LES 16

O B S E R V A T O R Y
ENVIRONMENTAL SCIENCE AND TECHNOLOGY (EST)
Teacher's guide A
Second Year of Secondary Cycle Two

AT TOP SPEED

STUDENT LOG

WORKING DOCUMENTS

EVALUATION DOCUMENTS

PROCEDURE AND EVALUATION: SSC1 – SCIENCE

Observatory / Guide
11129-A

Name: _____ Group: _____ EST

The problem to solve

ENVIRONMENTALLY FRIENDLY ROLLER COASTERS

Competition sponsored by *Young scientists*

When designing roller coasters, several factors must be considered. One of these factors is the loss of energy due to friction. A designer must take this loss of energy into account for the train to be able to climb to the top of every hill in the track.

***Young scientists* magazine is hosting a competition. This is the challenge:**

You must design a model for a roller coaster,

using a marble (the train) and a 3.6-m length

of foam pipe insulation cut in half lengthwise (the track).

The roller coaster must use potential and kinetic energy

as efficiently as possible.

The competition is divided into three parts; details are available on request.

In this context, you will prepare for the competition by completing the first two parts (described on the next page).

The problem to solve (*continued*)

Environmentally friendly roller coasters

A competition in three parts

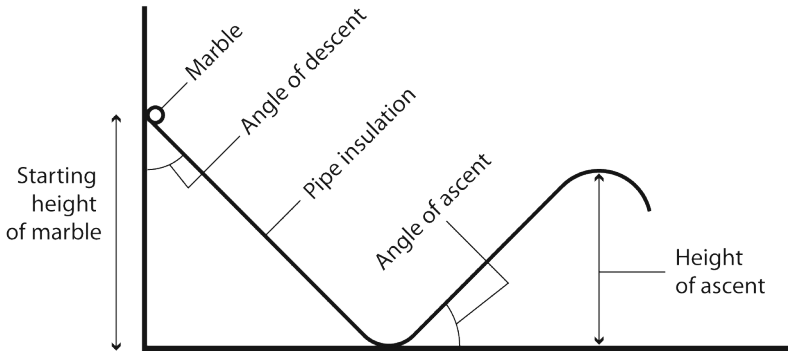
1. Each team will present a written report of the trials carried out to determine the energy lost to friction on every ascent of a roller coaster. To conduct these trials, the teams will use a 1.8-m length of foam pipe insulation. In their trials, they will vary two of the following parameters:

- the height of the starting point
- the mass of the marble
- the angle of descent
- the angle of ascent

The report must include the following information:

- the percentage of energy lost
- the force of friction
- the work done on the marble during the descent
- the maximum speed of the marble

Example of a setup for the trials (part 1)



2. Based on the results of these tests, each team will then draw a sketch of their model roller coaster or model its shape with fine electrical wire or string. The sketch must be accompanied by the following information:

- the energy of the marble at the starting point
- the maximum speed of the marble
- the work done on the marble during the first descent
- the minimum force needed to bring the marble back to its starting point

The team will also have to justify the configuration of the roller coaster (heights of the starting point and the ascents).

3. Each team will then build its model and present it on the day of the competition. During the presentation, the marble will have to run the entire length of the track as fast as possible, without stopping or deviating from its path. Each team will be allowed one trial run and three test runs.

Name: _____ Group: _____ EST

Creating the context

I ask myself questions

1. What is energy?

2. What is kinetic energy?

3. What mathematical formula is used to calculate the kinetic energy of an object? Identify each of the variables and its unit of measurement.

4. What is gravitational potential energy?

5. What mathematical formula is used to calculate the gravitational potential energy of an object? Identify each of the variables and its unit of measurement.

6. What is the relationship between kinetic and potential energy?

Creating the context (*continued*)

7. What mathematical formula is used to express the relationship between kinetic and potential energy? Identify each of the variables and its unit of measurement.

