Fatigue Failure

Materials Engineering

(40 minutes)

Authors

Ashley Carter

Matt Elledge

Chad Ward

SUBJECT/GRADE LEVEL

Subject: Science

Grade Level: High School

Materials

- 1 box of Non-skid Paper Clips (100 count)
- Metric Ruler/ Protractor
- Lesson Handout
- Pen/Pencil

STANDARDS

Next Generation Science Standards

- HS-ETS1-2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
- HS-ETS1-3 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.
- HS-PS2-6 Communicate scientific and technical information about why the molecular-level structure is important in the function of design materials.

LESSON OBJECTIVE(S)

Students will investigate fatigue failure in paper clip and design a new paper clip.

CAREER CONNECTION(S)

Mentor Background: Brett Boren is an engineer at Redstone Arsenal. Through the work of Brett Boren, there is a lot of confidence in equipment used for military operations. Brett Boren tests samples of materials to ensure that it meets quality assurance standards and specifications.

STEM Careers: Materials Engineering

ENGAGEMENT

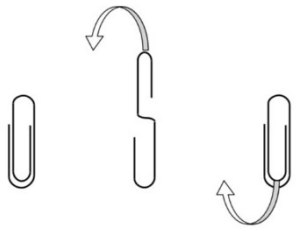
Brief Description: Students' prior knowledge to this lesson will be assessed.

Procedures:
Students will complete a "Do Now" question (why do objects break?). Students should provide examples of when they have fatigue failure of materials in their own lives. Students will have 1 to 2 minutes to reflect and answer this question in their own words. Students will then be selected and allowed to share their responses with the class or a partner. There will also be polls done to find out if students have witnessed the same examples of fatigue failure of materials in their own lives.

EXPLORATION

Brief Description: Students will participate in a hands-on activity example of fatigue failure.

Procedures:
1. Using your hands, carefully open the inner loop of the paperclip. Make the inner loop a 180 degree angle with the outer loop. (Teacher will demonstrate first and may call on students to repeat the instruction or what they observe/see)
2. Bend the paperclip back to its original position.



3. Repeat steps 1 and 2 until the paperclip breaks. Keep track of how many COMPLETE cycles of steps 1 and 2 were necessary to break the paperclip.
4. Each group's number of cycles will be recorded on the board. Data should also be recorded on each student's handout.
5. Students may have time to do repetitions, so enough data is collected.
6. Call on students to share/discuss the data.

EXPLANATION

Brief Description: Students will watch a video about fatigue failure.

Procedures:
Students will watch this video: https://youtu.be/hQG0TX-R22c. The teacher may stop the video to ask class questions and to give them time to update their warm-up (Do Now) question. For example, why would a company want to know about a material's fatigue failure?

ELABORATION

Brief Description: Students will apply what they know.

Procedures:
Students will answer the questions:

1. Based on today's activity and video, how do you think this experiment would be useful for engineers that build new objects?
2. What modification to the paper clip is needed to ensure that the paper clip will last longer?

Students will be given time to answer this question on a handout. The teacher will circulate to see students' responses and may read them aloud. Students will then be called on to answer the question. Students will be asked to show a silent thumb's up if they agree with a classmate. If a student disagrees, the teacher should call on the student to share their response.

To take it a step further, the class can come up with 3 criteria and 3 constraints in a new paper clip design and have a class competition for the best paper clip design.

EVALUATION

Brief Description: An exit ticket will be used to determine if students can demonstrate that they understand the objective of the lesson.

Procedures: students will answer the following question (using a complete sentence or sentences). "What caused the paper clip to break?"

The teacher will circulate the classroom and check off on the roster if each scholar has successfully completed the exit ticket. A future flex lesson may be done if a certain percentage of the class did not understand the lesson.

REFERENCES

- Engineering Laboratory 101 (cuny.edu)