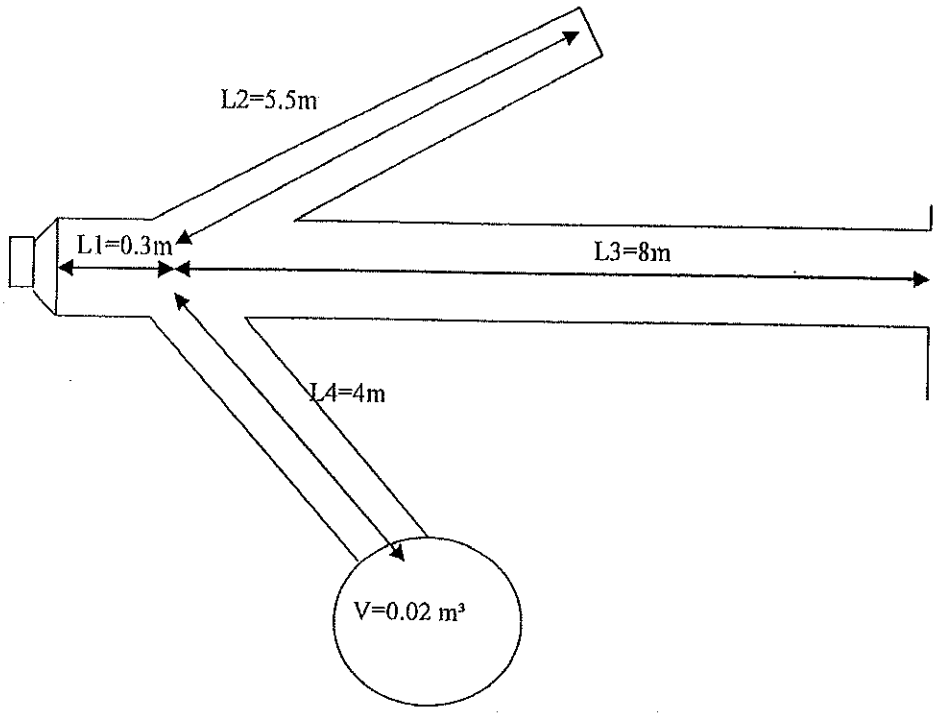
ELECTROACOUSTIC ANALOGIES – Exercise 1

The following acoustic system has an input pressure of P_{in} imposed by the loudspeaker in the figure. All the ducts have a circular section with a diameter of 20cm. The duct with length L_2 is closed by a rigid surface, the duct with the length L_3 ends with the opening of an infinite rigid baffle and the duct with length L_4 ends in a sphere of volume 0.02 m³.



Questions :

1) Draw the analog electric circuit of this system at the frequency 85 Hz.

2) What is the acoustic impedance presented to the loudspeaker (input impedance) at this frequency ?

3) Give the mathematical expression of the acoustic power radiated at this frequency.

Data :

The sphere can be modelled by an acoustic capacitance (lumped circuit element).

c=340 m/s ρ_0=1.2 kg /m³

ELECTROACOUSTIC ANALOGIES – Exercise 2

The following acoustic system is driven by a loudspeaker emitting a sinusoidal signal (pure tone).

The volumes are the following:

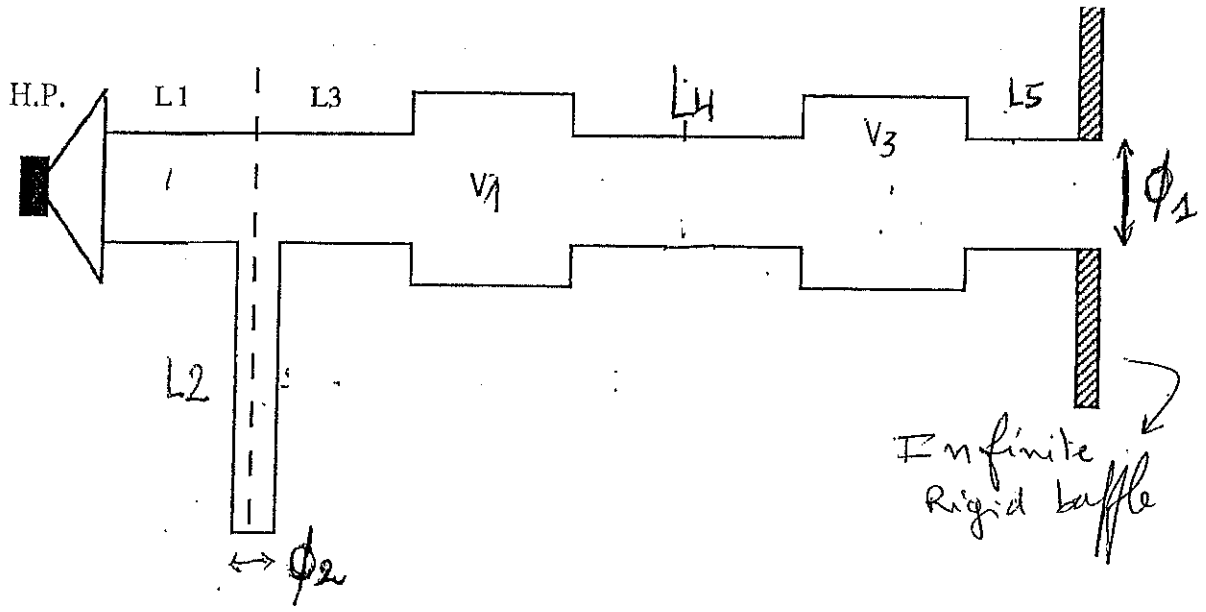
$V1 = 2000\ cm^3$	$\Phi 1 = 10$ cm
$V3 = 2000\ cm^3$	$\Phi 2 = 3$ cm