8. In a system without friction, what happens to mechanical energy?

9. On a roller coaster, where do cars have the maximum kinetic energy?

10. On a roller coaster, where do cars have the maximum potential energy?

11. What are the differences between mass and weight? Explain your answer.

12. What is a force?

13. What is the effective force?

14. What is the force that sets the cars in motion at the beginning of a roller coaster?

Creating the context (*continued*)

15. What mathematical formula is used to calculate gravitational force? Identify each of the variables and its unit of measurement.

16. When do we consider that work has been done?

17. What mathematical formula is used to express the relationship between work, force and travel? Identify each of the variables and its unit of measurement.

18. What mathematical formula is used to express the relationship between work and energy? Identify each of the variables and its unit of measurement.

19. Which parameters will you vary in your trials? Choose two.

Creating the context (*continued*)

20. What calculations will you perform to obtain the required information?

Calculating the percentage of energy lost

Calculating the force of friction

Calculating the work done on the marble during the descent

Calculating the maximum speed of the marble

Calculating the minimum force needed to return the marble to its starting point

Creating the context (*continued*)

I must

21. Reformulate the goal of the problem-solving activity.

22. What are the independent variables in your trials?

23. What are the dependent variables in your trials?

I think

24. What will you have to measure to perform your calculations?

25. What results do you expect to see? Formulate a hypothesis in qualitative terms and justify it.

Reflection

	Yes	No
Do I fully understand the scientific concepts covered in this situation?	☐	☐

Name: _____ Group: _____ EST

Planning the problem solving

I plan

1. Make a list of the materials you will need to conduct the experiment.

- _____
- _____
- _____
- _____
- _____
- _____
- _____
- _____
- _____
- _____

2. Draw a diagram of the setup for your trials, showing how you will conduct them in accordance with the parameters you have chosen. Indicate the various measurements.

Planning the problem solving (*continued*)

3. Write out the protocol for the trials. Remember to take your parameters into account.

4. Prepare the tables for recording the results for each of your parameters. Be sure to include all the data you will need for your calculations (see pages 6–7 if necessary). Remember to give each table a title.

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Planning the problem solving (*continued*)

4. *(continued)*

Reflection

	Yes	No
Have I considered other approaches to conducting my trials?	☐	☐

Initiating the problem solving

I experiment

1. Conduct the experiment and record your observations in the tables you have prepared.

2. For each of the test setups, calculate the percentage of energy lost, the force of friction, the work done on the marble during the descent, and the maximum speed of the marble.

First setup:

Calculating the percentage of energy lost

Calculating the force of friction

Calculating the work done on the marble during the descent

Calculating the maximum speed of the marble

Initiating the problem solving (*continued*)

Second setup:

Calculating the percentage of energy lost

Calculating the force of friction

Calculating the work done on the marble during the descent

Calculating the maximum speed of the marble

Name: _____ Group: _____ EST

Initiating the problem solving (*continued*)

Third setup:

_____

Calculating the percentage of energy lost

Calculating the force of friction

Calculating the work done on the marble during the descent

Calculating the maximum speed of the marble

3. Did you alter your plan of action during the experiment? If so, explain your answer.

_____

_____

_____

_____

_____

Reflection

	Yes	No
Did I record and justify each of the changes I made to my plan of action?	☐	☐

Name: _____ Group: _____ EST

Analyzing results and drawing conclusions

I analyze my results

1. Did you observe the same energy loss in each trial? Explain your answer.

2. What about the force of friction for each of the variables? Explain your results.

3. Is there a connection between the loss of energy and the force of friction?

4. What are the possible sources of error in your experiment? Suggest a way to eliminate them.

Analyzing results and drawing conclusions (*continued*)

I draw my conclusions

5. Make a sketch of your roller coaster on the graph paper on page 17, taking into account the results of your trials. Instead of a sketch, you could also use a piece of string or fine electrical wire to illustrate the roller coaster. Complete the requested information and justifications on the following pages.

