AP® PHYSICS B
2007 SCORING GUIDELINES

General Notes About 2007 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 one 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 and 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. For a description of the use of such terms as "derive" and "calculate" on the exams, and what is expected for each, see "The Free-Response Sections—Student Presentation" in the *AP Physics Course Description* .

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.

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Question 1

15 points total **Distribution of points**

(a) 2 points

For using a correct equation relating distance, speed, and time 1 point

$x = v\Delta t$

$\Delta t = \frac{x}{v}$

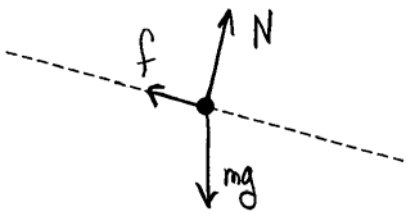
$\Delta t = \frac{21 \text{ m}}{2.4 \text{ m/s}}$

For the correct answer 1 point

$\Delta t = 8.75$ s

Note: Only 1 point was awarded for the correct answer with no supporting work.

(b) 3 points



For each correct force that is correctly labeled, is attached to the dot, and has an arrowhead pointing in the correct direction, 1 point was awarded. 3 points

For each incorrect vector, a point was deducted, with the minimum possible score being 0.

(c) 3 points

For recognizing that the sum of the forces upon the sled is zero 1 point

$\sum F = 0$

Writing the equation for the forces acting along the slope,

$\sum F = mg\sin 15° - f = 0$, where f represents the force of friction

For equating the force of kinetic friction with the component of weight that acts down the slope 1 point

$f = mg\sin 15°$

$f = (25 \text{ kg})(9.8 \text{ m/s}^2)\sin 15°$

For the correct answer 1 point

$f = 63.4$ N (64.7 N if $g = 10 \text{ m/s}^2$ is used)

Note: Only 1 point was awarded for the correct answer with no supporting work.

Question 1 (continued)

Distribution of points

(d) 3 points

For equating the force of kinetic friction to the product of the coefficient of friction and the normal force — 1 point

$f = \mu N$

$\sum F = mg\cos 15° - N = 0$

For equating the normal force to the component of the sled's weight that is normal to the slope — 1 point

$N = mg\cos 15°$

$\mu = \frac{f}{N} = \frac{mg\sin 15°}{mg\cos 15°} = \tan 15°$

For the correct answer or for an answer consistent with the friction force obtained in (c) — 1 point

$\mu = 0.27$

Note: Only 1 point was awarded for the correct answer with no supporting work.

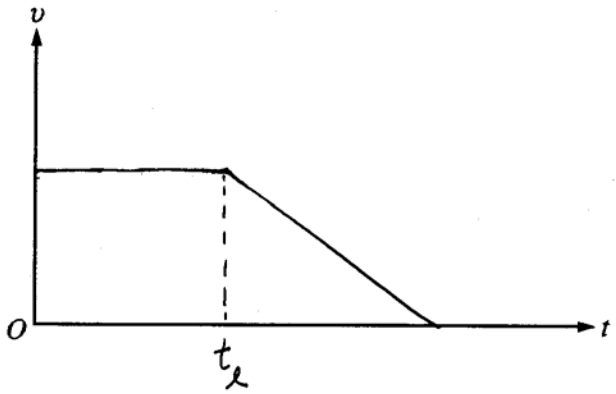
(e)

(i) 2 points

For implicitly or explicitly stating that the velocity of the sled decreases — 1 point

For explicitly stating that the acceleration of the sled is constant — 1 point

(ii) 2 points



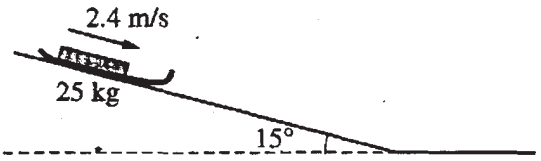
For sketching a horizontal non-zero line — 1 point

For sketching a line of constant negative slope that begins at the right-hand end of the previously drawn horizontal line and also indicating the time t_ℓ on the graph — 1 point

Note: The second point was awarded only if the first point was awarded.

PHYSICS B
SECTION II
Time—90 minutes
7 Questions

Directions: Answer all seven questions, which are weighted according to the points indicated. The suggested times are about 17 minutes for answering each of Questions 1 and 3 and about 11 minutes for answering each of Questions 2 and 4-7. 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 green insert.



1. (15 points)

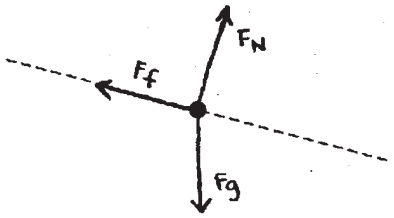
An empty sled of mass 25 kg slides down a muddy hill with a constant speed of 2.4 m/s. The slope of the hill is inclined at an angle of 15° with the horizontal as shown in the figure above.

