2025

AP® Physics 1: Algebra-Based

Sample Student Responses and Scoring Commentary

Inside:

Free-Response Question 2

- ☑ **Scoring Guidelines**
- ☑ **Student Samples**
- ☑ **Scoring Commentary**

Question 2: Translation Between Representations (TBR) — 12 points

A

For drawing one bar in Figure 2 that shows only gravitational potential energy (U_g) — **Point A1**

Scoring Note: The correct height of the bar is not required to earn this point.

For including only K and U_g in Figure 3 — **Point A2**

Scoring Note: The correct heights of the bars are not required to earn this point.

For drawing bars in figures 2 and 3 whose total height, respectively, equals $12E_0$ — **Point A3**

Example Response

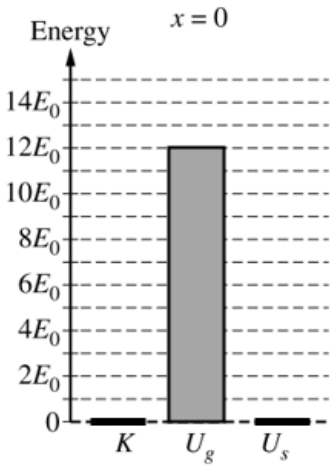


Figure 2

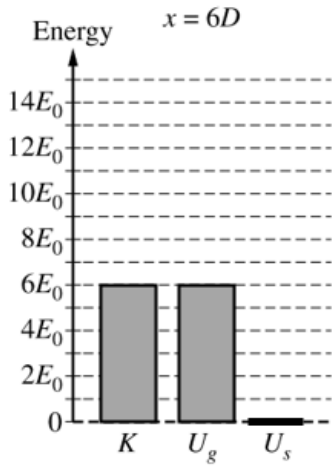


Figure 3

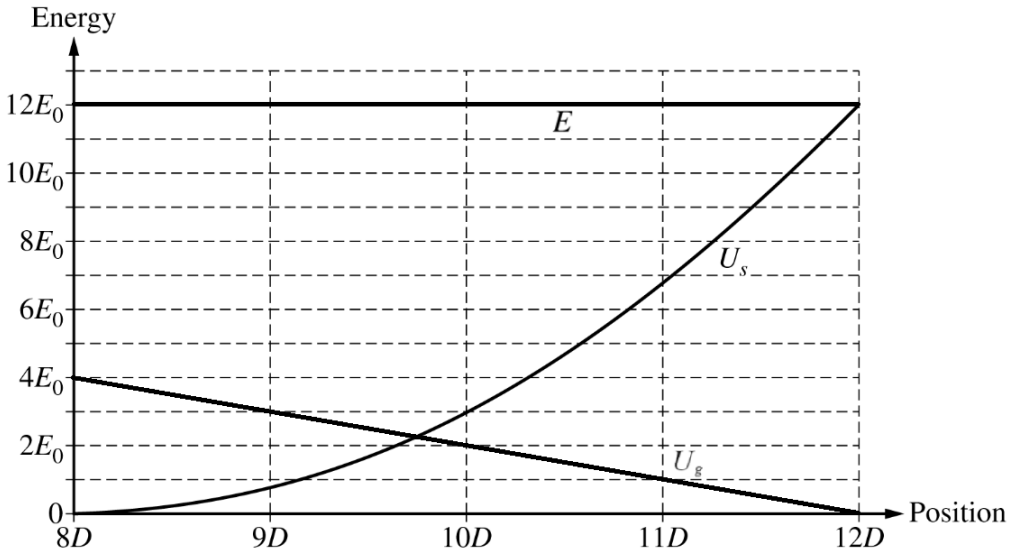
B	For a multistep derivation that includes conservation of energy	**Point B1**
	For equating the gravitational potential energy to the spring potential energy	**Point B2**
	For **one** of the following: • Substituting $12D\sin\theta$ for Δy in a gravitational potential energy expression • Substituting $4D$ in for Δx in a spring potential energy expression	**Point B3**
	For a correct expression for k Accept any algebraic equivalent of **one** of the following: • $k = \frac{3}{2}\frac{Mg\sin\theta}{D}$ • $\frac{3}{2}\frac{Mg\sin\theta}{D}$ **Scoring Note:** A correct, isolated, final expression of $k = \frac{3}{2}\frac{Mg\sin\theta}{D}$ earns points B2, B3, and B4.	**Point B4**
	Example Response $E_0 = E_f$ $U_g = U_s$ $mg\Delta y = \frac{1}{2}k(\Delta x)^2$ $Mg(12D\sin\theta) = \frac{1}{2}k(4D)^2$ $k = \frac{3}{2}\frac{Mg\sin\theta}{D}$	

