City University of New York (CUNY)
CUNY Academic Works

Open Educational Resources | LaGuardia Community College

2015

Engineering Laboratory 101

Reginald Eze
CUNY La Guardia Community College

How does access to this work benefit you? Let us know!

Follow this and additional works at: https://academicworks.cuny.edu/lg_oers


Part of the Engineering Commons

Recommended Citation
Eze, Reginald, "Engineering Laboratory 101" (2015). *CUNY Academic Works.*
https://academicworks.cuny.edu/lg_oers/29

This Activity or Lab is brought to you for free and open access by the LaGuardia Community College at CUNY Academic Works. It has been accepted for inclusion in Open Educational Resources by an authorized administrator of CUNY Academic Works. For more information, please contact AcademicWorks@cuny.edu.

Designing Information Assignments for Literacy

Professor's Name: Reginald Eze
Course Name: Engineering Laboratory 101
Activity Duration: 3 hours
Activity Learning Objectives: The student will be able to

Objective 1 Compare failure of different products
Objective 2 Demonstrate the variability of materials
Objective 3 Observe relationships between properties and processing of steels
Objective 4 Observe differences in properties of metals, plastics and ceramics

With these enhancements, the student will be able to:

a) Demonstrate the variability of metal and plastic failure
b) Compare failure for different materials
c) Observe relationships, properties and processing of metals and plastics
d) Observe different behavior of metals, plastics and ceramics with varying dimensions

Description: Fatigue Failure in Materials

This lab introduces students to the fatigue failure of steels, plastics and ceramics when they are stressed in a controlled manner until the fail. Materials are subjected to repeated stress called fatigue and fatigue properties of different materials vary with type, source, quality, type and duration of applied stress. In this lab, the student experience fatigue by subjecting different types and sizes of paper clips to stress while loading at different angles, thereby developing a clear understanding of relationships between plastics, metals and ceramic materials.

Materials such as metals, ceramics and polymers are tested by engineers and scientist to reveal certain mechanical properties, such as the maximum stress a material can withstand. The stress at which a material breaks is called is a mechanical measure of its strength. During application a material may degrade, causing it to fail at much lower stress. For instance if a material is repeatedly loaded over and over again, and then fails, it has undergone a mechanical process

called fatigue. Fatigue as a name for this phenomenon, is based on the notion of a material becoming "tired", i.e. failing at less than its nominal strength.

Fatigue is important as it is the largest cause of failure in metals, estimated to comprise approximately 90% of all metallic failures; polymers and ceramics are also susceptible to this type of failure. In a nutshell,

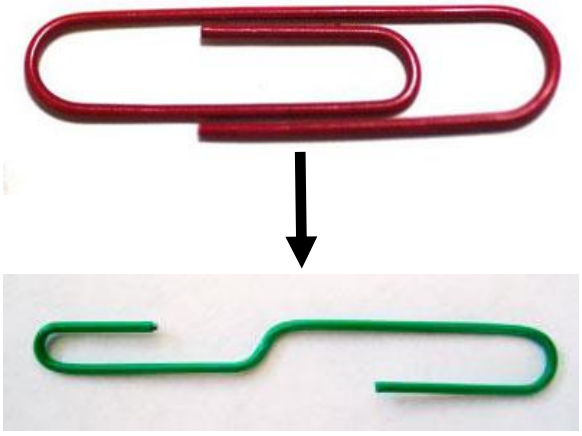
a) Fatigue is a form of failure that occurs in structures when subjected to dynamic and fluctuating stresses
b) Under these conditions it is possible for failure to occur at a stress level significantly lower than the tensile or yield strength for a static load.
c) It is ruinous and dangerous, occurring unexpectedly and without warning.
d) It is the primary design criterion in parts especially rotating shafts.
e) Cyclic strain and stress leads to fatigue failure.
f) It is also an issue for "static" parts, e.g. bridges.

