The Bridge

Scenario
You and your friends are stuck in an old mine shaft and have discovered a trolley of gold. You need to build a bridge to transport your gold to the outside world.

Aim
The aim of this full-day activity is to build a light and strong model bridge to carry ‘gold’ ingots from one side of the test rig to the other.

What to do
Your team needs to design and construct a model bridge from a fixed quantity of balsa, cardboard, wooden sticks, plastic sticks, masking tape and paper. Paper clips and thumbtacks are also available. You cannot use anything you’ve brought with you. No glue is allowed. A small saw, a cutting block, ruler and scissors will also be provided.

Your bridge will be tested at the end of the day in front of everyone present. The test involves running a trolley across the aluminium deck of the bridge. After each successful attempt, an ingot is added to the trolley.

Rules
Each team must construct one bridge to be tested at the end of the day. Prior to final testing, each team’s bridge must be placed in the test rig by its builders. The bridge can only be supported by the ledges on each end of the gap. The bridge must not be secured to the test rig in any way. When testing, the trolley must not be pushed or held back on release. The bridge is successful if the trolley rolls all the way across the deck on to the flat track on the other side of the gap. A bridge is unsuccessful if:
• It touches the bottom of the test rig, even if the trolley crosses the gap.
• The trolley almost crosses, but rolls back on to, the deck.
• The trolley falls off the test rig before all four wheels are on the flat track.
• The bridge breaks.

If the bridge doesn’t break you are allowed 3 attempts for each load. The official bridge judge(s) will decide if an attempt is successful, and if a bridge is sound enough for another attempt. Their decision is final.

Scoring
At the end of the session, immediately prior to final testing, each bridge will be weighed and pre-tested to check that it can support the weight of the deck. If it can, some points are awarded and the bridge becomes eligible for final testing. The final test involves placing each bridge, one at a time, into the test rig and rolling a trolley, loaded with an increasing number of ingots, across it. This continues until the bridge breaks, or supports all the ingots. Points are awarded based on the weight of the bridge and the number of ingots that it supports.

Tips
Your bridge must fit into the test rig; if your bridge doesn’t fit, it can’t be tested!
STUDENT NOTES
The Bridge

The problem
The aim of this full-day activity is to build a light and strong model bridge that can support a trolley carrying ‘gold’ ingots from one side of the test rig to the other. The trolley is released from the top of the sloped track on one side of the test rig. Lighter bridges earn more points than heavier bridges each time the trolley (and ingots) successfully crosses the gap.

Duration
This activity runs for a full day (approximately 4 hours).

Terms
There are some terms used in this activity that you may not be familiar with:

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test rig</td>
<td>The device, illustrated below, that holds the bridges for testing.</td>
</tr>
<tr>
<td>Track</td>
<td>The stainless steel guide that the trolley runs along from one end of the test rig to the other. The start side of the track is highest.</td>
</tr>
<tr>
<td>Ingots</td>
<td>The ‘gold’ masses that are added to the trolley during final testing.</td>
</tr>
<tr>
<td>Deck</td>
<td>The centre hinged aluminium part of the test rig that, when supported by the bridge that your team builds, joins the sloped track to the flat track.</td>
</tr>
</tbody>
</table>

Materials
A fixed quantity of balsa, cardboard, wooden sticks, plastic sticks, masking tape and paper is available to construct your team’s bridge. Paper clips and thumbtacks are also available. A small saw, a cutting block, ruler and scissors will also be provided.

Note that there is no glue; all joints must be made with the masking tape, paper clips and/or thumbtacks provided.

Treat your materials carefully. If any material is faulty at the beginning of the day, the Event Staff will replace it, but you won’t get new materials to replace things that you lose or break.
Rules

The bridge must span the gap completely and can only be supported by the ledges at the ends of the gap (see Figure 1 below). No part of the bridge may touch the bottom of the gap. The bridge must not be attached to the test rig in any way; it simply sits on the support ledges.

Teams have full access to the test rig until the bridges are officially weighed, just before pre-testing.

Teams may hold the trolley and ingots only after asking the Event Staff.

Teams are not allowed vary the design and change pieces of their bridges after it has been officially weighed.

The final testing at the end of the day runs to a very tight schedule. There will not be time for teams to make anything other than very minor adjustments while their bridge is being tested. If the bridge can’t be fitted, adjusted or repaired within 60 seconds, testing is finished and the bridge must be removed from the test rig.

Rules for the final test
1. Each bridge must be placed into the test rig by its builders.
2. The bridge can only be supported on the ledges on each end of the gap.
3. The bridge must not be secured to the test rig in any other way.
4. To test the bridge, a trolley will be released (not pushed) by a member of the team from a fixed, stationary position at the highest point of the slope.
5. The bridge is successful if the trolley (and ingots, if loaded) rolls all the way across the deck onto the flat track on the other side, i.e. all four wheels are off the deck, and no part of the bridge touches the bottom of the test rig, except at designated support points.
6. A bridge is unsuccessful if:
   - It touches the bottom of the test rig, even if the trolley crosses the gap.
   - The trolley almost crosses but rolls back onto the hinged deck.
   - The trolley falls off the test rig before all four wheels are onto the flat track.
   - The bridge breaks.
7. If the trolley does not cross the gap but the bridge does not break, your team will be allowed a maximum of two more attempts for each ingot.
The official bridge judge(s) will decide if an attempt is successful, and if each bridge is sound enough for another attempt. The bridge judge’s decision is final.

**Scoring**

**Pre-test**
The pre-test is conducted at the end of the activity time before the final presentation.

Firstly, each bridge will be weighed and its weight recorded on the score sheet. No changes can be made to the bridge after it has been weighed.

