Engineer it Out

Supplemental Activity Workbook

To download and print extra copies of this packet, visit www.readerstheater.com/supplements.

Name_____

Steps to Innovation

Directions: You learned in the story that the engineering process requires certain steps to be done in a certain order. On the numbered lines below, unscramble the following words so that they are in the correct order for an engineer to follow. Then, explain what is involved in each step in the lower section. Give examples using your imagination, as if you were designing your own invention.

Change it
Retest it
Research it
Success
Plan it
Test it
Picture it
Build it

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____

Name_____

Energize The Future!

Directions: Use the Internet to perform your own research about alternative energy sources. Fill out the diagram below with characteristics (both negative and positive) of water, wind, and solar energy. In the overlapping sections, write characteristics that apply to both/all of the energy sources.

Solar

Wind

Water

Name_____

Solar Power Plants of the World

There are a number of prominent, widely utilized solar power plants around the world. Below are some key facts about some of the most well known.

Sarnia Photovoltaic Power Plant
- Sarnia, Ontario, Canada
- Located on 950 acres
- Produces 120,000 MWh (Megawatt hours) per year
- Largest photovoltaic power plant in the world
- Capable of providing power for about 12,800 homes
- Produces no waste, and solar panels will be recycled after they wear out

Olmedilla Photovoltaic Power Plant
- Olmedilla de Alarcon, Spain
- Located on 266 acres
- Produces 85,000 MWh per year
- Cost $530 million to build

Solarpark Lieberose
- Turnow Preilack, Germany
- Located on 402 acres of land
- Produces 53,000 MWh per year
- Contains 700,000 solar modules

Recently Approved - Solana
- Phoenix, AZ
- Will have a capacity of 250 MW
- Concentrated solar plant
- Will contain 2,700 parabolic trough collectors
- Will cover 1920 acres

Recently Approved - Imperial Valley
- Imperial Valley - CA
- Will be located on 6,440 acres
- Will have a capacity of 750 MW

Directions: After reading the information on this page, discuss the following questions in class.

1. Do you consider solar power to be expensive or affordable for practical use?
2. Do you think the space required for solar energy is difficult to obtain? If so, in what ways can we work to solve this issue?
3. Do the characters in Engineer It Out loosely follow the "Steps to Building a Solar Power Plant"? How to the steps of the Engineering Process you learned compare to the steps below?

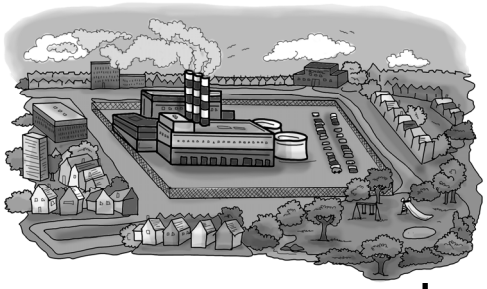
Steps to Building a Solar Power Plant

1. Finding and Selecting a Site
2. Preliminary Financial Analysis
3. Leasing or Buying Land
4. Engineering Design and Selection of Technological Features
5. Obtaining Permits
6. Power Purchase Agreement
7. Selection of Solar Installer
8. Financing the Project
9. Testing and Connection to Power Grid
10. Maintenance

Source: http://energyfuture.wikidot.com/solar-resources
http://www.greenworldinvestor.com/2011/04/12/solar-power-plant-project-how-to-build-a-solar-plant-in-10-steps/

