LAUSD Elementary Engineering

SUNDIAL CHALLENGE

Third Grade - Earth Science

PURPOSE

IN <u>SUNDIAL CHALLENGE</u>, STUDENTS WILL:

- Design a sundial using the Engineering Design Process (EDP)
- Exhibit understanding of relevant science content/concepts
- Construct relevant questions
- Use appropriate tools and materials to complete the task
- Determine effectiveness of their design
- Answer the Challenge Question: <u>How can your team design a sundial that can be used by the whole school?</u>

NEXT GENERATION SCIENCE STANDARDS

ETS (Engineering, Technology, and Application of Science Standards)

- **ETS1.A** Defining and Delimiting Engineering Problems
- **ETS1.B** Defining Possible Solutions

SCIENCE AND ENGINEERING PRACTICES (SEP):

- Asking Questions and Defining Problems
- Developing and Using Models
- Planning and Carrying Out Investigations

CROSSING CUTTING CONCEPTS (CCC)

- Patterns (CCC-1)
- Scale, Proportion, and Quantity (CCC-3)

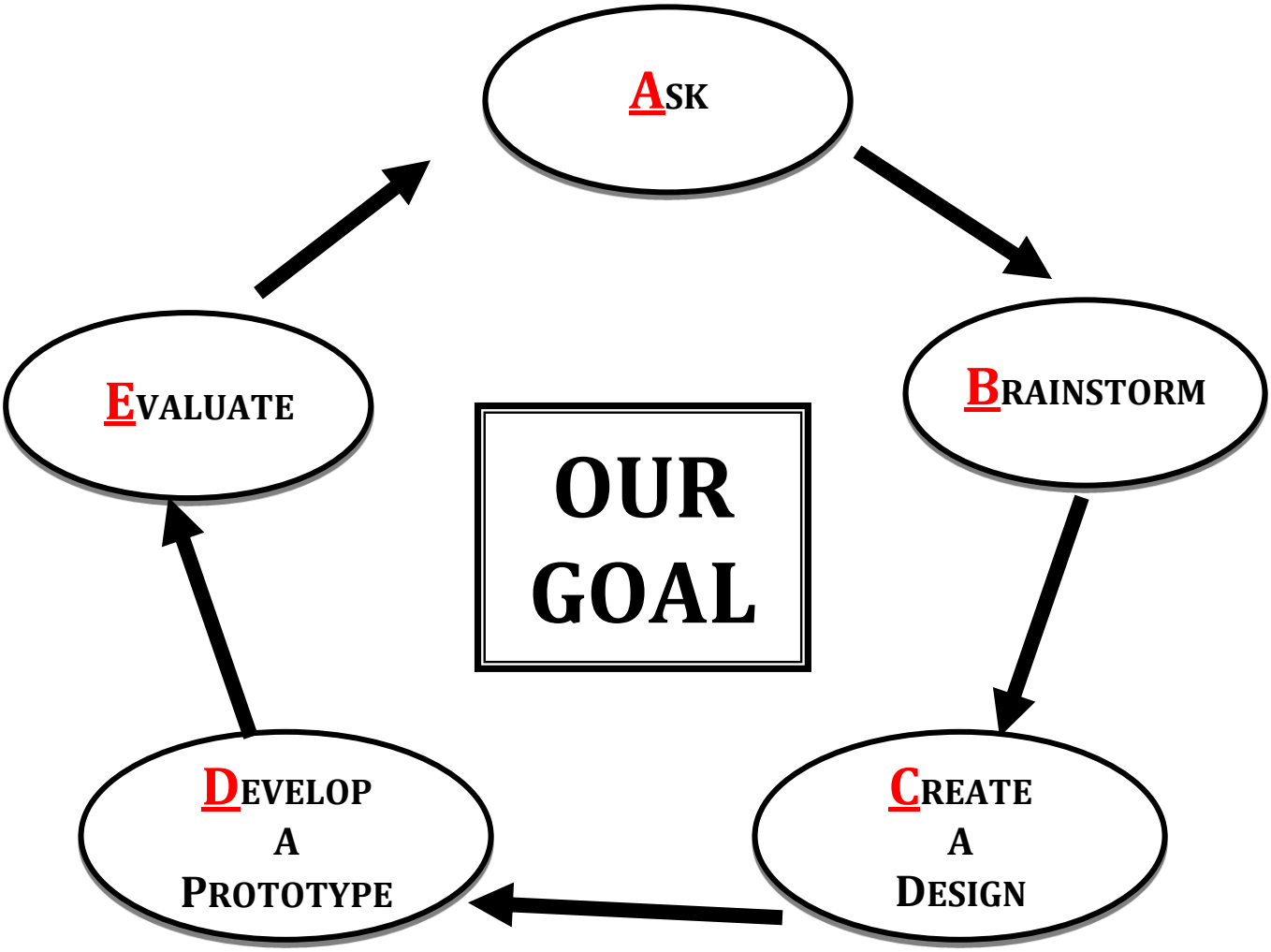
CA ENGLISH LANGUAGE DEVELOPMENT CONNECTIONS

- **P1.3.A.1** Exchanging information and ideas with others through oral collaborative discussions on a range of social and academic topics.
- **P1.3.A.3** Offering and supporting opinions and negotiating with others in communicative exchanges.
- **P1.3.B.5** Listening actively to spoken English in a range of social and academic contexts.
- **P1.3.C.11** Supporting own opinions and evaluating others' opinions in speaking and writing

