MAROOCHYDORE
Excellence in Education for All
STATE HIGH SCHOOL

Year 8 Science Assessment Cover Sheet - TREBUCHET — Term 4 2016

Student Name			
Year Level	Year 8	**Handout Date** (Week Beginning)	
Class	**SCI082D**	**Interim Check Date** (Week Beginning)	
Teacher	TURNGA	**Rough Draft Date** (Week Beginning)	
Unit Name	**Energy**	**Due Date** (Week Beginning)	

Task	**Trebuchet - construction, operation, and analysis of efficiency**			
Assessment Technique	Assignment			
Assessment conditions	**Summative.** Students will have 3 weeks in class to work on their assignment. Students must complete the details on this cover sheet and sign to verify authenticity of their work. Students must submit a draft on the due date and the final completed copy handed in on the due date.			
Specific Assessment requirements	**Literacy** Medium	**Numeracy** Medium	**ICTs** Medium	Other

Criteria Assessable content descriptors	**Grade**
Science Inquiry Skills (SI) **1. Planning and Conducting** a) working collaboratively to decide how to best approach an investigation b) taking into consideration all aspects of fair testing, available equipment and safe investigation when planning investigations c) identifying and explaining the differences between controlled, dependent and independent variables **2. Processing and analysing data and information** a) Construct and use tables and graphs to represent and analyse patterns or relationships in data b) Summarise data from students' own investigations and use scientific understanding to identify relationships and draw conclusions based on evidence **3. Evaluating** a) Reflect on scientific investigations including evaluating the quality of the data collected, and identifying improvements b) Use scientific knowledge and findings from investigations to evaluate claims based on evidence **4. Communicating** Communicate ideas, findings and evidence based solutions to problems using scientific language and representations, using digital technologies as appropriate	

Score	**/57**	**A**	**B**	**C**	**D**	**E**
		$A^+ \geq 53$ A ≥49 $A^- \geq 45½$	$B^+ \geq 43$ B ≥40 $B^- \geq 37$	$C^+ \geq 34$ C≥28½ $C^- \geq 25½$	$D^+ \geq 23$ D ≥17 $D^- \geq 14$	$E^+ \geq 11$ E ≥5½ $E^- < 5½$

Differentiation – Adjusted Assessment Conditions

☐Assignment broken into stages	☐Collaborative effort	☐Extension	☐Length of task/time altered
☐Teacher/Aide assistance	☐Assessment method altered	☐Task simplified	☐Use of reader/scribe
☐Print/Diagrams enlarged	☐Use of technology	☐Other	

Acknowledgement of assessment responsibility

I understand what I need to do for this assessment.

I understand the consequences of plagiarism/cheating and confirm this is my own work.

Student Signature:

……

Date: ……

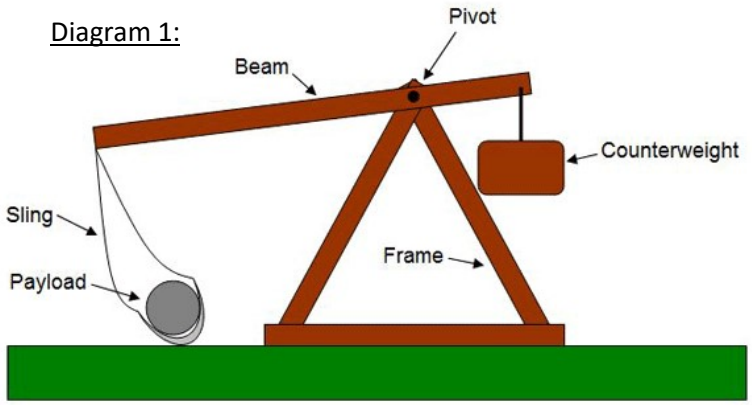
TREBUCHET- An investigation into Efficiency

