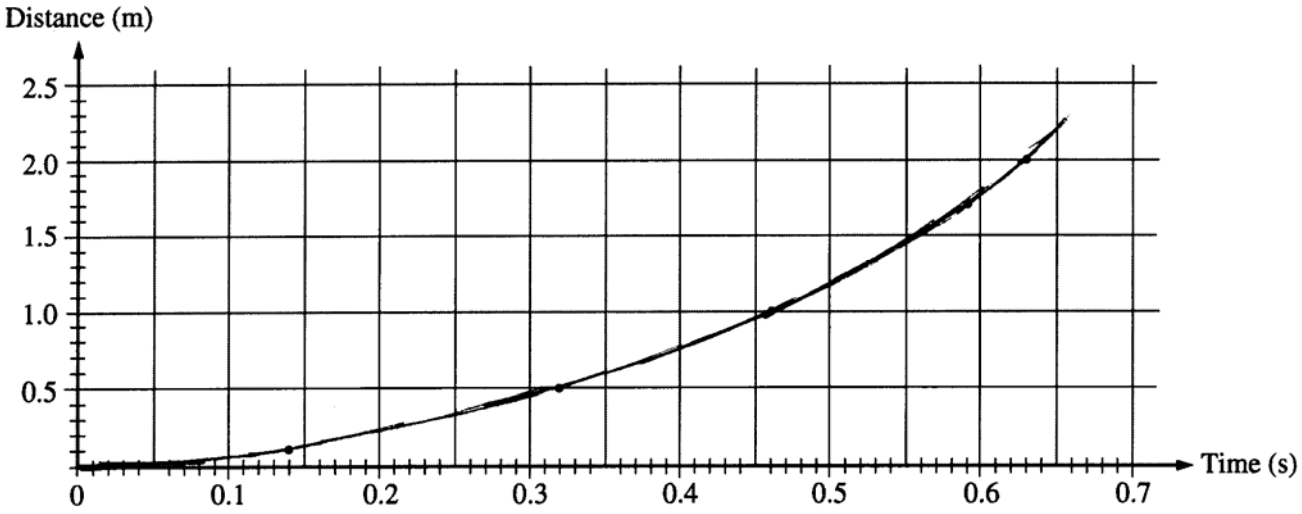
4. The scoring guidelines typically show numerical results using the value $g = 9.8 \text{ m/s}^2$, but use of 10 m/s^2 is of course also acceptable. Solutions usually show numerical answers using both values when they are significantly different.

5. Strict rules regarding significant digits are usually not applied to numerical answers. However, in some cases answers containing too many digits may be penalized. In general, two to four significant digits are acceptable. Numerical answers that differ from the published answer due to differences in rounding throughout the question typically receive full credit. Exceptions to these guidelines usually occur when rounding makes a difference in obtaining a reasonable answer. For example, suppose a solution requires subtracting two numbers that should have five significant figures and that differ starting with the fourth digit (e.g., 20.295 and 20.278). Rounding to three digits will lose the accuracy required to determine the difference in the numbers, and some credit may be lost.

Question 1

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

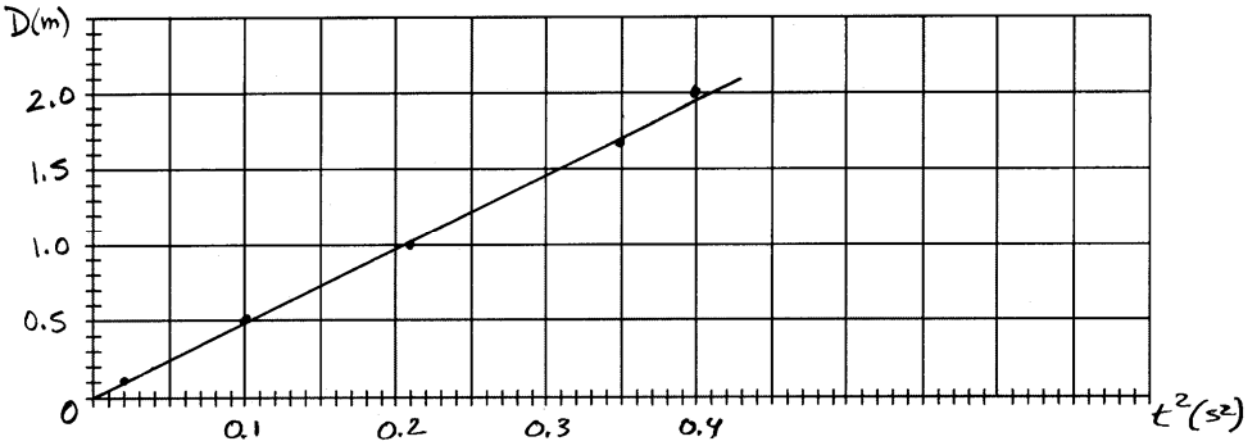
Question 1 (continued)