SPECIAL EDUCATION (SPED):

To make accommodations or modifications for students with special needs, provide simple directions, instructions, provide multiple opportunities for repetition, make frequent checks for understanding, use visuals to accompany all vocabulary, simplify questions, be specific with sequence and steps, provide opportunity for paraphrasing, and adjust time and pacing.

THE ENGINEERING DESIGN PROCESS (EDP)



ENGINEERING DESIGN PROCESS (EDP)

ASK

- What is the **problem** or **need**?
- What is already out there?
- What are the **requirements (criteria)** and **restrictions (constraints)**?

BRAINSTORM

- What are possible **solutions**?
- Choose your two best solutions.

CREATE - A - DESIGN

- **Draw** a diagram with labels.
- Have a critical design review (peer review & input).
- What materials are available?

DEVELOP - A - PROTOTYPE

- Follow your best diagram and **build** a Prototype.
- **Test** the prototype!

EVALUATE

- **Improve** your prototype!
- Conduct more compatibility tests.

BACKGROUND FOR THE TEACHER

You may teach this lesson once students have completed:

FOSS CA – Sun, Moon, Stars
Investigation #1 (part 1-2)

Students will have enough content knowledge to engage in the sundial challenge. Students enter the engineering challenge understanding that the Sun rises in the east and sets in the west. Shadows are the areas of darkness created when an opaque object blocks light. The shapes of shadows change over a day and depend on the position of the sun in the sky.

Tips for the Teacher:

<u>Things to consider</u>:

- Sun—No sun, no fun. (June Gloom or April Showers)
- Wind—Too much wind blows the dial plate around.
- Keep on the yard or take back to class each hour? (Kind students may bring the sundial to your class/others may touch your sundial.)
- Do not use decorations until all the hour lines have been drawn and given a test run for accuracy. Complete in class right before the sense-making discussion.

<u>What will be your grading criteria</u>?

- Able to work in a group using the Engineering Design Process?(See Engineering Notebook)
- A Team Sundial that works accurately and follows the requirements and restrictions guidelines? (Think in terms of a 3rd grader)
- Individual or group grade?

Background Information

- Shadows are cast on the ground opposite the position of the sun in the sky. For example, if the morning sun is in the east (right), the shadow will be on the left side of the sundial and travel to the right throughout the day. (like a clock)
- The shapes of a shadow change over the course of a day and the size of the shadow depends on the position of the sun in the sky.

Questions and Answers:

1. What are the parts of a sundial?
   Gnomon: The shadow caster, in a horizontal dial, the angle phi is equal to the Latitude of the location.
   Hour Line(s): The numbered lines that the shadow falls along.
   Nodus: A "marker" along the gnomon to get an exact point on the shadow.

2. Which way do you face a sundial?
   Find true North (in the Northern Hemisphere). The gnomon, set to the correct latitude, has to point to true North. You face North to read the sundial in front of you.

3. How do you read a sundial?
   The shadow moves past each of the lines marked with hours in a similar way that a clock's hour hand moves around its face.

4. Who invented the sundial?
   Theodosius of Bithynia (160 BCE – 100 BCE) invented the universal sundial that could be used anywhere on Earth. Before there were clocks, people generally relied on the sun's position in the sky.

   Extended optional advanced lesson: If you want to draw the hour lines based on mathematical calculations and draw them using a protractor, go to http:sundials.org. They have a java script calculator called Calculating Dial Lines – 2. To determine your school's latitude, use google maps. Put your school name in the google map's search bar. On the

address bar, after your school's name/ copy the first number (latitude) _ _._ _ for the sundial calculator. You will need to teach your students how to use a protractor.

