Exam Fundamentals of Structural Design 11-12-2020

1. A simply supported truss is given in file "Truss_f.ggb", see also Fig.1. The truss is loaded with 6 loads (F_1, F_2, …F_6). The loads are given in kN and are multiplied with the factor scForm. The material of the structure is steel with modulus of elasticity E=205GPa and yield strength σ_γ=275MPa.
   a) Draw the force polygon and the funicular polygon. Don't use another scaling factor for the force polygon in order to save time. Define the reactions on the supports.
   b) Find the internal forces in the truss graphically. Define tension and compression in one figure by coloring the members of the truss: blue for tension, red for compression. Define a circular cross-section that can sustain the maximum load in the truss.
   c) Define the member with largest compression and check the previously defined cross-section for buckling. (The critical buckling load can be defined as $P_{cr}=\pi^2 EI/L_{eff}^2$). Adjust the cross-section in case that it is not enough to resist buckling. When designing a truss what is our intention regarding members in compression compared to members in tension?
   d) Explain with your own words how you would calculate the displacement of the joint with coordinates (2,0.4), see Fig.1. Explain clearly the process. Which property of the structure can be defined by defining the displacement?
   e) Define the new coordinates (along the vertical line through the point) of the joint with initial coordinates (2,0.4) so that the member 1-3 does not carry any load at all (zero-force member).
   f) Which are the three main criteria that a truss and a structure in general needs to fulfill during the conceptual design process? Explain each one of those.

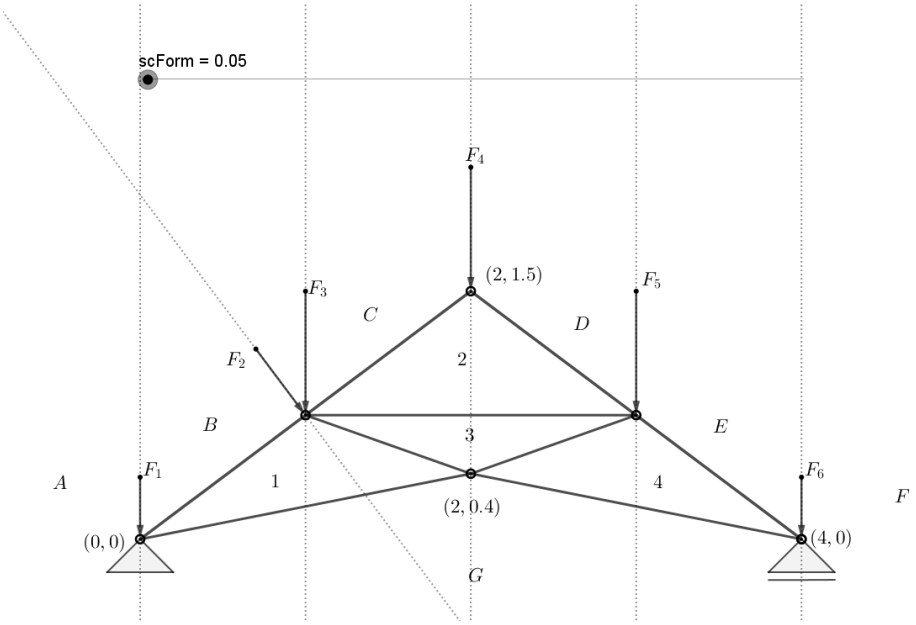

Fig.1. Simply supported truss.

2. A beam is shown in Fig.2 in "Beam.ggb". The beam is loaded with a uniform load and a unit load. The loads are given in kN and are multiplied with the factor scForm.

a) Draw the funicular and the force polygon. Don't use another scaling factor for the force polygon in order to save time. Define the reactions on the supports.
b) Define the new location of the roller support so that the bending moment in the midspan and on the roller support is the same. Select a rectangular cross-section, draw and define the maximum stresses due to bending (σ=MI/y, I is the second moment of area, y is the distance from centroid).
c) Compare the maximum stresses of the case (b) with the stresses of a simply supported beam (supports at the ends of the entire element) using the same cross-section. Define the ratio.
d) Find the new location of both supports in order to have the minimum absolute value of bending moment in the structure. Explain your line of thought to define it. Determine the stresses and define the ratio with cases (b) and (c).
e) Explain with your own words the process of determining the elastic curve of the beam with graphic statics. Which are the main criteria when designing a beam? Explain.

