2025

AP® Physics C: Mechanics

Sample Student Responses and Scoring Commentary

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Free-Response Question 1

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

Question 1: Mathematical Routines (MR) — 10 points

A **(i)** For drawing only one arrow for the momentum of Block 2 before the collision that points leftward and is 6 units long — **Point A1**

For drawing only identical arrows for the momentum of the two-block system before and after the collision that are equal to the sum of the momentums drawn for blocks 1 and 2 before the collision — **Point A2**

Example Response

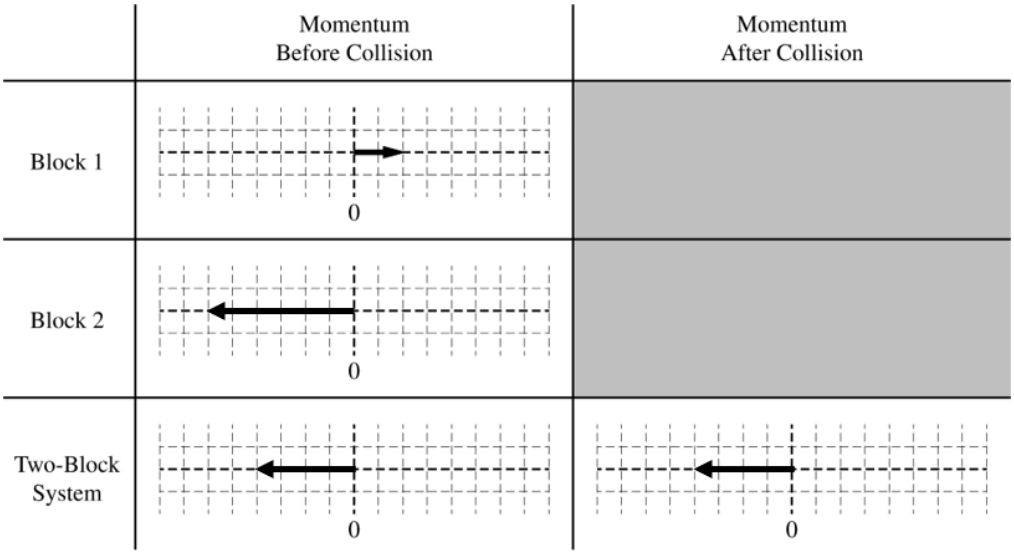

Figure 2

(ii) For a multistep derivation that includes the integral form of impulse or the differential form of Newton's second law — **Point A3**

For indicating **one** of the following: — **Point A4**

- The final speed of Block 1 or Block 2 is $\frac{4}{7}v_0$.
- The change in the momentum of Block 2 is $+\frac{18}{7}mv_0$.
- The change in the momentum of Block 1 is $-\frac{18}{7}mv_0$.
- The change in the velocity of Block 2 is $+\frac{3}{7}v_0$.
- The change in the velocity of Block 1 is $-\frac{18}{7}v_0$.

For substituting the given expression for $F(t)$ into an expression for the impulse exerted on either block or the differential form of Newton's second law — **Point A5**

For an integral with appropriate limits or a constant of integration — **Point A6**

For a correct expression for F_{max} in terms of given quantities — **Point A7**

Example Responses

$\vec{J} = \int_{t_1}^{t_2} \vec{F}_{\text{net}}(t)\, dt = \Delta\vec{p}$ OR $\vec{F}_{\text{net}} = \frac{d\vec{p}}{dt}$, $\int \vec{F}_{\text{net}}\, dt = \Delta\vec{p}$

$\sum \vec{p}_0 = \sum \vec{p}_f$

$(m)(2v_0) + (6m)(-v_0) = (m + 6m)(v_f)$

$v_f = -\frac{4}{7}v_0$

$\Delta p_{\text{Block 2}} = -\Delta p_{\text{Block 1}} = 6m\left(-\frac{4}{7}v_0 - (-v_0)\right)$

$\Delta p_{\text{Block 2}} = \int_0^{t_c} F_{\max} \sin(At)\, dt$

$\frac{18}{7}mv_0 = \frac{F_{\max}}{A}[-\cos(At)]\Big|_0^{t_c}$

$\frac{18}{7}mv_0 = \frac{F_{\max}}{A}[1 - \cos(At_c)]$

$F_{\max} = \frac{18}{7}\left(\frac{Amv_0}{1 - \cos(At_c)}\right)$

B	For a multistep derivation that includes conservation of momentum	**Point B1**
	For indicating that the magnitude of the final momentum of the two-block system is $7mv_0$	**Point B2**
	For a correct expression for v_1 in terms of v_0	**Point B3**

