the endpoints of the ruler so that they lay on the points between which you want to know the distance.

5. In the diagram , the data points seem to lie on a parabola. Right-click in the diagram window or press its tool button. Select 'Analyse' ▸ 'Function-fit' and try to find the parabola that fits best.

In other COACH activities about bridges and architectural structures you will encounter the parabola again and again. There are good reasons for this and with some knowledge of mathematics and physics you can find them.

Activitity 3: Five Weights

Introduction

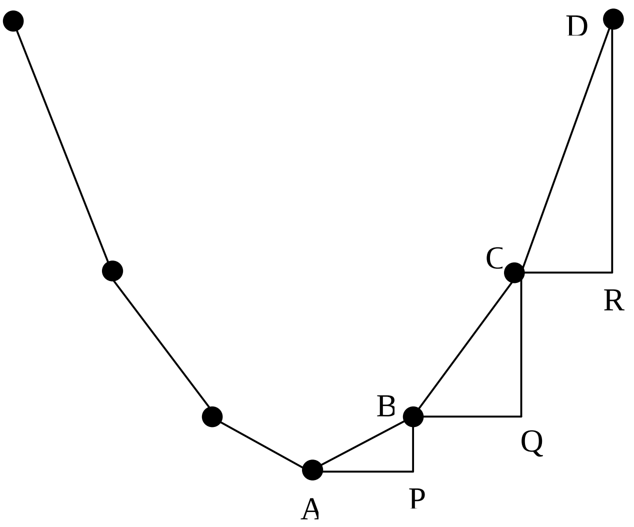
The parabolic shape of the Zeeburger Bridge and of the Bixby Creek Bridge is no coincidence. In this activity, the tasks and your own ingenuity will lead you to a mathematical and physical explanation.

Physical Model

The arch of the Zeeburger Brige can be seen as a parabolic shape, on which hang equal weights at equal distances (in horizontal direction). Each beam "bears" a same portion of the road surface.

The arch of the Bixby Creek Bridge is a parabolic shape which support equal weight placed at equal distances form each other (again, equal distances in horizontal direction).

We prefer to study the "inverted" model: a weightless chain on which hang equal weights at equal horizontal distances (See the picture below)



Choose the activity 3. Weights

The videoclip shows a chain on which hang five equal weights. These weight have placed symmetrically such that the horizontal distance is always 1 dm.

Coordinate system and scaling have already been chosen.

Tasks

1 Select seven video points: the two suspension points and the five points on the chain to which the five weights have been attached.

Text windows in COACH do not offer (yet) all possiblities of a real text editor. This is why the next exercises are on paper only. The above drawing is a simplified display of the video image.

2 Measure in the data video screen with the protractor the angles of inclination ∠A, ∠B, and ∠C.
Measure in the diagram window the slope of the segment AB, of segment BC, and of segment CD.

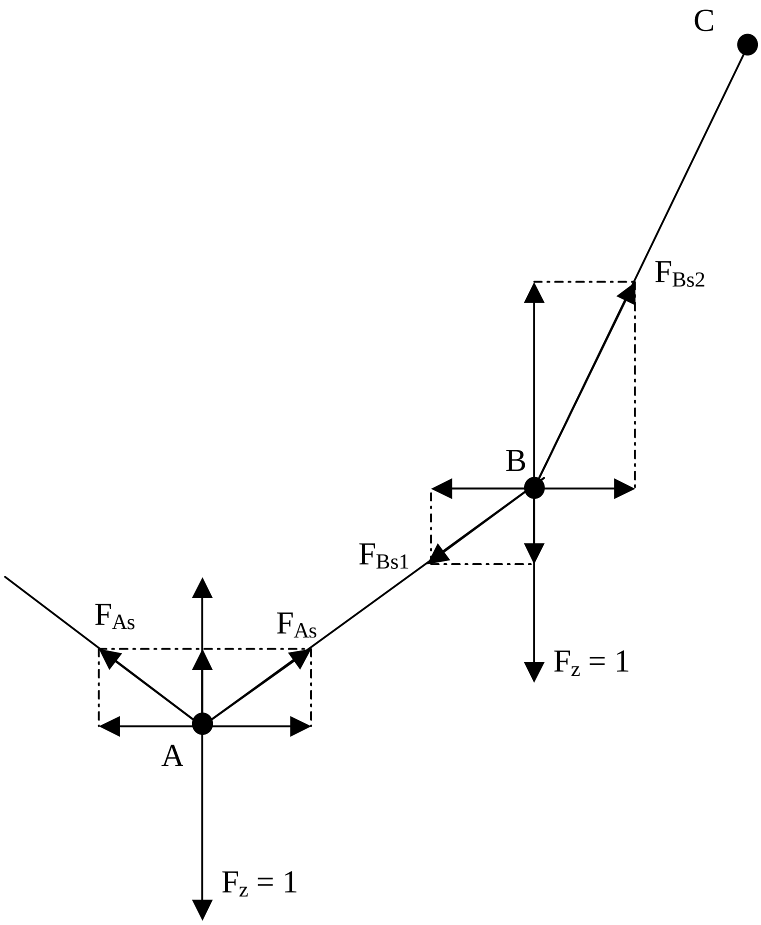
Maybe you notice some regularity in the angles and/or slopes or in their ratios?

3 Draw on paper the graph of the standard parabola $y = x^2$ with A(0,0), B(1,1), C(2,4), and D(3,9). Compute ∠A, ∠B en ∠C. Compute the slope of AB, of BC, and of CD.

4 Investigate whether the regularity that you have found in exercise (2) also occurs for the standard parabola. If you did not find a regularity in (2), try if you can find the regularity of exercise (3) back in (2), approximately. (If desired, compute the coordinates of more points of the standard parabola.)

Theoretical Closure

You have seen that the model of weights hanging on a weightless chain indeed leads to a parabolic shape. Hopefully you have also found that there exists a simple relation between the slopes of consecutive straight segments of the chain. This regularity can be expained by equilibrium of forces acting on the chain. The figure below is the basis of our reasoning:



The (equal) weights lead to a gravitational force F_z in each point of application. For simplicity we take $F_z = 1$.
The weight A hangs in equilibrium by the tension forces in F_{As} in left- en right-segment of the chain. Because of symmetry the tension forces on the left and on the right are equal in magnitude.
Easy reasoning gives that the vertical component of F_{As} must be equal to $0{,}5F_z$.
A gravitational force and two tension forces cause the equilibrium of the point of application B.

Exercise
Reason out that the slopes of AB, BC, and CD (if another weight would be placed) are in ratio 1 : 3 : 5 .

Epilogue
Not every hanging chain has a parabolic shape. More strongly: Christiaan Huygens (1629-1695) proved that an *unloaded* homogeneous chain certainly *not* hangs in a parabolic shape. Such a freely hanging chain you can find in activity *4. Necklace*.
With slopes in consecutive ratio 1 : 3 : 5 : 7 …, do you always get a graph of a parabola? And can you explain this?
What can be said if the weights are not all the same?
What can be said if equal weights hang symmetrically, but are even in number (i.e., no weight in the top)?
These and other questions you could investigate another time.