PENDULUM OSCILLATIONS: BETTER CHOICE?

One of the ever-popular favourites in the playground is the child swing. Kids love to ride the swings at the playground. Given the following situation: Ann (20kg) and Tom (30kg argue in front of two child swings (Length 2.4m and 2.5m), who is able to swing faster. Ann worries about her less weight and wants to take the longer swing. Tom agrees assuming that his much greater weight will easily outplay the difference of 10cm according to the length of the two swings.

What is your advice for Tom?

Before going on, write down your prediction, explain your reasoning and how you could design an experiment to give an appropriate advice to Tom!

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A. Preparation

1) Make a pendulum by tying a 100-cm string to a mass. Hold the string in your hand, let the mass swing and find out the time needed for one oscillation by only observing with your eyes.
2) Try a different mass on your string. Does the period seem to depend on mass? Discuss the question in your group.
3) Does the period seem to depend on the length of the string or the amplitude?

   Describe what parameters seem to influence the period of the oscillation:

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B. Observation of an experiment

Preliminary experiments:

1) Attach the string to a horizontal rod fixed to a stand and adjust the motion sensor to collect data on distance as a function of time for the swinging pendulum.
2) Make a sketch for the motion of the pendulum imagining the situation after having the pendulum started.

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3) Then initiate pendulum oscillations starting with a rather small angle, for example, approximately 10° and test your prediction.

By looking at the graph on the screen, describe what you did right and what was wrong:

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C. Modeling the situation in the laboratory

1) Analyze the scatter plot of distance vs. time and determine the period of oscillations from the graph.

Describe how you determined the period of oscillations:

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2) Repeat the data-collection for initial angles of approximately 15 and 20 degrees and explore the effect of the initial angle on the pendulum period.

Complete the following sentence:

The initial angle seems to have ……

3) Discuss with your group members, which factors basically could influence the period of the pendulum and the velocity of the mass.

Write down the results of your discussion:

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4) Conduct appropriate controlled experiments which enable you to make final conclusions according to the question which factors affect in what way the period of pendulum oscillations.

Complete the following sentence:

The following factors influence the period of the pendulum oscillations: ……

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5) Extension 1: Further you are supposed to develop a mathematical model for the period of oscillations using your experimental data.

6) Extension 2: Finally, you should be able to verify the mathematical model and derive a final equation for the period of the pendulum.

D. Evaluating the data obtained

1) Based on your data and observations, what can you conclude about the effect of the initial angle on the pendulum period? Do these results agree with your prediction? If not, describe any errors in your reasoning.

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2) Based on your data and observations, what can you conclude about the effect of the pendulum mass on its period? Do these results agree with your prediction? If not, describe any errors in your reasoning.

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3) Based on your data and observations, what can you conclude about the effect of the length of the pendulum on its period? Do these results agree with your prediction? If not, describe any errors in your reasoning.

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4) Plot a graph of pendulum period T vs. length l. Scale each axis from the origin (0, 0). Does the period appear to depend on the length of the pendulum? Do you have enough data to answer this conclusively?

5) Examine more carefully how the period T depends on the pendulum length l, and create two additional graphs of the same data: T^2 vs. length l and T vs. l^2. Which plot is most nearly a straight line that goes through the origin?

6) Does one of your graphs support the relationship $T = 2\pi \cdot \sqrt{\frac{l}{g}}$ or $T^2 = \left(\frac{4\pi^2}{g}\right) \cdot l$? If yes, determine a value for g from your experimental data.

E. Show your results

1) Thinking about your observations, discuss the correctness of the following statements:

   a) The mass dependence on the pendulum period is so small that it cannot be easily observed.

   b) If the length of the pendulum is increased there are more oscillations per second. Therefore, the velocity increases proportional to the length of the pendulum.

   c) The acceleration is zero when the mass is at the reversal points of the oscillation.

   a) ……

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   b) ……

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   c) ……

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2) Given what you observed in this experiment, write a set of rules for constructing a pendulum clock that is reliable under a variety of temperatures.

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Write general conclusions

Returning to the main question of this activity:

What should Tom do? Explain your advice for Tom! ……..

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Questions

a) It was easy for our group to design our own experiment and find an appropriate solution to the given task. Tick a number 1, 2, 3, 4 or 5 (1: strongly agree 5: strongly disagree)

Please explain your answer……

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b) The guidance in the worksheet helped us to perform the experiment and analyze the data in order to understand the physics behind and apply physics concepts to everyday life situations. Please, tick a number 1, 2, 3, 4 or 5 (1: strongly agree 5: strongly disagree) and explain your answer:

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