MATERIALS

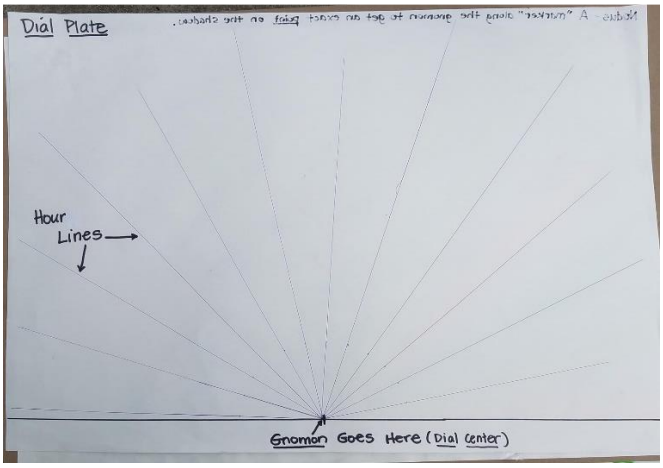
FOR EACH TEAM

- Bin or large zip-lock storage bag to carry team supplies.
- Premade dial plate—18 x 24 inch white construction paper glued to same size chipboard with East/West line drawn along the bottom and center of line marked
- Glue (to secure the golf tee to dial plate)(decorating later)
- 3 ¼ inch golf tee
- Chalk (for tracing the dial plate on the playground—first outing only)
- Pencil with eraser (to trace shadow line and for noting the time)
- Ruler/yardstick
- Compass (magnetic) (for aligning the dial plate-first outing and to check later)
- Watch (optional)

- Scissors (during decorating)
- Protractor (optional extended lesson)
- Transparent tape (optional)
- Rocks or glass gems (optional decoration)
- Straws (colored without bend, if possible) (optional decoration)

FOR THE LESSON

- Individual student engineering notebooks and pencils
- Dial Plate Diagram with East/West line, mid line mark, example hour lines and base labeled "Dial Plate" to be used to introduce vocabulary

- 

- Post-it with names of dial plate parts for vocabulary discussion
- Smartphone with compass app (to be used to align the dial plates' East/West lines with true East/West) and to tell students the time when on the yard.
- Flashlight with fresh batteries to show how a sundial works
- Additional decorating supplies—markers, pipe cleaners, stickers, etc.

GETTING READY

1. Schedule the Investigation

- The challenge will take approximately 2-3 day--(3) 45-minute lessons--EDP lesson, decorating time, sense making discussion, and time for data to be collected throughout the day. (Go out approximately 7 minutes before each hour or what you deem enough time. Allow **extra time** for the first outing to align the dial plates correctly.)

2. Gather/Obtain Materials

- **2 days before the lesson,** teacher prepares the dial plates and Dial Plate Diagram. (with post-it of vocabulary words teacher will add to the diagram as the lesson is carried out during Ask Questions or beginning of Brainstorming)
- **In the morning, 1 day before the lesson,** teams glue the gnomon on the dial plate and allow it to dry overnight or the teacher uses hot glue to put gnomon on the dial plates. Instruct students to observe possible places on the yard that are flat and will NOT get shade during the day from trees, play equipment, or buildings. Preferably, out of the walkways and away from students at play. (Students will discuss the possible locations during the "brainstorming" phase of the lesson.)

3. Prepare Materials

- Have materials for each team in science bins or large zip-lock bags. See materials list on the previous page. Decorating materials can be put on a table for viewing, but should not be placed in bins or bags until groups are done with data collecting.

4. Plan Teams

- Have teams of no more than 4 students

5. Challenge Question

- Have Challenge Question written on poster paper or on whiteboard – "How can your team design a sundial that can be used by the whole school?"

- Students record the Challenge Question in their Engineering Notebook or teacher creates labels with the Challenge Question for each student Notebook.

GUIDING THE ACTIVITY

Students will engage in the Engineering Design Process (EDP).

Share this story with your class to set the stage:

Our school has decided to have a Roman Festival Day out on the playground. Each display will depict an aspect of everyday life in Rome. Third grade has decided to show how Romans told time.

1. ASK

Setting the Context

Remind students of the previous science investigations where they explored what makes shadows. (If possible, show pictures of them doing the activities on the overhead)

- First, they went outside and traced the shadows of their bodies made on the schoolyard in the morning.
- Next, they drew these shadows.
- Then, they predicted where they would find their shadows when they observed it midday and just before the end of the school day.
- After, they traced their shadows for those times.
- Last, as a science talk, they related the change in their shadows' position to the change in the Sun's position in the sky. This understanding is important for making a sundial. They are a "human sundial".

Present Problem or Need

- Display the Challenge Question and have students write it in their engineering notebooks.

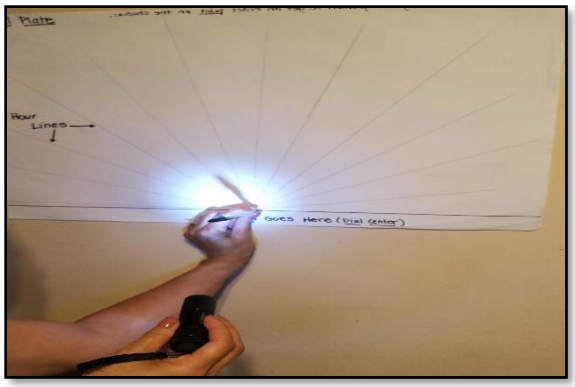
"***How can your team design a sundial that can be used by the whole school?"***

Students should be encouraged to ask questions.

- They should <u>record their questions and answers in their Engineering Notebook</u>. (What does a sundial look like? How does a sundial work?* How did others construct them? How much time do we have to create the sundial? Will we be working in groups or alone? What materials can we use?)

Model How a Sundial Works

- ***** Use a flashlight, the Dial Plate Diagram, and a pen. Place the bottom of the pen on the dial center. Aim the flashlight at the pen and look at



the shadow the pen creates. Move the flashlight around to show the "sun" moving and the shadow also moving across the dial plate. Dial Plate Diagram is taped to the wall so all can see.

- Teacher should provide images of sundials (Use this lesson's Title Page pictures), discuss similarities and materials used, and answer student questions.
- Show students your Dial Plate Diagram. Discuss names for the parts of the sundial. (Ask what students would call each part. When the class agrees on a name use a marker to label it on the Dial Plate Diagram. Use a different marker color as you explain the actual name and label the Diagram. Your Dial Plate Diagram becomes an Illustrated Vocabulary Reference. Leave this up during the sundial lessons)
- What about hours when you are at lunch or playing at recess?

Present Requirements and Restrictions (students record these in their Engineering Notebooks under the "Ask Questions" section.

- **Requirements** (Criteria): that must be met; rules/directions that must be followed:
  - Team must consist of 4 members
  - The Sundial must be free standing and at least two feet in diameter

- **Restrictions** (Constraints): (that keep something from being the best it could be; may be problems that arise or issues that come up):
  - Use materials that are cleared by the teacher
  - The team design must incorporate an aspect of each team member's design.
  - The structure must be large enough to be seen by large groups of people at school.

2. BRAINSTORM

- Have students brainstorm why and how the sundial could be used by the whole school.
- Brainstorm possible locations for data collection on the yard and solutions / designs.
- Allow students to view the decorating materials so they can incorporate them in their design.

3. CREATE - A – DESIGN

- Have student pick up their materials bin, this will give them an opportunity to see the materials and discuss how they may be used. Or they can gather around the art supply table to view supplies.

  - Without team members' input, each member must draw a design individually into their Engineering Notebook.

- Title the page "My design"
- Students should label the parts of their design (i.e. gnomon, base, hour lines) and include the materials needed.

- Team members share designs with one another, compromise, and collaborate in order to create a "team design". Team design must incorporate an aspect of each member's own design. (SEP-1)

  - Title the next page in the Engineering Notebook, "Team Design"
  - Team members should each draw and label parts of this collaborative design. Do not forget to indicate the materials of each part. Labels should show who contributed that part. (For example, Sally's gnomon.)

4. DEVELOP - A – PROTOTYPE

- Build it (SEP-2)
- Collect data - place the sundial outside where the sunlight will be unobstructed throughout the day. On the first time out, establish the correct position by lining up the East/West line with the compass. (Teacher puts smartphone with compass on the drawn East/West line of team's dial plate and together the dial plate is slowly rotated until the compass' East/West indicators match the drawn line. Try to hold the dial plate as close to the ground as possible when adjusting its position.) Remember to **allot plenty of extra time on the first outing** because the teacher will need to help align all 6 dial plates.

- Outline the dial plate with the chalk on the playground so you will know where to place it when you go out throughout the day.
- Use the ruler or yardstick to draw a line where the shadow falls on the dial plate to mark the hour (time).The line starts near the gnomon and radiates outward. Be careful not to shake or move the dial plate. The slightest movement makes it hard to draw an accurate line, Record the hour near the line you drew or at the top of the line.

- Record any observations, questions, or problems that arise in your Engineering Notebook. Make sure you note what time you are making the note. (at least at what hour you went out)
- Make hourly observations. Keep adding information to your notebook.
- Make sure the team keeps in mind the criteria and constraints.
- The next day, use a watch to see if the sundial is keeping time correctly. Group discusses if adjustments are necessary.
- When hour lines are accurate, team decorates the sundial. Make sure the team follows the "Team Design".

7. EVALUATE

- Teacher facilitates discussion about student successes and challenges.
- Students use the notes made in their Engineering Notebook to add observations and problems that came up.
- Class discusses how problems could have been solved or avoided.
- Students answer the challenge question in their Engineering Notebook.
- They also add their evaluation and reflection in their Engineering Notebook.
- Groups may decide to build a new sundial making it bigger or smaller. They may also see if they can use other materials.