Extended Experimental Investigation

READ THIS BEFORE YOU START **Guide to understanding this Assignment**	Students will be expected to : • Transfer plans for a desktop sized trebuchet to a piece of 7 mm plywood • Use wood glue and a screwdriver to construct the trebuchet to teacher specification (painting and decoration optional) • Use the trebuchet to propel a weight (or figurine of student choice) some distance through the air. • In PART 1…determine the most efficient length for the sling of the trebuchet. Calculate the efficiency for the trebuchet at this point. • In PART 2 … investigate the effect of altering either the swing arm length or the mass on the efficiency of the trebuchet. In addition students will be expected to complete this booklet and submit it for a grade. Each part of the booklet is given a mark which indicates how much that section contributes to the overall grade. No marks are allocated to actually building the trebuchet. Some sections of the booklet are considered more difficult or complex work. These sections will be clearly marked with "A/B section". Completing these sections is the only way a student can receive a grade higher than a C+.
Investigation Question **<u>Choose one</u> of these to investigate, tick the box**	☐ How does changing the mass of the counterweight affect the efficiency of the trebuchet? ☐ How does changing the swing arm length affect the efficiency of the trebuchet?
A/B Section **Introduction** The introduction has **three main parts**. All three parts are described below in the help section (left column), but only the first two are written for your report. You must complete the third part of the introduction. **1st Part** This paragraph provides a context for the investigation. It explains why this science is important in a "big picture" sense and explains some of	## Introduction: A trebuchet is a siege engine that was invented in the Middle Ages either to smash masonry walls or to throw projectiles over them. Large (5 metre high) trebuchets are capable of throwing projectiles with a mass of hundreds of kilos. While such weapons were expensive to build they were invaluable in the 12^{th} to 15^{th} centuries for armies laying siege to heavily fortified castles. The simplest trebuchet is basically a throwing arm (called a beam) pivoted on a fulcrum. On the shorter end of the beam, there is a raised counterweight (either fixed or hanging), which releases its potential energy when it falls and lifts the sling attached to the other end of the beam. The projectile in the sling is accelerated by being lifted and released at an angle to fly out in front of the trebuchet. A simplified diagram of the trebuchet is shown in diagram 1.

the real life implications. This part is covered in the first 4 paragraphs.

Diagram 1:



The trebuchet still represents an important physics problem that has affected human life day in and day out for thousands of years. The motion of the trebuchet duplicates human throwing, chopping, digging, cultivating, and reaping motions. This means in the modern world the non-linear movement of a trebuchet offers an excellent analogy for swing actions in sports such as baseball, golf, and tennis.

These sports have millions, perhaps billions of dollars invested in the pursuit of efficiency of action. Physicists using the analysis of trebuchet motion have made important contributions to the understanding of the physics of these sports.

The physics of trebuchet motion is very complex – due primarily to the initial linear and then circular acceleration of the projectile. However one aspect of the trebuchet which is relatively simple to investigate is its efficiency. The efficiency of the trebuchet is merely a comparison of the potential energy put into the trebuchet (as the counterweight falls) and the kinetic energy which comes out in the projectile (when it is released).

Determining the Potential energy put in as the counter weight falls is calculated using the equation for Gravitational Potential Energy:

$$\boldsymbol{GPE}\ (in\ joules) = mass\ of\ \boldsymbol{c}ounterweight\ (kg)\ \times gravity \times\ distance\ of\ fall\ (m)$$

$$\boldsymbol{GPE}\ (in\ joules) = mass\ of\ \boldsymbol{c}ounterwei\ \ ht\ (kg)\ \times 9.8 \times\ distance\ of\ fall\ (m)$$

2nd Part

Provide an explanation of all of the theory you will use in your investigation. It will list and describe any scientific laws or mathematical formulas being applied.

Some of the wording of this part has changed to make this easier to understand. For more detail go to the part A results table on page 6

Determining the Kinetic Energy of the projectile as it is released is more difficult. It is done in **two mathematical steps**. **First** the velocity of the projectile when it is released is calculated from the formula

$$Velocity\ (in\ metres\ per\ sec) = \sqrt{\left(\frac{d}{t}\right)^2 + (4.9 \times t)^2}$$

Secondly the Kinetic Energy is calculated using this velocity.

$$\boldsymbol{KE}\ (in\ joules)\ =\ ½\ \ x\ \ mass\ of\ projectile\ (kg)\ \ x\ \ velocity^2$$

The efficiency of the trebuchet can then be calculated by dividing the Kinetic Energy (KE) which came out of the trebuchet by the energy put into the trebuchet (the GPE), and converting to a percent value.