C **(i)** For sketching a horizontal line at $12E_0$, continuous from $8D$ to $12D$, with a label that indicates total mechanical energy **Point C1**

(ii) For sketching a straight line that is decreasing with a label that indicates gravitational potential energy **Point C2**

For starting the line that represents gravitational potential energy at the point $(8D, 4E_0)$ **Point C3**

Example Response



D For **one** of the following: **Point D1**

- Indicating $v_{9D} > v_{8D}$ if the graph in part C shows $U_g + U_s$ at $x = 8D$ is **greater than** $U_g + U_s$ at $x = 9D$
- Indicating $v_{9D} < v_{8D}$ if the graph in part C shows $U_g + U_s$ at $x = 8D$ is **less than** $U_g + U_s$ at $x = 9D$
- Indicating $v_{9D} = v_{8D}$ if the graph in part C shows $U_g + U_s$ at $x = 8D$ is **equal to** $U_g + U_s$ at $x = 9D$

For a justification consistent with the graph that correctly relates the speed to the gravitational potential energy, spring potential energy, and either kinetic energy or total energy **Point D2**

Example Response

The speed at $x = 9D$ is greater than the speed at $x = 8D$. From the graph, the kinetic energy at $x = 8D$ must be $8E_0$. At $x = 9D$, the spring potential energy is $< E_0$ and the gravitational potential energy is $3E_0$, leaving $> 8E_0$ of the energy as kinetic. Therefore, the speed must be greater at $x = 9D$ than at $x = 8D$.

Use a pencil or a pen with black or dark blue ink. Do NOT write your name. Do NOT write outside the box.

Question 2: Version J

PART A

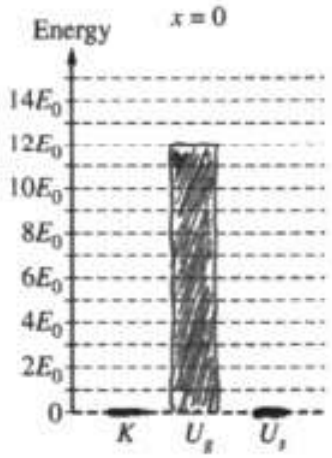


Figure 2

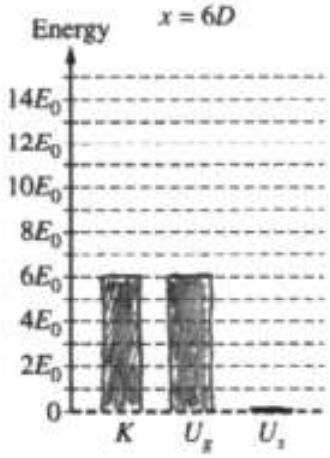


Figure 3

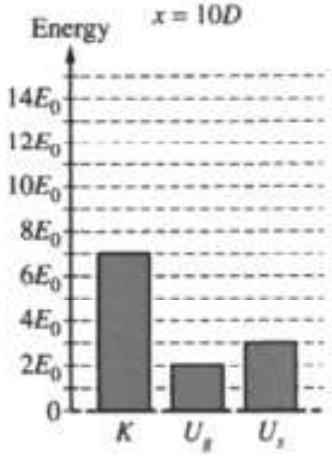


Figure 4

PART B Conservation of energy; Maximum U_g = Maximum U_s; No K

$12MgD\sin(\theta) = \frac{1}{2}k(4D)^2$

$12MgD\sin(\theta) = 8kD^2$

$mgh = \frac{1}{2}kx^2$

$U_g = U_s$

$$K = \frac{3Mg\sin(\theta)}{2D}$$

Question 2: Version J continues on the next page.

