Young Engineers Club Curriculum

COLLABORATORS			
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ACTION	*NAME*	*DATE*	*SIGNATURE*
WRITTEN BY	Arthur Davis	September 3, 2016	

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Introduction

Traditionally, education in the field of engineering is not made available to students until they reach the college level. Even though primary school students may not be prepared to handle the advanced science and mathematics that are the typical domain of the engineering disciplines it's never too early to apply engineering principles to solving problems.

The Young Engineers Club is open to all ages attending the Saratoga Independent School and will expose students to engineering fundamentals on a level they will find engaging and fun.

Each club meeting will briefly introduce an engineering discipline and then pose an open ended engineering challenge in that realm. Sometimes the whole club will work together to solve a problem, other times we will break out in to teams for some friendly competition. This self-directed problem based approach is an enjoyable way to foster engineering fundamentals such as innovation and original thought.

Engineering areas that we'll be exploring include: Acoustical, Aerospace, Architectural, Biomedical, Chemical, Computer Aided Design, Electrical, Mechanical, Naval, Optical, Robotics, Rocketry, Software and more. As the school year progresses, club members will add skills from earlier topics to their toolkit which they may bring to bear for solving more interdisciplinary challenges. If students develop an affinity to certain activities then we'll find ways to incorporate those activities into the various subjects that we cover. We'll also include tangential topics based on student interest.

Club members will be using tools that may typically be labeled "Keep out of reach of children" (e.g. cordless drill, soldering iron, etc.). We'll be sure to closely supervise as necessary but also promote empowering students to use tools safely and effectively. On days where we use tools we'll always start out by emphasizing safety procedures and make sure participants are wearing appropriate safety gear. Additional precautions will be taken based on age.

Occasionally we may ask students to bring in craft supplies, various recyclables or broken gadgets from home for use in the club. If you have a technological household item that you are going to throw away, consider hanging on to it to send in when called for so that we can explore some reverse engineering and disassembling skills.

Club meetings will be weekly occurring after school on Tuesdays. Parents are welcome to attend meetings to help with organization and safety but remember, please try to participate only as a passive resource. The process of trying to solve a problem without boundary is part of the joy of engineering. As difficult as it may be to watch your child try to do something the "wrong" way, this more often than not can lead to a very clever solution that you will find wonderfully surprising.

Finally, we may plan an occasional weekend meet up at local events that are of interest to the club (for example, FIRST LEGO tournament).

Part I

Workshop 1: What is Engineering?

Chapter 1

What is Engineering?

1.1 Disciplines

- Engineering Fundamentals

1.2 Setup

1.2.1 Resources

- http://www-tc.pbskids.org/designsquad/pdf/parentseducators/DS_Act_Guide_complete.pdf
- http://www.mechatronics-mec.org/downloads/Engineering%20Notebook08.pdf

1.2.2 Materials

- Large whiteboard and dry erase markers
- Masking tape (that will be easily removable from whiteboard)
- Index cards
- Computer workstation with internet access
- Make Magazines
- Various gears and other engineering like gizmos
- 3-hole engineering graph paper

1.2.3 Location

Indoor classroom/lab environment

1.2.4 Preparation

Distribute the gears/gizmos, magazines and index cards across all the classroom tables. Don't offer direction one way or another whether the kids are allowed to touch these things. When they do start playing/reading don't make them stop when you move on to new activities.

Have a computer workstation set up and pointing at the webpage: http://spacefem.com/quizzes/engineer/ During the challenge allow students to individually come up and take the quiz (with assistance if necessary). Have them log their results on the first page in their engineering notebook.

1.3 Challenge

Pose the question "What is engineering?". Allow the discussion to be driven by the students. Invite the students to write down or draw something on the index cards that they think has to do with engineering. Let them make as many index cards as they want.

Also create cards (optionally extra large) with your own selection of engineering disciplines. My choices include: Acoustical, Aerospace, Architectural, Automotive, Biomedical, Chemical, Civil, Computer Aided, Electrical, Manufacturing, Marine, Mechanical, Optical, Robotic, Software

Place your cards up on the board and have the kids group their cards with the topical areas they think they fit with. You can connect categories with marker lines and/or have multiple cards made if they fit into several categories. Add categories as necessary. Try to use Venn diagrams to group things together.

Based on the results ask the students to pick some of their favorite cards and try to identify a discipline that they like. Have them log the result in their notebook and compare that to their quiz results. Have them put their name and date on the page.

Redistribute the notebooks so everyone has somebody else's notebook. Invite the students to report on whose notebook they got and what kind of engineer their colleague is. As a "peer review" then they can sign and date their name at the bottom of the page and return the notebook to the owner.

