

## Activity C: Card deck experiment

### Introduction

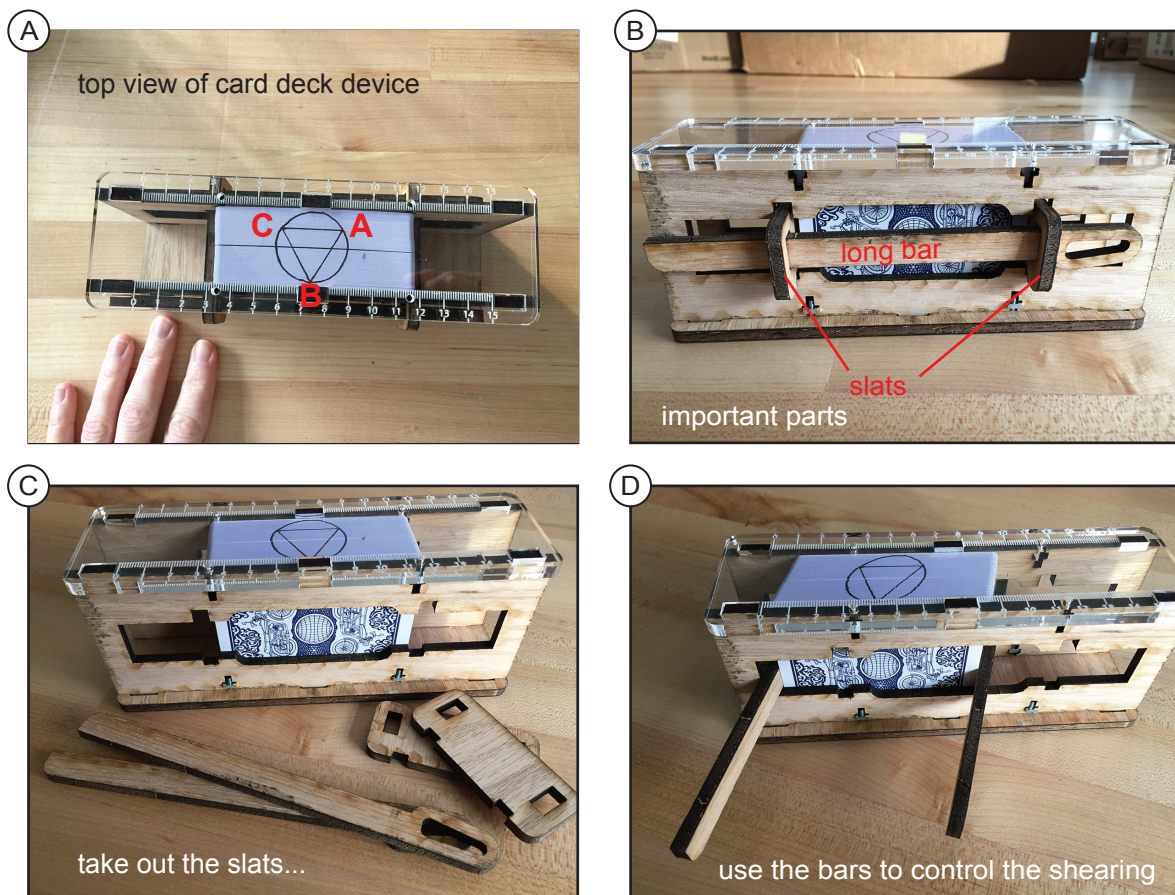
You will complete a classic simple shear experiment using a new personal-sized device designed by Aaron-the-machinist. The experiment is divided into increments and you will examine how the triangle (and circle) inscribed on the top of the card deck change as deformation progresses (Fig. 5A).

### Experiment

#### How do I set up the experiment?

First, on the practical side: remove the two long bars from each side of the device (Fig. 5B). These are going to be your tools for control the shearing of the card deck. Next, remove the two wooden slats that hold the card deck in the middle of the device. Set them aside (Fig. 5C). Now slide the two long bars back in, perpendicular to the card deck (Fig. 5D). These will allow you to control the amount of shearing.

Second, you need to figure out the magnitude of displacement to shear the card deck. The experiment will be performed in increments of  $0.25 \gamma$ , where  $\gamma$  is the shear strain. The easiest thing to do is figure out the value for one  $\gamma$ . (Think about how shear strain is defined...it's a simple geometric property.)



**Figure 5:** Four photographs illustrating parts of the set-up for the card deck experiment.

## How do I record data?

Use the table on the following page (or the blank Excel sheet included in Moodle) to record your measurements during the experiment. The rows in the table refer to  $\gamma$ . The columns refer to the lengths and the elongations ( $e$ ) for the three lines that make up the triangle drawn on top of the card deck – AB, BC, and AC (Fig. 5A).

## What is the experimental process?

- Measure the initial lengths of three material lines: AB, BC, and AC.
- Apply an increment of strain using the two long bars.
- Now measure the lengths of each of those lines again.
- Repeat for each increment of  $\gamma$  in the table.
- Now compute the elongation  $e$  for each line that corresponds to each step in the experiment. This should be a cumulative elongation (i.e., compared to the initial state, not to the previous increment). This is why you may find it easier to use Excel to record your length measurements.)
- Construct a graph of  $\gamma$  versus  $e$  for each of the three material lines (where  $e$  is on the vertical axis). You can sketch your results directly onto the blank graph provided or use Excel to make your own version.

