Unit 5 Progress Check: FRQ

1. This question is a long free-response question. Show your work for each part of the question.

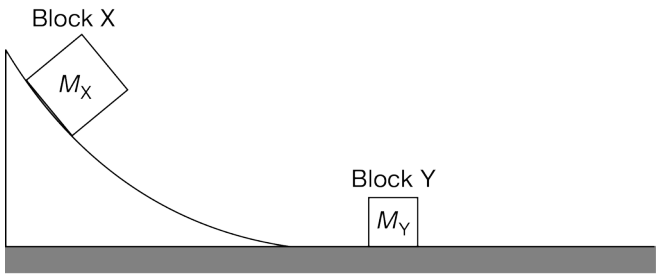

Figure 1. Initial Locations of the Blocks

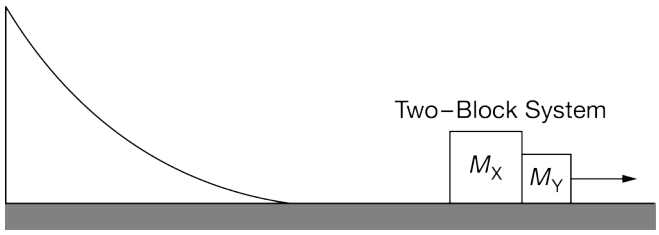

Figure 2. After the Collision

A solid block X of mass M_X may be placed at different locations along a curved ramp. At the bottom of the ramp is a solid block Y of mass M_Y that is at rest on a horizontal surface. Figure 1 shows both blocks before block X is released. A group of students must graphically determine the relationship between the release height of block X and the speed at which the two-block system travels after the blocks collide and stick together. Figure 2 shows both blocks after the collision. Frictional forces between block X and the ramp and between both blocks and the horizontal surface are considered to be negligible.

(a)

i. State the basic physics principles, laws, or equations that students could use to graphically determine the relationship between the release height of block X and the speed at which the two-block system travels after the blocks collide and stick together.

ii. Derive an equation that relates the initial release height H_X of block X and the speed v_s of the two-block system after the collision in terms of M_X, M_Y, and fundamental constants, as appropriate.

(b) Design an experimental procedure the students could use to graphically determine the relationship between the release height of block X and the speed at which the two-block system travels after the blocks collide and stick together.

In the table below, list the quantities and associated symbols that would be measured in your experiment and the equipment used to measure them. Also list the equipment that would be used to measure each quantity. You do not need to fill in every row. If you need additional rows, you may add them to the space just below the table.

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Quantity to be Measured	Symbol for Quantity	Equipment for Measurement

Describe the overall procedure to be used, referring to the table. Provide enough detail so that another student could replicate the experiment, including any steps necessary to reduce experimental uncertainty.

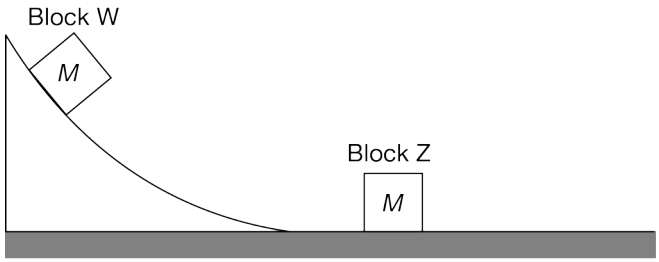

Figure 3. Initial Locations of the Blocks

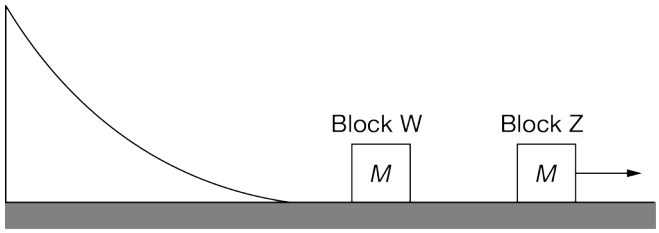

Figure 4. After the Collision

Actual Speed of Block W After Collision $(\mathrm{m/s})$	Actual Speed of Block Z After Collision $(\mathrm{m/s})$	Predicted Speed of Block Z After Collision $(\mathrm{m/s})$
0.1	1.32	1.57
0.1	1.63	1.98
-0.2	2.11	2.43
0.0	2.53	2.71

Students repeat the experiment but replace block X and block Y with block W and block Z, as shown in Figure 3. Block W and block Z have identical mass M. When the experiment is conducted, the students observe that the

blocks do not stick together, as shown in Figure 4. The students predict the speed of block Z after the collision by assuming that the collision is perfectly elastic. They then collect data about the actual speeds of both blocks immediately after the collision, as shown in the table.