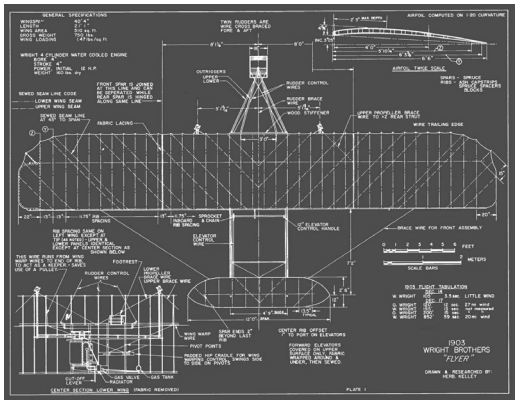
Name_____

Make a Blueprint



Directions: A **blueprint** is a drawing made to scale by engineers to show details of a larger object to be constructed. Blueprints contain measurements showing the actual dimensions of the intended objects. A sample of a blueprint is shown below to assist you.
In the space provided, draw a blueprint of a proposed solar power plant for Batsford in the Playbook® story, ***Engineer It Out!*** You may need to use a separate sheet of paper and make several separate drawings to convey all aspects of the plant, including outer building structures and inner functional mechanisms. (*Your drawing does not need to be completely scientifically exact; the purpose of the assignment is to explore blueprints and solar power structures.)*

Choose the ***type*** of solar power structure you think would work best for Batsford's situation and use it in your blueprint. Below are six different types which you can read about here: http://www.energydigital.com/sectors/energy/beyond-solar-panels-six-types-solar-power-plants



- **Photovoltaic Panels**
- **Parabolic Troughs**
- **Solar Dish**
- **Fresnel Reflector**
- **Solar Power Tower**
- **Solar Chimney**

Use the Internet to research the information you need to create a simple blueprint.. Here is one graphic showing the features of Photovoltaic Panels which you may find useful: http://solar.coolerplanet.com/extras/images/articles/SolarEnergySystemsFull.jpg.

Name_____

Get This "Re-SEARCH" Going!

Directions: Find and circle the following words from the story. Some are vertical; some are horizontal, and some are diagonal.

F W N U S U C C E S S S E

U N C L E N E D X T O P N

L A D C H R I S O W L D E

V S P I R T S I D E A E T

S O U R C E U C U M R J G

D R E T E S T L R O P P Y

P H P C N B A T S F O R D

R T R E S E A R C H W I W

I U O L M O Y B A S E V I

V G B E N G I N E E R A N

A L L C A R L A N X K T D

Word Box

engineer	**solar**	**power**
Batsford	**electric**	**research**
idea	**plan**	**success**
retest	**Carla**	**private**
Chris	**Uncle Ned**	**problem**
base	**dam**	**source**
energy	**wind**	**sun**

Name_____

Vocabulary Challenge

Directions: Write the letters of the words from the box below next to the correct definitions.

1. _____ to interrupt or cause disorder
2. _____ a supply or resource
3. _____ endlessly; for eternity
4. _____ not reusable; possible to consume
5. _____ changed from one form on thing to another
6. _____ a question
7. _____ other option
8. _____ a performance or feat
9. _____ impaired or defective
10. _____ to reach or acquire
11. _____ leveled
12. _____ not continuous; stopping and starting

A. unsound	B. stunt	C. alternate	D. disrupt
E. expendable	F. intermittent	G. reserve	H. obtain
I. graded	J. inquiry	K. perpetuity	L. converted

Build a Bridge
(Activity Guide for Teacher Use Only)

The links below include teacher/instructor resources for bridge building activities and the engineering principles behind bridge design and construction.

- **Building Big from PBS:** Covers types of bridges, bridge facts, forces involved in bridge function, links to additional bridge-related activities, and more. http://www.pbs.org/wgbh/buildingbig/bridge/index.html

- **Build a Paper Bridge:** Activity plan for students to build a bridge out of paper. http://www.learnnc.org/lp/pages/3050

- **Build a Popsicle Stick Bridge:** Includes instructions for building, testing, and many photo examples of different types of popsicle stick bridges. http://www.garrettsbridges.com/popsicle-stick-bridges/