Example Response

$\sum \vec{p}_0 = \sum \vec{p}_f$

$mv_1 + 6m(-v_0) = 7m(v_0)$

$mv_1 = 13mv_0$

$v_1 = 13v_0$

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

Question 1: Version J

PART A

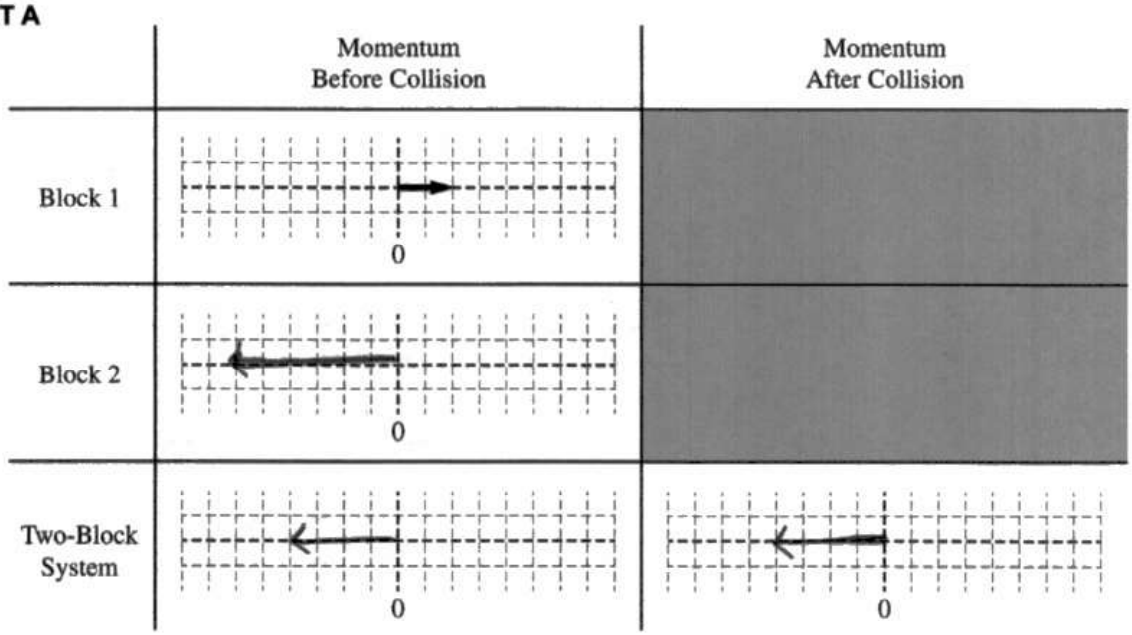

Figure 2

ii. $\Delta p = J = \int F\,dt = \int_0^{t_c} F_{max}\sin(At)\,dt = -\frac{F_{max}}{A}\cos(At)\Big|_0^{t_c}$

$m_1v_1 + m_2v_2 = (m_1+m_2)v_f$

$2mv_0 - 6mv_0 = 7mv_f$

$v_f = -\frac{4v_0}{7}$

$\Delta p = m(v_f - v_i) = 6m\left(-\frac{4v_0}{7} + v_0\right) = \frac{18}{7}mv_0$

$-\frac{F_{max}}{A}\cos(At_c) + \frac{F_{max}}{A} = \frac{18}{7}mv_0$

$F_{max}(-\cos(At_c)+1) = \frac{18Amv_0}{7}$

$\overline{F_{max} = \left|\frac{18Amv_0}{7(1-\cos(At_c))}\right|}$

PART B $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

$mv_1 - 6mv_0 = (m+6m)v_0$

$v_1 = 6v_0 + 7v_0 = 13v_0$

Go to Question 2 in Bluebook when you're done with this question.

