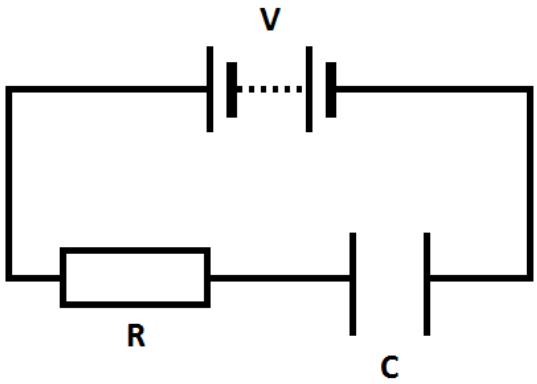
Homework – Capacitive and Inductive Circuits

1. A capacitor has a capacitance of 500 μF and a negligible internal resistance. The capacitor is connected in the circuit as shown below.

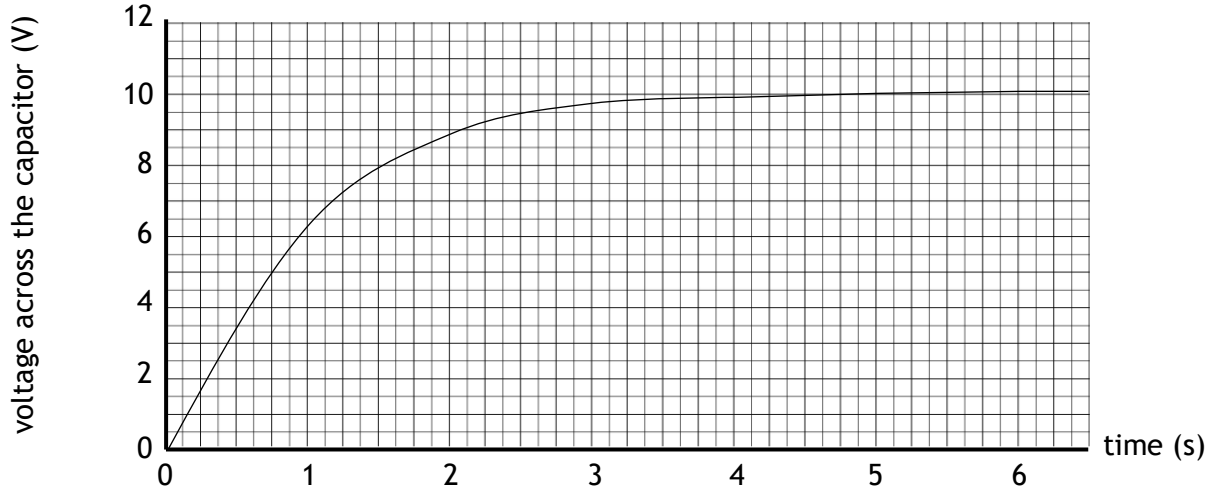


The capacitor is fully charged, using the 10·0 V battery, through the series resistor of 2·0 kΩ.

(a) Calculate the time constant for this charging circuit.

(b) Show that the units of the time constant are seconds.

(c) A graph of the charging voltage against time is created and is shown below.

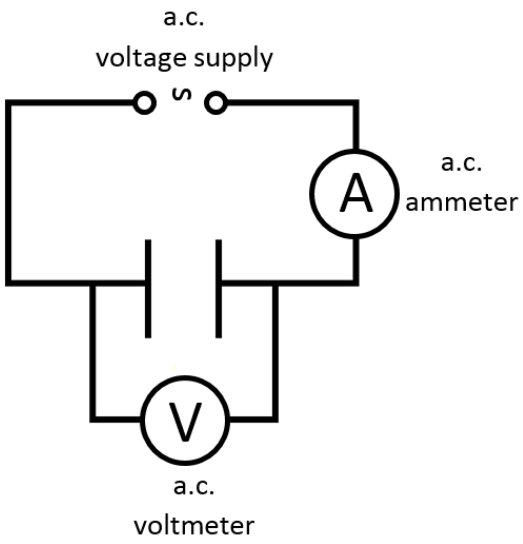


(i) Use the information from the graph to show that the capacitor is 63% charged after one time constant.

(ii) Use information from the graph to determine how many time constants are required for this capacitor to be considered fully charged.

Homework – Capacitive and Inductive Circuits

2. A capacitor is connected to an 8·0 V alternating supply as shown in the circuit below.



The frequency of the supply is set to 60 Hz.
The ammeter reads 20 mA.

(a) State the meaning of capacitive reactance.

(b) Calculate the capacitive reactance of the circuit.

(c) Calculate the capacitance of the capacitor.

The frequency of the supply is increased from 60 Hz to 600 Hz.

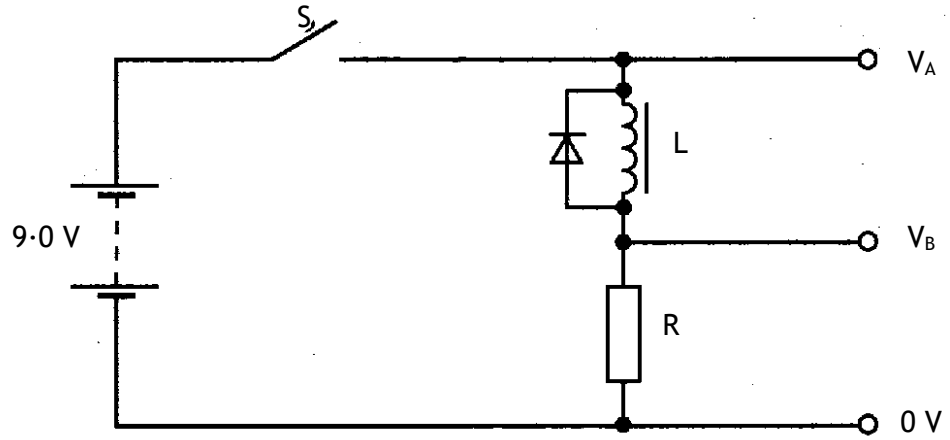
(d) Create a sketch of a graph that shows the relationship between the frequency of the supply and the r.m.s. current for the capacitive circuit.

