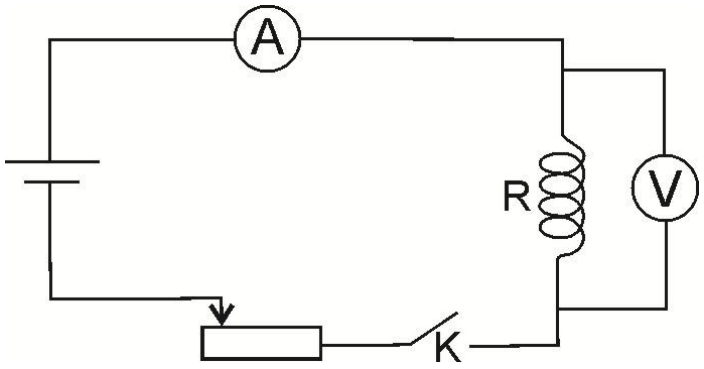
M7. Modeling the electrical properties of biological systems. Properties of RLC circuit

Topics:

- The basics of electrodynamics [1] – Chap 21; electric charge - Chap. 21-2 and Coulomb's law – Chap. 21-4
- The electric field [1] – Chaps. 22-1 through 22-4, 22-8 through 22-9
- Electric potential [1] – Chaps. 24-1 through 24-6 and 24-10
- Capacitor and capacitance [1] - Chap. 25; connecting capacitors – Chap. 25-4, energy stored in a capacitor – Chap. 25-5
- Electric current [1] – Chaps. 26; the laws of electric current flow: Ohm's law – Chaps. 26-5 through 26-6, power – Chap. 26-7
- Electrical circuits [1] - Chap. 27
- Direct current and alternating current (DC/AC) [1] - Chaps. 26-2 and 31-6
- Modeling of the basic biological structures. The electric model of a cell membrane.
- Inductor and inductance [1] – Chap. 30; Faraday's law of induction – Chap. 30-3, Lenz's law – Chap. 30-4, inductors – Chap. 30-7 and energy stored in a magnetic field – Chap. 30-11
- Electromagnetic oscillations in an AC circuit [1] – Chap. 31
- Inductor in DC and AC circuit [1] - Chaps. 31-2 through 31-4
- Capacitor in an AC circuit [1] - Chaps. 31-2 through 31-4
- Electrical impedance. Resonance in the RLC circuit. Power in an AC circuit [1] – Chaps. 31-7 through 31-11

Instruction

1. Assemble the circuit shown in the Scheme 1.



Scheme 1

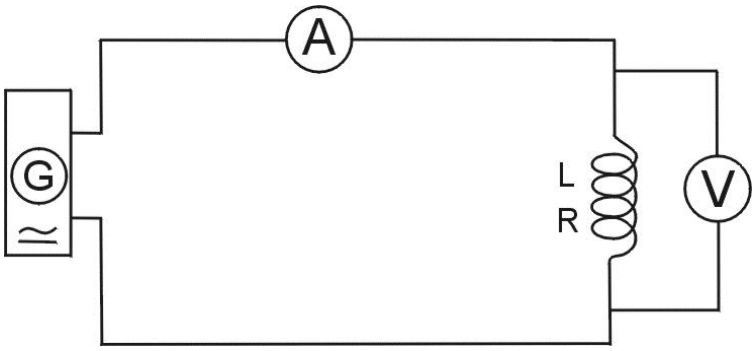
2. For three different voltages (three positions of the slide block on the resistor) determine the resistance *R* of the inductor.

$$R = \frac{U}{I}$$

3. Enter the results into the table. Remember to write down classes and ranges of the meters, which were set for the measurement.

no.	***U* (V)**	***I* (A)**	***R* (Ω)**
1			
2			
3			

4. Assemble the circuit shown in the Scheme 2.



Scheme 2

5. Determine impedance of the inductor Z_L as a function of current frequency (change the frequency from 20 to 200 Hz, with 10 Hz step).

$$Z_L = \frac{U_s}{I_s}$$

6. Calculate inductive reactance as a function of frequency:

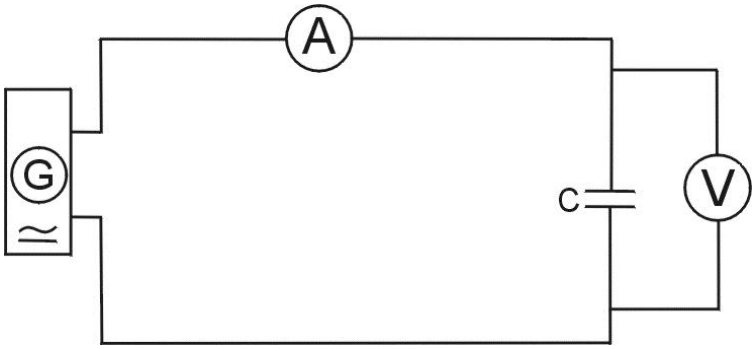
$$R_L = \sqrt{Z_L^2 - R^2}$$

7. Enter the results into the table.

***f* (Hz)**	U_s **(V)**	I_s **(A)**	Z_L **(Ω)**	R_L **(Ω)**
50				
60				
70				
80				
90				
100				

110				
120				
130				
140				
150				
160				
170				
180				
190				
200				

8. Assemble the circuit shown in the Scheme 3.



Scheme 3

9. Determine capacitive reactance Z_C as a function of frequency (from 20 to 200 Hz, with 10 Hz step).

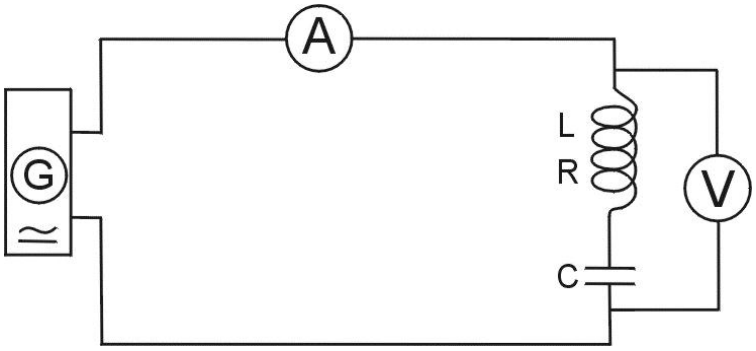
$$Z_C = \frac{U_s}{I_s}$$

10. Enter the results into the table.

f **(Hz)**	U_s **(V)**	I_s **(A)**	Z_c**(Ω)**
50			
60			
70			
80			
90			
100			
110			
120			
130			
140			
150			
160			

170			
180			
190			
200			

11. Assemble the circuit as shown in the Scheme 4.



Scheme 4

12. Determine impedance *Z* of the RLC circuit (connect inductor and capacitor in series) as a function of frequency.

$$Z = \frac{U_s}{I_s}$$

13. Enter the results into the table.

f **(Hz)**	U_s **(V)**	I_s **(A)**	***Z*(Ω)**
50			
60			
70			
80			
90			
100			
110			
120			
130			
140			
150			
160			
170			
180			
190			
200			

14. On the single sheet plot the following functions: $F(f) = R_L$, $F(f) = Z_C$, $F(f) = Z$. Use the plot to find the resonance frequency f_r.

[1] Walker J., Halliday and Resnick, Principles of physics : international student version, 9 th ed., extended, Hoboken : John Wiley & Sons, Inc., 2011. , ISBN 978-0-470-56158-4