Distribution of points

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

For an expression relating g to the slope — 1 point

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

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

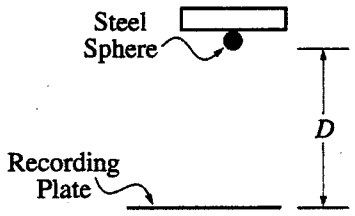
In the example given, $g = 2\left(4.9\ \text{m/s}^2\right) = 9.8\ \text{m/s}^2$

(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."

PHYSICS B
SECTION II
Time—90 minutes
6 Questions

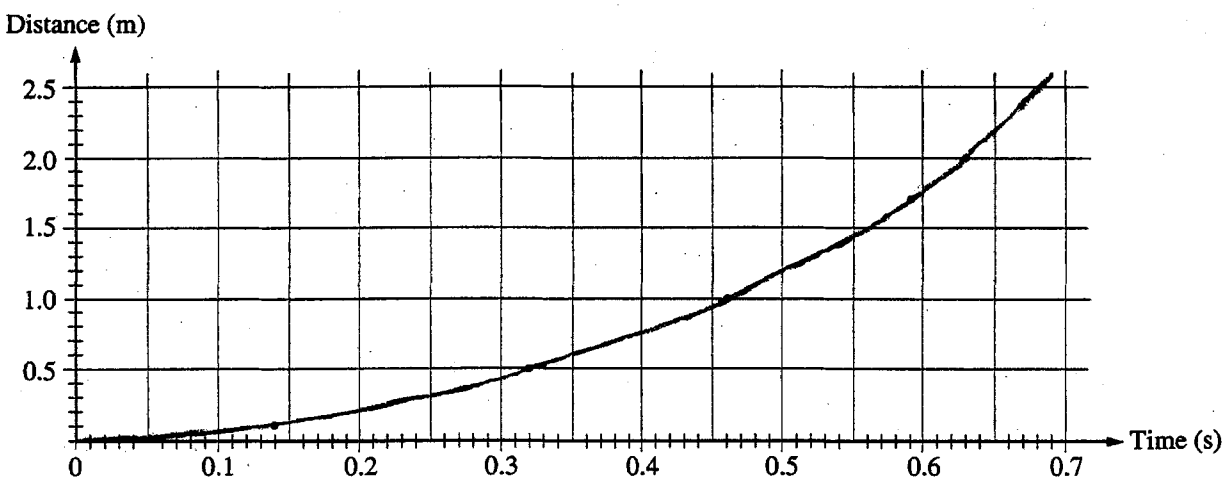
Directions: Answer all six questions, which are weighted according to the points indicated. The suggested time is about 17 minutes for answering each of questions 1-4, and about 11 minutes for answering each of questions 5-6. The parts within a question may not have equal weight. Show all your work in this booklet in the spaces provided after each part, NOT in the lavender insert.



1. (15 points)

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



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

GO ON TO THE NEXT PAGE.

