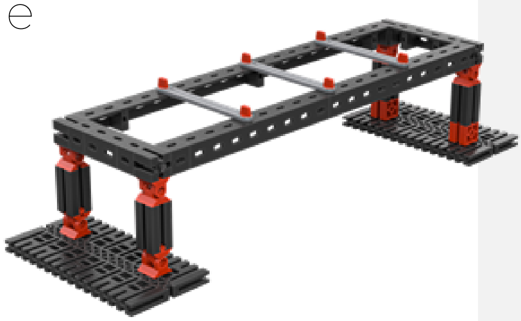
Model 12
Bridge, beam bridge

The students receive the building instructions for the construction of the bridge.



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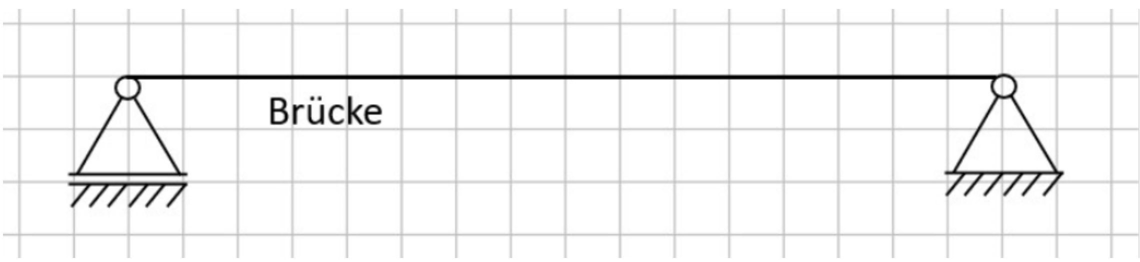
THEMATIC TASK

Viewed simply, the bridge looks like this in two dimensions:

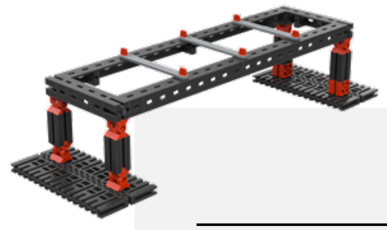


On the left side is a pendulum support, which acts as a single-value bearing for the bridge structure. This bearing can only absorb compressive or tensile forces perpendicular to the bearing. This type of bearing is also called a sliding or loose bearing, as it can move freely in the horizontal direction.

On the right is a fixed bearing, i.e., a support that can absorb both horizontal and vertical forces.

Both bearings are equipped with a joint, which means that no rotation can be transferred to the bridge.

External static determinacy refers to a component being mounted in such a way that all possible movements are absorbed. In a two-dimensional surface, this includes movement in the horizontal and vertical directions as well as rotation. If not all directions of movement are balanced by the bearing forces, the component can move; this is referred to as static underdetermination. If a component is statically determined and another bearing is added, this is referred to as static overdetermination: this can cause internal stresses to arise, even though no further loads are acting on the component. For this reason, attempts are made to prevent this as far as possible.



EXPERIMENTAL TASK

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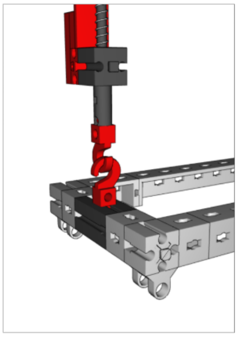
1. Installation example for the spring balance:



In our example, only vertical forces act on the bridge:

Distance s_n	Bearing force F_n	Weight force F_L
s_1 = 75 mm	0.75 N	1 N
s_2 = 150 mm	1.5 N	1 N
s_3 = 300 mm	3 N	1 N
s_1 = 75 mm	1 N	2 N
s_2 = 150 mm	2 N	2 N
s_3 = 300 mm	4 N	2 N
s_1 = 75 mm	1.25 N	3 N
s_2 = 150 mm	2.5 N	3 N
s_3 = 300 mm	5 N	3 N

* F_n after half the weight of the bridge has been deducted (130 g / 2 = 65 g ~ 0.65 N)

This can also be calculated, for example, by considering the moment equilibrium around the right side. The bridge does not move, which means that the sum of all moments around this bearing must be "0".

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Please note that for these values, half the weight of the bridge must be subtracted from the measured value. In reality, the weight of a bridge is much greater in relation to the traffic or wind loads acting on the structure.

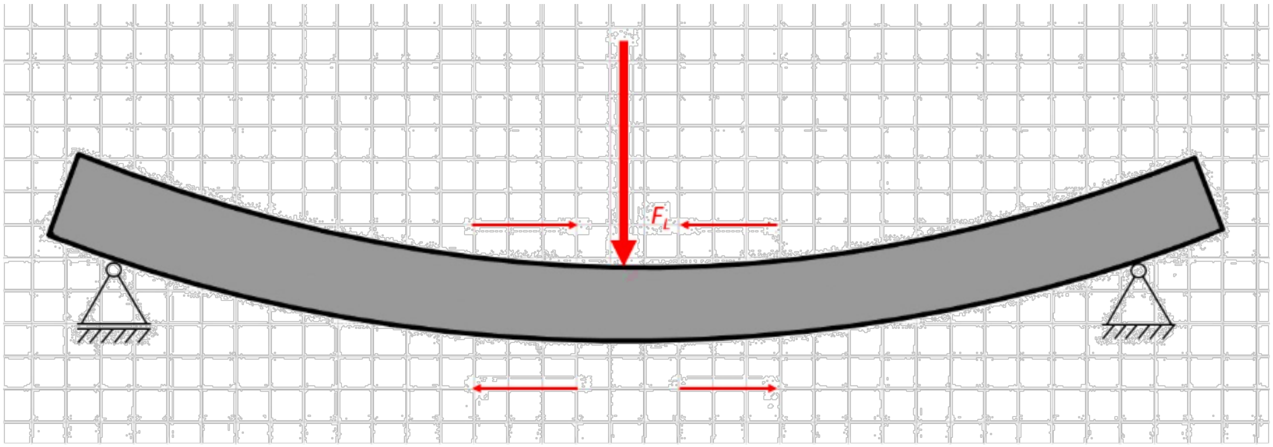
Internal static determinacy

However, determining static determinacy can also be interesting within a structure, especially in trusses. Due to the design, there should be no or only minimal stresses, so static determinacy would also be desirable here. This means exactly enough beams and ties to absorb the forces that occur and at least enough to prevent the system from being "movable."

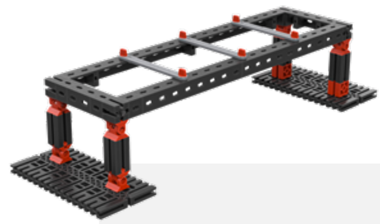
2. Upper chord or lower chord?

To increase the stability of the bridge, a truss upper chord or lower chord can be added. This addition reduces deflection enormously. The further the upper or lower chord is from the roadway, the greater the effect.

In the lower chord, tensile forces act on the girder, while in the upper chord, compressive forces counteract the deflection.



3. Whether a superstructure or substructure is used in a structure is not decided by the structural engineer, but by the architect: what purpose should the bridge serve? For a bridge over a river, the clearance height is an important criterion. When crossing a valley with a railway bridge, the clearance under the bridge may not be as relevant, but the view for train passengers is decisive for the design of the bridge.



APPENDICES

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Building instructions and templates for the gearboxes and models:

Model 12: Building instructions for beam bridge.