When instructed by the Event Staff, each team will place their bridge into the test rig and carefully lay the deck across it. If the bridge supports the deck, it is awarded some points and is eligible for the final test (and more points).

**Final testing**
This will happen at the end of the day in front of all the other schools. Your team will be called forward from where you are sitting with your school in the audience. The final test involves running a trolley across the deck supported by the bridge.

After each successful crossing, one ingot of ‘gold’ is added to the trolley, up to a total of five ingots. If the bridge holds the trolley and the five ingots, the ingots are removed and replaced with the large ‘Super Ingot’. If the bridge holds the trolley and the Super Ingot, this ingot is left in place and the ‘Bridge Buster’ ingot is placed on top.

There are no further tests if the bridge successfully supports the Bridge Buster.

**The final score will depend on the weight of the bridge and the load it carries.** Bridges also earn one bonus point per gram under the upper weight limit of the weigh category they fall into. This means a lighter bridge will score more points per ingot than a heavier bridge. It is therefore possible for a school to win The Bridge even if they do not get the Super Ingot or Bridge Buster across - see the Score Sheet.

**Tips**
- Your bridge will be tested at the end of the day in front of all the Event Staff, visitors and other competitors, so it is important that your team plans carefully and builds a good bridge.
- Before you start to build, it is essential that you measure the test rig carefully. Throughout the day you should continue to check that your bridge fits. If your team build a bridge that doesn’t fit the rig, it can’t be tested and you can’t score any points!
- Triangles are common in bridges and other structures as they are very strong. You can join triangles together to produce rigid structures but remember that triangles are two-dimensional and the bridge is a three-dimensional structure.
- Materials perform differently if they are compressed, stretched or bent.
- There is a big difference between a load that remains still (a static load) and one that is thrown or dropped on a structure (a dynamic load). Keep this in mind when you are placing the deck on top of the bridge; a sudden drop could prove catastrophic!
- If the top of the bridge is uneven, the deck will not lie completely flat. This can cause the trolley to bounce as it crosses the deck. Neat construction reduces the dynamic load of the trolley (and ingots) when it crosses the bridge, and also reduces the likelihood of the trolley bouncing off the side of the bridge.
- Remember, light bridges earn more points, so choose your materials carefully and weigh your bridge often, but do not sacrifice weight for strength.
# SCORE SHEET

The Bridge

School name: ___________________________________________

Bridge mass in grams g. This determines the column of available points.

*Track down the appropriate mass column in the table below. Tick the cell if the trolley (and ingots) crosses. Place a large cross in the cell when the bridge fails.*

*The team is awarded STRENGTH points from the cell above the cross plus one bonus MASS point for every gram the bridge is under the upper limit of its mass category (except if the bridge is in the 171+ column). For example:*

A bridge weighs 80 grams and breaks when trying to carry the trolley + 4 ingots.

*It scores (450 strength points for 3 ingots) + (90 – 80 = 10 mass points) = 460 total*

<table>
<thead>
<tr>
<th>Bridge mass (grams)</th>
<th>0 to 30</th>
<th>31 to 50</th>
<th>51 to 70</th>
<th>71 to 90</th>
<th>91 to 110</th>
<th>111 to 130</th>
<th>131 to 150</th>
<th>151 to 170</th>
<th>171+</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PRE-TEST</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Points for supporting the deck only</td>
<td>400</td>
<td>370</td>
<td>350</td>
<td>330</td>
<td>310</td>
<td>290</td>
<td>270</td>
<td>250</td>
<td>210</td>
</tr>
<tr>
<td><strong>FINAL TEST</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trolley only</td>
<td>430</td>
<td>400</td>
<td>380</td>
<td>360</td>
<td>340</td>
<td>320</td>
<td>300</td>
<td>280</td>
<td>240</td>
</tr>
<tr>
<td>Trolley + 1 ingot</td>
<td>460</td>
<td>430</td>
<td>410</td>
<td>390</td>
<td>370</td>
<td>350</td>
<td>330</td>
<td>310</td>
<td>270</td>
</tr>
<tr>
<td>Trolley + 2 ingots</td>
<td>490</td>
<td>460</td>
<td>440</td>
<td>420</td>
<td>400</td>
<td>380</td>
<td>360</td>
<td>340</td>
<td>300</td>
</tr>
<tr>
<td>Trolley + 3 ingots</td>
<td>520</td>
<td>490</td>
<td>470</td>
<td>450</td>
<td>430</td>
<td>410</td>
<td>390</td>
<td>370</td>
<td>330</td>
</tr>
<tr>
<td>Trolley + 4 ingots</td>
<td>550</td>
<td>520</td>
<td>500</td>
<td>480</td>
<td>460</td>
<td>440</td>
<td>420</td>
<td>400</td>
<td>360</td>
</tr>
<tr>
<td>Trolley + 5 ingots</td>
<td>580</td>
<td>550</td>
<td>530</td>
<td>510</td>
<td>490</td>
<td>470</td>
<td>450</td>
<td>430</td>
<td>390</td>
</tr>
<tr>
<td>Trolley + Super Ingot</td>
<td>620</td>
<td>590</td>
<td>570</td>
<td>550</td>
<td>530</td>
<td>510</td>
<td>490</td>
<td>470</td>
<td>430</td>
</tr>
<tr>
<td>Trolley + Super Ingot + Bridge Buster</td>
<td>680</td>
<td>650</td>
<td>630</td>
<td>610</td>
<td>590</td>
<td>570</td>
<td>550</td>
<td>530</td>
<td>490</td>
</tr>
</tbody>
</table>

**STRENGTH:** Points awarded for carrying ingots from above table

**MASS:** Add 1 bonus point per gram under the upper weight category

**FINAL SCORE**