(a) Calculate the time it takes the sled to go 21 m down the slope.

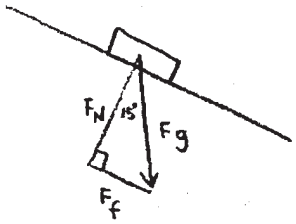
$d = 21\text{ m}$ $\quad v = 2.4\text{ m/s}$ $\quad d = vt$

$t = d/v = \frac{21\text{ m}}{2.4\text{ m/s}} = 8.75\text{ s}$

(b) On the dot below that represents the sled, draw and label a free-body diagram for the sled as it slides down the slope.



(c) Calculate the frictional force on the sled as it slides down the slope.



$\sin 15° = \frac{F_f}{F_g}$ $\quad F_g = mg$

$F_f = F_g \sin 15°$

$= mg \sin 15°$

$= (25\text{ kg})(9.8\text{ m/s}^2)\sin 15°$

$= 63\text{ N}$

GO ON TO THE NEXT PAGE.

(d) Calculate the coefficient of friction between the sled and the muddy surface of the slope.

$F_f = \mu F_N$

$\mu = \frac{F_f}{F_N}$

$= \frac{63\ N}{237\ N}$

$= .266$

$\cos 15° = \frac{F_N}{F_g}$

$F_N = F_g \cos 15°$

$= (25\ kg)(9.8\ m/s^2)\cos 15°$

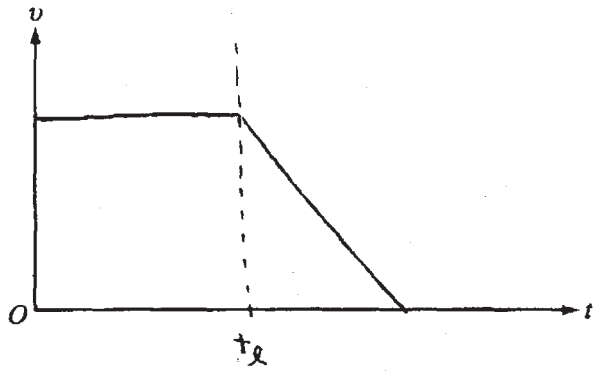
$= 237\ N$

(e) The sled reaches the bottom of the slope and continues on the horizontal ground. Assume the same coefficient of friction.

i. In terms of velocity and acceleration, describe the motion of the sled as it travels on the horizontal ground.

Due to friction, the sled continues in the same direction with a negative acceleration (is slowing down). Velocity is positive but decreasing sled will slowly come to a stop.

ii. On the axes below, sketch a graph of speed v versus time t for the sled. Include both the sled's travel down the slope and across the horizontal ground. Clearly indicate with the symbol t_l the time at which the sled leaves the slope.



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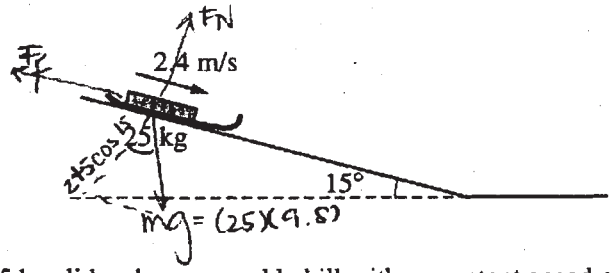


1. (15 points)

An empty sled of mass 25 kg slides down a muddy hill with a constant speed of 2.4 m/s. The slope of the hill is inclined at an angle of 15° with the horizontal as shown in the figure above.

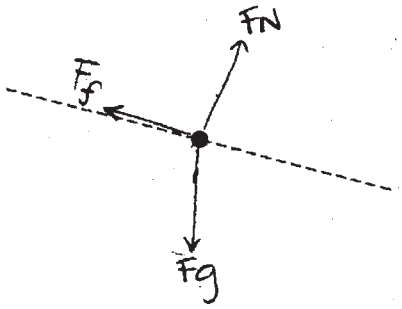
(a) Calculate the time it takes the sled to go 21 m down the slope.

$v = \frac{d}{t}$

$2.4 = \frac{21}{t}$

$t = 8.75\text{s}$

(b) On the dot below that represents the sled, draw and label a free-body diagram for the sled as it slides down the slope.



(c) Calculate the frictional force on the sled as it slides down the slope.

$F = ma = (m)(\frac{v}{t})$

$F_f = (25)(\frac{2.4}{8.75})$

$F_f = 6.86\text{N}$

GO ON TO THE NEXT PAGE.

(d) Calculate the coefficient of friction between the sled and the muddy surface of the slope.

