2025

AP® Physics C: Mechanics

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 indicating that K_{block} is zero	**Point A1**
	For drawing bars with positive heights for U_A and U_B	**Point A2**
	For drawing a bar for U_B with a height that is twice the height of the bar drawn for U_A **Scoring Note:** This point may be earned regardless of the signs of either bar.	**Point A3**

Example Response

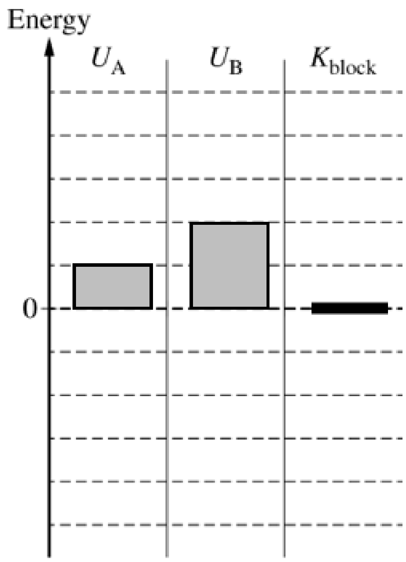


Figure 3

B	For a multistep derivation that includes energy conservation or simple harmonic motion	**Point B1**
	For relating the presence of both springs to the behavior of the system	**Point B2**
	For relating positions $x = x_1$ and $x = \frac{1}{2}x_1$ to the oscillation of the block	**Point B3**
	For a correct expression for v in terms of given quantities	**Point B4**

Example Responses

$$E_{\text{tot},0} = U_A(x_1) + U_B(x_1) + K_{\text{block}}(x_1)$$
$$E_{\text{tot},f} = U_A\left(\frac{1}{2}x_1\right) + U_B\left(\frac{1}{2}x_1\right) + K_{\text{block}}\left(\frac{1}{2}x_1\right)$$

$$E_{\text{tot},0} = \frac{1}{2}(k)(x_1)^2 + \frac{1}{2}(2k)(x_1)^2 + 0$$
$$E_{\text{tot},f} = \frac{1}{2}(k)\left(\frac{1}{2}x_1\right)^2 + \frac{1}{2}(2k)\left(\frac{1}{2}x_1\right)^2 + K_{\text{block},\,\frac{1}{2}x_1}$$

$$E_{\text{tot},0} = E_{\text{tot},f}$$
$$\frac{1}{2}kx_1^2 + kx_1^2 = \frac{1}{8}kx_1^2 + \frac{1}{4}kx_1^2 + K_{\text{block},\,\frac{1}{2}x_1}$$
$$\frac{3}{2}kx_1^2 = \frac{3}{8}kx_1^2 + K_{\text{block},\,\frac{1}{2}x_1}$$

$$K_{\text{block},\,\frac{1}{2}x_1} = \frac{9}{8}kx_1^2$$
$$\frac{1}{2}mv^2 = \frac{9}{8}kx_1^2$$

$$v = \frac{3}{2}x_1\sqrt{\frac{k}{m}}$$

OR

$$x = x_{\max}\cos(\omega t + \phi)$$

$$x(t) = x_1\cos\omega t$$
$$v(t) = -x_1\omega\sin\omega t$$

$$k_{\text{eff}} = k + 2k = 3k$$
$$\omega = \sqrt{\frac{3k}{m}}$$

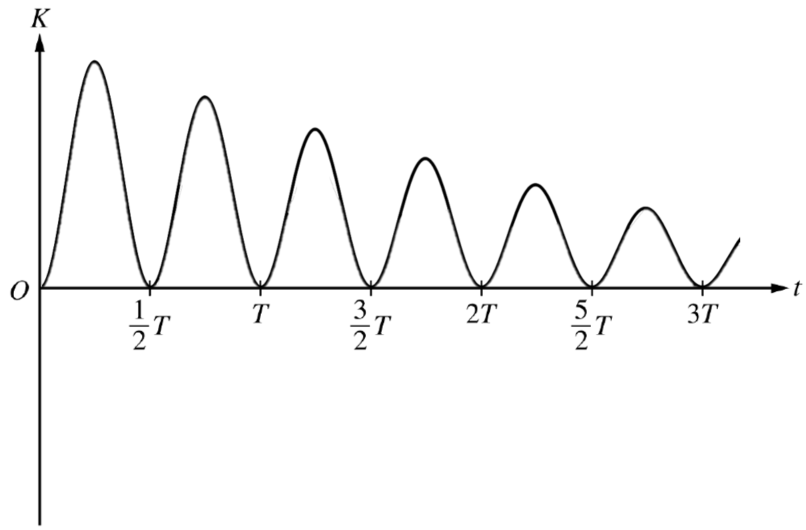
$$\frac{x_1}{2} = x_1\cos\omega t_{\frac{1}{2}x_1}$$
$$\cos\omega t_{\frac{1}{2}x_1} = \frac{1}{2}$$
$$t_{\frac{1}{2}x_1} = \frac{\pi}{3\omega}$$

