Advanced Manufacturing & Prototyping Integrated to Unlock Potential

6TH GRADE MATH

Experimental Design

SOME ASSEMBLY REQUIRED

Packaging Challenge

6EDM

SECTION 1 – PACK THOSE KITS!

1.1 INTRODUCTION

Dr. Ellery Ingall is a Georgia Tech scientist who studies oceanography. One of the places where he conducts his research is in the Antarctic. It takes Dr. Ingall and other scientists ten days cruising aboard the ODEN icebreaker ship to reach this icy destination.

Since it is such a long journey, scientists decorate their lockers, staterooms, and living spaces aboard research ships just like students do, so that it feels like home. Their decorations often include pictures, mirrors, or other items that they hang or bolt onto surfaces, as shown in these images.

Just Like Home is a company that produces kits containing hardware for hanging pictures or other items in lockers or on walls. The standard ***Just Like Home*** *Away from Home Hardware Kit* includes two nut and bolt sets, four plastic anchors, four picture hangers, and a ***Just Like Home*** logo as shown below.

Nut and Bolt Sets

Plastic Anchors

Picture Hangers

Logo

Each type of hardware must be packaged in its own bag, and all of the bags must be placed into a larger bag. Your team has been asked to serve as **industrial engineers**, and to help the company determine the fastest and most consistent way to package these *Away from Home Hardware Kits*. Packaging the kit in the quickest and most efficient manner increases the number of kits that Just Like Home can sell, and helps the company make money.

KEY TERMS

Industrial Engineer: The job of an industrial engineer is to examine every part of the manufacturing system to find ways to make the work easier and more efficient.

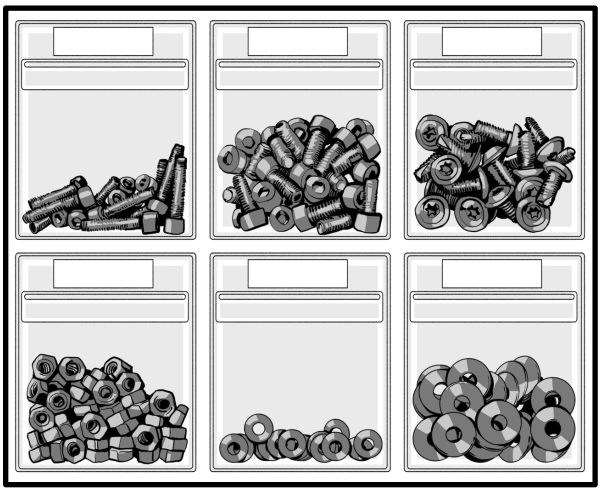
THE CHALLENGE

In this challenge, you will be working as an industrial engineer who is part of the ***Just Like Home*** packaging design team, hired by the ***Just Like Home*** owner, Ms. Casandra Hinkleberry. Your team will investigate different procedures to find the fastest and most consistent packaging process. You will use your findings to recommend the procedure that ***Just Like Home*** should use to package their *Away from Home Hardware Kits*.

PLEASE DO NOT WRITE IN THIS BOOK.

1.2 INVESTIGATE THE CURRENT PACKING PROCEDURE

At the ***Just Like Home*** assembly plant, all the individual parts of the kits, like the bolts and wall hangers, are stored in separate bins on shelves in the storeroom. Employees currently assemble kits individually, with each person pulling pieces out of the bins to put in their kit. Your packaging design team thinks there may be a more efficient way to do this but needs evidence to know for sure. Rather than move everything around in the plant to try a different system, you decide to collect and analyze data using the same procedure as the employees, only you will do it in your classroom.



Your group will receive a detailed procedure that describes the steps to follow so that you package the kits in the same way as ***Just Like Home*** employees currently do, individually. This procedure is called the *Procedure #1 - Individual Assembly of Kits*.

AVAILABLE MATERIALS

- Hardware (Nuts, Bolts, Plastic Anchors, and Picture Hooks)
- ***Just Like Home*** logos
- Small Snack Bags
- Full Kit Sandwich Bags
- *Investigation Sheet #1*
- *Procedure #1—Individual Assembly of Kits* procedure sheet

Procedure:

1. Read through *Procedure #1 - Individual Assembly of Kits* procedure sheet to make sure you understand it. In order for all the packaging design teams in your class to collect good data, it is very important that all groups use exactly the same procedure. Work with your team to organize the materials you are given according to the instructions.
2. Conduct four trials using the *Procedure #1 - Individual Assembly of Kits*. After each trial, count how many completed bags your group packaged in three minutes.
    - Only count completed bags. If a bag is partially packaged, or is not completely sealed and the contents fall out when you turn it upside down, you may not count it as complete.
3. Record the result of each trial on your *Investigation Sheet #1* in the data table, in the *By Your Group* column.