Use a pencil or a pen with black or dark blue ink. Do NOT write your name. Do NOT write outside the box.

Question 2: Version J

PART C

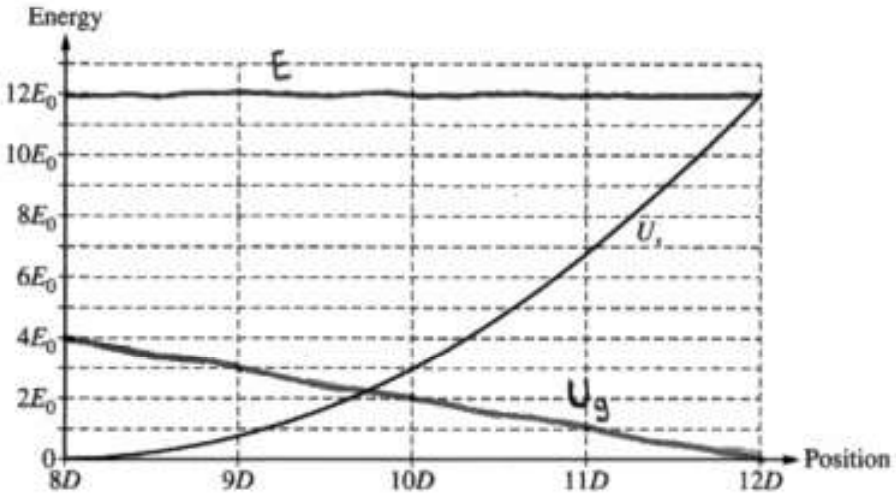


Figure 6

PART D

✓ $v_{9D} > v_{8D}$ ____ $v_{9D} < v_{8D}$ ____ $v_{9D} = v_{8D}$

The kinetic energy of the system at any position is equal to $12E_0$ (total mechanical energy) minus U_g and U_s at that position, due to conservation of energy. At position 8D, the graph shows that $U_g = 4E_0$ and $U_s = 0$, while at position 9D, $U_g = 3E_0$ and $U_s < E_0$. Since there is less total U_g and U_s at 9D, there is more kinetic energy. $K = \frac{1}{2}mv^2$, and since the mass is constant, the velocity of the block at 9D must be greater than at 8D.

Go to Question 3 in Bluebook when you're done with this question.

Use a pencil or a pen with black or dark blue ink. Do NOT write your name. Do NOT write outside the box.

Question 2: Version J

PART A

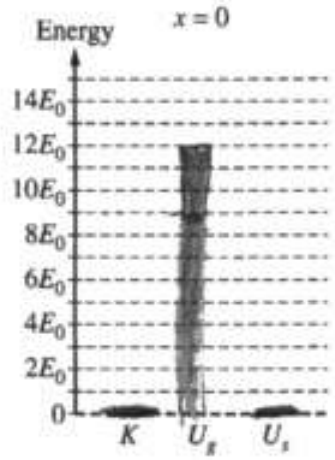


Figure 2

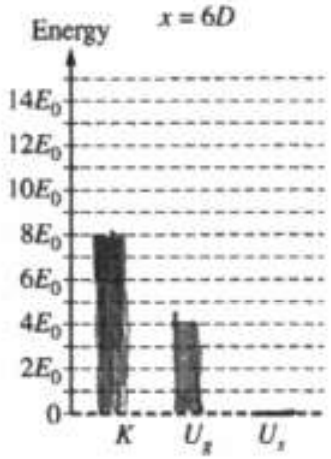


Figure 3

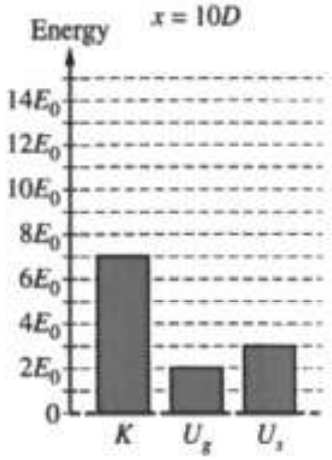


Figure 4

PART B

$U_g = U_s$

$mg\sin\theta = \frac{1}{2}k(D)^2$

$mg\sin\theta = \frac{1}{2}kD^2$

$\frac{2mg\sin\theta}{16D} = \frac{kD^2}{D^2}$

$\frac{2mg\sin\theta}{D^2} = k$

Question 2: Version J continues on the next page.

