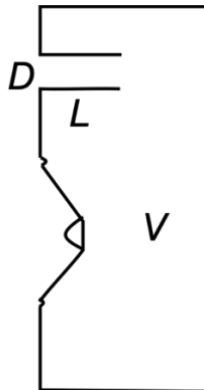# Modeling of a loudspeaker

The Figure below shows the lateral cross section of a loudspeaker with a vented cabinet.
The vent is represented by the tube, with a circular cross section, that links the external air with the inner volume of the cabinet. The diameter D of the venting tube is 7cm, and its length L is 24.7 cm. The volume of the cabinet V is 20 liters.

The loudspeaker - not including the cabinet - in mechanical terms, can be thought of as a mass-spring-resistance system attached to a force generator. The mass is equal to 45.5 grams, and the resonance frequency is 49 Hz. The quality factor of the system is 50 at resonance.

Mechanical characterization

a) Find the stiffness of the mechanical compliance of the loudspeaker (not considering the coupling with the cabinet).
b) Derive the mechanical schematic of the whole system (in terms of masses, springs and resistances).

Equivalent electric circuit

c) From the mechanical system derive the equivalent electric circuit;
d) From the equivalent electric circuit, derive the transfer function of the whole system;

System characterization from the equivalent electric circuit

e) Derive the resonance frequency of the overall system;
f) Verify that, at resonance, the lumped element approximation is valid (i.e. that the maximum dimension of a possible cabinet with the given volume does not exceed 1/10 of the wavelength), and suggest a possible strategy to assess the error introduced by this approximation.

Notes & suggestions:

- Answer concisely;
- Describe – concisely - the procedure used to obtain the results: if an error is present, I cannot identify the reason – numerical or conceptual - if the procedure is not described: in grading I will be forced to use the worst-case option.
- Upload the report by November 25th.
- **All students must upload the report.**
- When uploading the PDF file, specify the name, surname and ID of all the students participating to the HW, if more than one student worked on it.