Part II

Workshop 2: Siphon and Boat

Chapter 2

Siphon

2.1 Disciplines

- Naval Engineering

2.2 Setup

2.2.1 Materials

- Large tub or large watertight storage bin
- 20ft of clear 1" diameter tubing
- Several large balloons
- Food coloring
- Step ladder

2.2.2 Location

Best to do this activity on a hot day outside.

2.3 Demonstration

Illustrate the workings of the siphon.

- Place the tub up on the step ladder and fill it with water.

Warning
STUDENTS MUST STAY CLEAR OF THE LADDER. A LARGE TUB OF WATER UP HIGH IS A FALLING HAZARD.

- Fill the hose with water, block it with your thumb and take one end out to demonstrate siphoning.

- Go to aim the end of the hose at the students but bring it up above the level of the tub as you do so and the water will stop flowing.
- Bring the hose down to look into the end "Huh I wonder why it's not working" to get sprayed in the face for raucous laughter.
- Partially block the tube output with your thumb to spray the water.
- Ask the class if they think you can spray the water back up into the tub and show what happens.
- Ask what will happen if an empty balloon is put at the end of the siphon. A balloon full of air? Hold the tube above the level of the tub to stop the flow of water and put a drop of food coloring in. Then try the different tests with the balloon.
- Fill the tube with water, add food coloring and plug it with your thumb. Bring it down below the level of the tub. Remove the end in the tub and allow some water to bleed out with your thumb so there is a large air gap on the tub side. Put the tube on the tub side back in the water. Ask the class what they think will happen when you remove your thumb and show them. Try it with different sized air gaps.
- Challenge the students for a way to get the siphon going without submerging the tube. If the water and the tube are clean enough, demonstrate sucking out the air in the tube to get the siphon started.

Important
WARN AGAINST ATTEMPTING THIS AS IT IS A CHOKING HAZARD AND SHOULD ESPECIALLY BE AVOIDED IF THE LIQUID IS TOXIC.

- Alternatively if there is a hose available to backfill the tube (or make a water balloon that can be used to back fill the tube) this also will get the siphon going.
- When demonstration is complete, drain the tub to a safe weight and take it down from the ladder to refill on the ground for the club's engineering challenge.

Chapter 3

Unsinkable Boat

3.1 Disciplines

- Naval Engineering

3.2 Setup

3.2.1 Resources

- http://www-tc.pbskids.org/designsquad/pdf/parentseducators/DS_Act_Guide_complete.pdf
- http://pbskids.org/designsquad/parentseducators/resources/watercraft.html
- http://www-tc.pbskids.org/designsquad/pdf/parentseducators/DS_Act_Guide_Watercraft.pdf
- http://pbskids.org/designsquad/build/watercraft/

3.2.2 Materials

- 50 plastic straws per team
- 1 roll of tape per team
- 25 pennies
- 5 paper cups per team
- Plastic Wrap
- Additional coins/washers
- Large tub or large watertight storage bin
- Stopwatch
- Digital scale (or triple balance scale)
- Internet Media Access

3.2.3 Location

Inside or outside on a warm day.

3.2.4 Preparation

Fill the tub with water.

3.3 Demonstration

Show the Design Squad video: http://pbskids.org/designsquad/build/watercraft/

3.4 Teaming

Teams of 2-3 making sure youngest are teamed with older student(s)

3.5 Challenge

Build a boat that can hold 25 pennies for at least 10 seconds before sinking

Give each team tape and straws and let them have at it. Have teams log their designs and results in their engineering notebooks. For those interested, try adding additional weight (coins and/or washers) to see how much their boats can take before sinking.

Students can weigh the coins/washers their boat held and log it in their notebook. If the scale is sensitive enough they might also weigh their boat.

Part III

Workshop 3: Paddle Power

Chapter 4

Paddle Power

4.1 Disciplines

- Naval Engineering
- Mechanical Engineering

4.2 Setup

4.2.1 Resources:

- http://www-tc.pbskids.org/designsquad/pdf/parentseducators/DS_Act_Guide_complete.pdf
- http://pbskids.org/designsquad/build/paddle-power/
- Design Squad Season 2, Episode 8: Aquatic Robots

4.2.2 Materials

- Large tub or large watertight storage bin
- Stopwatch
- Internet Media Access
- Per team:
  - Chipboard cardboard (such as a cereal box)
  - Plastic tape
  - 2 paper cups ($\geq$8oz)
  - Plastic wrap
  - 5 rubber bands
  - Scissors
  - Straws
  - Washers
  - Dowels

4.2.3 Location

Inside or outside on a warm day

4.2.4 Preparation

Fill the tub with water.