$F_f = (F_N)(\mu)$

$0.86 = (245\cos 15)(\mu)$

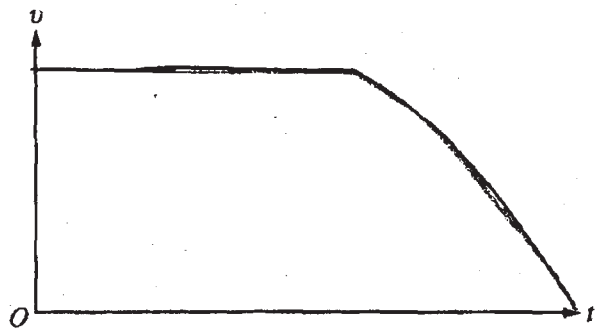
$\mu = .029$

(e) The sled reaches the bottom of the slope and continues on the horizontal ground. Assume the same coefficient of friction.

i. In terms of velocity and acceleration, describe the motion of the sled as it travels on the horizontal ground.

the velocity will decrease and the acceleration will become more negative

ii. On the axes below, sketch a graph of speed v versus time t for the sled. Include both the sled's travel down the slope and across the horizontal ground. Clearly indicate with the symbol t_ℓ the time at which the sled leaves the slope.



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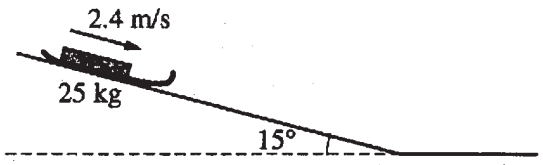


1. (15 points)

An empty sled of mass 25 kg slides down a muddy hill with a constant speed of 2.4 m/s. The slope of the hill is inclined at an angle of 15° with the horizontal as shown in the figure above.

(a) Calculate the time it takes the sled to go 21 m down the slope.

$V = 2.4 m/s$ $X = tV$
$X = 21m$ $21 = t(2.4)$
$m = 25kg$ $t = 8.75$
$\theta = 15°$

time is 8.75 seconds

(b) On the dot below that represents the sled, draw and label a free-body diagram for the sled as it slides down the slope.

(c) Calculate the frictional force on the sled as it slides down the slope.

$F = ma$ $V = V_0 + at$
$F_{fric} \leq \mu N$ $2.4 = 0 + a(8.75)$
$.27 = a$

$F = ma$
$F = 25(.27)$
$F = 6.75$

$Fric \leq \mu\, 6.75$

GO ON TO THE NEXT PAGE.

(d) Calculate the coefficient of friction between the sled and the muddy surface of the slope.

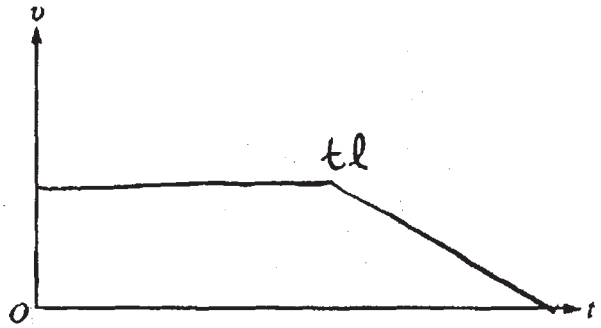
$\mu \geq \frac{F_{fric}}{N}$

(e) The sled reaches the bottom of the slope and continues on the horizontal ground. Assume the same coefficient of friction.

i. In terms of velocity and acceleration, describe the motion of the sled as it travels on the horizontal ground.

The acceleration will become negative as it slows down the speed which will decrease.

ii. On the axes below, sketch a graph of speed v versus time t for the sled. Include both the sled's travel down the slope and across the horizontal ground. Clearly indicate with the symbol t_ℓ the time at which the sled leaves the slope.



AP® PHYSICS B
2007 SCORING COMMENTARY

Question 1

Overview

This 15-point question was designed to measure students' understanding of several topics in mechanics: basic kinematics, Newton's second law, and kinetic friction. Part (a) asked a simple question involving constant-velocity motion of a sled on an incline. Part (b) asked students to draw the free-body diagram for the sled. In part (c) they had to calculate the frictional force on the sled and in part (d) find the coefficient of sliding friction. In part (e) students were told that the sled reached horizontal ground at the bottom of the incline, and they were asked to describe the subsequent motion and sketch a graph of speed versus time.

Sample: B1A
Score: 14

The only point not earned in this response is in part (e), where the student does not indicate that the acceleration is constant.

Sample: B1B
Score: 10

Parts (a) and (b) received full credit, but there is no correct work in part (c) so it earned nothing. Part (d) earned full credit, since the correct work is done using the incorrect answer from part (c). Only 1 point was earned in part (e)(i) since the student does not indicate that the acceleration is constant. Part (e)(ii) also only earned 1 point for the horizontal part of the graph. The remaining part appears curved, and t_ℓ is not labeled.

Sample: B1C
Score: 6

Part (a) received full credit, but there is no correct work in parts (b) or (c) so they earned nothing. Part (d) received 1 point for the correct expression for friction. Part (e)(i) earned 1 point for indicating that the sled slows down, and part (e)(ii) earned full credit.