ESTRUCTURES AEROESPACIALS

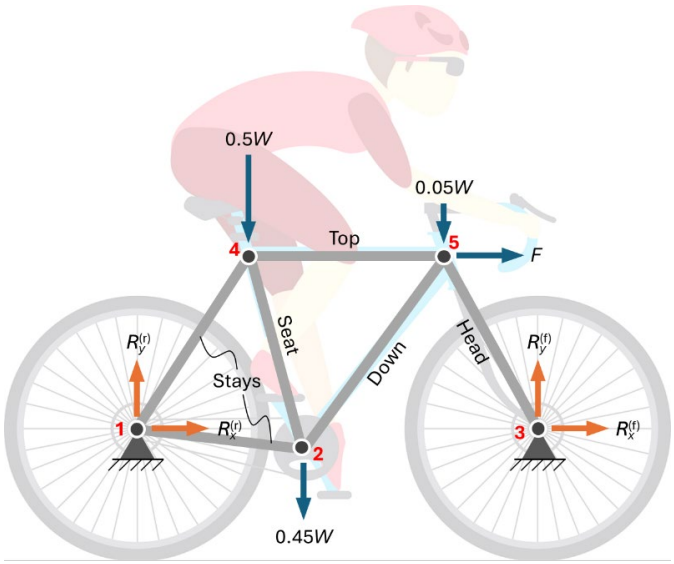
2D bars structure: Bicycle

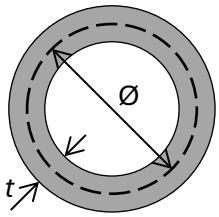
February 19th 2024

The goal of this assignment is to study the structural response of a bicycle. To do so, the analysis will be split into two parts: (1) the frame, and (2) the wheels.

Part 1

The goal of this first analysis is to transfer the loads applied by the rider to the wheels. For that, the frame structure—made of a material with a Young's modulus $E = 71$ GPa—as depicted in Figure 1 is studied. The mass of the rider is 75 kg and a net force in the horizontal direction F is applied to produce a forward acceleration of $a = 2.5$ m/s^2. Assuming the mass of the frame is negligible, the following is asked:





Tube	Ø (mm)	*t* (mm)
Head	36	1.5
Down		
Top	30	1.2
Seat		
Stays	20	1.0

Figure 1. Frame structural model with bars. The rider's weight W is distributed among nodes 2, 4 and 5 and the net horizontal force F is applied at node 5. Displacement at nodes 1 and 3 is fixed. The geometric features of the tubes cross-section are given in the table.

a) Plot of the deformed frame structure and stress state of each bar.
b) Reaction forces at the prescribed nodes.

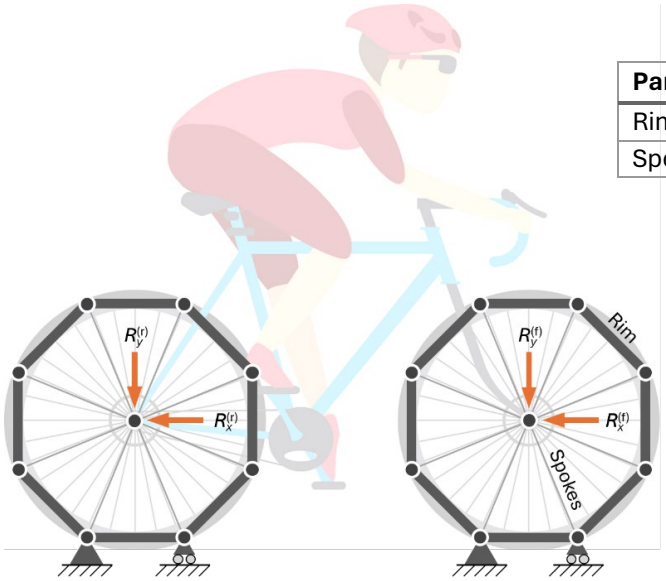
Part 2

To model the wheel's structural response, the simplified bar structure depicted in Figure 2 is considered. In this case, the input loads correspond to the reactions of the frame structure obtained in Part 1. For each wheel, the following is asked:

a) Obtain the nodal coordinates and connectivities matrices for the bars model in Figure 2.
b) Plot of the deformed structure and stress state of each bar.
c) Assessment of the risk of buckling of the spokes. Consider the critical stress given by:

$$\sigma_{\text{cr}} = \frac{\pi^2 EI}{l^2 A}$$

with l being the bar's length, A the cross-section area, and I the second moment of area.
d) How much prestress (initial stress) in the spokes is required to guarantee a safety factor (for buckling) of at least 2.5? Obtain the deformed structure and stress state of each bar in this case.



Part	*E* (GPa)	A (mm^2)	I (mm^4)
Rim	70	140	1470
Spokes	210	3.8	1.15

Figure 2. Wheels structural model with bars. The radius of each wheel is 35 cm. The table gives the material and cross-section properties of the rims and spokes.

The assignment can be done in groups of maximum two people. The MATLAB® script files and a report with the required results (including a brief discussion of the same) must be submitted to Atenea by either one of the members (not both).