B1A ✓

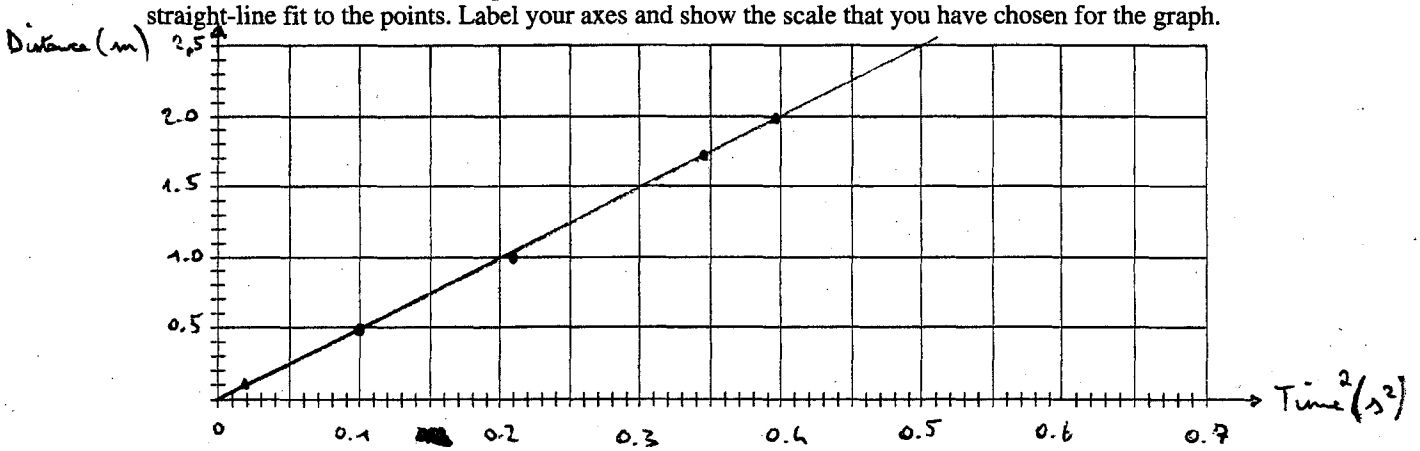
The student can use these data for distance D and time t to produce a second graph from which the acceleration g due to gravity can be determined.

(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?

* $D = D_0 + v_0 t + \frac{1}{2} a t^2 \Rightarrow D = \frac{1}{2} g t^2 \Rightarrow D$ is proportional to t^2, not to t.

Therefore, the student should use the quantities D and t^2.

(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.

$D = \frac{1}{2} g t^2 \Rightarrow \frac{1}{2} g$ is the slope. The slope equals $\frac{D_2 - D_1}{t_2^2 - t_1^2} = \frac{1}{2} g$

$\Rightarrow \frac{2.0\,m - 0.5\,m}{0.4\,s^2 - 0.1\,s^2} = \frac{1}{2} g$. Solving for g yields: $g = 10\,m/s^2$

(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.

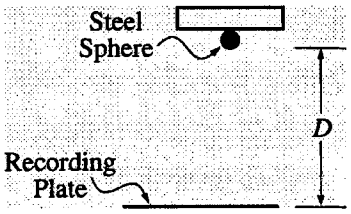
The student could increase the distance D (so that t^2 also increases). This improves the accuracy, because greater numbers are less "sensitive" to measuring mistakes (i.e. greater numbers rule out the imperfect measuring accuracy of his measuring devices).

- He could also use measuring devices with a greater accuracy.

GO ON TO THE NEXT PAGE.

PHYSICS B
SECTION II
Time—90 minutes
6 Questions

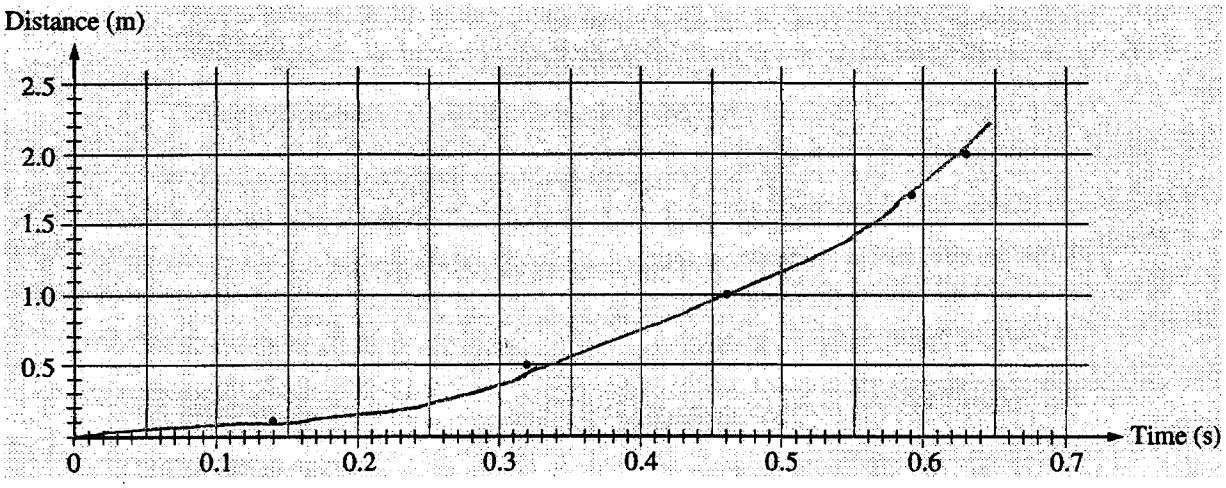
Directions: Answer all six questions, which are weighted according to the points indicated. The suggested time is about 17 minutes for answering each of questions 1-4, and about 11 minutes for answering each of questions 5-6. The parts within a question may not have equal weight. Show all your work in this booklet in the spaces provided after each part, NOT in the lavender insert.