$$v_{\frac{1}{2}x_1} = -x_1\omega\sin\omega t_{\frac{1}{2}x_1}$$
$$v_{\frac{1}{2}x_1} = -x_1\sqrt{\frac{3k}{m}}\sin\frac{\pi}{3}$$

$$v = \left|v_{\frac{1}{2}x_1}\right| = \frac{3}{2}x_1\sqrt{\frac{k}{m}}$$

C	For sketching a curve that starts at zero and is always positive or zero	**Point C1**
	For sketching a periodic curve with zeros that have a period of $\frac{1}{2}T$	**Point C2**
	For sketching a periodic curve with a decreasing amplitude	**Point C3**

Example Response



Scenario 2

Figure 5

D	For indicating **one** of the following: • The period increases. • The rate at which the graph approaches zero increases. • The maximum value of K over each period is less than the graph drawn.	**Point D1**
	For a correct justification relevant to the feature indicated	**Point D2**

Example Responses

The period of the graph increases. The period of a simple harmonic oscillator increases with increasing mass.

OR

The rate at which the graph approaches zero amplitude increases. Because the mass of the block is larger, the force of friction is greater, which causes the block to lose energy at a greater rate.

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

$U_A = \frac{1}{2}kx^2 = \frac{1}{2}kx_1^2$

$U_B = \frac{1}{2}kx^2 = \frac{1}{2}2kx_1^2$

$= kx_1^2$

$U_B = 2U_A$

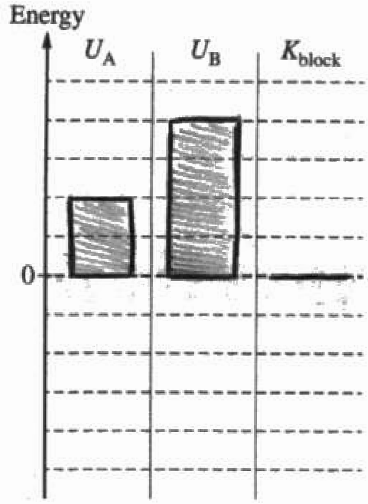


Figure 3

PART B

energy is conserved

$E_{tot} = \frac{1}{2}kA^2$ $\quad$ $k_{tot} = k_A + k_B = 3k$

$\frac{1}{2}k_{tot}A^2 = U_A + U_B + KE$

$\frac{1}{2} \cdot 3k\, x_1^2 = \frac{1}{2} \cdot k\left(\frac{1}{2}x_1\right)^2 + \frac{1}{2}(2k)\left(\frac{1}{2}x_1\right)^2 + \frac{1}{2}mv^2$

$3kx_1^2 = \frac{1}{4}kx_1^2 + \frac{2}{4}kx_1^2 + mv^2$ $\quad$ $3 \cdot 4 = 12$

$3kx_1^2 = \frac{3}{4}kx_1^2 + mv^2$ $\quad$ $\frac{9}{4}kx_1^2 = mv^2$

$\frac{12}{4}kx_1^2 - \frac{3}{4}kx_1^2 = mv^2$ $\quad$ $\frac{9kx_1^2}{4m} = v^2$

$v = \sqrt{\frac{9kx_1^2}{4m}} = \frac{3}{2}x_1\sqrt{\frac{k}{m}}$

Question 2: Version J continues on the next page.

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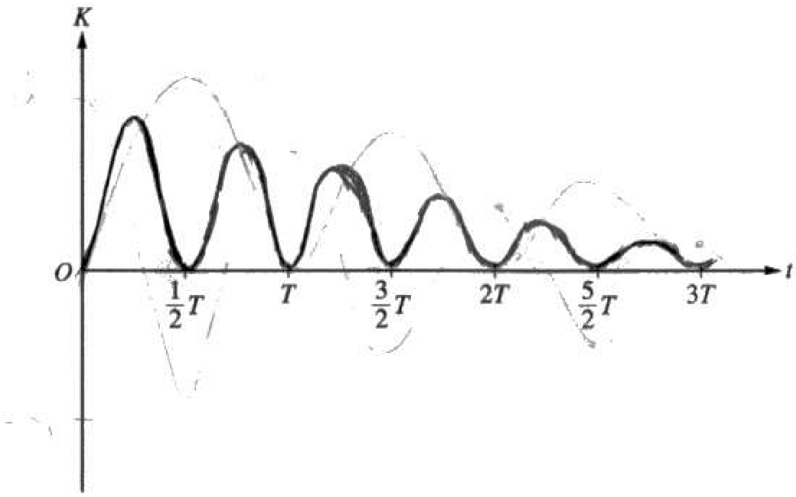
Question 2: Version J

PART C



Scenario 2

Figure 5

PART D

The peaks on the graph for scenario 3 would be lower than the graph in part C. Since $F_{fr} = \mu F_N$, and in this case $F_N = F_g = mg$, $F_{fr} = \mu mg$, and since μ and g don't change, F_{fr} is proportioned to mass. Greater m means a greater F_{fr}, which in turn increases W_{fr}. Since energy is conserved, more W_{fr} leads to a bigger decrease in KE in the same period, and thus the peaks on the graph would be lower.