The cavities V1 and V3 can be modelled by lumped circuit elements and the effect of the connection between L1, L2 and L3 can be neglected.

Data: c=344 m/s and $\rho_0 = 1.2\ kg/m^3$.

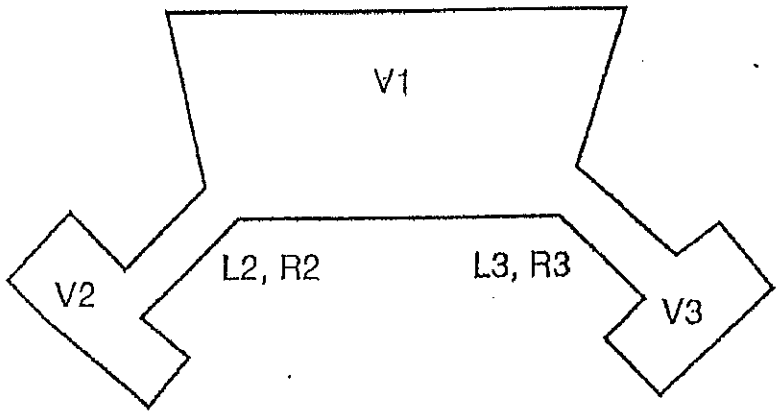
Questions :

1) Draw the analog electric circuit of this system and mention the frequency limits for each element;
2) If the plane wave condition is valid for all the circuit elements, what is the minimum length of L2 able to cancel any radiated power at 500 Hz ?
3) Is it possible to reach the same goal by replacing the duct L2 by an Helmholtz resonator composed of a tube with L2=5cm and diameter $\Phi 2 = 3$ cm, connected with a volume V2 (lumped circuit element) ? if so, calculate the value of V2;
4) What is the input acoustic impedance at 1000 Hz in the original system (question 2) if the following conditions are established:
   L2=L4=L5 and L1=L3=L2/2 ?



Exercise 5

Give the analog electrical circuit of the following acoustic system (the *artificial ear*):



Exercise 6

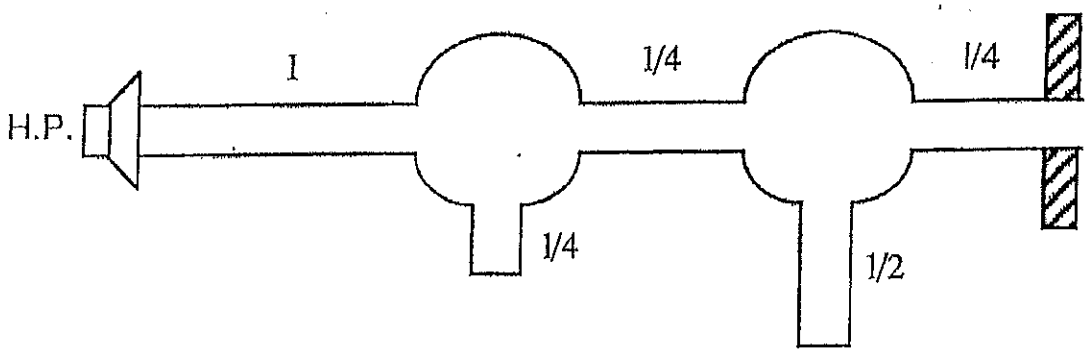
The following acoustic system is composed of several tubes having the same diameter 5cm. Their length is a fraction of the same length "l = 2.15m" (l, l/2 or l/4). The two spheres are identical and have the same diameter of 10cm. The output of the system radiates in an infinite rigid baffle.

C = 344 m/s.

Questions:

a) Give the analog electrical circuit

b) Compute the input acoustic impedance as seen by the loudspeaker (sound 'generator') at the entrance of the system. The emitted signal is a pure tone at 80 Hz.



Solution :

Z_{in} = -j 538000 (Pa . s/m³) (capacitive)