

## Student Log and Activities

### Material and joint testing

1. Glue materials for testing.

#### Activities

You have been assigned to complete one of the tests. Some preliminary work needs to be done before you can begin testing. Joints need to be assembled accurately and beams should be glued carefully.

Follow the procedures that are detailed in the Test Instruction Sheets.

#### Resources Needed (based on 6 groups of 4 each)

White glue

24 feet of 1/8" square balsa (or similar material)

4 index cards

Information resources as above

#### Thought Questions

How can we get the separate groups to use the same testing procedures?

What factors can influence your testing results and even make the test less accurate?

## Student Log and Activities

2. Test materials and joints, record results (groups of 4)

### Activities

Perform the material tests as accurately as possible.

Follow the procedures that are detailed in the Test Instruction Sheets and record the results.

### Resources Needed

- Glued balsa test beams and joints from Lesson 1.
- Four test devices (see instructions to construct)
- One 45-degree testing device (see instructions to construct)
- Four pairs of locking pliers or other clamping devices
- 6 cans or other containers to hold test weights
- 30 pounds of test weight such as fishing weights, scale weights, sand, nails, tire weights, etc.
- String or fishing line
- Student instruction sheets and worksheets

### Thought Questions

How do we make certain that all groups use the same testing procedures?

What mistakes will ruin test results (letting joint rock, throwing weight in can without support, adding all of weight at once, etc.)?

## Student Log and Activities

3. Present test findings to class, discuss and complete documentation (groups of 4)

### Activities

Each group presents their results to the class. The class discusses meaning of results, implications for structure design, and testing discrepancies. Then the class will discuss issues of consistent procedures in gluing and testing, comparisons of beam and joint strength, and student theories as to why structures failed should be addressed.

### Resources Needed

- Student worksheets
- Visual Aids (posters of charts and graphs)

### Thought Questions

What factors besides joint and material strength influenced the results?

Did the gussets make the joints significantly stronger?

Did the results of the beam test agree with the Relative Strength formula?

## Student Log and Activities

4. Conduct further research. Generate and draw 3 design ideas per student (groups of 4)

### Activities

Each person in the group should individually sketch three designs of the structure. Then the group will compare ideas. Select and draw the three best design ideas per group. Include two of the sketch ideas pages in the group portfolio.

### Resources Needed

- Graph paper

### Thought Questions

What did you <sup>use as a basis for</sup> ~~base~~ your failure prediction? <sup>or?</sup>

How did the group select the "three best designs"?

- What is the variety of designs produced?
- Which design ideas show creativity or a different approach?
- How did each student come up with three different ideas?

## Student Log and Activities

5. Divide into two member teams select and draw a detailed plan of your final design. Establish construction procedures to ensure that you will build a quality structure. Construct your structure and document your failure prediction, and testing.

### Activities

Meet as a two member team and decide which plan (or combination) to build. Draw a detailed plan using grid paper, drafting instruments, or CAD. This plan should be detailed enough to build from. It should show the thickness of the materials and include a side and top view.

Complete the Failure Prediction Worksheet. Under an unlimited load all structures will fail. Your structure will be tested until it fails. Use what you have learned to predict where and how your structure will fail. Failure can be defined as a beam failure, a post failure, a brace failure, or a joint failure. Note the type and location of the expected failures. In reality, several of these failures can occur almost simultaneously. The West Point and John Hopkins software that you explored earlier may help you with this prediction.

Complete the Procedures and Quality Control Worksheet. Write down how you plan to construct the structure. List the order of the actions you will take. List any concerns or questions you have about details of the plan. Remember not to handle the materials or the adhesive any more than necessary.

### Resources Needed

- Failure Prediction Worksheet
- Grid paper, or drafting tools and plain paper, or CAD and plotter

## Student Log and Activities

6. Construct structure and keep notes, check failure prediction

### Activities

Build your structure on the styrofoam boards using the design you created in the last activity. Keep notes of questions or problems that came up during construction and how you and your team member dealt with them.