$$Efficiency\ (\%) = \frac{KE}{GPE} \times 100$$

3rd Part This should be a general description of how you will do your investigation – that is describe what you will do to answer your Investigation question (you chose this on page 2) front page. Do not list steps, just summarize the process of completing the investigation. • General advice – do not use "you", "us", "we", "they" or other personal pronouns • At the end of your introduction write any website addresses you have used **A/B / 3**	
<u>PART A starts here.</u>	**PART A will be teacher guided and assisted. Make sure you understand how to do this part of the assignment – ask questions if you do not. You will need this understanding for PART B. You will receive less assistance for Part B. Work in groups to complete the experiments, however you must work individually to complete this booklet.**
Aim	**Aim -** To investigate how changing the string length of the pendulum affects the efficiency of the trebuchet
Hypothesis A hypothesis has two sentences – the first is what you expect to happen, the second is why you think it will happen.	**Hypothesis:** The string length will affect the efficiency of the trebuchet, with the most efficient string length being approximately the length of the projectile arm. Too short a string length will not allow the projectile to accelerate enough, and too long a string length will cause the projectile to not be released from the trebuchet.
Method List the materials you will use in your experiment. Read the procedure (next page) to ensure you have all you need (make 2 columns if you need more bullet points) **/2**	**Method:** <u>Materials:</u> • Trebuchet (see diagram 1) • • • •

Draw a neat and reasonably accurate diagram of your trebuchet and label all the main parts.

/3

Diagram 1

What were the **steps in the investigation**?
Write a **numbered list of steps**.
Each step describes something you did in the experiment
You can use either past tense ("the solution was poured" or present tense ("pour the solution") but DO NOT mix tense.
Do not use personal pronouns such as "you", "us", "we", or "they".

Procedure:

1. Arrange the trebuchet as shown in diagram 1
2. Attach the counterweight of 0.150 kilograms
3. Attach the projectile using a string length of 36 cm
4. Draw the projectile back underneath the trebuchet into a firing position.
5. Release the counterweight and time from the moment the projectile is released to the time it hits the ground
6. Measure the distance in metres from the centre of the trebuchet to where the projectile first hit the ground.
7. Repeat steps 3- 6 two more times and calculate an average time and average distance. Record these values in table 2.
8. Repeat steps 3 – 7 for string lengths of 32 cm, 28 cm, 24 cm, 20 cm, and 16 cm.

Independent variable is the one you are changing deliberately.
Dependent variables are done for you.
Controlled variables are those you try to keep the same all the time.

INDEPENDANT VARIABLE: (one only) - string length

DEPENDANT VARIABLE: (one only) - Efficiency

CONTROLLED VARIABLES: (at least 2) – projectile mass, counterweight mass, arm length ratio.

Risk assessment

Fill in the table for the things in your experiment which may be a source of harm. Check with your teacher for some if you are not sure

/3

Risk assessment:

Table 1 – Possible risks in experiment

Source of risk	What amount of harm could it cause? (circle)	Safety precautions taken	If an incident occurred what should I do?
	Minor Significant major		
	Minor Significant major		
	Minor Significant major		

Results

Use the table on the right to collect your primary data.

There is room (rows) to do six different lengths of the projectile string.

All of the subsequent results will depend on the accuracy of your measurements here – so be very careful.

/5

Results

Table 2– Changing string length to measure efficiency.

- Ratio of arm lengths (counterweight arm : projectile arm) = _____(constant)
- Mass of Projectile = _____ kg (constant)
- Mass of counterweight = _____ kg (constant)
- Distance the counterweight falls vertically = _____ metres (constant)

Length of string (cm)	Time projectile was in the air (sec)	distance projectile travelled from centre of trebuchet (metres)	GPE put into trebuchet (Joules)	KE Out of trebuchet (Joules)	Efficiency (%)

on efficiency

For this column calculate the **GPE** input of the trebuchet.

$$GPE = mass\ of\ counterweight\ (kg) \times 9.8 \times distance\ of\ fall\ (m)$$

To calculate the **GPE** (gravitational Potential Energy) you need to use the following three values

- Mass of the counterweight (in kilograms, divide the mass in grams by 1000)
- Gravity (use 9.8 as this represents the acceleration towards the earth due to gravity)
- Distance of fall (this is the vertical fall of the counterweight in metres – divide cm by 100)

When you calculate the GPE it will be the same value for all the string lengths. Write this value in all rows of column 4

For this column calculate the efficiency of the trebuchet using the formula:

$$Efficiency\ (\%) = \frac{KE}{GPE} \times 100$$

Use the KE and GPE values in columns 5 and 4.