Use a pencil or a pen with black or dark blue ink. Do NOT write your name. Do NOT write outside the box.

Question 2: Version J

PART C

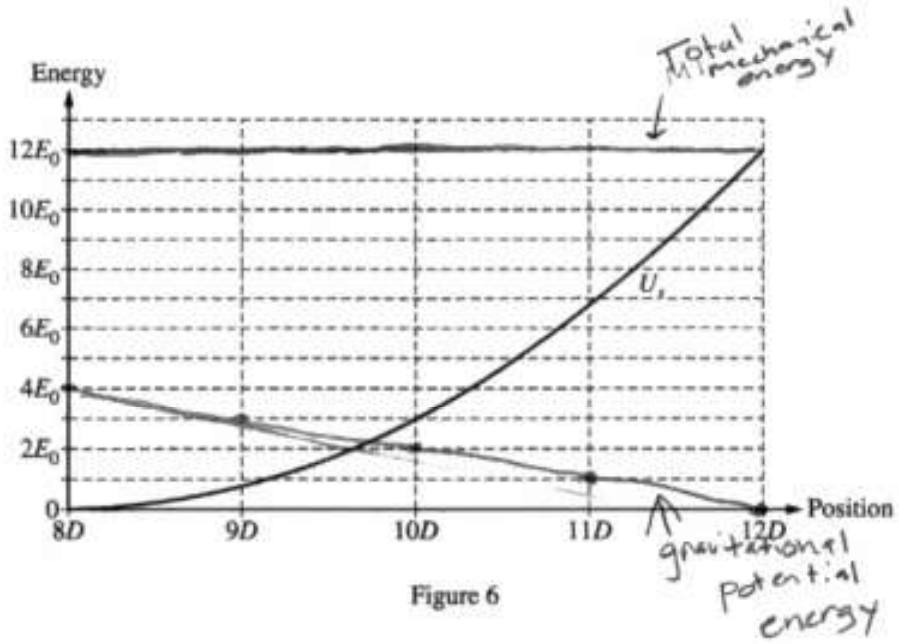


Figure 6

PART D

___ $v_{9D} > v_{8D}$ ✓ $v_{9D} < v_{8D}$ ___ $v_{9D} = v_{8D}$

the kinetic energy of 8D is greater than 9D b/c the kinetic energy of 9D is being transferred to the spring

Go to Question 3 in Bluebook when you're done with this question.

Use a pencil or a pen with black or dark blue ink. Do NOT write your name. Do NOT write outside the box.

Question 2: Version J

PART A

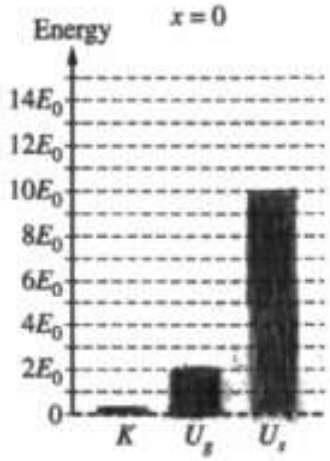


Figure 2

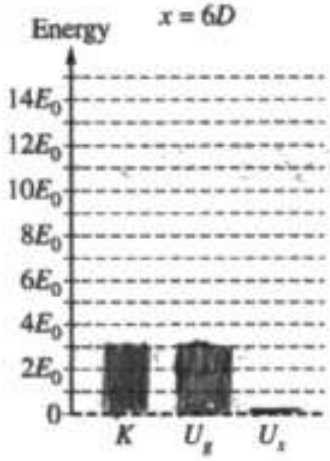


Figure 3

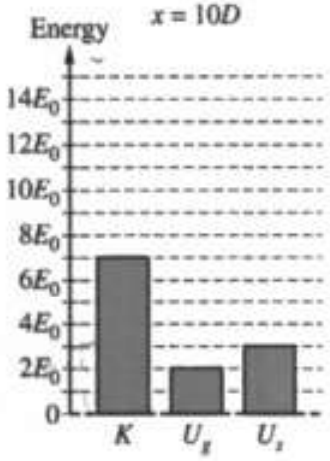


Figure 4

PART B

$\Sigma F = ma$ $F_g = G\frac{m_1 m_2}{r^2}$ $F_s = -K\Delta\vec{x}$

Question 2: Version J continues on the next page.