### Resources needed for 12 pairs

- White glue
- Wax paper
- Straight pins
- Soft base material for pinning (Celotex, styrofoam, etc.)
- 240 feet of 1/8" square balsa
- 12 3" by 5" note cards
- X-Acto knife or similar cutting tool
- Questions and Concerns During Construction worksheet

### Thought Questions

How well did you follow your quality plan?

Did your finished structure match your detailed drawing plan?

## Student Log and Activities

### 7. Test to failure and record results (class)

#### Activities

Weigh your structure carefully before testing. Use an apparatus as close as possible to that described in the TSA Competition Guide to test your structure to failure. Record the results.

#### Resources Needed

- Testing apparatus
- Failure Analysis Worksheet

#### Thought Questions

Which structure was the strongest and why?

Which structure was the most efficient (strength/weight) and why?

Did your structure perform the way you expected? Why or why not?

## Student Log and Activities

8. Conduct failure analysis, document your results, suggest improvements, draw new improved plan.

### Activities

Record the weight held by the structure at failure. Carefully collect the remains of the structure and attempt to analyze where the failure occurred first. Try to figure out how the stresses and strains caused the failure. A video of the testing process can help greatly in failure analysis. Even still digital photos near the time of failure can provide valuable information. Make specific suggestions for possible design improvements.

### Thought Questions

Why did your structure fail where it did?

What was the most common failure point among all of the structures?

Was workmanship a factor in the different structure efficiencies?

## Student Log and Activities

9. Draw a detailed plan, construct structure number 2 and keep notes, check failure prediction

### Activities

Now that you have built one structure and tested it and recorded the results, let's take the information learned and build a second structure.

- Follow the same procedures as you did with the first structure.
- Meet as a team and decide which plan (or combination) to build.
- Draw a detailed plan.
- Under an unlimited load all structures will fail and your second structure will be tested until it fails.
- Using what you have already learned, predict where and how the structure will fail.
- Review your "construct the structure" plan.
- List any concerns or questions you have about details of this plan. Remember not to handle the materials or the adhesive any more than necessary.
- Review your quality control plan and alter it as necessary.

### Resources Needed

- White glue
- Wax paper
- Straight pins
- Soft base material for pinning (Celotex, etc.)
- 240 feet of 1/8" square balsa
- 12 3" by 5" note cards
- X-Acto knife or similar cutting tool

### Thought Questions

How well did you follow your quality plan?

Did your construction match your detailed drawing plan?

Do you think this structure will be stronger or more efficient than your previous one? Why or why not?

## Student Log and Activities

### 10. Test to failure and record results (class)

#### Activities

Use an apparatus as close as possible to that described in the TSA Competition Guide to test your structure to failure. Record the weight held by the structure at failure. Carefully collect the remains of the structure and attempt to analyze where the failure occurred first. Try to figure out how the stresses and strains caused failure. A video of the testing process can help greatly in failure analysis. Even still digital photos near the time of failure can provide valuable information. Make specific suggestions for possible design improvements.

#### Resources Needed

- Testing apparatus
- Failure Analysis Worksheet

#### Thought Questions

Which structure was the strongest and why?

Which structure was the most efficient (strength/weight) and why?

Did your structure perform the way you expected? Why or why not?

Did this structure perform better than the first structure?

## Student Log and Activities

11. Complete and submit documentation portfolio

### Activities



Photograph your structure. Gather all materials generated during this activity and collect them to submit as a portfolio. Reflect on what you have learned.