1. (15 points)

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
t^2	0.02	0.10	0.21	0.35	0.40



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

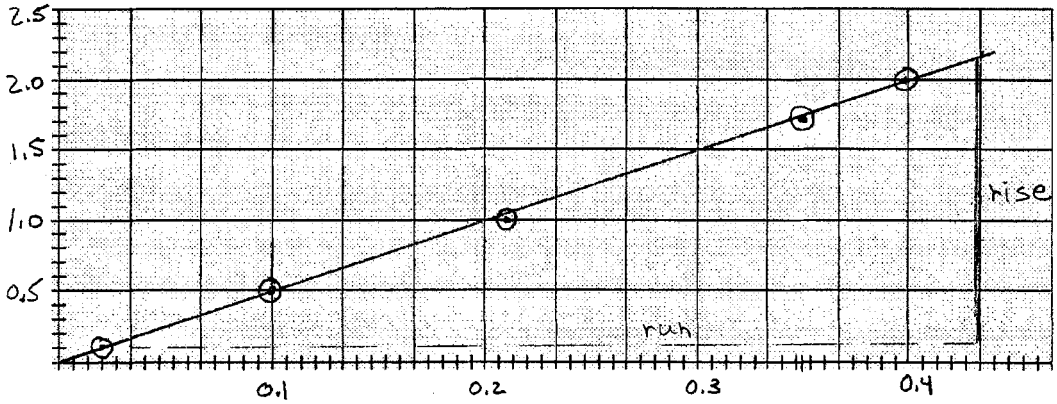
GO ON TO THE NEXT PAGE.

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? $D = \frac{1}{2}at^2$

D & t^2

(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.

$\text{slope} = \frac{\text{rise}}{\text{run}} = \frac{2.2 - 0.1}{0.43 - 0.02} = \frac{2.1}{0.41} = 5.12$

$D = \frac{1}{2}at^2$

$\text{slope} = \frac{D}{t^2} = \frac{1}{2}g \qquad g = 2(\text{slope}) = 10.2$

$g = 10.2$

(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.

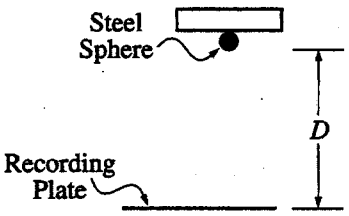
Decrease air resistance

GO ON TO THE NEXT PAGE.

B1C1

PHYSICS B
SECTION II
Time—90 minutes
6 Questions

Directions: Answer all six questions, which are weighted according to the points indicated. The suggested time is about 17 minutes for answering each of questions 1-4, and about 11 minutes for answering each of questions 5-6. The parts within a question may not have equal weight. Show all your work in this booklet in the spaces provided after each part, NOT in the lavender insert.