Look at all 6 data points carefully. What pattern or "trend" do they make? **trend line** where you th "trend" or "pattern" of points is.

The trend line may be a line, or it may be a curv curve draw it with a sm curve. The trend line dc have to go through all, any of the points.

For this column calculate the **Kinetic Energy** of the projectile as it is released in **two steps**.

First calculate the velocity of the projectile when it is released using the distance (column 3) and time (column 2)

$$Velocity\ (in\ metres\ per\ sec) = \sqrt{\left(\frac{d}{t}\right)^2 + (4.9 \times t)^2}$$

Secondly calculate the Kinetic Energy using.

$$KE\ (in\ joules) = ½\ x\ mass\ of\ projectile\ (kg)\ x\ velocity^2$$

The KE will vary for each string length – depending on distance and time

PART B starts here.	**Work in groups to complete the experiments, however you must work individually to complete this booklet.** **Use your graph to determine which string length is the most efficient to use for the second part of this investigation.** **In the next part of the investigation you will investigate the research question you have chosen earlier.**
Aim **Complete the sentence** on the right. This depends on which research Q you have chosen to investigate **/1**	**Aim** - To investigate how changing the _____ _____ _____
Hypothesis A hypothesis has two sentences – the first is what you expect to happen, the second is why you think it will happen. Write **a hypothesis for the investigation question you have chosen.** **/ 2**	**Hypothesis:** _____ _____ _____ _____ _____ _____
Method Fill in the **list of variables**. **Independent** variable is the one you are changing deliberately. **Dependent variable is the one being changed by the independent variable – that is – the one you are measuring**. **Controlled** variables are those you try to keep the same all the time. **/ 2** List the materials you will use in your experiment. You may use more than the bullet points provided (make two columns if you need to) **/2**	INDEPENDANT VARIABLE: (one only)_____ DEPENDANT VARIABLE: (one only)_____ CONTROLLED VARIABLES: (at least 2) _____ _____ **Method:** <u>Materials:</u> • • • • •

What were the **steps in the investigation**?

Write a **numbered list of steps**.

Each step describes something you did in the experiment

You can use either past tense ("the solution was poured" or present tense ("pour the solution") but DO NOT mix tense.

Do not use personal pronouns such as "you", "us", "we", or "they".

/4

Procedure:

Results

What values do you need to know as being constant – see Part A as an example

Use the table on the right to collect your primary data.

There is room (rows) to do six different values for the independent variable (which is in column 1)

/5

Results

Table 3– Changing _____ to measure efficiency.

-
-
- Mass of Projectile = _____ kg (constant)

	Distance the counterweight falls vertically (m)	Time projectile was in the air (sec)	distance projectile travelled from centre of trebuchet (metres)	GPE put into trebuchet (Joules)	KE Out of trebuchet (Joules)	Efficiency (%)

Draw a scatter graph (crosses for each data point) of:

Efficency (Table 3, column 6) versus whatever your independent variable is (table 3, column 1).

Choose your scale carefully

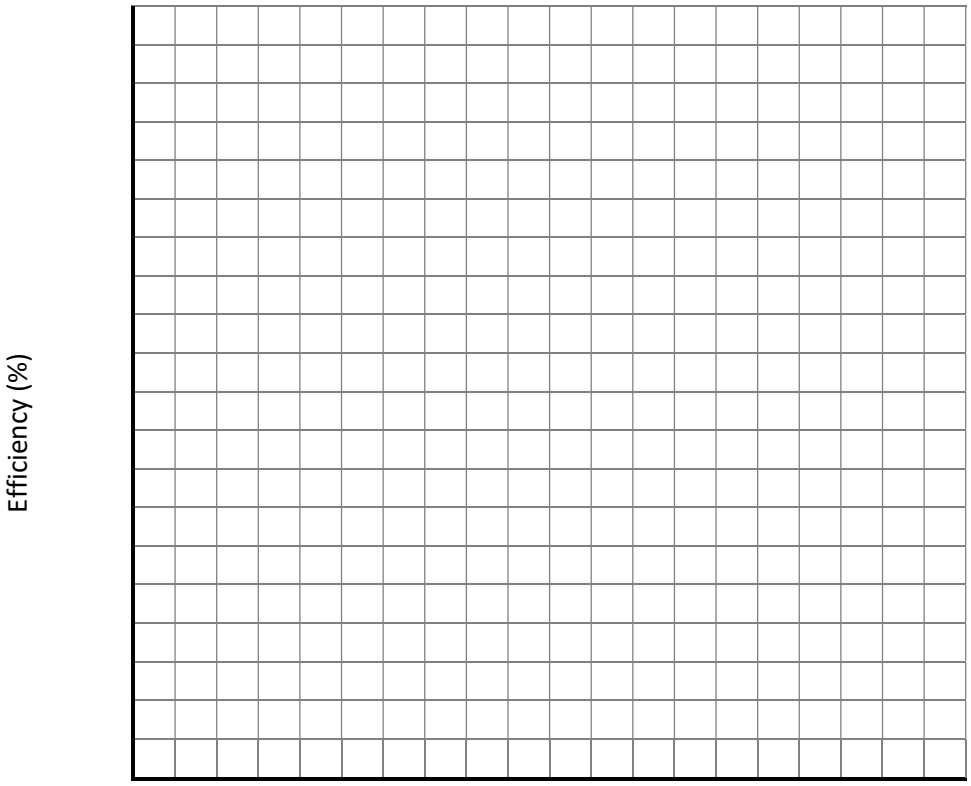
You should have 6 data points (crosses) on your graph

