2025

AP® Physics C: Mechanics

Scoring Guidelines

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

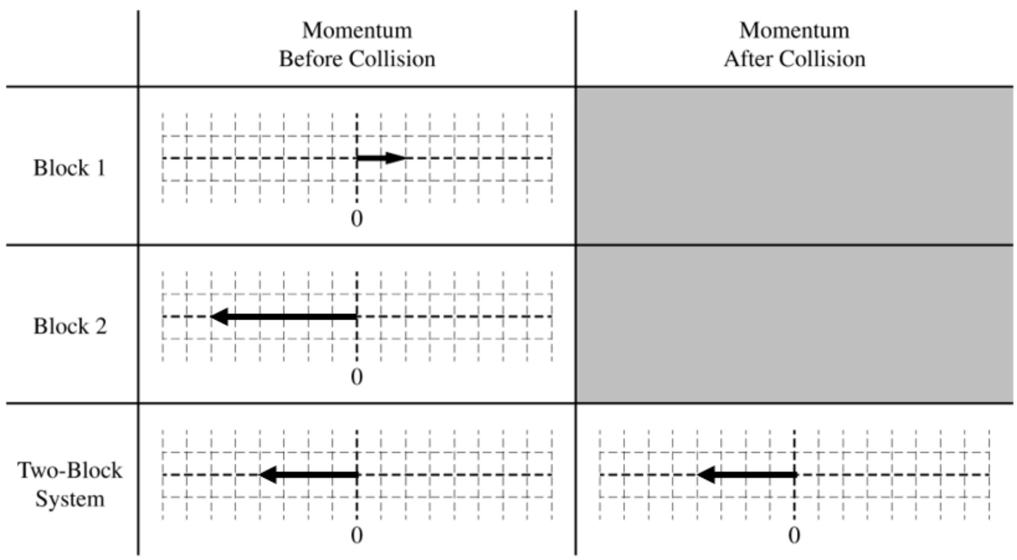


Figure 2

(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

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

$\int \vec{F}_{net}\, dt = \Delta\vec{p}$

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

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

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

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

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

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

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

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

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

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

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

$mv_1 = 13mv_0$

$v_1 = 13v_0$

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

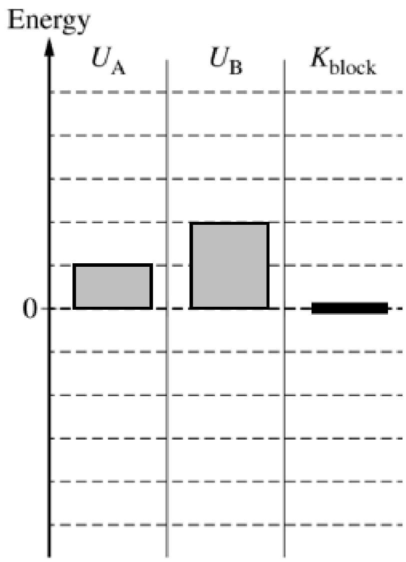


Figure 3

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

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

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

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

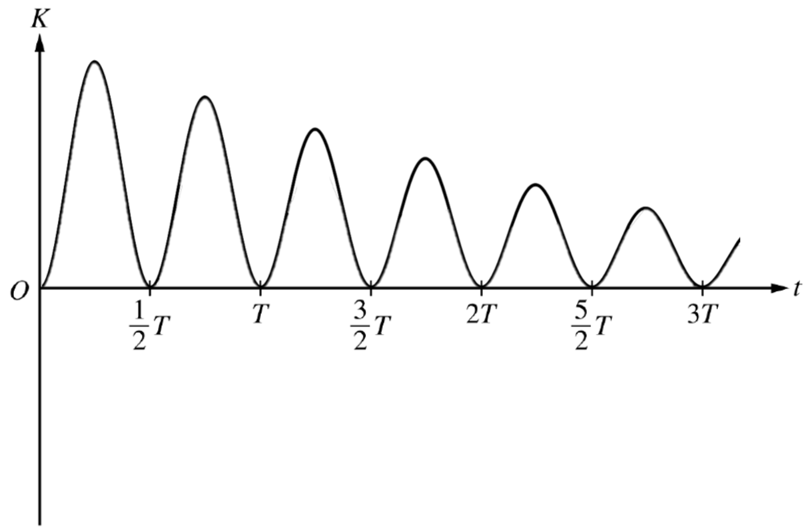
$$\frac{x_1}{2} = x_1\cos\omega t_{\frac{1}{2}x_1}$$
$$\cos\omega t_{\frac{1}{2}x_1} = \frac{1}{2}$$
$$t_{\frac{1}{2}x_1} = \frac{\pi}{3\omega}$$