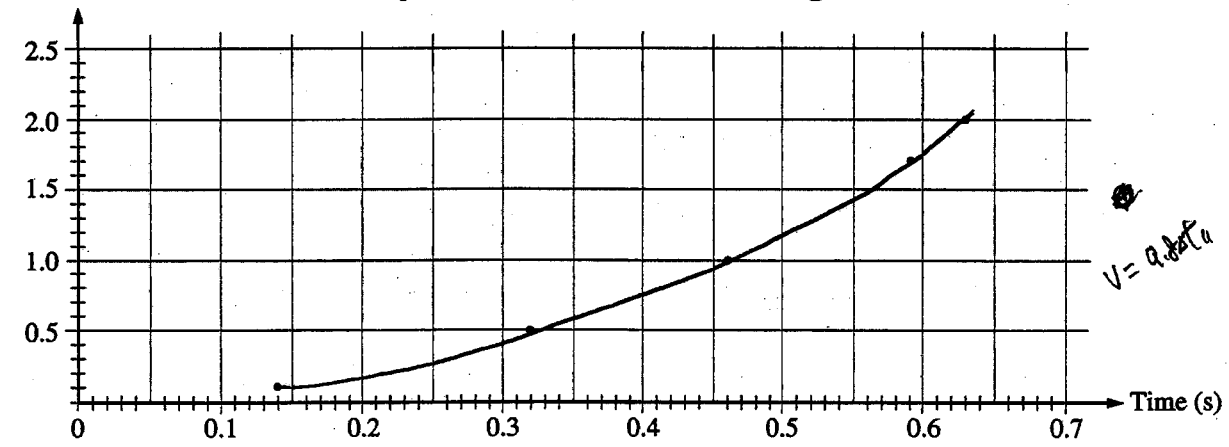


1. (15 points)

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

$\frac{1}{2}a\times(0.14)^2=0.1$ $D=v_0t+\frac{1}{2}at^2$ $2\cdot a\cdot s=v^2$



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

GO ON TO THE NEXT PAGE.

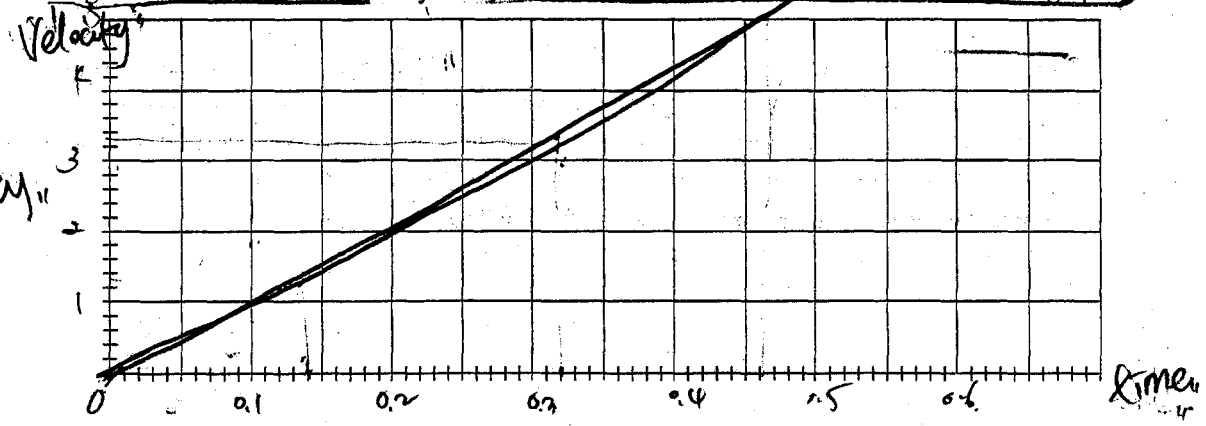
B1C2

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?

velocity and time

(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 due to gravity in this experiment.

9.8 m/s²

(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.

GO ON TO THE NEXT PAGE.

AP® PHYSICS B
2006 SCORING COMMENTARY (Form B)

Question 1

Sample: B1A
Score: 15

This response earned full credit on all parts and includes a very good method for improving accuracy.

Sample: B1B
Score: 11

Parts (a) and (b) received full credit. Part (c) earned 2 of the 4 points since there are no labels on the graph axes. Part (d) earned full credit, but part (e) earned only 1 point for reduction of air resistance.

Sample: B1C
Score: 5

Part (a) received full credit, but part (b) earned nothing since the answer is not expressed in terms of the required variables. In part (c) the last two data points are not plotted since the student's values apparently ran off the vertical scale, although the correct values would have fit. However, the axes are scaled and labeled, and a reasonable line is drawn, so the maximum 2 points for correct work with incorrect variables was awarded. Although the answer in part (d) is in the acceptable range, no credit was earned without work shown since this is the value provided in the table of information.