Materials and Resources

Equipment:

1. Four different paper clips namely:

i. Small metal paperclip
ii. Large metal paperclip
iii. Small plastic paperclip
iv. Large plastic paperclip

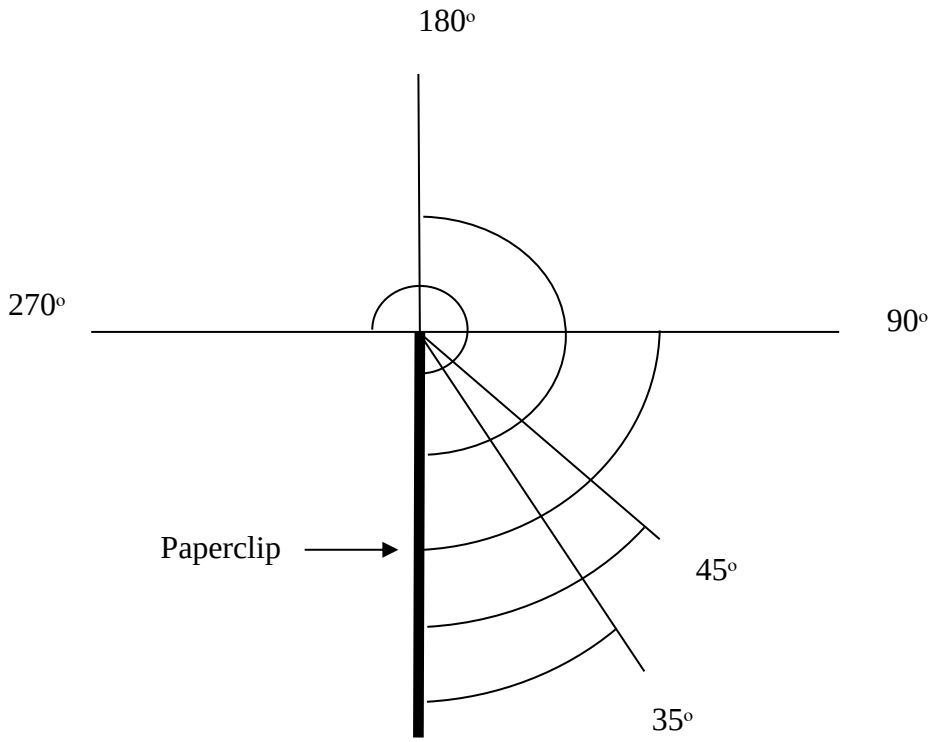


g) A ceramic material (replace with a serrated paperclip)
h) Metric ruler
i) Protractor

Steps:

1. Open your paperclips so that it resembles a backwards "S"

2. Use the protractor to produce a template to enable you bend a paperclip to a 35°.
3. Bend the paperclip back to its original angular position on the template [up and down]. This is considered as one loading cycle.
4. Repeat until the paperclip breaks. Count the number of times you bent your paperclip and record the number of your loading cycles in the table.
5. Complete the experiment by testing the rest of paper clips at 35°.
6. Continue the experiment by testing each type of paperclip at 45°, 90°, 135°, 180°and 270° respectively.