1.3 SHARE AND COMMUNICATE YOUR RESULTS

Procedure:

1. Each group will report to the class the results of their investigation of *Procedure #1–Individual Assembly of Kits*.
2. As each group shares their results, record the numbers in the data table on *Investigation Sheet #1*. The first group to report should be placed in column 1, the second group in column 2, and so on. After the last group reports, you will have a complete set of data for the whole class.
3. Your teacher will record the outcomes on a graph known as a **histogram**, or **line plot**, as shown in Box 1 below. For each result measured during the investigations, your teacher will place an "X" on the graph.
4. You should chart those trials on your copy of the graph at the same time. You will do this by placing an "X" for every data point on Histogram #1 on *Investigation Sheet #1*.

Box 1: Graphing a Histogram

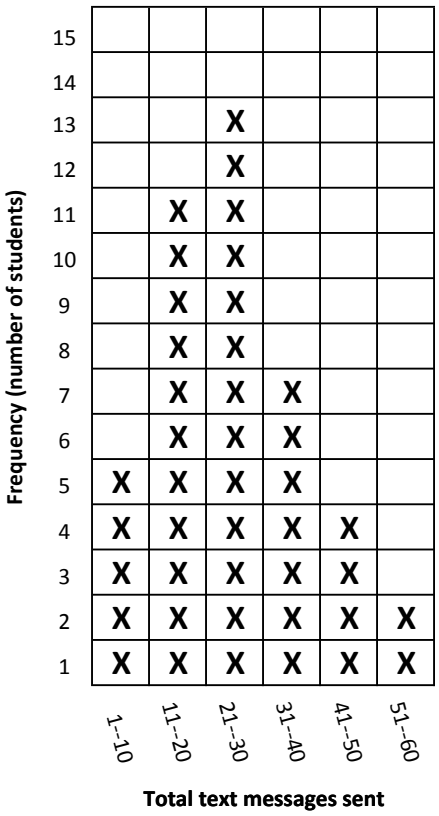
Graphs are a visual way to display data and are valuable because they make trends easier to see. A histogram (sometimes called a *line plot*) is a type of graph that shows the **frequency** (number of times) that a specific outcome occurred.

All graphs should have the following features:

- Title
- Horizontal (or X) axis label and units (if label is a measurement)
- Vertical (or Y) axis label and units (if label is a measurement)

For instance, suppose you wanted to see the number of text messages that the students in your class sent last week. You could count the number of students that sent 0-10 messages, the number of students that sent 11-20 messages, etc. If four students sent 0-10 messages, then the frequency of 0-10 messages is four. A hypothetical graph of these data is on the right. *Total Text messages Sent* is on the horizontal or X-axis and *Frequency (number of students)* is on the vertical or Y-axis.

Figure 1: Text Messages Sent by Students



PLEASE DO NOT WRITE IN THIS BOOK.

1.4 ADD TO YOUR UNDERSTANDING: STATISTICAL MEASURES

Measures of Center

Engineers and scientists analyze and communicate their findings from experiments by summarizing their data and looking for trends or patterns. Data can be analyzed in various ways. One way is to examine the **measures of center**. Measures of center all use a single number to summarize or describe a larger set of data. Each measure is different and tells you a particular thing about the data. We will use these measures to analyze the data about the effectiveness of *Procedure #1– Individual Assembly of Kits* for packaging *Away from Home Hardware Kits*.

The **mean**, the **median**, and the **mode** are three different measures of center that are used to summarize data.

- The **mean** is the arithmetic average of the data. The mean is determined by adding up the numbers and dividing by how many data values you have.
- The **median** is the middle number of an ordered sequence of numbers. If the sequence has an even number of numbers, the median is the average between the middle two numbers.
- The **mode** is the most frequent value. If no number appears more often than the rest, then there is no mode.

The mean, the median, and the mode are sometimes the same, but when they are different, they can tell you interesting things about the data. As we continue with the Packaging Challenge, we will use these measures of center and explore what they can tell us.

Measures of Spread

Scientists and engineers also analyze their data by describing how much it varies. These measures are called **measures of spread.** They can show how consistent a procedure is. One common measure of spread is called the **range**.