Use a pencil or a pen with black or dark blue ink. Do NOT write your name. Do NOT write outside the box.

Question 2: Version J

PART C

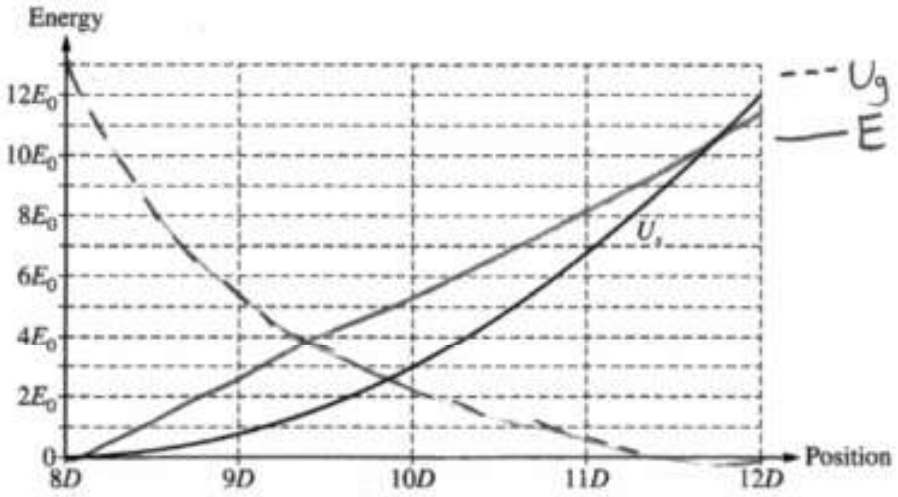


Figure 6

PART D

✓ $v_{9D} > v_{8D}$ ____ $v_{9D} < v_{8D}$ ____ $v_{9D} = v_{8D}$

The speed is greater at speed v_{9D} than speed v_{8D} because the mechanical energy increases over time and the gravitational potential energy decreases resulting in a greater speed.

Go to Question 3 in Bluebook when you're done with this question.

Question 2

Note: Student samples are quoted verbatim and may contain spelling and grammatical errors.

Overview

NEW for 2025: The question overviews can be found in the *Chief Reader Report on Student Responses* on AP Central.

Sample: 2A
Score: 12

Part A earned all three points. The first point (A1) was earned because the response includes only one bar in the energy bar chart for Figure 1, and it correctly represents gravitational potential energy. The second point (A2) was earned because the response shows two bars in Figure 2, one for kinetic energy and one for gravitational potential energy. The third point (A3) was earned because the sum of the heights of all energy bars in both Figure 2 and Figure 3 equals $12E_0$, demonstrating conservation of energy between these two positions.

Part B earned all four points. The first point (B1) was earned because the response presents a multistep derivation that includes conservation of energy, as indicated by the statement "Maximum U_g = Maximum U_s." This statement also earned point B2, as it correctly equates gravitational potential energy to spring potential energy in the context of energy conservation. The third point (B3) was earned because the response includes accurate substitutions: $12D\sin\theta$ for the change in height Δy in the gravitational potential energy expression and $4D$ for the displacement Δx in the spring potential energy expression. The fourth point (B4) was earned because the derivation included the correct expression for the spring constant k in terms of the given variables.

Part C (i) earned the point. The point for this part (C1) was earned because the response includes a continuous, horizontal line at the energy level of $12E_0$ and the line is labeled as the total mechanical energy, "E." Part C (ii) earned both points. The first point (C2) was earned because the response includes a straight, decreasing line that is labeled as gravitational potential energy, "U_g." The second point (C3) was also earned because the response accurately indicates the initial conditions on the graph by correctly starting the line for the gravitational potential energy at the point $(8D,\ 4E_0)$.