## Clean-up

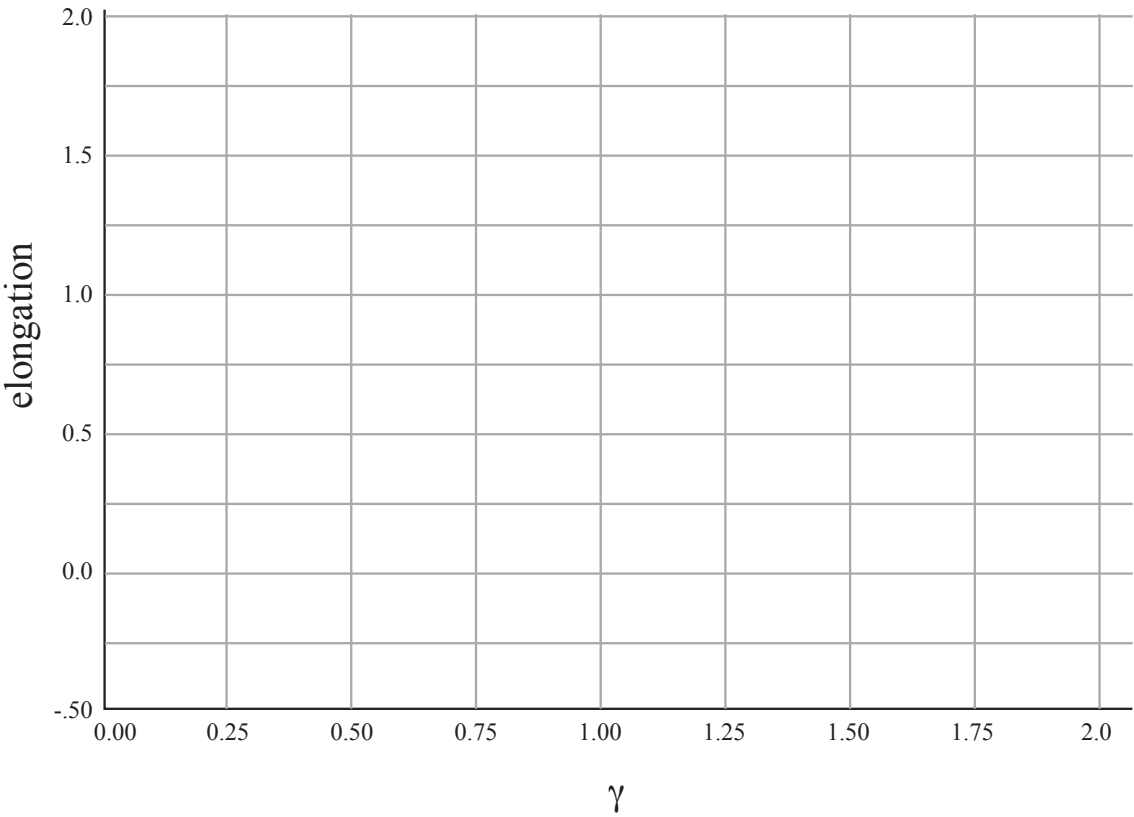
When you are finished with the experiment, move the card deck so it is in the center of the device again. Slide in the two short wooden slats to hold it in place. Slide in the long wooden bars into the holes in the short slats. Then ooh and ahh at Aaron-the-machinist's design for this little device.

## Questions

Type up short answers to the following questions. Include the graph as part of your submitted answers.

1. What happens to the aspect ratio and orientation of the finite strain ellipse during deformation?
2. Describe in words the changes in lengths of lines AB, BC, and CA during progressive deformation of the card deck.
3. What is the physical significance of the minimum on the curve for BC? What is the orientation of the line at this point?
4. What is the physical significance of the point where the curve for BC crosses the  $\gamma$  axis? What is the orientation of the line at this point?
5. Based on your limited data, any of the variations in  $e$  linear with respect to  $\gamma$ ? Do you expect them to remain linear if we could deform the system infinitely?

| displacement<br>for card deck<br>(cm) | $\gamma$ | measured lengths (cm) |    |    | elongation ( $e$ ) calculated after<br>each increment (cumulative) |    |    |
|---------------------------------------|----------|-----------------------|----|----|--------------------------------------------------------------------|----|----|
|                                       |          | AB                    | BC | CA | AB                                                                 | BC | CA |
|                                       | 0.00     |                       |    |    |                                                                    |    |    |
|                                       | 0.25     |                       |    |    |                                                                    |    |    |
|                                       | 0.50     |                       |    |    |                                                                    |    |    |
|                                       | 0.75     |                       |    |    |                                                                    |    |    |
|                                       | 1.00     |                       |    |    |                                                                    |    |    |
|                                       | 1.25     |                       |    |    |                                                                    |    |    |
|                                       | 1.50     |                       |    |    |                                                                    |    |    |
|                                       | 1.75     |                       |    |    |                                                                    |    |    |
|                                       | 2.0      |                       |    |    |                                                                    |    |    |



**Figure 6:** Top - table for recording data for the card deck experiment. Bottom - graph for plotting elongations for each increment of strain.