**What does 500 Tons of Toilet Paper have to do with Math?**

**Lesson Plan**

**Video:** <https://www.youtube.com/watch?v=1z2bydTgcH0>

**Teacher Note:**  Please preview the entire video and pre-work the solutions in order to anticipate students’ needs, misconceptions and materials that may be unique to your classroom.

You will also need to determine the background knowledge of your students regarding the following topics, and decide the best method for providing that background in order to support the conceptual understanding of the mathematics shown in the video.

* The unit of measure “ton”.
* Rate of Change

**Common Core Mathematical Content Standards**

5.OA - Write and interpret numerical expressions

6.RP.3 - Use ratio and rate reasoning to solve real-world and mathematical problems

High School Modeling Standard

**Common Core Mathematical Practice Standards**

1. Make sense of problems and persevere in solving them.

2. Reason abstractly and quantitatively

3. Construct viable arguments and critique the reasoning of others.

 5.  Use appropriate tools strategically.

**Company Information**

With approximately 300 facilities across North America, South America and Europe, Georgia-Pacific is one of the world's leading manufacturers and marketers of bath tissue, paper towels and napkins, tableware, paper-based packaging, office papers, cellulose, specialty fibers, nonwoven fabrics, building products and related chemicals. In Northeastern Wisconsin, its Green Bay facilities make nationally-known products (Quilted Northern®, Angel Soft® and Compact® bath tissue; enMotion® and SofPul® paper towels; and Vanity Fair® and Mardi Gras® napkins) and packaging is produced in Sheboygan and Oshkosh. Each year, GP's Ecosourceä facility in Green Bay recycles nearly 100,000 tons of wastepaper - equal to 1.7 million trees - and saves 5 million cubic feet of landfill space. In addition, its Neenah-based research and development laboratory, iNNOVATION institute®, constantly develops creative and innovative products, and tests them in Green Bay using the latest technology available. For more information, visit: gp.com.

**Summary**

This video takes students through a real world problem solving process from start to finish.  A customer has ordered 500 tons (2.5 million rolls) of toilet paper and it needs to be produced in one day so that it can get to the customer by the end of the week.  How can Georgia Pacific’s production team use their paper machines and converting lines in the most efficient and cost effective way in order to meet this important deadline?

**Pre-Activity Discussion:**

* There are two main processes to making toilet paper; making the paper and making it into usable rolls.  The second process is called “converting”.
* Once the paper is made, it is on one large roll.  It needs to be “converted” to the small rolls of toilet paper that the customer ordered.  This requires the use of different machines. Multiple machines are lined up along with conveyors to handle all the steps in the process.  These are called “converting lines”.
* As students complete the tables in Part 1 and Part 2, encourage them to think about strategies that could help them reduce the number of combinations that they should test.
* Vocabulary
	+ Maximum Capacity
	+ Fixed Cost
	+ Variable Cost

**Differentiation:**

* The questions on the student handout are scaffolded to meet the needs of students who may need extra support.
* Eliminating some of the added questions/tables, and just posing the questions from the video would be a possible differentiation strategy for students who do not need the extra support.
* Students may also benefit by working with others as part of a partner/group investigation.

**Part 1:  (0:00 – 1:20)**

BREAK 1

* Problem posed in Part 1 of the video: “*How can the three paper machine be utilized so that the toilet paper can be made quickly and at the lowest cost?”*
* Information in Part 1
	1. **Each machine can only be used once but the machine does not have to make it’s full capacity.**
	2. Produce exactly 500 tons.
	3. Machine A has the capacity to make up to 200 tons per day at a cost of $750 dollars per ton.
	4. Machine B has the capacity to make up to 200 tons per day at a cost of $800 dollars per ton.
	5. Machine C has the capacity to make up to 300 tons per day at a cost of $770 dollars per ton.
* Have students use Part 1 of student handout to document their discussion, problem solving process, 5 or more possible combinations, and final recommendation.
* Share ideas whole group
* Answer is provided at the beginning of Part 2.

**Part 2: (1:23 – 2:14)**

 BREAK 2

* Problem posed in Part 2 of the video*“Which combination of the three converting lines will get the 500 ton job done at the lowest cost?”*
* Information in Part 2
	1. **Each line can only be used once, but the line does not have to to make it’s full capacity.**
	2. Line X has the capacity to make up to 150 tons per day at a cost of $300 dollars per ton.
	3. Line Y has the capacity to make up to 250 tons per day at a cost of $250 dollars per ton.
	4. Line Z has the capacity to make up to 300 tons per day at a cost of $400 dollars per ton.
* Have students use Part 2 of student handout to document their discussion, problem solving process, at least 5 possible combinations, and final recommendation.
* Share ideas whole group
* ***Question on student handout - “As you completed the tables in Part 1 and Part 2, What strategies did you use to help you reduce the number of combinations that you should test?***
* Answer is provided at the beginning of Part 3.

**Part 3:  (2:17 – 2:38)**

BREAK 3

* Problem posed in Part 3 *“What would be the total cost of production for the 500 tons of toilet paper?”*
* *What is the production cost per ton?*
* Have students use Part 3 of student handout to document their discussion, problem solving process and final cost.
* Would this be what you would charge the customer for the 500 tons of toilet paper? Why or Why not? (See part 4)
* Share whole group.
* Total Cost is provided at the beginning of Part 4.

**Part 4: (2:41 – 3:12)  STOP Before Bonus Question Graphic - It is incorrect**

BREAK 4

* The video ends with students being asked to think about other costs associated with production.
* We have discussed the “fixed” costs of the paper making and the paper converting, but what about the “variable” costs like labor, and energy/power?
* Have students use part 4 of student handout to document their discussion about other costs to consider when determining “total cost” to the manufacturer and price to charge the customer.
* Share ideas whole group

 **\*\*\* Disregard the line graphs at the end of the video\*\*\***

**Extension:**

* What is the production cost per roll of toilet paper?
* Compare the efficiency of each of the machines and converting lines. Is there justification to scrap one of them and replace it?  Create a proposal that explains and justifies your calculations and reasoning.
* If the requested amount was 700 tons, how would your combinations change?  Does this change your recommended machines and lines to use?
* Research labor costs (or energy costs) in your area.  Determine an estimated labor (or energy) cost for the production of the 500 tons of toilet paper.
* What about shipping costs?  What would be needed to figure out the cost of shipping 2.5 million rolls of toilet paper?  Use your findings to get an estimated shipping cost from Green Bay, Wisconsin to Birmingham, Alabama.
* What is your estimate for the total cost for this job?  If the company needs to make a profit, what would be the total price you would charge the customer?

**Student Handout - *What Does 500 Tons of Toilet Paper have to do with Math?***

 Name(s):

**Pre-Video Discussion:** *Notes on important background information.*

**Problem:** *How can Georgia Pacific best utilize their paper machines and converting lines to produce 500 tons of toilet paper quickly and at the lowest cost?*

 **Break 1:**

1. Fill in the able with the information provided in the video

|  |  |  |
| --- | --- | --- |
| Paper Machine | Maximum Capacity (tons per day) | Cost (dollars per ton) |
| A |  |  |
| B |  |  |
| C |  |  |

 2. *How can the three paper machine be used so that the toilet paper can be made quickly and at the lowest cost?*Use the table below to help you organize your trials.  Circle the combination that you would recommend.

|  |  |  |  |
| --- | --- | --- | --- |
| Required Weight (tons per day) | Combinations of Paper Machines and tons produced on each | Cost Calculations  | Total Cost |
| 500 |  |  |  |
| 500 |  |  |  |
| 500 |  |  |  |
| 500 |  |  |  |
| 500 |  |  |  |

**Break 2:**

**3**. Fill in the able with the information provided in the video

|  |  |  |
| --- | --- | --- |
| Converting Line | Maximum Capacity (tons per day) | Cost (dollars per ton) |
| X |  |  |
| Y |  |  |
| Z |  |  |

 4. *How can the three converting lines be used so that the toilet paper can be made quickly and at the lowest cost?*  Use the table below to help you organize your trials.  Circle the combination that you would recommend.

|  |  |  |  |
| --- | --- | --- | --- |
| Required Weight (tons per day) | Combinations of Converting Lines and tons produced on each | Cost Calculations  | Total Cost |
| 500 |  |  |  |
| 500 |  |  |  |
| 500 |  |  |  |
| 500 |  |  |  |
| 500 |  |  |  |

*5.  As you completed the tables in Part 1 and Part 2, What strategies did you use to help you reduce the number of combinations that you should test?*

**Break 3**

6. *What would be the total cost of production for the 500 tons of toilet paper?*

*7.  What is the production cost per ton?*

**Break 4**

8.  There are other costs to consider when determining “total cost” to the manufacturer and price to charge the customer.  *What would be some of those other costs?*

**ANSWER KEY – What does 500 Tons of Toilet Paper have to do with Math?**

 **Break 1:**

1. Fill in the able with the information provided in the video

 2. *How can the three paper machine be used so that the toilet paper can be made quickly and at the lowest cost?*Use the table below to help you organize your trials.  Circle the combination that you would recommend.

**NOT ALL POSSIBLE TRIALS ARE SHOWN IN TABLE**

|  |  |  |  |
| --- | --- | --- | --- |
| **Paper Machines and tons produced on each** | **Maximum Capacity (tons per day)** | **Cost (dollars per ton)** | **Total Cost** |
| **A (200) and C(300)** | **500** | **(200T x $750/T) + (300T x $770/T)** | **$381,000** |
| **B(200) and C(300)** | **500** | **(200T x $800/T) + (300T x $770/T)** | **$391,000** |
| **A (200) + B (200) and C (100)** | **500** | **(200T x $750/T) + (200T x $800/T) + (100T x $770)** | **$387,000** |
|  **A (100) + B(100) + C(300)** | **500** | **(100T x $750/T) + (100T x $800/T)+ (300T x $770/T)** | **$386,000** |

**Break 2:**

**3**. Fill in the able with the information provided in the video

 4. *How can the three converting lines be used so that the toilet paper can be made quickly and at the lowest cost?*  Use the table below to help you organize your trials.  Circle the combination that you would recommend.

**NOT ALL POSSIBLE TRIALS ARE SHOWN IN TABLE**

|  |  |  |  |
| --- | --- | --- | --- |
| **Required Weight (tons per day)** | **Combinations of Converting Lines and tons produced on each** | **Cost Calculations**  | **Total Cost** |
| **500** | **Z(300) + Y(200)** | **(300T x $400/T) + (200T x $250/T)** | **$170,000** |
| **500** | **X(150) + Y(250) + Z(100)** |  | **$147,500** |
| **500** |  |  |  |
| **500** |  |  |  |
| **500** |  |  |  |

*5.  As you completed the tables in Part 1 and Part 2, did you use any strategies to help you reduce the number of combinations that you should test?  If so what were they?*

**Break 3**

6. *What would be the total cost of production for the 500 tons of toilet paper?*

 **381,000 + 147,500 = $528,500**

7.  What is the production cost per ton?   **$1057 per ton**

**Break 4**

8.  There are other costs to consider when determining “total cost” to the manufacturer and price to charge the customer.  *What would be some of those other costs?*

 Some examples: **Labor, energy, equipment, administration, benefits, transportation**