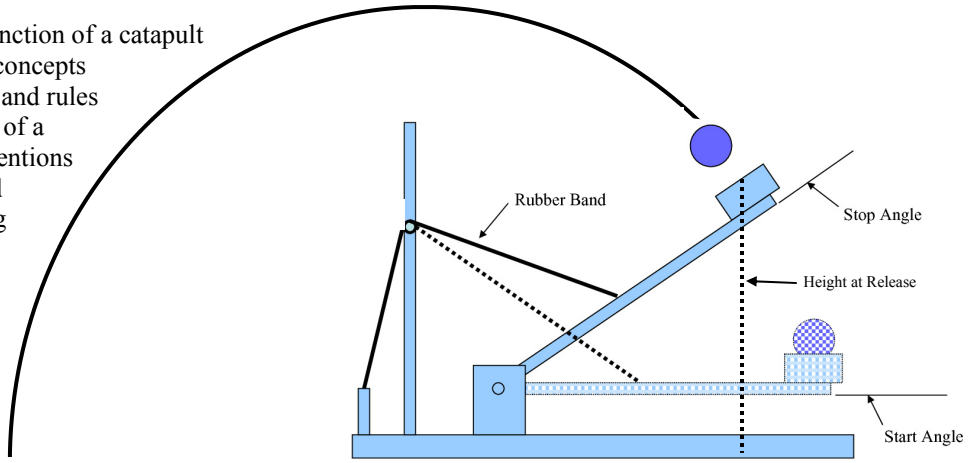
- **Virtual Bridge Site Evaluation:** Interactive web game lets students select which bridge would best fit certain locations and circumstances. http://www.pbs.org/wgbh/nova/tech/build-bridge-p1.html

- **Math Behind Bridge Building:** Includes information on the math principles behind bridge construction. http://passyworldofmathematics.com/sydney-harbour-bridge-mathematics/

Name_____

Catapult Math

Directions: The structure and function of a catapult demonstrates key mathematical concepts including the quadratic equation and rules about the dimensions and angles of a triangle. While these ancient inventions were first used without advanced mathematical knowledge, relying instead on basic trial and error, engineers today can optimize performance of these tools and better understand the reasons why some designs work better than others using the laws of math and physics. Solve the problems below using the numbers given.



The Quadratic Equation: $f(t) = at^2 + bt + c$

The quadratic equation can be used to graph a parabola. The Equation of Motion is an example of its practical applications and can describe the path of an projectile launched by a catapult. Applied in this way, *y(t)* equals the height of the projectile, *x(t)* equals the horizontal distance of the projectile, and *t* equals the time elapsed since launch, where a is acceleration, b is initial velocity and c is initial position.

For questions 1-5, use the following information: A particular catapult launches a projectile that follows a path described by the equations….

$y(t) = -(1/4)t^2 + 2t + 5$

$x(t) = -(1/10)t^2 + 2t + 0$

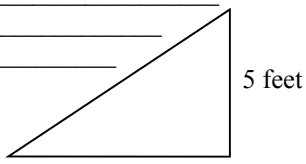
1. Complete the following table showing the number of seconds elapsed since the projectile's release.

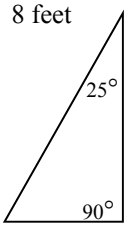
t	0	1	2	3	4	5	6	7	8	9	10
y											
x											

2. How high does the catapult's arm suspend the projectile at the time of launch? _____
3. Based on the chart, approximately how high is the catapult capable of launching the object? _____
4. Based on the chart, how long does it take the projectile to reach its highest point? _____
5. How far is the catapult capable of launching the object? _____
6. The triangle on the right (top) represents the angle and height of the arm of a catapult when it releases a projectile. Find the length of the arm. _____
7. Using the triangle on the right, (bottom) find the angle of the arm of a catapult at the time of launch._____
8. The ideal initial angle of launch for a projectile is 45°. What does this mean in terms of results? What happens if the angle is less than 45°? What happens if it is more than 45°?

   _____

   _____





9. Why do you think this is?

   _____

   _____

10. **Bonus question:** Explain what the following equation represents. $R = v_o^2 \sin(2\theta)/g$

Name_____

Being an Engineer

Directions: Explore the vast potential and range of choices for an engineering career. Read the information below and explore the web links provided.

Engineering is one of the most promising fields for new graduates today. Entry-level positions typically require a bachelor's degree and starting salaries are some of the highest of new college graduates.