1. **RESULTS**

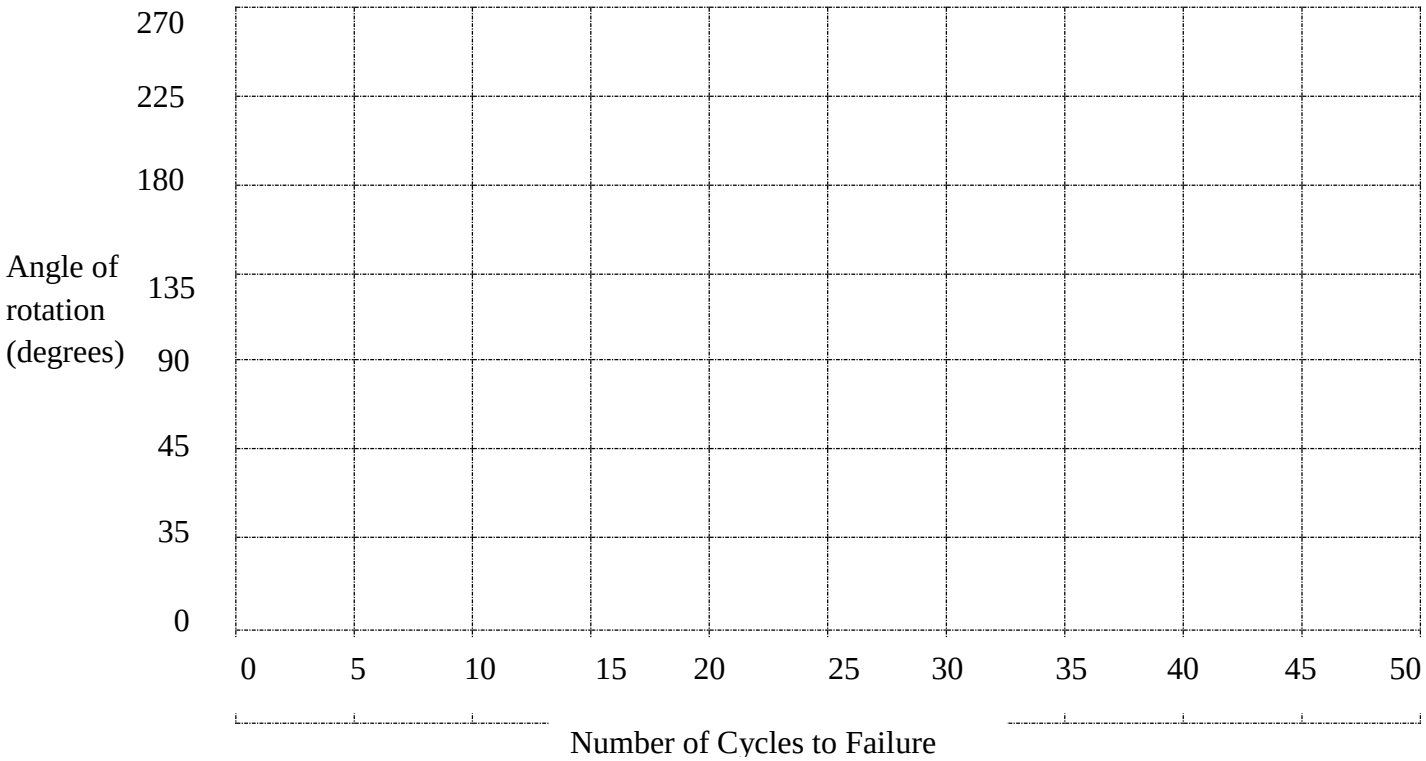
	Failure				
	Number of Cycles before Material Failure				
Fatigue angle (degrees)	Small Metal Paperclip	Large Metal Paperclip	Small Plastic Paperclip	Large Plastic Paperclip	Ceramic

35°					
45°					
90°					
180°					
270°					

In this experiment you compared three types of materials that varied in size and material properties:

Questions:

1. Which type of paperclip lasted the largest number of cycles before failure?
2. Which type of paperclip lasted the least number of cycles before failure?
3. Which angle [35°, 45°, 90°, 135°, 180°and 270°] was associated with the fewest number of cycles before failure?
4. Give three reasons why different paperclips may break at different number of bends.
5. Does the bending technique make a difference? Why?
6. Collect the data and draw a histogram of the results, which should show the number of cycles to failure versus angle of rotation.



Plot for angle of rotation in degrees versus number of cycles

DISCUSSION

i. Did the paper clip get warmer during bending? If so, what does this indicate?
ii. Discus the differences noted for each clip with respect to frequency of bending and material type
iii. What is the effect of bending stress on a material at 90° versus 180°?

Questions:

1) Explain how you think the experiment would be useful for engineers that build new objects.
2) What are the possible sources of error in your result? [human and material]
3) What changes would you make to the experiment in order to yield more accurate results?
4) If you were designing the World's best paperclip, what designer criteria would you use? Explain.
5) If you were designing a paperclip to be used for space, what designer criteria would you use? Explain.
6) What is the material compositions of steels used for paperclips?

2. **Reflection** about the Activity (please write several paragraphs):
   What did you learn by doing this activity with your students?
   What was successful? What would you do differently next time?
   Were there challenges or surprises?
   How did you change your activity to make it more focused on inquiry and problem solving? How does your activity address the college's Inquiry and Problem Solving competency?