Justifying the starting height

Calculating the energy of the marble at the starting point

Calculating and justifying the height of the first ascent
(Remember to take into account the energy lost to friction.)

Calculating and justifying the height of the second ascent *(if applicable)*

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Analyzing results and drawing conclusions (*continued*)

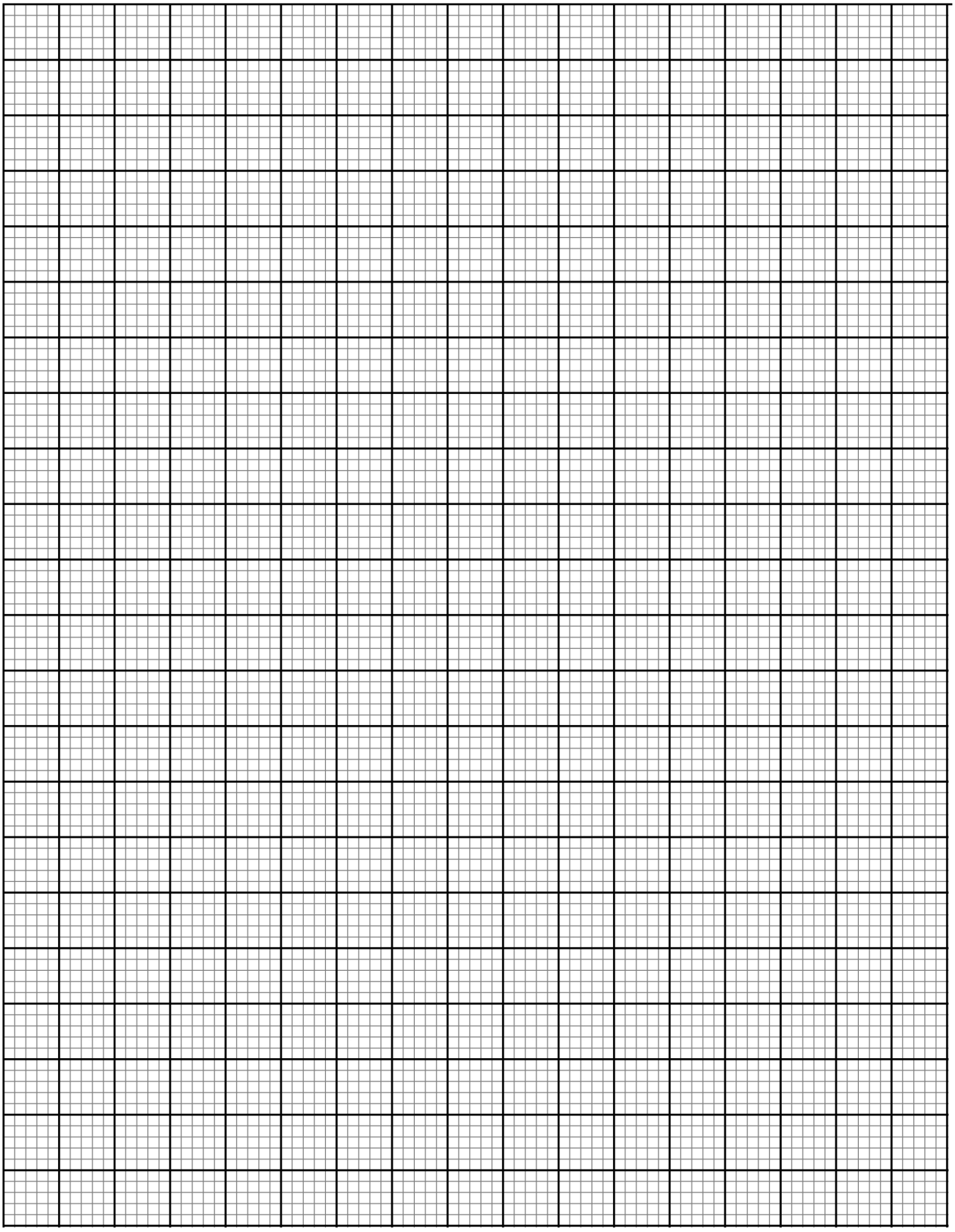
Calculating and justifying the height of the third ascent *(if applicable)*

Calculating the work done on the marble during the first descent
(For this calculation, measure the distance travelled during the descent on your sketch.)