### Thought Questions

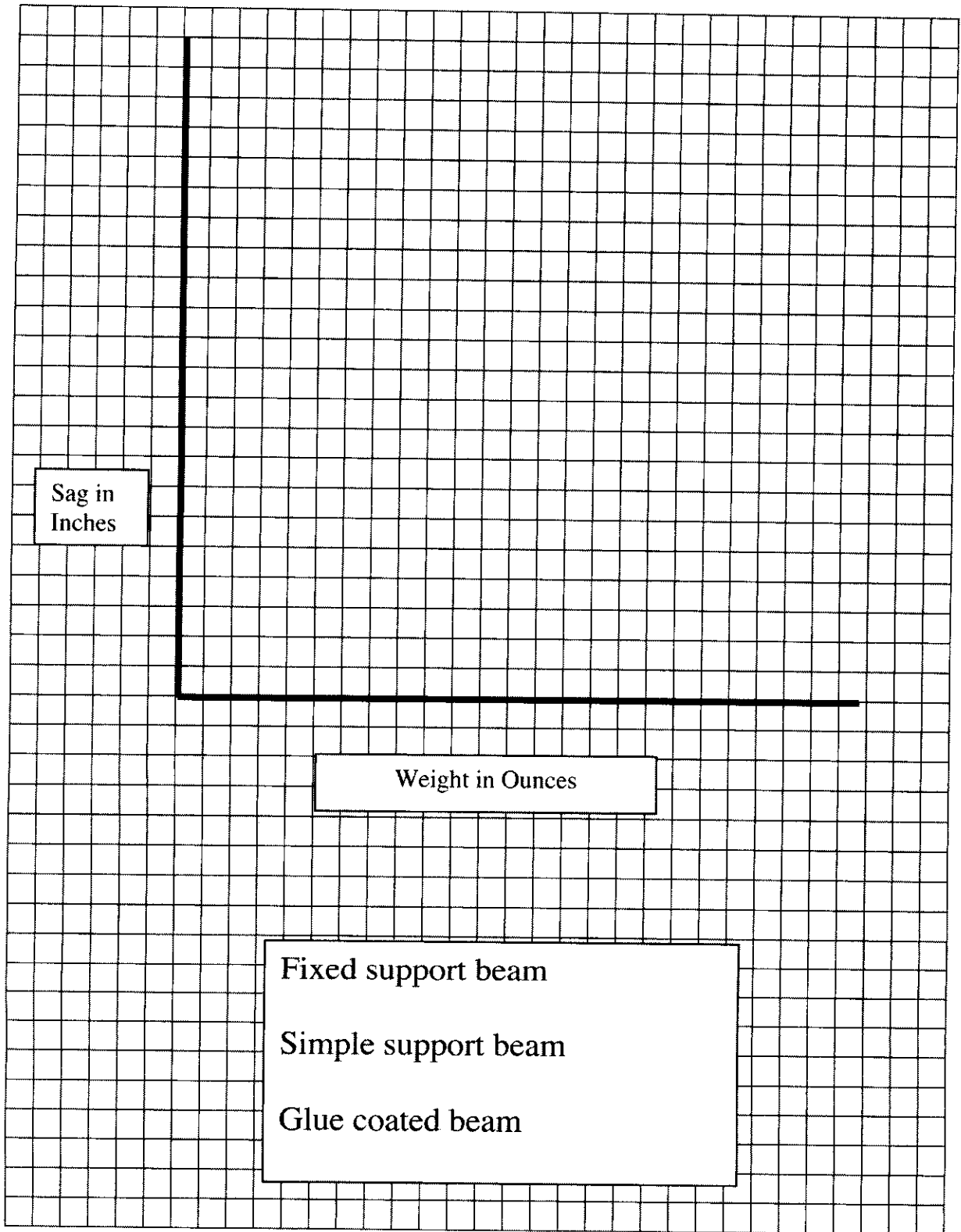
In what way is your final structure better than your first design?

In what way are the two structures similar?

What is the most important thing you have learned during this activity?