(c) Why does the predicted speed of block Z after the collision not agree with the actual speed of block Z after the collision?

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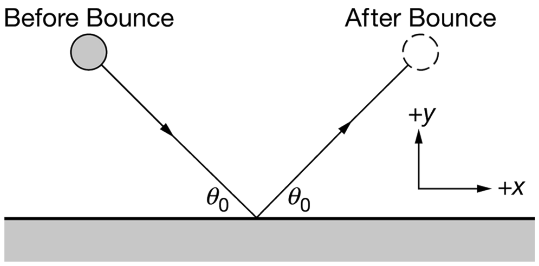
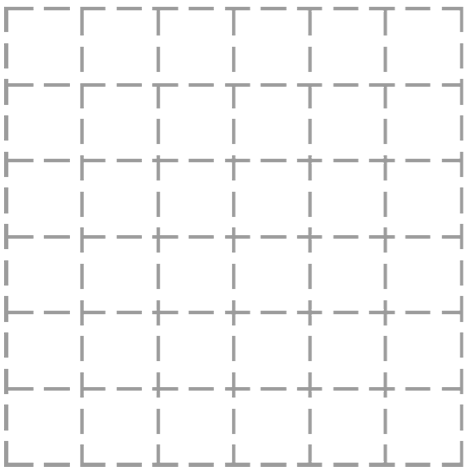
2. This question is a short free-response question. Show your work for each part of the question.



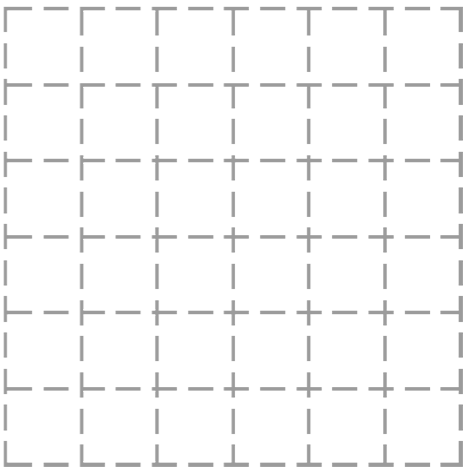
A ball is thrown toward the ground. The figure shows the direction of the ball before it reaches the ground and the direction of the ball after it bounces off the ground. After the bounce, the ball leaves the ground with the same speed that it had before the bounce. The angle between the ground and the ball's direction of travel is θ_0 before and after the ball bounces off the ground. The positive directions are indicated in the figure.

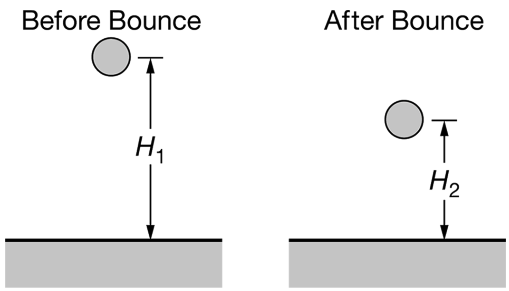
(a) Each grid below represents a component of the change in momentum of the ball as a result of the bounce. On each grid, draw a vector arrow to indicate the direction and relative magnitude of the change in momentum of the ball as a result of the bounce. If there is no change in momentum for a given component, write "NO CHANGE" under the corresponding grid.

Horizontal Component



Vertical Component





(b) A ball of mass M is released from rest at height H_1 above the ground. After the ball reaches the ground, it

bounces and travels to height H_2 above the ground, as shown in the figure. In a clear, coherent paragraph-length response that may also contain equations and drawings, explain, using the conservation of momentum and the conservation of energy, why $H_2 < H_1$.