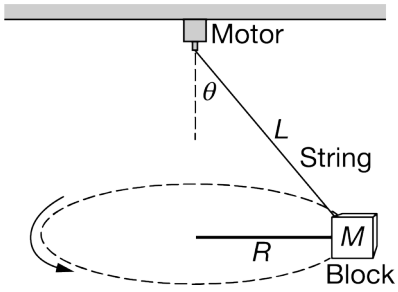
Unit 3 Progress Check: FRQ

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



In the apparatus shown above, one end of a string of length L is attached to a block of mass M and the other end is connected to the axle of a motor that rotates, causing the block to move in a circle of radius R at a constant speed v_T such that the string makes an angle θ with the vertical. A student wants to use the apparatus to make measurements and create a graph that can be used to estimate the acceleration g due to gravity at the surface of Earth. The student can adjust the motor to achieve different tangential speeds of the block.

(a)

i. The dot below represents the object as it travels in a horizontal circle at a constant tangential speed at the position shown in the figure above. On the dot, draw and label the forces (not components) exerted on the object. Each force must be represented by a distinct arrow starting on, and pointing away from, the dot.



ii. Derive an expression for the block's centripetal acceleration a_c in terms of M, θ, and physical constants, as appropriate.

(b) Using the experimental apparatus shown above and the available equipment, design an experimental procedure the student could use to estimate the acceleration g due to gravity at the surface of Earth.

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

Unit 3 Progress Check: FRQ

Quantity to be Measured	Symbol for Quantity	Equipment for Measurement

ii. Describe an experimental procedure to estimate the acceleration g due to gravity at the surface of Earth using the apparatus. Give enough detail so that another student could replicate the experiment. As needed, include a diagram of the experimental setup. Assume equipment usually found in a school physics laboratory is available.

(c) The student wants to analyze data collected from the experiment by creating a linear graph that can be used to estimate the acceleration g due to gravity at the surface of Earth.

i. State what quantity should be plotted on the horizontal axis and what quantity should be plotted on the vertical axis to produce the linear graph.

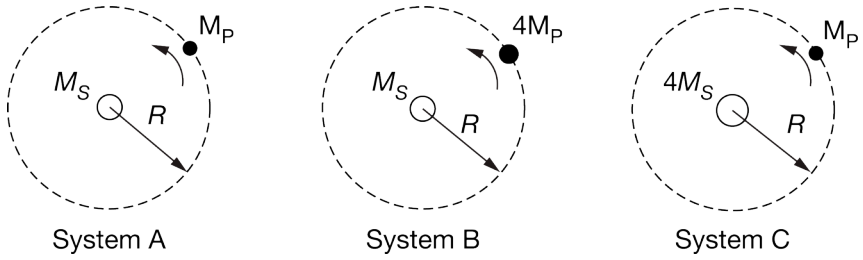
Horizontal axis:_____

Vertical axis:_____

ii. Indicate which feature of the graph could be used to determine g.

Unit 3 Progress Check: FRQ

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



Three different planet-star systems, which are far apart from one another, are shown above. The masses of the planets are much less than the masses of the stars.

In System A, Planet A of mass M_p orbits Star A of mass M_s in a circular orbit of radius R.

In System B, Planet B of mass $4M_p$ orbits Star B of mass M_s in a circular orbit of radius R.

In System C, Planet C of mass M_p orbits Star C of mass $4M_s$ in a circular orbit of radius R.

(a) The gravitational force exerted on Planet A by Star A has a magnitude of F_0. Determine the magnitudes of the gravitational forces exerted in System B and System C.

___ Magnitude of gravitational force exerted on Planet B by Star B

___ Magnitude of gravitational force exerted on Planet C by Star C

(b) How do the tangential speeds of planets B and C compare to that of Planet A? In a clear, coherent paragraph-length response that may also contain equations and/or drawings, provide claims about

why the tangential speed of Planet B is either greater than, less than, or the same as that of Planet A, and
why the tangential speed of Planet C is either greater than, less than, or the same as that of Planet A.