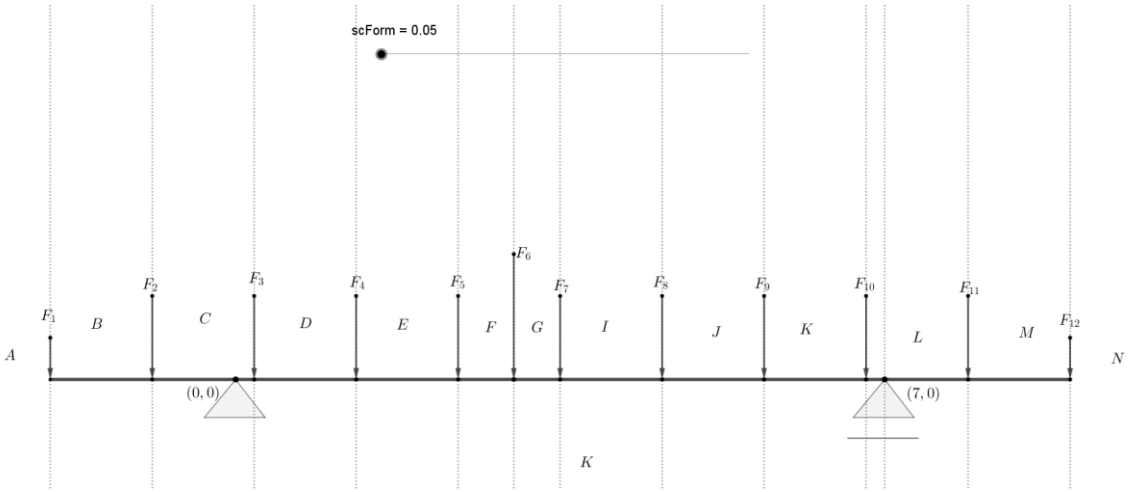

Fig.2. Simply supported beam.

3. In file the "Arch.ggb" a three-hinged arch is provided, see Fig.3. The loads are given in kN and are multiplied with the factor scForm.

a) Draw the force and the funicular polygon.
b) What would be the shape of the arch structure that would not take bending moment for this loading case? Explain.
c) How would the axial and shear stresses be defined at a certain segment of the structure, show and explain.
d) If you would like to design a tied-arch that passes through the same support points and has the same support reactions, what would you do? Show an example and explain. How would the tied arch system deal with the concept of bending moments in this case?

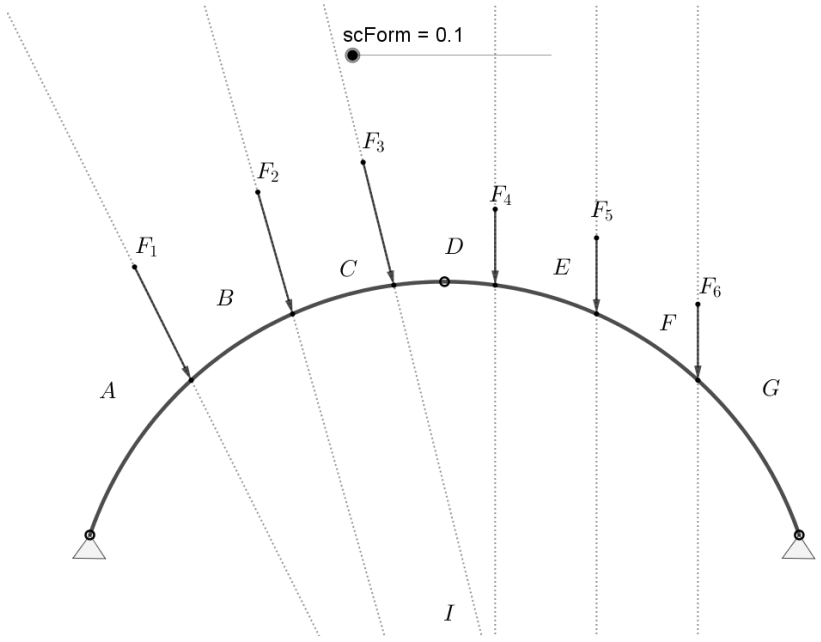

Fig.3. Arch

Grading:

1. 35%
2. 35%
3. 30%