4.3 Demonstration

Watch the Design Squad video when done. http://pbskids.org/designsquad/build/paddle-power/

Loop a 1x2" piece of cardboard through a rubber band hold taught between your fingers. Illustrate winding it up and letting it go to show how it spins.

Introduct potential (wound up rubber band) and kinetic energy (unwinding rubber band and spinning paddle).

4.3.1 Class Inquiry

- Where is the energy stored?
- How can the potential energy be increase?
- How can you tell when potential energy is being used?
- What are the different kinds of kinetic energy that occurs as the boat moves through the water?
- What other examples of potential and kinetic energy can you think of?

4.4 Teaming

Teams of 2-3 making sure youngest are teamed with older student(s)

4.5 Challenge

Build a boat that paddles itself using a rubber band as its power source.

Time how long it takes for the boat to travel across the tub. Have students keep records in their engineeering notebooks.

Part IV

Workshop 4: Block Tower Battle

Chapter 5

Block Tower Battle

5.1 Disciplines

- Architectural Engineering

5.2 Setup

5.2.1 Materials

- Large Building blocks
- Alternatively plastic cups, cut up 2x4's, paper/cardboard crafted blocks
- 10-20 foam balls or wiffle balls
- Tape measure
- Stopwatch
- TODO: materials for ball hurling contraptions

5.2.2 Location

Gymnasium or outdoors

5.2.3 Preparation

TODO: Locate some appropriate video on the topic

5.3 Demonstration

5.3.1 Class Inquiry

5.4 Teaming

Split the ctudents into 2 evenly distributed teams or teams of 4-6 each.

5.5 Challenge

"Build the best structure for a variety of challenges"

If you have enough building blocks for all teams, they can build their architectural structures simultaneously. Otherwise one team can build their structure while the other teams constructs a ball hurling device that will be used to try to knock it down.

Start with a 5 minute limit. See who can build the tallest structure. Measure with a measuring tape and have the students make a schematic in their notebook of their structure and its dimensions.

If everyone was able to build their own structures at the same time then each team can be tasked with building it's own "wrecking ball" device to see who can knock down their tower with the fewest shots. Otherwise teams can pit their building agains other teams wrecking contraptions. Be sure to encourage keeping track of the the results in the students notebooks.

5.5.1 Class Inquiry

5.5.2 Further Challenges

Part V

Supplemental Workshops

Chapter 6

Ramp Racers

6.1 Disciplines

- Mechanical Engineering
- Automotive Engineering

6.2 Setup

6.2.1 Resources

- http://www.thingiverse.com/thing:1219729

6.2.2 Materials

- Ramp. A large board or table that can be tipped at an angle. You may even task the students to come up with a suitable ramp.
- Building materials on hand like gears, wheels, Legos, K'Nex. Let the kids find what they may.
- Stopwatch
- Ball
- Slingmobiles: http://www.thingiverse.com/thing:1219729
- Board or otherwise improvised road block

6.2.3 Location

Classroom/lab with materials on hand for improvised construction

6.2.4 Preparation

Write the challenge statement up on the whiteboard. Don't call the "racer" a "car" and don't call attention to the fact that it doesn't have to be a car. Many students may start out building cars.

6.3 Demonstration

6.4 Teaming

Students may form teams or work individually

6.5 Challenge

"Build a racer that is the fastest down the ramp."

As students complete their builds use the stopwatch to time their racer down the ramp. They should record each time in their engineering notebook. They are free to modify their racer and try again. Changes and new trial times are good details to keep records of in their notebook. Keep a leader board of times.

Ask them to review their notes to identify the changes that made the best improvement to their times.

6.5.1 Class Inquiry

- Why does the racer go down the ramp?
- What is gravity?
- Put a car sideways on the ramp. Why doesn't it go down the ramp?
- What is friction? Where is the friction? (High friction where the wheel meets the ramp, low friction on the wheel axles).
- Can anyone come up with a racer that will slide (instead of roll) down the ramp?
- How will larger or smaller diameter wheels affect the racer?

6.5.2 Further Challenges

- Facilitator enter your own racer for a time trial. Start with just a ball. When the students object, point at the challenge on the whiteboard indicating that a "racer" doesn't need to be a car.
- Allow the kids to make a new round of "racers" and have them keep track of their new designs and times.
- Race your ball again this time giving it a strong rolling push at the starting line. Also not expressly against any rules.
- The kids will probably get carried away in the next round zooming their racers down the ramp.
- Add the constraint that the racers may no longer be pushed down the ramp.
- Bring out the Slingmobiles with their rubber band catapult and see how they do in the time trials.
- Invite the kids to build their own launching systems.
- Add a board or otherwise complete roadblock halfway down the middle of the ramp. See how the kids design around surmounting that challenge.