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

0072920

Q5523/09

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

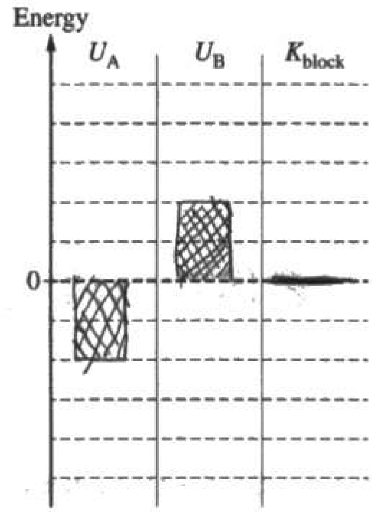


Figure 3

PART B

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

$K = \frac{1}{2}mv^2$

$\frac{1}{2} \cdot 2k \cdot \left(\frac{1}{2}x_1\right)^2 + \frac{1}{2} \cdot k \cdot \left(\frac{1}{2}x_1\right)^2 + \frac{1}{2}mv^2 = \frac{1}{2} \cdot 2k \cdot x_1^2 + \frac{1}{2}kx_1^2$

$\frac{1}{4}kx_1^2 + \frac{1}{8}kx_1^2 + \frac{1}{2}mv^2 = kx^2 + \frac{1}{2}kx^2$

$\frac{1}{2}mv^2 + \frac{3}{8}kx^2 = \frac{3}{2}kx^2$

$\frac{1}{2}mv^2 = 4$

$mv^2 = 8$

$v = \sqrt{\frac{8}{m}}$

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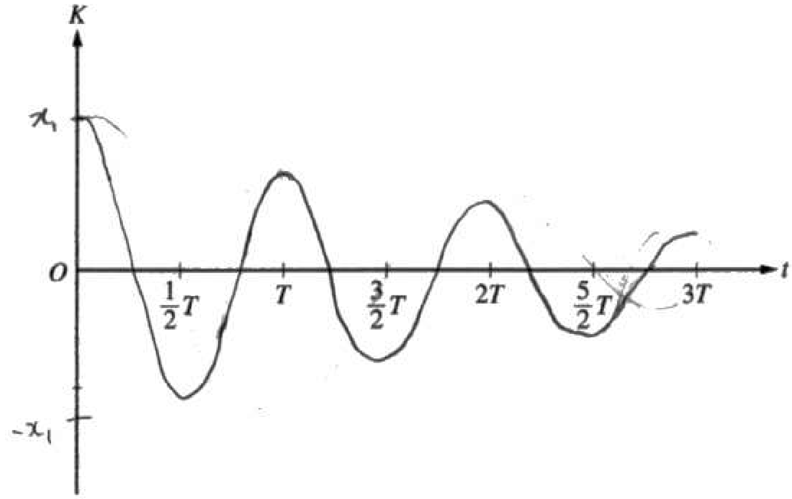
Question 2: Version J

PART C



Scenario 2

Figure 5

PART D

The period of each oscillation will increase. meaning, that the the time it takes to complete one oscillation will increase because, according to the formula: $T_s = 2\pi\sqrt{\frac{m}{k}}$, period is affected by mass, as they have a positive relationship, meaning that an increase in mass will cause an increase in period

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

0039096

Q5523/09

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Question 2: Version J

PART A

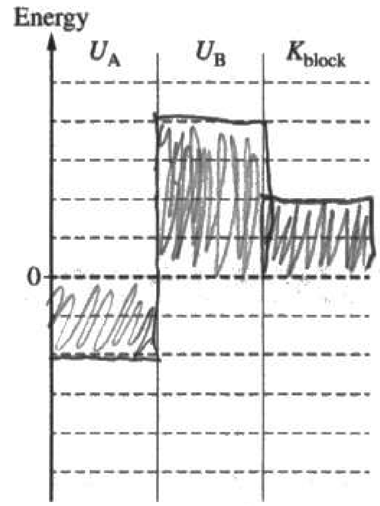

Figure 3

PART B $X = \frac{1}{2} X_1$

$V_k = \frac{m(k-k)}{(X_1 - X)}$

Question 2: Version J continues on the next page.