Look at all 6 data points carefully. What pattern or "trend" do they make? **Draw the trend line** where you think the "trend" or "pattern" of the dots is.

The trend line does not have to go through all, or even any of the dots.

/ 4

Graph 2: _____



_____ (___)

A /B Level Section

Think: It is important to show your process clearly to the person marking your work. Be organised, be neat. Use formulas, show substitution of values, show answer with units (3 steps at a minimum)

Questions.
Part A

1. What was the highest efficiency you achieved in part A?_____
2. Which projectile string length caused the highest efficiency? _____ .
3. In the space below show all of the steps and calculations you used to calculate the efficiency at this particular string length?

Think: It is important to refer to your data to explain your answer

4. Reread the hypothesis for Part A (p. 4). Was it correct? Explain using evidence from your results table or graph

5. Looking at graph 1:

5a - Think: How close are the six data points to the trend line?

a) How accurate is your data in this graph? Explain why you think this.

5b - Think: There are three ways to judge errors

Firstly (and most importantly) - Is your answer correct? Compare it with the expected result or your common sense? If it is not correct you probably have error.

Secondly –do the points on your graph make a consistent trend (are the points close to the trend line or a little "scattered"?).The closer the points to the trend line the less likely it is that error has occurred.

Thirdly – Look at the three trials, are the values for each trial reasonably close to the other two trials (all 3 should give the same result)? If the three results are very different to each other then you have error

b) Is there a significant amount of error in Part A of this investigation? Justify your answer.

6. Do you think that the efficiency of the trebuchet is the same as the effectiveness of the trebuchet as a siege engine? Justify your answer

A/B /9

A/B Section
Analysis of <u>PART B</u> results

Have a careful look your results in **<u>Part B</u>** of this investigation. Write and analysis of your **<u>Part B</u>** results. There are 2 main parts to an analysis

1st Part

1st Paragraph - Write a sentence describing the main conclusion you found. Describe data which supports your conclusion (refer to Table 3 or graph 2). Explain the theory behind this conclusion if you can

2nd Paragraph - Write a sentence describing any other conclusion you found. Describe data which supports your conclusion (refer to Table 3 or graph 2). Explain the theory behind this conclusion if you can

Are there any other conclusions or observations about the results you could describe (not errors yet, they come later). If you notice something else, write another paragraph about this.

2nd Part

1st Paragraph - Write a sentence about how much error there is in the Part B results. Then you have to explain why you think this (rest of the paragraph). Judge the error using at least 1 of the 3 methods described on page 10.

2nd Paragraph - State how the error occurred (what caused it). Then make suggestion about how this could have been avoided.

3rd Paragraph - State if the conclusion you made earlier are valid. This will depend on how much error you believe you have. Use the amount of error you have to justify your decision.

DO NOT use personal pronouns such as "you", "us", "we", or "they"

Use the TEEL structure for each paragraph.

T – <u>T</u>opic sentence which is short and simple.

E – <u>E</u>laborate or Explain any complex ideas or complex words you have in your topic sentence

E – provide <u>E</u>vidence to support your topic sentence

L – if possible <u>L</u>ink your topic to the topic in the next paragraph.

A/B /8

Analysis: