Recycling Paper

Grade Level:	**Total Time Required:**
5	approximately five 45-minute sessions

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Lesson Objectives:

Students will be able to:

1. Explain a process used for recycling paper in an industrial setting.
2. Calculate the volume and mass of an irregular material (e.g., pile of shredded paper) or mixture (sludge).
3. Design and build a recycling method that meets specific design criteria.

Indiana Standards:

5.PS.1 Describe and measure the volume and mass of a sample of a given material.

5.PS.2 Demonstrate that regardless of how parts of an object are assembled the mass of the whole object is identical to the sum of the mass of the parts; however, the volume can differ from the sum of the volumes. (Law of Conservation of Mass).

3-5.E.1 Identify a simple problem with the design of an object that reflects a need or a want. Include criteria for success and constraints on materials, time, or cost.

Next Generation Science Standards:

Discipline Core Ideas

3-5.ETS1-1 Identify a simple problem with the design of an object that reflects a need or a want. Include criteria for success and constraints on materials, time, or cost.

Science/Engineering Practices
1. Asking questions (for science) and defining problems (for engineering)
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence

Crosscutting Concepts
2. Cause and effect: Mechanism and explanation.

Concepts and Vocabulary

Term	*Defined by a scientist or engineer*	*Defined by a student*
Waste Paper	Paper that no longer has a use.	Paper that no longer has a use
Pulp	Wood or plant fiber that is crushed or blended to make paper.	Mixture of paper and water that looks like a mash
Evaporation	To convert into vapor; to dissipate or draw off vapor.	Converting liquid such as water into gas such as vapor
Extraction	Extract: to pull or take forcibly; to withdraw by physical or chemical process.	Separate two things with force
Mass	The amount of matter that something contains.	The amount of matter that something contains
Volume	The amount of space occupied by a three dimensional object as measured in cubic units.	The amount of space taken by an object
Weight	Force of an object due to gravity.	Measure of how heavy an object is
Fiber	A long thin piece of a natural or artificial substance.	Long and thin piece of material such as thread
Reuse	Using something again. This includes conventional reuse where the item is used again for the same function, and new-life reuse where it is used for a different function.	Use again
Reduce	To bring down to a smaller extent, size, amount, number, etc.	Lower
Recycle	To process used materials (waste) into new products to prevent waste of potentially useful materials.	Reuse

Equipment, Materials, and Tools

Materials		
Scrap Newspaper or Shredded Paper	Water	Newspaper, Felt or Plastic (backing material to support paper during drying)
Sponge or Cloth (to assist in removal of excess water)	Wooden Frame/Mold	Screen or mesh with differing mesh sizes (cheese cloth, fly netting, screen material from screen doors) (for designing the screen for the strainer)
Plastic Tub or Basin with Min. opening of 8"x11" (up to 12"x12") (to hold pulp mixture, needed for each team)	Water Containers	

Tools		
Blender (to make pulp mixture)	Stapler (to attach screen to frame)	Iron (optional)(to assist in smoothing and/or flattening the paper after dry)
Roller or Press (remove excess water)		

Safety Guidelines:
Watch students so that they do not dispose of left over pulp/slurry through the sink. This will plug the drain system. The left-over material first needs to be drained and then recycled or disposed properly.

Typical industrial paper recycling processes

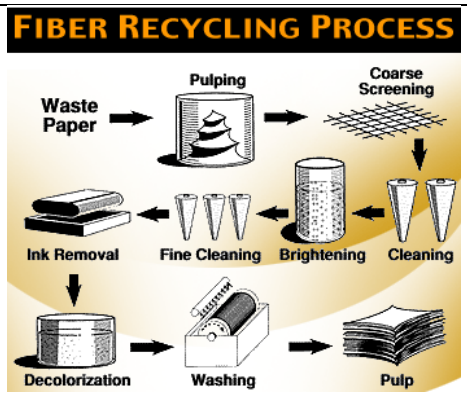


Figure 1. The Paper Tigers (2010)

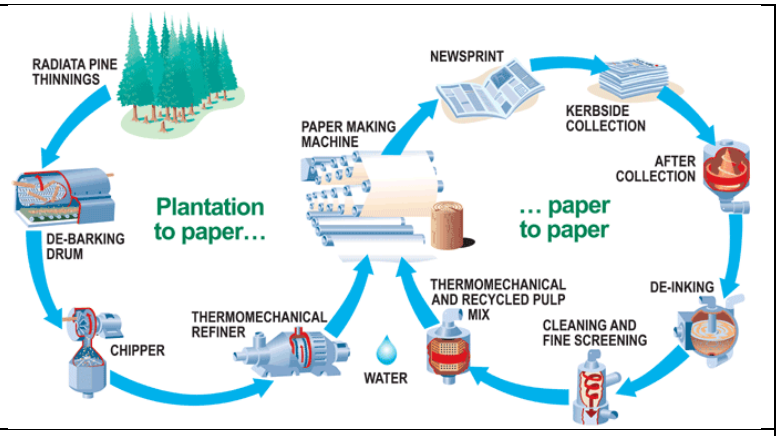


Figure 2. IQS Directory

The Paper Tigers (2010). Fiber recycling process. Retrieved from http://www.papertigers.com/recycling_process.html

IQS Directory (2012). Recycling Equipment. Retrieved from http://www.iqsdirectory.com/industry/recycling_equipment/index.htm

3R Concepts: Reduce, Reuse, Recycle

Symbols

Product or package is both recyclable & made entirely from recycled material	Product or package that is recyclable (requires access to collection program in the community)	Made from 100% recycled fiber	Made from less than 100% recycled fiber	Made from 100% recycled fiber	Made from 100% recycled paperboard
	Recyclable	Recycled	XX% total recycled fiber	100% Recycled Fiber	100% Recycled Paperboard

American Forest and paper Association (2010). Recycling Symbol Guidelines. Retrieved from http://www.afandpa.org/PaperRecycling.aspx

Also see http://www.paperrecyclingcoalition.com/recycled/index.php/faqs/

Synopsis of Engineering Design Activity

Synopsis of the Design Activity:

Problem:	Greater Lafayette is generating increased paper waste.
Goal:	Design a process to produce very thin recycled paper.
Who is the client:	City of Lafayette
End-User:	Citizens of Lafayette
What is the design:	Design a process to produce very thin recycled paper.
Criteria:	• Paper produced should be as thin as possible. • Paper should have equal or consistent thickness throughout the paper. • There should not be any holes in the paper. • Paper should be at least 3” x 5”. • Use 2.5 liters of water.
Constraints:	• You may only use the materials, tools, and paper available to you in the classroom. • Paper blending must be done by your teacher. • Time.

Lesson Plan #1
Guiding Question – What happens to the paper in our daily life?

Time: 15 – 30 minutes

Procedure:

1. Play a trivia game with the students (*note: correct answers are highlighted*).

    1) True or false? More paper is recycled than sent to landfills.

    2) In 2010, approximately what percentage of paper consumed in the U.S. was recovered for recycling?
        (a) 10%
        (b) 30%
        (c) 60%
        (d) 80%
        (e) 100%

    3) In 2010, total paper recovery per person was approximately…
        (a) 5 lbs
        (b) 50 lbs
        (c) 250 lbs
        (d) 350 lbs

    4) Approximately what percentage of Americans has access to curbside or drop-off paper recycling programs?
        (a) 10%
        (b) 30%
        (c) 50%
        (d) 90%

    5) Which one of the following is recycled the most in weight from municipal solid waste streams?
        (a) paper
        (b) glass
        (c) plastic
        (d) aluminum

2. Start a classroom discussion by asking the following questions:

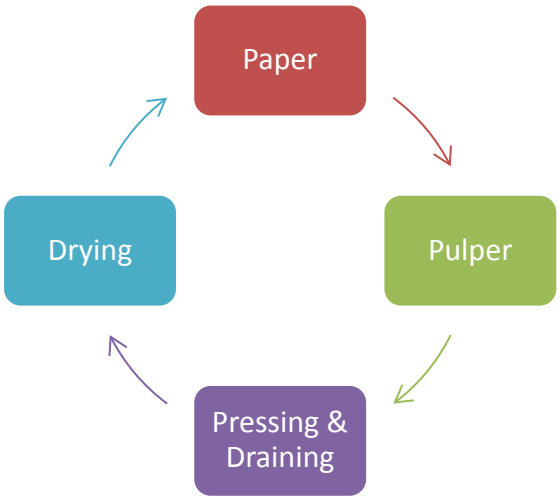
   - *What do you do with the paper?*
   - *What are different uses of paper? (Writing, Packaging, Cleaning)*
   - *How much paper (writing, packaging, cleaning) do you think you use in a day?*
   - *What do you do after you use paper?*
   - *Do you throw used paper/box into trash or recycling bin?*
     - *What happens to the paper that is thrown into trash?*
     - *What happens to the paper that is thrown into recycling bin?*
   - *Which is good? Trash or recycling?*
   - *Do you know what recycling means?*
   - *Do you know how paper is recycled? For example, a newspaper will become another news paper or a box will become another box?*

3. After the discussion, teacher will show a video clip of a paper recycling plant.
   UPM Video: http://www.youtube.com/watch?v=7tiZEtvLsjE (start at minute 3:00)

4. After watching the clip, ask students to draw a diagram showing how paper is recycled.

5. Ask students, *what is the role or job of the engineer in this industrial setting?*
   - Monitoring the process (i.e., quality control). Identifying the cause of problems if there are any quality problems.
   - Designing the paper recycling process.
   - Refining and improving the paper recycling process.

6. On the board, draw a diagram with input from the students. This process diagram may look like this:



   Next, ask students what happens between the Pulper and Dryer (video clip does not show the details). How is the pulp (i.e., mash of paper) made into paper?

7. Show another clip showing a strainer system. North Carolina Video:
   https://www.youtube.com/watch?v=_LRewWjDz1o

Re-draw the process diagram on the board with additional details.

8. Ask students, which part of the process they would focus on if *your goal was to make paper as thin as possible?*

    - The following variables that would impact paper thickness should emerge from this discussion:
        - Size of the mold (strainer)
        - Size of the mesh holes (i.e., how fine is the weave?)
        - Size of the frame
        - Amount of pressure applied to strain water
        - How chunky is the slurry (paper-water mixture)
        - The amount of material collected by the strainer

Lesson Plan #2
Guiding Question – Can You Design a Process that Produces the Thinnest Recycled Paper?

Time: 90 minutes (2 45-minute class sessions with at least a day apart)

Set-Up:

Each team needs:

- 3 full sheets of newsprint = 35 - 40 grams
- 1 - 4 x 6 inch wooden picture frame
- Straining material (mesh material or cheese cloth)
- Sponge
- Felt (11 x 14 inches)
- Roller or squeegee (or use a piece of wood to squeeze out water)
- Water: 2.5 to 3 liters

Procedure:

1. The teacher will describe the design challenge: "Your challenge for today is to design a strainer system that can be used in recycling paper. You design must meet the constraints and criteria as laid out in the design brief."

2. Review the design challenge sheet and student resource with students.

    - *What is the problem?*
    - *What is your goal?*
    - *Who is the client?*
    - *Who is the end user?*
    - *What are the criteria?*
    - *What are some of the constraints?*

3. Review the different materials that are available to accomplish the design task.

4. Form teams of 4 students. Review team rules and expectations (see below).
    a. Everyone contributes with all tasks
    b. Professional behavior
    c. Safety
    d. Everyone has a clear role.
        i. Example 1: Recorder, time keeper, materials gatherer, measurer
        ii. Example 2: Each student is in charge of a specific task: measuring, cutting, etc.

5. Instruct students to begin the first phase entitled "START PROCESS" (See student handout)

6. DRY SHREDDED PAPER:
    a. Each team will be given some volume of shredded paper and water. They will measure mass and volume of both dry paper and water and record in the measuring sheet.

    b. Explain the difference between mass and volume. Students will use available containers to measure the volume of water and paper.

    c. Provide a scale to measure the mass of the paper.

    d. Provide a handout to measure volumes of different types (cylinder, cone, rectangular) of containers.

7. WET SHREDDED PAPER
    a. Ask students to mix their dry shredded paper with some (less than 500 ml) amount of water, and bring this to the teacher for blending. Teacher will blend and give the paste back to each group. This paste can then be mixed with the remaining water to create the usable paper pulp.

    b. Calculate the total mass and volume of the mixture of paper and water (pulp).

    c. Question: Do you think the mass and total volume will change after blending? Ask students to measure the mass and volume of the blended paper pulp. Report the numbers in their measuring sheet. Discuss the results.

8. Direct each group to the available materials for making the screening system. Discuss the constraints. The paper should be at least 3 in x 5 in.

9. After designing the screen, students will put the pulp on the screen. Weigh the wet paper, and record in the measurement sheet.

10. Let dry the wet paper for one day. Weigh the dry paper and record in the measurement sheet.

11. As students continue to take measurements, discuss with students exactly how they will determine or test for the following: 1) overall thickness of the paper; 2) consistency in the paper width; and 3) ability to be folded multiple times.
    - How can we devise a test or a way to determine whether or not one paper sample is thicker than another?
    - How can we devise a test or a way to determine how well one paper sample folds versus another?
    - Examples may include:
        - Using a ruler to measure in metric the thickness on all four sides and calculating the average
        - Putting the paper sample up against a light and observing whether or not you can see through the paper and creating a scale from 1 to 5 of thickness.

12. In design teams, students then employ the tests and record their results.

Assessment

The following are possible sources of formative and summative assessment:

- Notebook entries: Students can record their initial ideas and conceptions about the use of paper. Students can record their ideas for recycling paper. After the design challenge, students can record their new and more informed ideas about recycling paper and its importance.

- Performance assessment: Give students samples of recycled paper prepared by different design teams and encourage students to measure the mass and volume of the samples. Discuss which samples are less dense and which samples would be most effective for packaging, stationery, or memo pads and why (i.e., based on what physical properties).

- Re-design: Depending on how thick your paper is, how would you redesign your strainer or the process?

Lesson Extensions and Resources

Web Resources:

Teacher Resource Videos:

- http://www.youtube.com/watch?v=vl-jbIVwo6Q (Professional)
- http://www.youtube.com/watch?v=aQoz1pkKmdA&feature=related (4th grade Classroom)
- http://www.youtube.com/watch?v=wAl_7IDYfVc (Green Parent)
- http://www.youtube.com/watch?v=_LRewWjDz1o brief intro (North Carolina)
- http://www.youtube.com/watch?v=7mn9RhxS8kg animation

SLED
Science Learning through Engineering Design

Recycling Paper for Your School

The greater Lafayette area is facing the problem of increased paper waste. The city of Lafayette is interested in recycling the paper waste. They need your help to design a strainer system for the recycling plant that will produce very thin recycled paper.

Criteria

- Paper produced should be as thin as possible
- Paper should have equal or consistent thickness throughout the paper
- There should not be any holes on the paper
- Paper should be at least 3”x 5”
- Use 2.5 liters of water

Constraints

- You can only use the materials, tools, and paper available to you in the class
- Paper blending has to be done only by your teacher

Deliverables

- A dry recycled paper that has dimensions of 3 inches by 5 inches.

Planning Your Paper Recycling Process

1. PLAN: Draw a flowchart or a step by step list of the process you will use to recycle paper.

2. Pick up materials and implement your plan

Before Blending, make the following measurements:

The thickness of a typical paper is about 0.0076 cm

RAW MATERIALS	Volume	Mass
Paper	cm^3	grams
Water	ml	grams
Total Values	ml	grams

3. Mix your shredded paper and 500 ml of water

4. Do you think the mass and total volume will change after blending?

After Blending, make the following measurements:

MATERIALS	Volume	Mass
Paper pulp	ml	grams

5. Did the mass and total volume change after blending? Why (not)?

6. Build your strainer and make recycled paper. Draw a picture of your strainer below.

7. DESIGN REFLECTION QUESTIONS:
    a. How do the properties of the straining material (e.g., type of material, mesh size, etc.) impact the design of the process as well as the quality of your recycled paper?

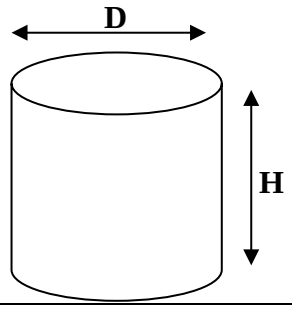
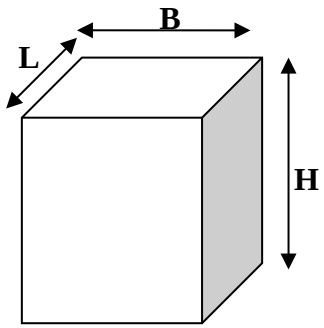
    b. How will your design change if you have to control the size of your paper?

    c. How will your design change if you have to control the thickness of your paper?

8. RE-DESIGN: Describe any changes you made to the process you described above. Explain the reasons for these changes.

9. Excess Materials: It is likely you have some leftover pulp. Pouring this pulp into the sink would plug the drains. Come up with a plan on what to do with the left over material.

Volume Equations

$V = \frac{\pi D^2}{4} x\ H$	
V = L x B x H	

OTHER DOCUMENTS

Engineering Vocabulary

Term	***Defined by a scientist or engineer***	***Defined by a student***
Criteria	Functions, attributes, capabilities, characteristics, or qualities that a solution, product, process, or service are expected to meet.	Requirements you need to meet
Constraints	Limitations to a given problem solution space that limits certain design alternatives. The design constraint must be met.	Something that restricts your ideas or keeps an idea from becoming real.
Optimization	The selection of a best element from some set of available alternatives by maximizing or minimizing an expected outcome.	Making something better and more efficient than it was before
Trade-offs	Trade-offs has to be made when solving problems involving competing criteria or constraints. This process involves losing one quality or aspect in return for gaining another quality or aspect and requires a decision-making process that evaluates both the upside and downside of a particular choice.	Giving something away to get something back
Prototype	A representation of a product or process. An early sample or model built to test a concept or process.	A small and simple model
Variables/ Parameters	The factors that can be manipulated to affect the results of an experiment.	Something you can change or measure in an experiment

Expectations and Checklist for Student and Teacher Evaluation

Student Name: _____
TEAM Name: _____

	Student Evaluation	Teacher Evaluation
Technical Quality	❑ Measurement and calculations are accurate ❑ Final solution meets design criteria and constraints	❑ Measurement and calculations are accurate ❑ Final solution meets design criteria and constraints
Scientific & technical Communication	❑ Student uses of scientific and engineering vocabulary in explanations & justifications. ❑ Justifications are based on data and/or reasoning	❑ Student uses of scientific and engineering vocabulary in explanations & justifications. ❑ Justifications are based on data and/or reasoning
Teamwork	❑ All team members have clear roles. ❑ Everyone is participating and engaged.	❑ All team members have clear roles. ❑ Everyone is participating and engaged.

Using a Triple Beam Balance to Measure Mass

Name_____

Date_____

First - Make sure that the balance is calibrated. Push all the sliders to zero (far left) and align the pointer(far right) at zero.

There are two methods of measuring the mass(weight) of an object.

A. Measuring the mass directly
   1. Place the object on the pan of the balance.
   2. Move the hundreds slider one notch at a time until the beam drops below zero, then move it back one notch.
   3. Repeat with the tens slider.
   4. Slide the front slider across the beams until the pointer rests on zero.
   5. Add the numbers from all three beams together and record the results in your data table.

B. Finding the mass by difference
   1. Find the mass of an empty beaker. Record the mass on paper.
   2. Put the object in the empty beaker.
   3. Find the mass of the beaker and the object together.
   4. Subtract the mass of the beaker from the mass of the beaker and the object.

Practice:

1. The mass of a beaker is 50 grams. The mass of a beaker and an object is 75 grams. What is the mass of the object by itself without the beaker?

Mass of beaker and object		grams
Mass of beaker	-	_____grams
	=	grams

2. The mass of a beaker is 50 grams. The mass of the beaker full of water is 125 grams. What is the mass of just the water?

3. The mass of a beaker is 50 grams. The mass of a beaker with 190 ml of water is 240 grams. What is the mass of just the water?

Use the TRIPLE BEAM BALANCE to measure the mass of the following objects. Make sure that you label the units on each measurement. (Grams)

ITEM TO MEASURE	MASS (Grams)
Wood Block	grams
Pencil	
Paper Clip	
Popsicle Stick	
Metal Washer	
Calculator	
Domino	
Bottle of Glue	
Empty 250 mL beaker	
Empty 500 mL beaker	
250 mL beaker with 25 mL of water	
250 mL beaker with 50 mL of water	
250 mL beaker with 75 mL of water	
250 mL beaker with 200 mL of water	
500 mL beaker with 200 mL of water	
500 mL beaker with 150 mL of water	
500 mL beaker with 200 mL of water	
500 mL beaker with 250 mL of water	

4. Using your answers from the beaker measurements above, what is the mass of:

(a) 200 ml of water by itself

(b) 250 ml of water by itself

5. Using questions (a) and (b), what would be the mass of 100 ml of water? (Don't Measure with the balance! Estimate!)

For water:

1 mL of water = 1 cm^3 of water = 1 g of water