

Objective

- To design and build the lightest bridge spanning a 50 cm gap that can support a 10 kg load at mid-span.

Construction Rules

Bridge

- The bridge must span a 50.0 cm gap between two tables (Figure 1).

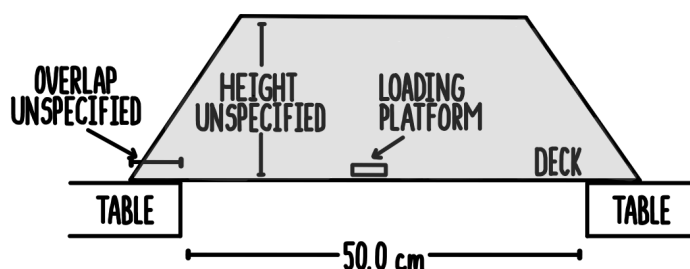


Figure 1: Sideview of the bridge setup. The bridge will be positioned between two tables placed 50 cm apart. The overlap onto the table is unspecified but it is recommended that the bridge be no less than 55.88 cm (22 inches).

- The only materials which may be used in the construction of the bridge are the following:
 - White printer paper (8.5" × 11" or 8.5" × 14")
 - Elmer's glue (generic white glue) or Elmer's glue stick (generic glue stick)
 - *White glue will not discolour or change the opaque characteristic of the paper. Any white glue or glue stick that discolours the paper is not allowed.*
 - Wood toothpicks
- While no materials other than those listed above are permitted, the following are notable prohibited materials:
 - tape
 - hot glue
- The bridge can be a maximum of 500 g.
- The bridge may not be coloured or decorated. The colour of the bridge must reflect the colour of the paper and glue used.
- The bridge must incorporate a truss design. Students should research truss designs or design their own unique truss design.
 - Bridge Design Simulation - <http://www.jhu.edu/virtlab/bridge/truss.htm>
- Inverted bridges are not allowed (i.e. no trusses beneath the roadway).

- The bridge must contact only the top surfaces of the support tables on either side. The bridge may not be anchored to either support table except by gravity. The bridge may not contact any other surface of the support tables, or the floor, ceiling, walls, or other object (Figure 2).

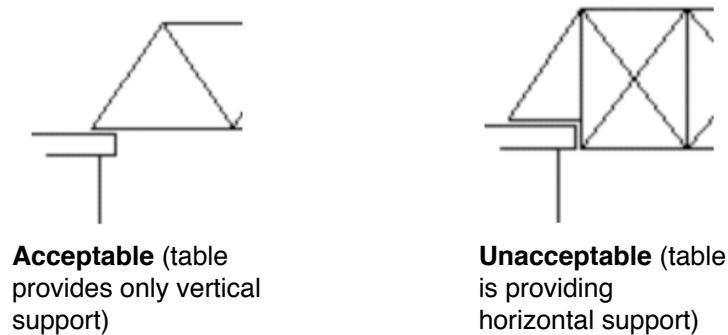


Figure 2: Acceptable and unacceptable contact with the table surface.

- The bridge must have a loading zone at which the mass will be suspended (see loading zone below).
- The bridge must have a continuous horizontal deck at least 5 cm wide without gaps (see deck below).

Loading Zone

- You must incorporate a "loading zone" at the midpoint of the span along the centreline of the bridge (Figure 3).
- The loading platform (to be provided in class) is a 5 cm × 10 cm flat block of wood which will be placed at the loading zone.
- The loading platform has a mass no greater than 250 g. This mass is not included in the 10 kg that your bridge must support.
- A half-inch diameter hole must be located at the centre of the loading zone and pass completely through the deck and all bridge supports beneath the deck.
- A bolt will be inserted through the hole from beneath the deck and attached to the loading platform (Figure 3).

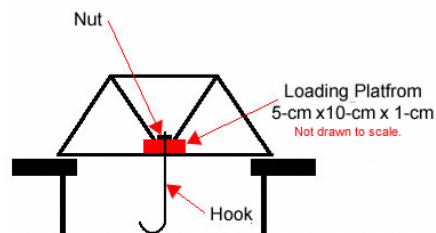
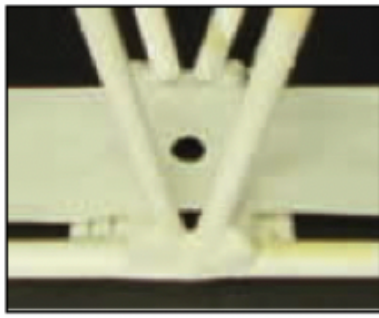


Figure 3: The loading platform will be positioned above the loading zone at the centre of the bridge.

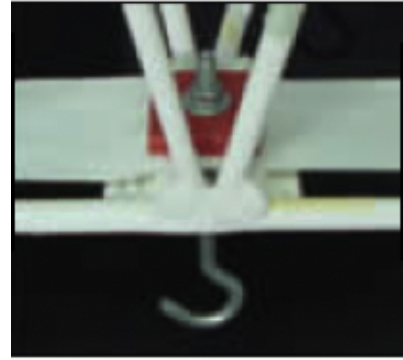
A poorly designed and reinforced loading zone may result in structural failure only at the loading zone. This unfortunate oversight may leave the rest of the bridge structurally intact. Loading zone reinforcement should not be limited to excess use of glue but may include the construction of additional members (i.e. layers and/or joint construction). Remember the entire weight supported by the bridge is applied at the loading zone.



