Unit 6 Progress Check: FRQ

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

In a physics lab, a group of students are provided with a sphere of unknown mass, a roll of string, a ring stand, and measuring devices that are commonly found in a physics lab. The students must graphically determine the acceleration due to gravity near Earth's surface by putting the sphere into simple harmonic motion.

(a) State a basic physics principle, law, or equation that the students could use to graphically determine the acceleration due to gravity near Earth's surface by putting the sphere into simple harmonic motion.

(b) Design an experimental procedure the students could use to graphically determine the acceleration due to gravity near Earth's surface by putting the sphere into simple harmonic motion.

In the table below, list the quantities and associated symbols that would be measured in the experiment and 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.

Quantity to Be Measured	Symbol for Quantity	Equipment for Measurement

Describe the overall procedure to be used, referring to the table. Include any steps necessary to reduce experimental uncertainty. Provide enough detail so that another student could replicate the experiment. As needed, use the symbols listed in the table and include a circuit diagram of the setup.

(c) The students must graph the data that they have collected so that they can determine the acceleration due to gravity near Earth's surface.

i. Indicate below which quantities could be graphed on the horizontal axis or the vertical axis to determine the acceleration due to gravity near Earth's surface by using a best fit line. You may use the remaining columns in the table above, as needed, to record any quantities (including units) that are not already in the table.

Vertical axis:_____ Horizontal axis: _____

ii. The students determine that the slope of the line is m. Derive an equation that can be used to determine the acceleration due to gravity near Earth's surface by using the slope of the graph that is described by the quantities plotted from part (c)i. Express your answer in terms of the slope m and any other fundamental constants.

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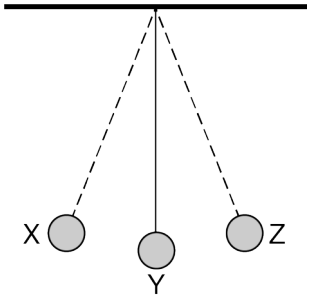

In a second experiment, the students attach a sphere to a string such that it undergoes simple harmonic motion between points X, Y, and Z, as shown in the figure. Points X and Z are at the sphere's maximum displacement from its equilibrium position, and point Y is at the sphere's equilibrium position. As the sphere swings along its arc, a student cuts the string at point Z.

(d) Predict the motion of the sphere after the string is cut in terms of the sphere's displacement, initial speed, and acceleration.

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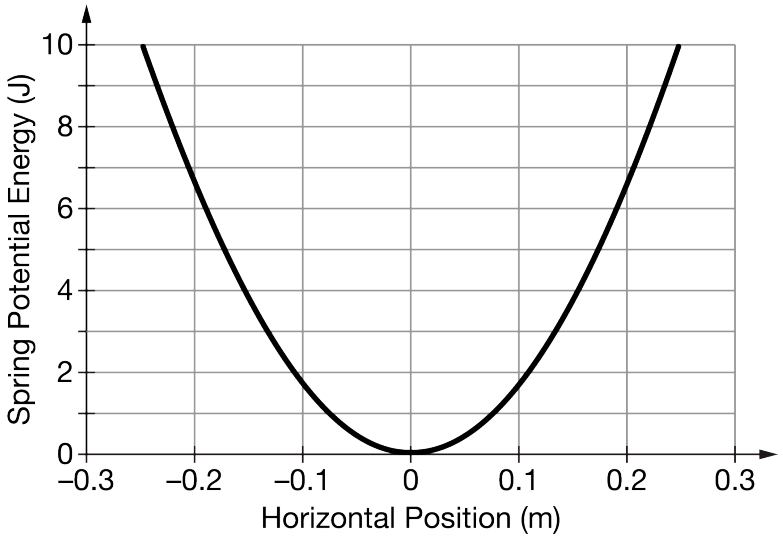
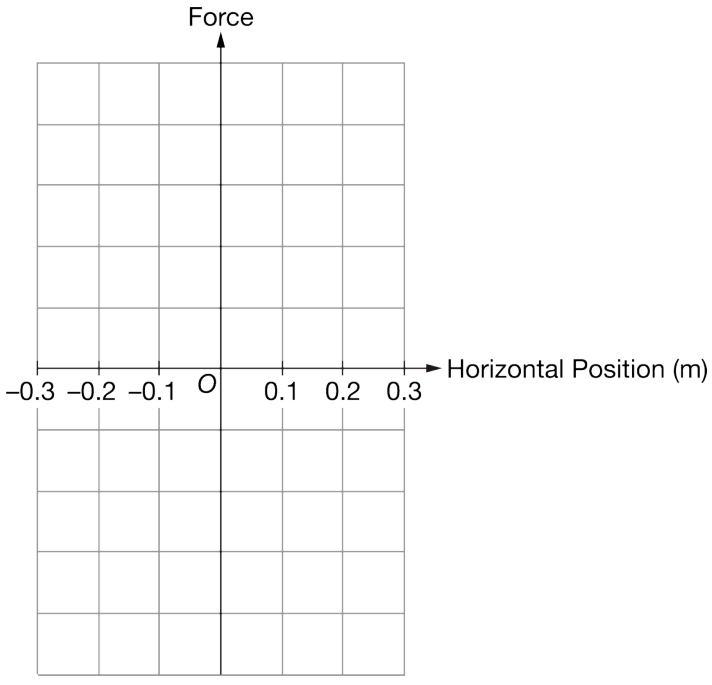
2. This question is a short free-response question. Show your work for each part of the question.



A block of mass $0.4\,\text{kg}$ on a horizontal surface is attached to a horizontal spring of negligible mass. The other end of the spring is attached to a wall, and there is negligible friction between the block and the horizontal surface. The center of mass of the block is stretched a horizontal distance $x = 0.25$ beyond its equilibrium position and released from rest such that the block-spring system undergoes simple harmonic motion. A graph of the spring potential energy of the block-spring system as a function of the horizontal position of the center of mass of the block is shown. The positive direction is considered to be to the right.

(a) On the grid below, sketch a graph of the force exerted by the spring on the block as a function of the block's horizontal position.



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(b) Calculate the period of oscillation for the block-spring system.

A new block of mass $1.0\,\text{kg}$ is attached to the spring. The center of mass of the block is stretched a horizontal distance $x = 0.25\,\text{m}$ beyond its equilibrium position and released from rest such that the block-spring system undergoes simple harmonic motion.

(c) The grid below represents the kinetic energy of this new block-spring system as a function of the horizontal position of the center of mass of the block. Sketch the curve for the kinetic energy of the block-spring system as a function of the horizontal position of the center of mass of the block.