Part D earned both points. The first point (D1) was earned because the response indicated the correct claim: $v_{9D} > v_{8D}$. The second point (D2) was earned because the response provides a justification that is consistent with the graph and with energy conservation principles. The justification accurately relates velocity to kinetic energy and supports the claim by calculating the potential energies at $8D$ and $9D$. The response indicates that with constant total mechanical energy, a lower potential energy at $9D$ corresponds to higher kinetic energy, and therefore greater speed, at that position.

Question 2 (continued)

Sample: 2B
Score: 8

Part A earned all three points. The first point (A1) was earned because the response includes only one bar in the energy bar chart for Figure 1, and it correctly represents gravitational potential energy. The second point (A2) was earned because the response shows two bars in Figure 2, one for kinetic energy and one for gravitational potential energy. The third point (A3) was earned because the sum of the heights of all energy bars in both Figure 2 and Figure 3 equals $12E_0$, demonstrating conservation of energy between these two positions.

Part B earned two out of four points. The first point (B1) was earned because the response includes a multistep derivation that clearly includes conservation of energy, as indicated in the initial equation of the derivation. The second point (B2) was also earned as the response correctly equates gravitational potential energy and spring potential energy within the same initial equation. The third point (B3) was not earned because the response does not include correct substitutions for either Δy in the gravitational potential energy expression or Δx in the spring potential energy expression. The fourth point (B4) was not earned because the final expression for the spring constant k is incorrect.

Part C (i) earned the point. The point (C1) was earned because the response contains a continuous, horizontal line at the $12E_0$ level and labels it as the total mechanical energy. Part C (ii) earned both points. The first point (C2) was earned because the graph includes a straight, decreasing line labeled as gravitational potential energy U_g. The second point (C3) was also earned as the gravitational potential energy line starts at the point $\left(8D,\ 4E_0\right)$, reflecting an accurate initial condition.

Part D did not earn either point. The first point (D1) was not earned because the response does not indicate the correct claim that $v_{9D} > v_{8D}$, which would be consistent with the graph sketched in part C. The graph shows that the combined gravitational and spring potential energy at $8D$ is greater than at $9D$. The second point (D2) was not earned because the justification fails to reference gravitational or spring potential energy.

Question 2 (continued)

Sample: 2C
Score: 2

Part A earned one out of three points. The first point (A1) was not earned because the response incorrectly includes two bars in Figure 1. The correct response should only include one bar that represents gravitational potential energy. The second point (A2) was earned as the response correctly included two bars in Figure 2: one for kinetic energy and one for gravitational potential energy. The third point (A3) was not earned because the sum of the heights of all bars in Figure 3 equals $6E_0$, rather than $12E_0$, which fails to demonstrate conservation of energy across the figures.

Part B did not earn any of the four points. The first point (B1) was not earned because the response does not include a multistep derivation that includes conservation of energy. The second point (B2) was not earned as the response fails to equate gravitational potential energy to spring potential energy. The third point (B3) was not earned because the response lacks the correct substitutions for Δy in a gravitational potential energy expression and Δx in a spring potential energy expression. The fourth point (B4) was not earned because the final expression for the spring constant k is incorrect.

Part C (i) did not earn the point. The point (C1) was not earned because the response does not include a horizontal line at $12E_0$ labeled as the total mechanical energy. This omission reflects a misunderstanding of energy conservation over the course of the motion. Part C (ii) did not earn either point. The first point (C2) was not earned because the response does not show a straight, decreasing line for gravitational potential energy U_g, which is expected as the block descends. The second point (C3) was also not earned because the gravitational potential energy line incorrectly starts at the point $(8D,\ 13E_0)$ rather than at $(8D,\ 4E_0)$, indicating an incorrect initial condition for the potential energy graph.

Part D earned one out of two points. The first point (D1) was earned because the response indicates the correct claim that $v_{9D} > v_{8D}$, reasoning that the sum of gravitational and spring potential energy is greater at $8D$ than at $9D$, which implies greater kinetic energy and thus a higher speed at $9D$. The second point (D2) was not earned as the justification is incomplete and is not consistent with the graph. The response does not correctly relate the speed to gravitational potential energy, spring potential energy, and either kinetic energy or total energy as it does not reference the change in spring potential energy.