There are more than 25 areas of specialization in the engineering field! For example:

- Aerospace Engineering - *design aircraft*
- Architectural Engineering - *design buildings and other structures*
- Bioengineering - *use biology and engineering to advance biomedical field*
- Chemical Engineering - *work with pharmaceuticals, food processing, polymers, and other chemicals*
- Civil Engineering - *leaders in technology*
- Computer Engineering - *work with hardware and software systems*
- Electrical Engineering - *design electronic inventions and equipment*
- Environmental Engineering - *work to solve issues of pollution, recycling, waste control, and public health*
- Mechanical Engineering - *use knowledge of energy, materials, and mechanics to design wide variety of devices*

Read about the opportunities in these fields and more with the following resource:

http://www.tryengineering.org/explore-engineering/engineering-majors

Preparation for a Career in Engineering: Students interested in engineering can start working toward that goal in junior high and high school by choosing courses that will be useful to their education. Some of these include but are not limited to….

- Algebra II
- Biology
- Calculus
- Chemistry
- Physics
- Foreign Language

Resources for Pursuing a Career in Engineering: The following links provide information on the engineering field and how to plan for a career.

http://www.careerpath.com/jobs-in/engineering/?industry=engineering&cbRecursionCnt=1
http://www.tryengineering.org/explore-engineering

Engineer it Out
Answer Key
For Teacher Use Only

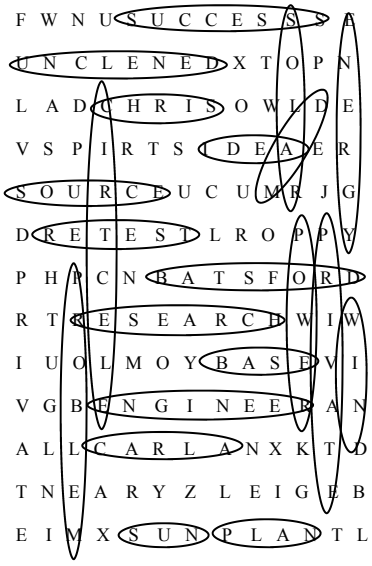
Steps to Innovation

1. Picture it
2. Research it
3. Plan it
4. Build it
5. Test it
6. Change it
7. Retest it
8. Success

Vocabulary Challenge

1. D
2. G
3. K
4. E
5. L
6. J
7. C
8. B
9. A
10. H
11. I
12. F

Get This Re-SEARCH Going!



Catapult Math

1.

t	0	1	2	3	4	5	6	7	8	9	10
y	5	6.75	8	8.75	9	8.75	8	6.75	5	2.75	0
x	0	1.9	3.6	5.1	6.4	7.5	8.4	9.1	9.6	9.9	10

2. The projectile is at a height of 5 units at the time of release.

3. The highest point is when the projectile is 9 units high.

4. It takes 4 seconds for the projectile to reach its highest point.

5. It can launch the object 10 units.

6. sqrt(89) or about 9.4

7. 65 degrees

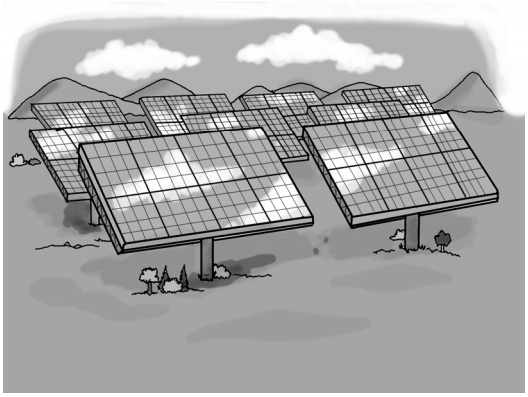
8. It maximizes the distance that the object will travel before hitting the ground. If the release angle is less than 90°, the object will not fly as high and will hit the ground closer. If the release angle is larger than 90°, the object will fly higher but hit the ground closer.

9. The distance a projectile travels is determined by two factors—the initial speed **in the x direction** and the time spent in the air. While a **larger** release angle results in a faster launch speed, the distance a launched object will travel is limited by the short time it spends in the air. A **smaller** release angle results in a longer time in the air, but a slower speed. A 45° release angle does not result in the fastest or the longest time in the air, but it travels the farthest because it does reasonably well in both categories.

10. v_0 is the launch speed, θ is the launch angle, and g is the gravitational acceleration. So this equation allows us to calculate how far an object can be launched at a certain angle at a certain speed.

Energize the Future

Answers will vary.



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