

PENDULUM PATTERNS

Performance Standard 12D/11B/13A/13 B.D

Students will apply the processes of technological design to explore the periodic motion of pendulums accordingly:

- *Knowledge*: Know the principles and variables in the motion of a simple pendulum.
- *Application*: Design a way to investigate the variables associated with the energy of a pendulum.
- *Communication*: Explain the conclusions from the class pendulum investigations in terms of each variable.

Procedures

1. ***In order to know and apply the concepts that describe (force and) motion and the principles that explain them (12D), the concepts, principles and processes of technological design (11B) and apply scientific habits of mind (13A) and apply scientific technologies (13B),*** students should experience sufficient learning opportunities to develop the following:
 - Brainstorm the design dilemma associated with which variables matter to pendulums and how long it takes to complete a ‘period’ (one swing back and forth).
 - Determine procedural sequence, success criteria and design options to test the choices of variables associated with the periodic motion of a pendulum.
 - Collect, display and analyze data from investigation,
 - Communicate the findings to explain the variables and the only one that matters.
 - Generate possible alternative designs for testing their pendulums again.

Note to teacher: This activity relates to knowledge associated with standard 12D, while addressing the performance descriptors for stage D within standard 11B. Applying scientific habits of mind in standard 13A are foundational. Using various technologies to estimate, measure and record data address some performance descriptors in 13B.
2. Have students review and discuss the assessment task and how the rubric will be used to evaluate their work.
3. Introduce multiple examples of pendulums, each with different lengths or kinds of suspending ‘string’, weights and kinds of ‘bobs’, height or reasonable force for release of ‘bob’, etc. Offer sufficient time for testing the different pendulums with timers. This may be accomplished as a classroom demonstration or small group testing if time permits. Ask students to brainstorm the kinds of variables that are associated with the energy of the pendulum. The technological design dilemma questions how to test the variables in a pendulum. Assign groups to test the variables, such as only varying:
 - The mass of the bob: Attach 1, 2, 3, 4 or 5 washers at assigned string lengths,
 - The force of release: Gentle to medium to high (but reasonable) force, and
 - The length of the suspending string: Strings with knots at 10 cm intervals so that students will know where to attach their weights.
4. The role of time in this investigation is very important. Careful timing of a period will be very important to the success of the investigation. Because of reflex time, it may be more appropriate to time several complete periods so that data can be more accurately recorded. If their mathematical skills are appropriate, they can time the completion of three or more complete periods of pendulum swings and average the time for one period. They should conduct at least three trials with each variation of their single variable (e.g., three tests for 10 cm string, three tests for 20 cm string, three tests for 30 cm string, etc.).
5. Students must record the appropriate data for their assigned variable on the provided tables. It is important to emphasize that students should record their data accurately. Students will need to plot their data from their table on a line graph. Encourage the students to determine a ‘best-fit’ line. Generalize the results of all of the investigations and the final line graphs. (The only variable that alters the period of a pendulum is the length of the string.)
6. Evaluate each student’s work using the Science Rubric as follows and add the scores to determine the performance level:
 - *Knowledge*: The identification of the possible variables affecting pendulum motion were accurate.
 - *Application*: The procedures for investigating assigned variables were well-executed.
 - *Communication*: The investigation’s conclusions about each variable were well-reasoned and accurate.

Examples of Student Work not available

Time Requirements

- 15-20 minutes to introduce the pendulum parameters; 10 minutes for preparation for investigation; 15 minutes for testing variables; 20 minutes for data analysis; 15 minutes for class discussion of final graphs and analysis.

Resources

- String, metal washers
- Stop watches
- Device to suspend pendulum for free motion
- Copies of Pendulum data tables
- Science Rubric

TABLE SAMPLER FOR PENDULUM

If we change the variable for the length of the pendulum:

- We must keep the weight the same every time.
- We must release the weight from the same height every time.
- We must release the weight with the same force every time.
- We must test each length three times and record the time for three periods.

Trial	Length	Weight	Height	Force	TIME
#1	40 cm	5 washers	high	easy	
#2	40 cm	5 washers	high	easy	
#3	40 cm	5 washers	high	easy	

Find the average time for a period: _____

#1	60 cm	5 washers	high	easy	
#2	60 cm	5 washers	high	easy	
#3	60 cm	5 washers	high	easy	

Find the average time for a period: _____

#1	80 cm	5 washers	high	easy	
#2	80 cm	5 washers	high	easy	
#3	80 cm	5 washers	high	easy	

Find the average time for a period: _____

Now create a practice line graph which compares the length of the pendulum to the averaged time of its period

Special note: Tie your pendulum securely to its support. Measure out the length of the pendulum carefully for each set of trials. You can try different lengths, if you choose, but conduct multiple trials at each length.