0018105

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Question 1: Version J

PART A

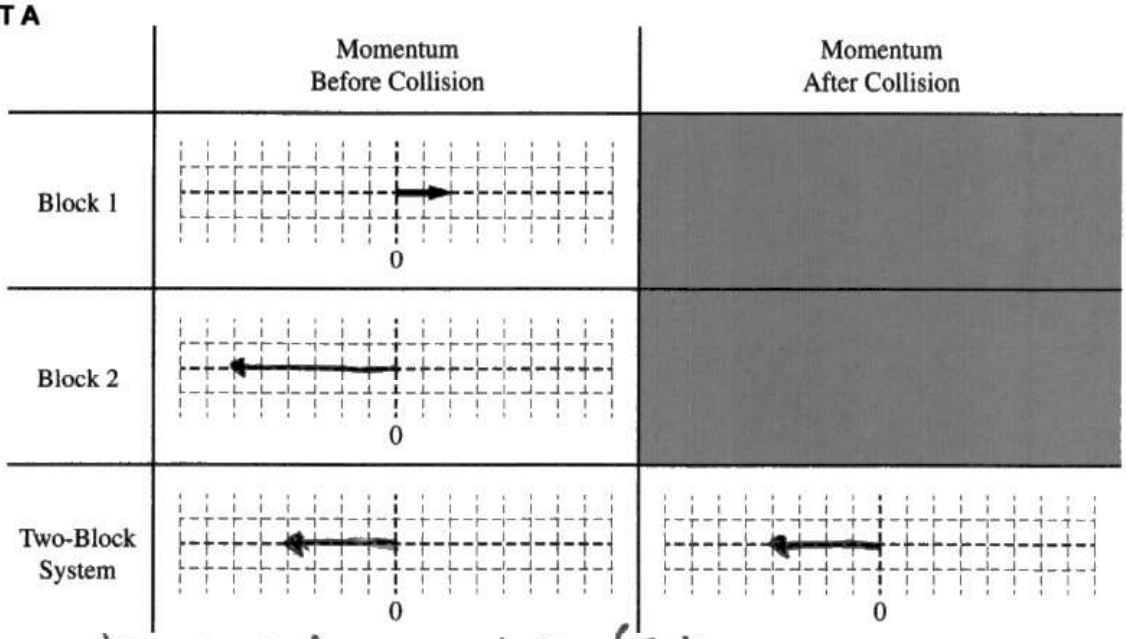

Figure 2

Impulse = Change in momentum = $\int F \cdot dt$

$J = \Delta m$ (during collison) $= -4mv_0 - 0 = -4mv_0$

$$= \int_0^{t_c} F\,dt = F_{max}\int_0^{t_c} \sin(At)\,dt = F_{max}\left(-\frac{\cos(At_c)}{A} + \frac{1}{A}\right)$$

$$\Rightarrow F_{max} = \frac{4mv_0 A}{1-\cos(At_c)}$$

PART B Consv momentum:

$m_1 v_{1i} + m_2 v_{2i} = m_1 v_{1f} + m_2 v_{2f}$

$\Rightarrow mv_1 - 2mv_0 = 3m(v_0) \Rightarrow v_1 - 2v_0 = 3v_0$

$\Rightarrow v_1 = 5v_0$

Go to Question 2 in Bluebook when you're done with this question.