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1. Obtain sag test device from your teacher and three 12" pieces of  $\frac{1}{8}$ " X  $\frac{1}{8}$ " balsa.
  2. Glue a 12" piece of balsa to your test device, making sure that you have 2" on each end and it is centered over the hole for the fixed support test.
  3. Take a second 12" piece of balsa and coat all four sides with glue.
  4. Set these aside to dry for 24 hours.
  5. Begin loading the beam you glued to the test device using the testing method set up by your teacher.
  6. Load your beam in 10oz. (283g.) increments; record the amount of sag as each weight is added.
  7. Continue to add weight until your beam breaks.
  8. Plot points on a graph and draw a best-fit line. Create a different line for each beam.
  9. Now place the other uncoated beam on the test device, but do not glue it for the simple support test.
  10. Do steps 5-8.
  11. Now place the glue-coated piece of balsa on the test device just like you did in step 9 and do steps 5-8.
  12. Was there any difference in the three results?
  13. Why?
  14. What does this tell you about the bridge, truss, or tower that you are going to build?

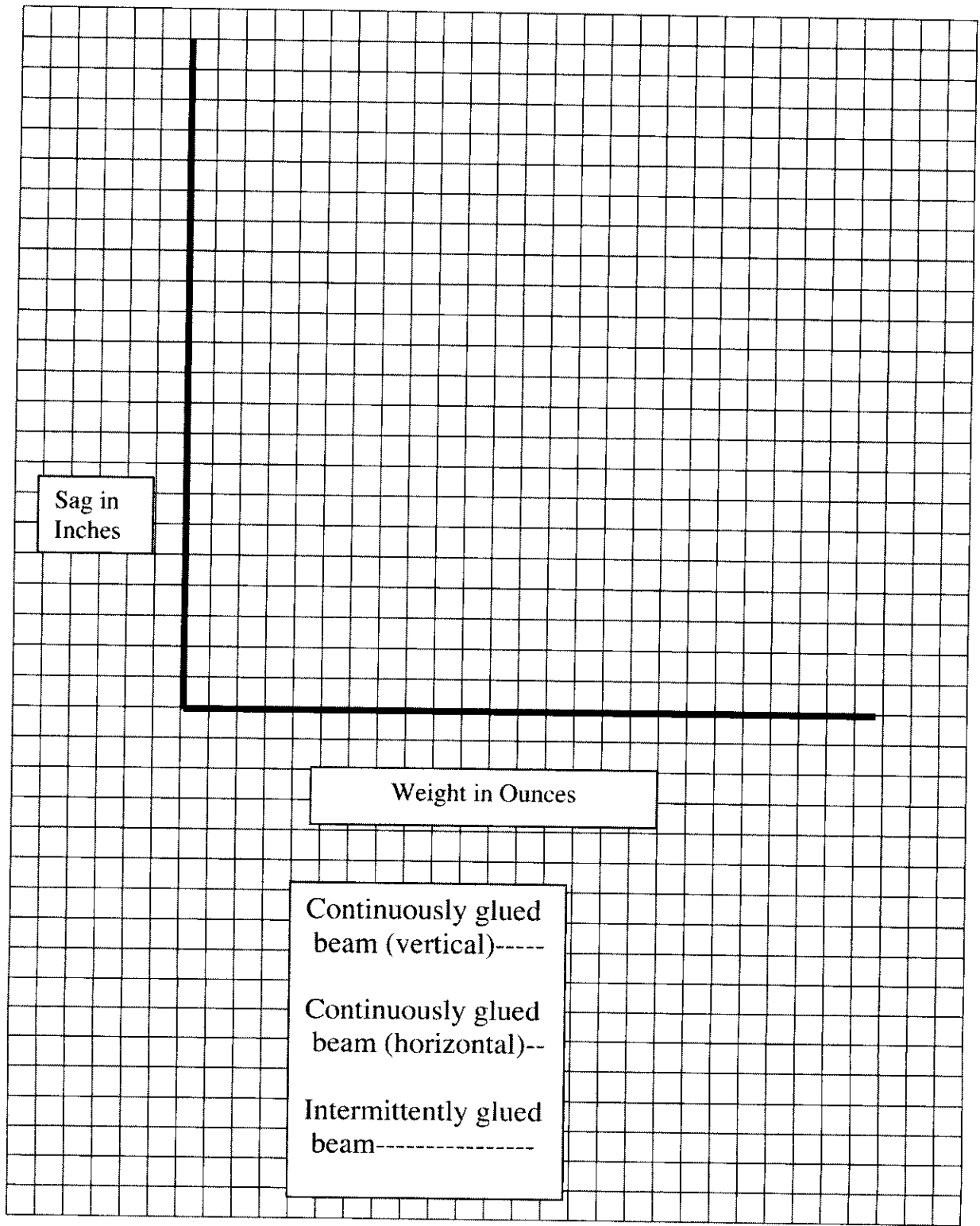
# Test 1 Graph for Single Beams



## Test 2 Instruction Sheet For Bridge Building

1. Prepare three beams for testing. You will need 6 12" pieces of balsa.
2. Glue 4 pieces creating two beams using a continuous glue joint.
3. Create a third beam by gluing 2" on each end and 2" in the middle.
4. Set these aside to dry for 24 hours.
5. When beams are dry, obtain the sag test device from your teacher.
6. Place one continuously glued beam in the test device vertically and begin loading the beam using the testing method set up by your teacher.
7. Load your beam in 10oz. (283g.) increments; record the amount of sag as each weight is added. Continue to add weight until your beam breaks.
8. Plot points on a graph and draw a best-fit line. Create a different line for each beam.
9. Now place the other continuously glued beam in the test device horizontally.
10. Do steps 5-8.
11. Now place the intermittently glued beam in the test device vertically and do steps 5-8.
12. Was there any difference in the three results?
13. Why?
14. What does this tell you about the bridge, truss, or tower that you are going to build?