- The **range** is determined by taking the highest data value and subtracting the lowest data value.

1.5 ANALYZE YOUR DATA

Procedure:

1. Using the class data on *Investigation Sheet #1*, calculate and record the **mean** of the number of bags that the class was able to package in three minutes.
2. Calculate and record the **median** of the number of bags on *Investigation Sheet #1* using the following procedure:
    - In the Data Ordering Box at the bottom of *Investigation Sheet #1*, write each of the numbers your class reported, in order from smallest to largest. Your teacher will demonstrate this to the class.
    - If the number of data points is odd, find the one in the exact center. If the number of points is even, take the mean of the two middle numbers.
3. By looking at your histogram, determine and record the **mode** of the data set on *Investigation Sheet #1*, if there is one.
4. Determine and record the **range** in your data from Data Table #1 on *Investigation Sheet #1*.

Discuss these questions as a class:

1. Did your group have any difficulties (mistakes, keeping up with time, etc.) while completing the procedure? Describe each one.
2. How similar were the results of different groups?
3. Why do you think there are differences in the data from different groups?
4. What did the distribution, or spread, of data on the histogram graph look like? What do you think this says about how similar the class's data is?
5. What could the class do to get more similar results?

SECTION 2 – DATA FROM THE PACKAGING PLANT

2.1 ANALYZING ADDITIONAL DATA

The nine ***Just Like Home*** employees work for 30 minutes packaging *Away from Home Hardware Kits*, then take a short stretch and rest break. During each work day, they work twelve 30-minute shifts, and have an hour for lunch. Your packaging design team decided to collect additional data about the effectiveness of the current procedure for packaging kits. The team will count how many kits each employee packages at three different times during the day. The times chosen were at the beginning of the day, the middle, and the end. The data is shown in the table below next to each employee's name and is also shown on *Factory Data Sheet #1*.

Name	9:00-9:30 a.m.	1:00-1:30 p.m.	4:00-4:30 p.m.
Jose	45	45	44
Gertrude	48	47	40
Sally	46	43	44
Paul	45	45	36
Monique	33	28	30
Lester	42	44	20
Eve	46	48	35
Ting	24	26	20
LaTasha	43	45	46

2.2 CRITICAL QUESTIONS

In order to determine how efficiently and consistently the ***Just Like Home*** employees work using the current procedure, your Packaging Design team needs to answer some critical questions. The questions are listed on the next page but are also listed on your *Factory Data Interpretation Sheet #1, Parts A and B* along with instructions on how to solve the questions. To answer these questions, you will need to use your understanding of measures of center, measures of spread, and regular arithmetic. You will record your data and calculations on *Factory Data Sheet #1*.

1. On average, how many kits can one member of the group package in 30 minutes?
   On average, how many kits can the whole group together package in 30 minutes?

2. Ting and Monique are very new to the job. The other workers are much more experienced. Does this make a difference in how many kits they can package in 30-minute shifts? Which Measure of Center would reveal that there are differences between groups? How does that measure compare to the Mean?

3. Which workers are most consistent in the number of kits they package in 30 minutes? What is the most common, or frequent, number of kits that workers can produce in 30 minutes?

4. Is the mean number of kits packed by all employees the same at all times of the day? If not, which times are they fastest and package the most kits, and which times are they slowest?

Use your mathematics and the data on the *Factory Data Sheet #1* to answer the questions on the *Factory Data Interpretation Sheet #1, Parts A and B*.

Discuss these questions as a class:

1. What conclusions can you make by looking at the data in the table in *Factory Data Sheet #1*? How much variation is there between employees?

2. Is there variation in the data at different times of the day? What are some possible reasons?

3. How does the **mean** of the factory data compare to the **median**? Why are they different?

4. Are there employees that the owner of ***Just Like Home***, Ms. Casandra Hinkleberry, should be concerned about? Explain.

PLEASE DO NOT WRITE IN THIS BOOK.

SECTION 3 – CHANGING THE PROCEDURE

3.1 ASSEMBLY LINES

Your packaging design team has now thoroughly analyzed the way ***Just Like Home*** currently packages its *Away from Home Hardware Kits*. What are alternative ways of packaging?

Watch ***Meals for Kids*** video #1.

Discuss these questions as a class:

1. What is an assembly line?
2. How is it different from the Individual Assembly procedure?
3. Do you expect an assembly line to be quicker or slower? Why?