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

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

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.

Question 3: Experimental Design and Analysis (LAB) — 10 points

A

For describing a procedure that includes measuring h and the speed of the block as the block moves across the surface — **Point A1**

For a procedure that indicates a reasonable method of reducing experimental uncertainty — **Point A2**

Examples of acceptable responses may include the following:

- Repeating the experiment multiple times for the same value of h
- Repeating the experiment for multiple values of h

Example Response

Measure the height h at which the block-box system is released. Measure the speed of the block as the block slides across the horizontal surface. Repeat the measurement of the speed of the block for varying release heights.

B

For describing a graph that has linear trend that can be used to find g — **Point B1**

Examples of acceptable responses include the following:

- v^2 vs. $2h$
- $\frac{1}{2}v^2$ vs. h
- v^2 vs. h
- v vs. $\sqrt{h}$

Scoring Notes:

- Reponses that include the reciprocals of the preceding examples, in addition to other equivalent graphs, also earn this point.
- This point may be earned independently of the response in part A.

For correctly relating the slope of the best-fit line to g — **Point B2**

Examples of acceptable responses include the following:

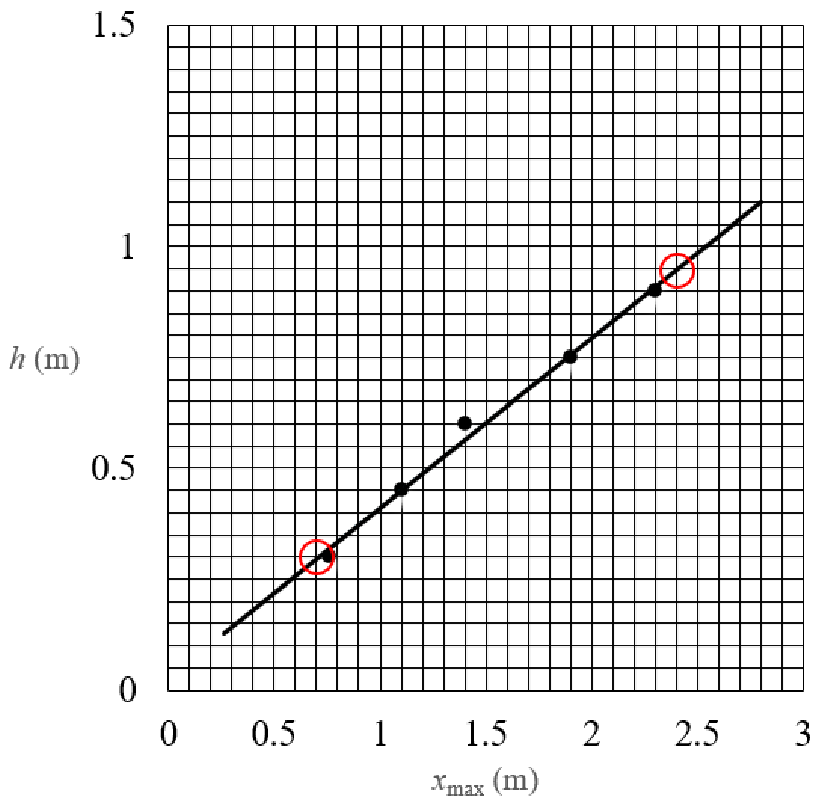
Graph	Analysis
v^2 vs. $2h$	slope $= g$
$\frac{1}{2}v^2$ vs. h	slope $= g$
v^2 vs. h	slope $= 2g$
v vs. $\sqrt{h}$	slope $= \sqrt{2g}$

Example Response

Plot v^2 on the vertical axis and $2h$ on the horizontal axis. The slope of the best-fit line is equal to g.