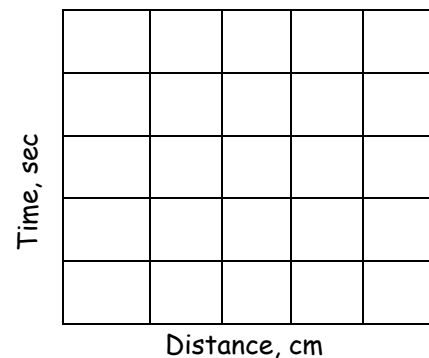


TABLE SAMPLER FOR PENDULUM

If we change the variable for the weight of the bobs:

- We must keep the length of the pendulum the same every time.
- We must release the weight from the same height every time.
- We must release the weight with the same force every time.
- We must test each weight three times and record the time for three periods.

Trial	Length	Weight	Height	Force	TIME
#1	60 cm	2 washers	high	easy	
#2	60 cm	2 washers	high	easy	
#3	60 cm	2 washers	high	easy	

Find the average time for a period: _____

#1	60 cm	3 washers	high	easy	
#2	60 cm	3 washers	high	easy	
#3	60 cm	3 washers	high	easy	

Find the average time for a period: _____

#1	60 cm	5 washers	high	easy	
#2	60 cm	5 washers	high	easy	
#3	60 cm	5 washers	high	easy	

Find the average time for a period: _____

Now create a practice line graph which compares the weight of the bob to the averaged time of its period

Special note: You must secure your washers to your pendulum string securely. Remember that you will need to remove the washers at the end of the investigation. You can use a different length than the 60 cm suggestion, but you must use the same length in every trial.

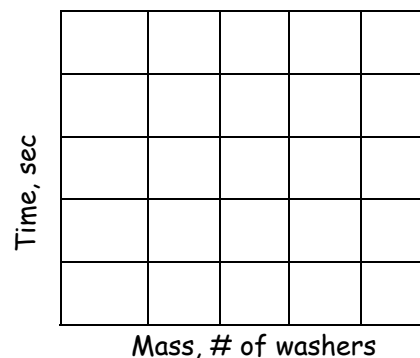


TABLE SAMPLER FOR PENDULUM

If we change the variable for the height of the release of the bob:

- We must keep the weight the same every time.
- We must keep the length of the pendulum the same every time.
- We must release the weight with the same force every time.
- We must test each release height three times and record the time for three periods.

Trial	Length	Weight	Height	Force	TIME
#1	60 cm	5 washers	high	easy	
#2	60 cm	5 washers	high	easy	
#3	60 cm	5 washers	high	easy	

Find the average time for a period: _____

#1	60 cm	5 washers	medium	easy	
#2	60 cm	5 washers	medium	easy	
#3	60 cm	5 washers	medium	easy	

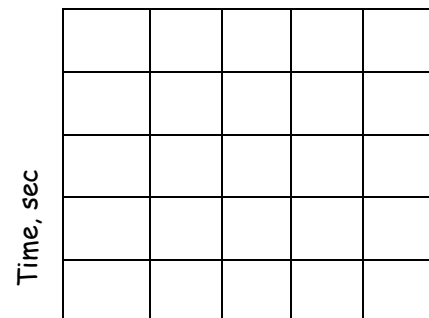
Find the average time for a period: _____

#1	60 cm	5 washers	low	easy	
#2	60 cm	5 washers	low	easy	
#3	60 cm	5 washers	low	easy	

Find the average time for a period: _____

Now create a practice line graph which compares the height of the release to the averaged time of its period

Special note: You must decide how to make sure that you release the bob from the same height each time. You could use a ruler to guide you for your high, medium and low heights. You could record the height for release on your table, instead of high, medium and low.



Height of release
(low, medium, high)

TABLE SAMPLER FOR PENDULUM

If we change the variable for the force of the release of the bob:

- We must keep the weight the same every time.
- We must release the weight from the same height every time.
- We must keep the length of the pendulum the same every time.
- We must test each length three times and record the time for three periods.

Trial	Length	Weight	Height	Force	TIME
#1	60 cm	5 washers	high	easy	
#2	60 cm	5 washers	high	easy	
#3	60 cm	5 washers	high	easy	

Find the average time for a period: _____

#1	60 cm	5 washers	high	medium	
#2	60 cm	5 washers	high	medium	
#3	60 cm	5 washers	high	medium	

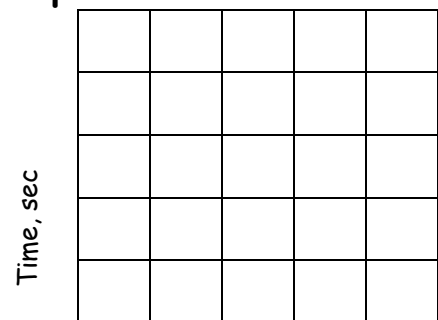
Find the average time for a period: _____

#1	60 cm	5 washers	high	strong	
#2	60 cm	5 washers	high	strong	
#3	60 cm	5 washers	high	strong	

Find the average time for a period: _____

Now create a practice line graph which compares the force of the release of the bob to the averaged time of its period

Special note: You must decide how to keep the force for your release the same for each set of your trials. Try to push the bob weakly the first trial and then a little more strongly the second trial and then more strongly for the last trial. Don't make the bob wrap around!



Force of release
(easy, medium, strong)