## Test 2 Graph for Laminated Beams



## Lab 3 Instructions: Build the Joints

1. Out of the 7 joints listed below prepare the ones assigned to you by your instructor. You will need 2 3" pieces of balsa for each joint.
  - a. Butt joint
  - b. Butt joint with gusset
  - c. 45(angle with one piece cut to fit)
  - d. 45(angle with one piece cut to fit with gusset)
  - e. right angle joint
  - f. right angle joint with gusset
  - g. laminated butt joint(one piece overlaps the other by 1")
2. Glue 2 pieces together to create each joint. Set these aside to dry.
3. When dry, obtain test device from your teacher.
4. Place one joint in the test device and begin loading using the method your teacher has arranged.
5. Load your beam in 10oz. (283g.) increments until your joint breaks.
6. Plot points on a graph and draw a best-fit line.
7. Now place another joint in the test device.
8. Do steps 6-7.
9. Continue this process until all joints have been tested.
10. Which joints were the strongest?
  
11. Why were these joints the strongest?
  
12. What does this tell you about the bridge, truss, or tower that you are going to build?
  
13. Present your findings to the class.

JOINT	FAILURE WEIGHT
Butt	
Butt w/ gusset	
45	
45 w/ gusset	
Right angle	
Right Angle w/ gusset	
Laminated butt joint	


Person Cutting \_\_\_\_\_ Person Assembling \_\_\_\_\_

Be sure and double-check your measurements before cutting or assembling.

Assembly steps:

How will you ensure uniform quality as you complete each step in your plan?

What questions or problems did you have during construction and how did you solve them?



1. After drawing your structure plan, predict where and how it will fail first. You may predict a beam failure, a post failure, a brace failure, or a joint failure. Note or mark the exact spot of predicted failure on a sketch of your plan or on the plan itself.

2. After constructing the structure, explain whether or not you have changed your prediction of the failure point. Review the Procedures and Quality Control Worksheet first. Explain why you changed or did not change your prediction.



Weight at failure-

Draw failed structure, showing points where members broke and if possible, label order in which the members broke.

Make suggestions for improvements by writing them down or drawing on your sketch.



Structure 1



Structure 2

