

NAME _____

DATE _____

Scenario

Consider a class of physics students in a three-story schoolroom with a high ceiling. (The ceiling is high enough to be the ceiling of the third floor.) The teacher connects a long rope to the ceiling. The free end of the rope is connected to a heavy ball that almost touches the floor when the rope is vertical, creating a very large-scale pendulum where the ball travels almost completely in the horizontal direction. The teacher pulls the heavy ball a small distance to the side and releases it so that it oscillates with a certain period, amplitude, and average speed. The teacher then repeats the demonstration but releases the ball from a greater displacement than before. The teacher asks the students to think about how the period, amplitude, and average speed will change for this greater displacement.

Carlos and Angela agree that the amplitude will be greater but disagree on other points. They reason as follows:

Angela: “The period will be greater because the distance the ball must travel in one cycle depends on the amplitude. A greater amplitude means a greater distance, which means it takes a longer time to complete one cycle.”

Carlos: “The period should be shorter because the ball will have a greater average speed as it cycles. A greater average speed would mean that it takes less time to complete a full cycle.”

Quantitative Analysis

PART A: Suppose that A represents the amplitude, the distance that the ball travels from equilibrium to one endpoint of its oscillation, and T represents the period of the oscillation. Write an equation for v_{avg} , the average speed (in terms of the amplitude A and period T) of the ball as it oscillates.

i. Explain how this equation shows support for Angela’s reasoning.

ii. Explain how this equation shows support for Carlos’s reasoning.

Argumentation

PART B: Carlos is correct that a greater amplitude of oscillation will result in a greater average speed.

- i. Explain why this is the case, reasoning in terms of the forces exerted on the ball as it oscillates.

- ii. Explain again, this time reasoning in terms of the mechanical energy of the ball-Earth system.

PART C: Give a correct prediction about whether the period increases, decreases, or remains the same as amplitude increases, assuming that the pendulum undergoes small-angle oscillations in both cases. Use one student's explanation or synthesize the two explanations to justify your claim.

Period will: _____ Increase _____ Decrease _____ Remain the same