Calculating the maximum speed of the marble

Calculating the minimum force required to return the marble to its starting point

Name: _____ Group: _____ EST



Name: _____ Group: _____ EST

My evaluation

Use the evaluation grid on the following page to evaluate yourself. Write A, B, C, D or E in the "Me" column of the chart below.

SSC1—Seeks answers or solutions to scientific or technological problems				
Criteria*	**Observable indicators**	**Me**	**Teacher**	**Comments**
1	**Creating the context** Definition of the goal and formulation of the hypothesis		☐ With help	
2	**Planning the problem solving** Relevance of the elements of the plan of action: materials, diagram of the setup, and procedure		☐ With help	
3	**Initiating the problem solving** Accuracy of the results and calculations		☐ With help	
4	**Analyzing results and drawing conclusions** Analysis of the results and conclusion (sketch)		☐ With help	

*** Evaluation criteria**

1 Appropriate representation of the situation
2 Development of a suitable plan of action for the situation
3 Appropriate implementation of the plan of action
4 Development of relevant conclusions, explanations or solutions

Evaluation grid

Name: _____ Group: _____

EST

SSC1 Seeks answers or solutions to scientific or technological problems

Criteria*	Observable indicators	A	B	C	D	E
1	**Creating the context** Definition of the goal and formulation of the hypothesis	The goal and hypothesis are very clearly defined and relevant to the problem to be solved.	The goal and hypothesis are clearly defined and relevant to the problem to be solved.	The goal and hypothesis are not very clearly defined OR are irrelevant to the problem to be solved.	The goal and hypothesis are not very clearly defined AND are irrelevant to the problem to be solved.	The work must be done again.
2	**Planning the problem solving** Relevance of the elements of the plan of action: materials, diagram of the setup, and procedure	The list of materials is complete. The diagram of the setup is relevant. The procedure is very clearly formulated and relevant.	The list of materials is almost complete. The diagram of the setup is relevant. The procedure is clearly formulated and relevant.	Several items are missing from the list of materials. The diagram of the setup is not very relevant, OR the procedure is not very clearly formulated, nor very relevant.	Several items are missing from the list of materials. The diagram of the setup is not very relevant, AND the procedure is poorly formulated or irrelevant.	The work must be done again.
3	**Initiating the problem solving** Accuracy of the results and calculations	All of the results are accurately recorded and relevant. All the calculations have been performed correctly.	Most of the results are accurately recorded and relevant, OR the calculations contain a few minor errors.	Some of the results are accurately recorded and relevant, OR the calculations contain many errors.	The results are not accurately recorded and are irrelevant, AND the calculations contain many errors.	The work must be done again.
4	**Analyzing results and drawing conclusions** Analysis of the results and conclusion (sketch)	The analysis of the results is relevant to the goal of the problem solving. The conclusion takes into account the results of the calculations and includes all the requested information.	The analysis of the results is relevant to the goal of the problem solving. The conclusion takes into account the results of the calculations and includes all the requested information but contains a few minor errors.	The analysis of the results is not very relevant to the goal of the problem solving, OR the conclusion takes only partial account of the results of the calculations.	The analysis of the results is not very relevant to the goal of the problem solving, AND the conclusion takes only partial account of the results of the calculations.	The work must be done again.

*** Evaluation criteria**

1 Appropriate representation of the situation
2 Development of a suitable plan of action for the situation
3 Appropriate implementation of the plan of action
4 Development of relevant conclusions, explanations or solutions