0040413

Q5523/03

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

Question 1: Version J

PART A

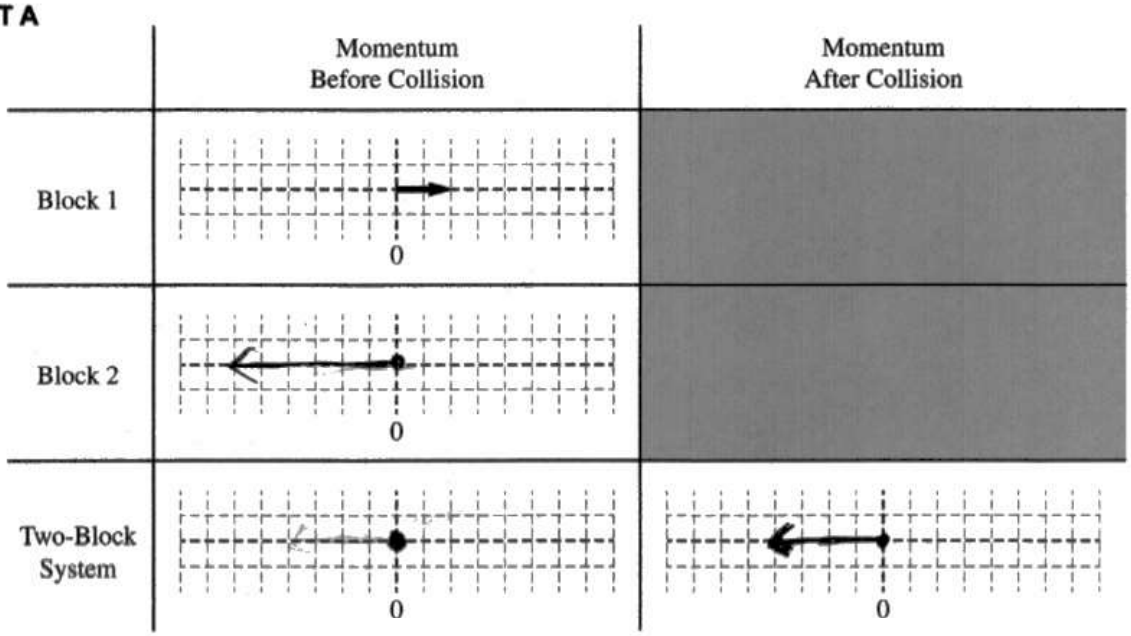

Figure 2

$p = m \cdot v$

$p = 6m \cdot (-v)$

$p = -6mv$

↳ left and 6 units

$m_1 v_1 + m_2 v_2 = (m_1 + m_2) v_f$

$m \cdot 2v - 6mv = -4mv$

left and 4 units

PART B

$m_1 v_1 + m_2 v_2 = (m_1 + m_2) v_f$

$m \cdot v_1 + 6m \cdot v_0 = 7m \cdot v_0$

$v_1 = 13 v_0$ in the +X direction

Go to Question 2 in Bluebook when you're done with this question.

0061057

Q5523/03

Question 1

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: 1A
Score: 10

Part A (i) earned both points. The first point (A1) was earned because the response correctly indicates a leftward arrow for the momentum of Block 2 before the collision, with a length of 6 units. The second point (A2) was earned for correctly showing identical arrows for the momentum of the two-block system before and after the collision, equal to the sum of momenta of the individual blocks. Part A (ii) earned all five points. The first point (A3) was earned as the response includes a multistep derivation using the integral form of impulse. The second point (A4) was earned because the response correctly shows the change in momentum for Block 2. The third point (A5) was earned for substituting the given force function $F(t)$ into the impulse expression. The fourth point (A6) was earned as the response includes a proper integral with the appropriate limits. The fifth point (A7) was earned because the expression for $F_{\max}$ in terms of the given quantities is correct.

Part B earned all three points. The first point (B1) was earned due to a multistep derivation based on conservation of momentum. The second point (B2) was earned because the response correctly indicates the magnitude of the final momentum of the two blocks as $7mv_0$. The third point (B3) was earned for providing a correct expression for v_1 in terms of v_0.

Sample: 1B
Score: 6

Part A (i) earned both points. The first point (A1) was earned for indicating a leftward momentum arrow for Block 2 that is 6 units long. The second point (A2) was earned because the response displays identical arrows for total momentum before and after the collision, matching the sum of momenta of the individual blocks. Part A (ii) earned three out of five points. The first point (A3) was earned for including a multistep derivation using the integral form of impulse. The second point (A4) was not earned because the final speed for either Block 1 or Block 2 was not correctly shown. The third point (A5) was earned as the response substitutes the given function $F(t)$ into the impulse expression. The fourth point (A6) was earned for including an integral with proper limits. The fifth point (A7) was not earned because the expression for $F_{\max}$ is not correct.

Part B earned one out of three points. The first point (B1) was earned due to a multistep derivation employing conservation of momentum. The second point (B2) was not earned because the final momentum magnitude is not correctly stated as $7mv_0$. The third point (B3) was not earned because the response is lacking a correct expression for v_1 in terms of v_0.

Question 1 (continued)

Sample: 1C
Score: 4

Part A (i) earned one out of two points. The first point (A1) was earned for correctly indicating a 6-unit leftward momentum arrow for Block 2. The second point (A2) was not earned because the momentum arrows before and after the collision are not shown to be identical or equal to the total initial momentum. Part A (ii) did not earn any of the five points. The first point (A3) was not earned due to the absence of a multistep derivation using impulse or Newton's second law. The second point (A4) was not earned because the final speeds of Blocks 1 and 2 are not correctly indicated. The third point (A5) was not earned because the substitution of $F(t)$ into the impulse expression or differential form of Newton's second law is missing. The fourth point (A6) was not earned as the integral is absent. The fifth point (A7) was not earned because the expression for $F_{\max}$ is missing.

Part B earned all three points. The first point (B1) was earned for a multistep derivation utilizing conservation of momentum. The second point (B2) was earned because the response correctly states that the magnitude of the final momentum of the two blocks is $7mv_0$. The third point (B3) was earned for providing a correct expression for v_1 in terms of v_0.