Watch ***Flockheed Eggcraft Factory*** video #2.

3.2 INVESTIGATE A NEW ASSEMBLY LINE PAGKAGING PROCEDURE

Your group will receive a new procedure that describes how you should run your experiment to reliably test out a new procedure for packaging *Away from Home Hardware Kits*. This procedure is called *Procedure #2 – Kit Assembly Line*.

Procedure:

1. Read through *Procedure #2 – Kit Assembly Line procedure sheet* to make sure you understand it. Work with your team to organize the materials you are given according to the instructions.
2. Conduct four trials using *Procedure #2 – Kit Assembly Line*. After each trial, count how many completed bags your group packaged in three minutes. Only count completed bags.

AVAILABLE MATERIALS

- Hardware (Nuts, Bolts, Plastic Anchors, and Picture Hooks)
- ***Just Like Home*** logos
- Small Snack Bags
- Full Kit Sandwich Bags
- *Investigation Sheet #2*
- *Procedure #2—Kit Assembly Line*

3. Record the result of each trial on your *Investigation Sheet #2* in the data table, in the By Your Group column.
4. Each group will report to the class the results of their investigation of the assembly line packaging procedure. As each group shares their results, record the numbers in the data table on *Investigation Sheet #2* so that you have a full set of data. Create Histogram #2 on *Investigation Sheet #2* using the class data.

3.3 ANALYZE YOUR DATA

Procedure:

1. Using the class data on *Investigation Sheet #2*, calculate and record the **mean** of the number of bags that the class was able to package in three minutes.
2. Calculate and record the **median** number of bags on *Investigation Sheet #2*.
3. By looking at your histogram, determine and record the **mode** of the data set on *Investigation Sheet #2*, if there is one.
4. Determine the **range** in your data, and record on *Investigation Sheet #2*.

PLEASE DO NOT WRITE IN THIS BOOK.

Discuss these questions as a class:

1. Did your group have any difficulties while running the assembly line procedure? Describe each one.
2. How similar were the results of different groups?
3. What did the distribution, or spread, of data on the histogram graph look like? What do you think this says about how similar the class's data is?
4. How did the results from the assembly line procedure compare to the results from the individual assembly procedure?

3.4 MAKE YOUR RECOMMENDATION

Your packaging design team should now make a formal recommendation to the owner of ***Just Like Home*** on the *Letter to Ms. Casandra Hinkleberry* student sheet. Should the factory reconfigure into an assembly line, or should they stick with the individual packaging procedure? Why or why not? You should support your conclusion with evidence.

Watch ***Charlie Chaplin—Modern Times*** video #3.

SECTION 4 – NEW DATA FROM THE PACKAGING PLANT

4.1 ANALYZING THE ASSEMBLY LINE

Based on recommendations from advisors, Ms. Casandra Hinkleberry rearranged her workers into three teams of three people each. Each team then worked as an assembly line. Industrial engineers always gather data about how well a new process or procedure is working. One month after the change, your team repeated your packaging plant study. The teams and the number of kits each team produced are shown below.

Number of kits packaged by teams at different of the day				
	Name	**9:00-9:30 a.m.**	**1:00-1:30 p.m.**	**4:00-4:30 p.m.**
Team 1	Jose	142	142	139
	Rosalinda			
	Sally			
Team 2	Paul	138	142	141
	Monique			
	Lester			
Team 3	Eve	140	145	139
	Ting			
	LaTasha			

Use *Factory Data Sheet #2* and *Factory Data Interpretation Sheet #2, Parts A and B* to help you address the critical questions.

PLEASE DO NOT WRITE IN THIS BOOK.

Discuss these questions as a class:

1. Does the new data that you collected from the ***Just Like Home*** assembly line support changing the procedure from the individual assembly? Why or why not?

2. Which procedure (Assembly Line or Individual Assembly) gives more consistent results?

3. Can you think of other procedures that you might use to get even better results?

Watch ***Krispy Kreme*** video #4.

Georgia Tech

Center for Education Integrating Science, Mathematics & Computing

This curriculum is produced by Advanced Manufacturing & Prototyping Integrated to Unlock Potential (AMP-IT-UP) supported by National Science Foundation Award #1238089 through Georgia Institute of Technology's Center for Education Integrating Science, Mathematics, and Computing (CEISMC).

For more information about AMP-IT-UP
and to download our curriculum,
please visit our website at www.ampitup.gatech.edu.