INSTRUCTORS FEEDBACK: COURSE EVALUATION FOR STUDENTS

1. What is your major?
   i. Mechanical Engineering
   ii. Civil Engineering
   iii. Electrical Engineering
   iv. Environmental Engineering
   v. Physics
   vi. Other (explain)
2. Was the importance of fatigue and material testing made clear at the beginning of the lab?
3. Was the background material adequate?

4. Was the lab activity clear and understandable?
5. Was the instructor helpful?
6. Did the instructor answer your question?
7. What is the most interesting thing that you learned from this lab? Explain.

REFERENCES

1. Benenson, Ganatos, Ghosn. Activities and Assignments for ENGR 10100: Engineering Design Freshman Manuel. Third Edition. 2006
2. Thomas Stoebe, Paper Clip Experiment: Properties and Failure, Edmonds Community College, 2007
3. International Standard, ISO 1143-1975 (E): Metals-Rotating Bar Bending Fatigue Testing
4. K. Komvopoulos, Mechanical Testing of Engineering Materials, 2nd ed. University Readers San Diego, CA, 2011

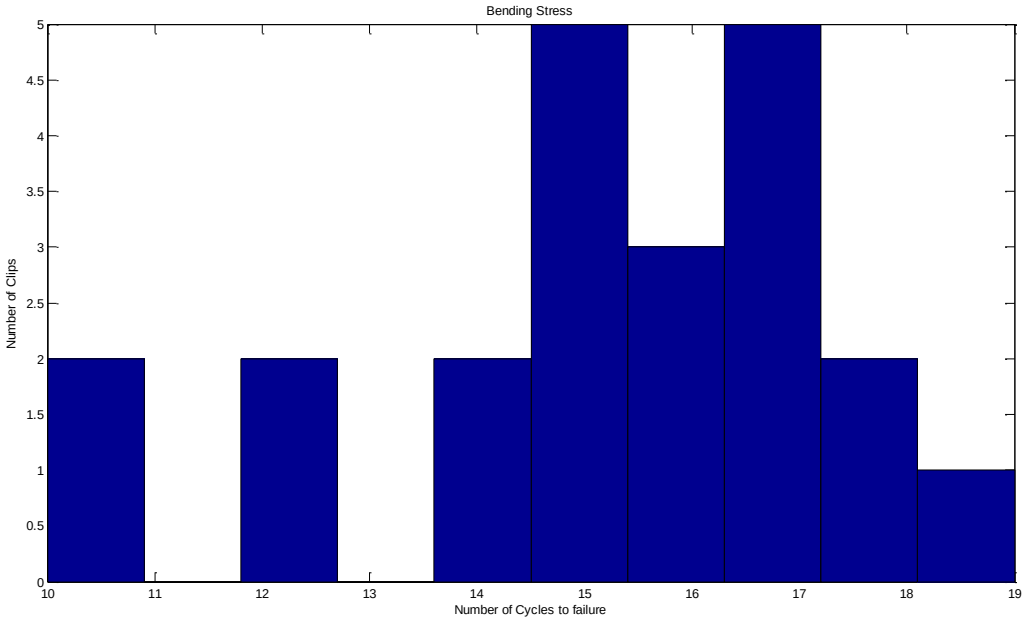
APPENDIX

a) **Matlab computer code template** for plotting the Histogram as an appendix (Microsoft Excel is also adequate)

```
MATLAB Pseudo code
number_clip=[14 12 15 15 12 17 15 16 17 14 19 18 15 15 17 16 17
16 18 10 10 17] ;
x0=0;
number_clip=number_clip-x0;
iplot=1 ;
figure(iplot)
hist(number_clip,10)
xlabel('Number of Cycles to failure')
ylabel('Number of Clips')
title('Bending Stress')
```

b) An electronic copy of the current version of this lab (as an attachment)
c) More practical applications and examples of fatigue in engineering and science.
d) Time duration for this lab

Sample result


Bending Stress
Number of Clips
Number of Cycles to failure
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
10
11
12
13
14
15
16
17
18
19