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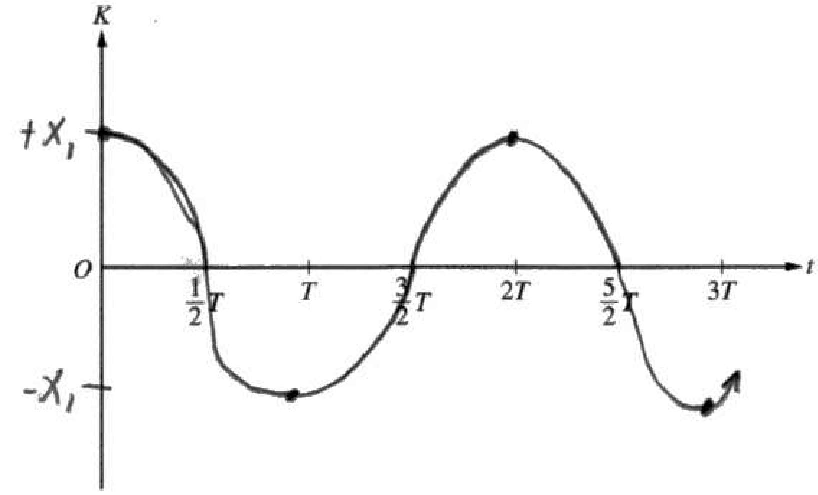
Question 2: Version J

PART C



Scenario 2

Figure 5

PART D

The period of the graph K would be longer because the mass would requier more forces if it was moving at the same speed.

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

0066391

Q5523/09

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 indicates that the kinetic energy of the block is zero. The second point (A2) was earned for showing that the bars representing the potential energies of the springs have positive heights. The third point (A3) was earned as the bar for Spring B is shown to be twice the height of the bar for Spring A.

Part B earned all four points. The first point (B1) was earned for a multistep derivation that applies conservation of energy. The second point (B2) was earned because the derivation correctly includes both spring constants. The third point (B3) was earned for correctly referencing both positions of the block in the energy equation. The fourth point (B4) was earned for producing the correct final answer.

Part C earned all three points. The first point (C1) was earned for a curve that starts at zero and remains nonnegative. The second point (C2) was earned for a curve with zeros at intervals of $\frac{1}{2}T$. The third point (C3) was earned for a curve with a decreasing amplitude.

Part D earned both points. The first point (D1) was earned for indicating that the amplitude of the peaks in Scenario 3 is lower than in Scenario 2. The second point (D2) was earned for explaining that a greater mass increases the frictional force, which results in a larger fraction of energy lost in each cycle.

Sample: 2B
Score: 8

Part A earned one out of three points. The first point (A1) was earned because the response correctly states that the block's kinetic energy is zero. The second point (A2) was not earned because it incorrectly depicts the energy of Spring A as negative. The third point (A3) was not earned because it incorrectly shows equal energy bars for both springs.

Part B earned three out of four points. The first point (B1) was earned for including a multistep derivation that applies conservation of energy. The second point (B2) was earned for referencing both spring constants. The third point (B3) was earned for referring to both block positions in the derivation. The fourth point (B4) was not earned due to an incorrect final answer.

Part C earned two out of three points. The first point (C1) was not earned because the curve does not start at zero and includes negative values. The second point (C2) was earned for showing zeros separated by intervals of $\frac{1}{2}T$. The third point (C3) was earned for a curve that has a decreasing amplitude.

Part D earned both points. The first point (D1) was earned for noting that the period of oscillation increases. The second point (D2) was earned for explaining that the increased mass leads to a longer period.

Question 2 (continued)

Sample: 2C
Score: 3

Part A earned one out of three points. The first point (A1) was not earned because the kinetic energy of the block is incorrectly described as positive. The second point (A2) was not earned due to the negative height for the potential energy bar of Spring A. The third point (A3) was earned for correctly showing that the bar representing the potential energy of Spring B is twice the height of that for Spring A.

This response earned one out of four points for Part B. The first point (B1) was not earned because it lacks a multistep derivation using conservation of energy or simple harmonic motion. The second point (B2) was earned for referring to both springs in describing the system's behavior. The third point (B3) was not earned because it does not reference both positions of the block. The fourth point (B4) was not earned for not producing the correct answer.

Part C did not earn any of the three points. The first point (C1) was not earned as the curve begins at a nonzero value and dips below zero. The second point (C2) was not earned because the curve's zeros are separated by time intervals of T rather than $\frac{1}{2}T$. The third point (C3) was not earned because the curve does not show decreasing amplitude.

Part D earned one out of two points. The first point (D1) was earned for claiming that the period increases in Scenario 3. The second point (D2) was not earned because the justification does not support the claim.