Example Loading Zone



Loading Platform (to be provided)



Example Loading Zone with Loading Platform

Figure 4: Example of the loading zone constructed at the centre of a bridge. A half-inch diameter hole is located at the loading zone allowing for a bolt to pass through and attach to the loading platform as pictured. Note that the purpose of these pictures is to aid in the explanation of the bridge project requirements. These pictures are not intended to be examples of quality construction or design.

Deck

- The bridge must include a decking of paper to provide a suitable road surface at least 5 cm wide across the full span of the bridge (Figure 5).
- Four conditions must be met:
 1. The deck may not have any gaps (with the exception of the half-inch diameter hole required for the loading platform).
 2. A block of wood 5 cm × 10 cm × 1 cm representing a car must be able to move along the length of the deck unobstructed from end to end.
 3. The highest point of the deck may be no higher than 5 cm above the tabletop to allow for loading zone reinforcement.
 4. The deck of the bridge must either be flat across its entire span or inclined upwards towards the loading zone (Figure 6).

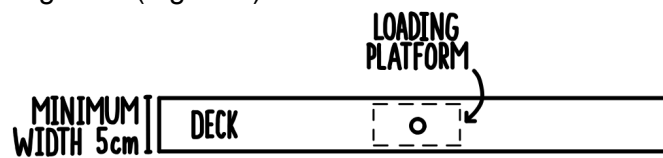


Figure 5: Overhead view of the deck. The loading platform will be placed above the deck. A half-inch diameter hole allows for the bolt to pass through and attach to the loading platform.

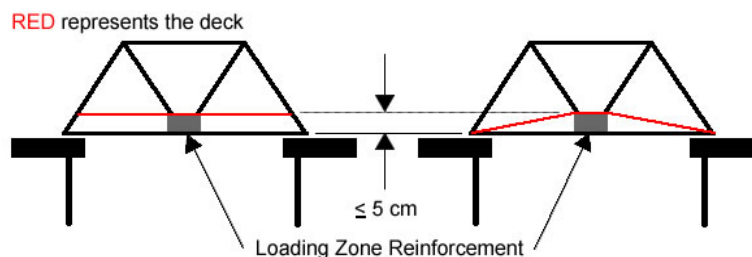


Figure 6: Sideview of two acceptable deck configurations. The deck must pass over the loading zone. To allow for loading zone reinforcement, the deck may be elevated a maximum of 5 cm from the table surface.

Bridge Testing

1. All bridges must be registered on the competition date. All bridges will be inspected to ensure that all contestants have met the construction rules. Upon inspection, bridges will be assigned a scoring zone colour (see scoring below).
2. A load (force) will be applied to the loading zone.
3. The load will be increased until structural failure is reached or until 10 kg is reached, whichever comes first.
4. Upon reaching 10 kg, the load must be supported for 60 seconds without structural failure.
5. Structural failure is defined as:
 - a member fails: tears or buckles,
 - a joint fails: breaks or pulls out,
 - the loading platform pulls through the loading zone,
 - the roadway deflects vertically 3 cm, or
 - the bridge is pulled through the 50 cm gap.
6. The mass of the bridge, given that it supports a 10 kg load, will determine the final grade. Refer to the bridge rubric for details.

Scoring

Upon inspection, bridges will be assigned a scoring zone colour.

Green: Acceptable bridges

Orange: Acceptable bridges with minor infractions

Red: Unacceptable bridges with major infractions

If a bridge has both an orange zone and a red zone infraction, it will be evaluated according to the red zone infraction.

Students may submit a makeup bridge for testing given it meets the requirements of the green zone. All makeup bridges will be scored using the orange scale.

Criteria	Scoring Zone		
	Green	Orange	Red
Design	Truss design		No truss design
Materials	Permitted		Disallowed
Mass	$m \leq 500 \text{ g}$	$500 \text{ g} < m \leq 600 \text{ g}$	$m > 600 \text{ g}$
Length	$> 50 \text{ cm}$		$< 50 \text{ cm}$
Width	$> 5 \text{ cm}$	$< 5 \text{ cm}$	
Deck	Properly designed	Improperly designed	
Loading Zone	Loading platform fits correctly at the loading zone	Loading platform fits incorrectly at the loading zone or loading platform is not at the centre of the deck	Loading platform does not fit at the loading zone or no loading zone is incorporated into the design

Bridges will receive a score based on either the bridge mass or placing among all Physics 12 classes, whichever is higher. Only bridges in the green zone are eligible to place.

Bridge Mass (rounded up)	Scoring Zone		
	Green	Orange	Red
100 g	100	80	70
120 g	99	79	69
140 g	98	79	69
160 g	97	78	68
180 g	96	78	68
200 g	95	77	67
220 g	94	77	67
240 g	93	76	66
260 g	92	76	66
280 g	91	75	65
300 g	90	75	65
320 g	89	74	64
340 g	88	74	64
360 g	87	73	63
380 g	86	73	63
400 g	85	72	62
420 g	84	72	62
440 g	83	71	61
460 g	82	71	61
480 g	81	71	61
≥500 g	80	70	60
Bridge supports 5 kg but less than 10 kg	70	65	55
Bridge supports 2 kg but less than 5 kg	65	60	50
Bridge collapses under its own weight	0	0	0

Place	Scoring Zone
	Green
1st	100
2nd	98
3rd	96
4th	94
5th	92

One bonus point will be awarded for every 5 g under 100 g. Bonus points are awarded only to green zone bridges which can successfully support a 10 kg load. Red and orange zone bridges are ineligible for bonus points.