C	**(i)**	For indicating appropriate quantities that could be plotted to produce a linear graph that can be used to determine μ, such as h **vs.** x_{max} **Scoring Note:** Reponses that include the reciprocal of the preceding example, in addition to other equivalent graphs, also earn this point.	**Point C1**
	(ii)	For labeling the axes (including units) with a linear scale	**Point C2**
		For plotting data points consistent with **one** of the following: • The quantities indicated in part C (i) • The quantities provided in Table 2 • The axes indicated on the grid	**Point C3**
	(iii)	For drawing a line or curve that approximates the trend of the plotted data	**Point C4**

Example Response



D For correctly relating the slope of the best-fit line to the value of μ **Point D1**

Examples of acceptable responses includes the following:

Graph	**Analysis**
h vs. x_{max}	slope $= \mu$

For a value of μ within a range of 0.30 to 0.50 **Point D2**

Example Response

$E_0 + W = E_f$

$mgh - F_f x_{max} = 0$

$mgh = \mu mg x_{max}$

$h = \mu x_{max}$

$y = mx + b$

$h = \mu x_{max}$

slope $= \mu$

$$\text{slope} = \frac{0.95\text{ m} - 0.30\text{ m}}{2.4\text{ m} - 0.70\text{ m}}$$

slope $= 0.38$

$\mu =$ slope $= 0.38$

Question 4: Qualitative Quantitative Translation (QQT) — 8 points

A

For indicating $f_D < f_R$ — **Point A1**

For a justification that compares **one** of the following: — **Point A2**

- The motions of the disk and the ring using translational kinematics
- The motions of the disk and the ring using rotational kinematics
- The rotational inertias of the disk and the ring

For a justification that includes **one** of the following: — **Point A3**

- Reasoning that attempts Newton's second law in translational form
- Reasoning that attempts Newton's second law in rotational form
- Reasoning that attempts conservation of energy

Example Response

The ring has a greater rotational inertia because it has more mass distributed towards the edge. So the ring travels farther and has less acceleration down the ramp. Because the ring and the disk have the same mass, the gravitational forces exerted on the shapes are the same. From Newton's second law, the ring must have less net force down the ramp and more friction up the ramp.

B

For a multistep derivation that includes Newton's second law in both translational and rotational forms — **Point B1**

For indicating opposite signs for the gravitational force and frictional force in an expression for Newton's second law — **Point B2**

For using the relationship $a = r\alpha$ in an attempt to solve a system of equations — **Point B3**

Scoring Note: Responses that include conservation of energy may earn full credit.

Example Response

$$\alpha_{sys} = \frac{\sum \tau}{I_{sys}}$$

$$\left(\frac{a}{R}\right) = \frac{fR}{I}$$

$$a = \frac{fR^2}{I}$$

$$\vec{a}_{sys} = \frac{\sum \vec{F}}{m_{sys}}$$

$$f - Mg\sin\theta = -Ma$$

$$f - Mg\sin\theta = -M\frac{fR^2}{I}$$

$$f + M\frac{fR^2}{I} = Mg\sin\theta$$

$$f\left(1 + \frac{MR^2}{I}\right) = Mg\sin\theta$$

$$f = \frac{Mg\sin\theta}{1 + \frac{MR^2}{I}}$$

C	For indicating "Equal to"	**Point C1**
	For a justification that includes that kinetic friction is only dependent on the surfaces (or equivalently, the coefficient of kinetic friction between those surfaces) and normal force	**Point C2**
	Example Response *The forces of kinetic friction are equal. If slipping, the friction is kinetic, and the force of kinetic friction on the hoop and the disk are the same because the coefficient of kinetic friction is only dependent on the surfaces, and the normal forces on both are the same.*	