The capacitor is now replaced with a resistor and the frequency is altered as before, from 60 Ha t 600 Hz.

(e) Create a sketch of a graph that shows the relationship between the frequency of the supply and the r.m.s. current for the resistive circuit.

Homework – Capacitive and Inductive Circuits

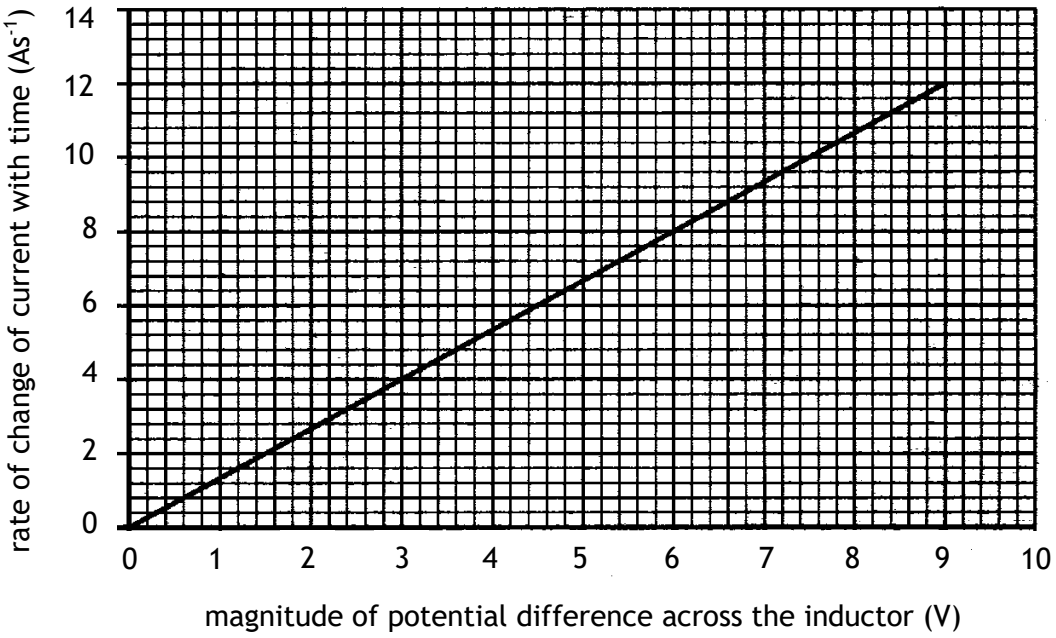
3. A datalogger is used to investigate the rate of change of current in the circuit shown below.



The datalogger measures the potential V_A and the potential V_B.

(a) State which other piece of information is required to allow the computer software to determine the current in the circuit.

The switch, S, is closed and the datalogger software produces the graph shown below.



(b) Assuming that the resistance of the inductor is negligible, calculate its inductance.

The current in the circuit eventually reaches a steady value of 100 mA.

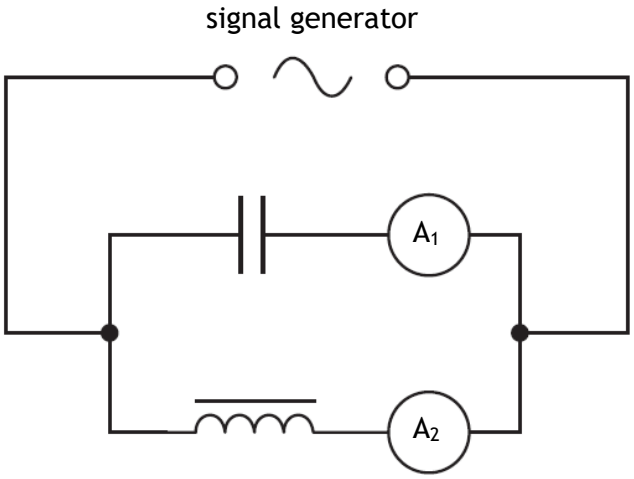
(c) Calculate the energy stored in the magnetic field of the inductor.

The diode in the circuit is necessary to protect the datalogger against the high voltage which can arise when the switch, S, is opened.

(d) Explain why this high voltage is produced.

Homework – Capacitive and Inductive Circuits

4. A pupil sets up the circuit shown in the diagram below to investigate the relationship between current and frequency for a capacitor and for an inductor.



At a frequency of 75 Hz the readings on ammeter A_1 and A_2 are the same.

The frequency of the supply is increased from 75 Hz to 150 Hz. The supply voltage remains constant.

(a) Explain what happens to the reading on ammeter A_1.

(b) Explain what happens to the reading on ammeter A_2.

5. A pupil sets up an LC circuit, as shown in the diagram below.

The maximum current occurs at the resonant frequency f_0. Resonance occurs when the capacitive reactance equals the inductive reactance.

(a) Show that the resonant frequency f_0 is given by

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

The capacitance of the capacitor is 20 μF.

(b) Calculate the inductive reactance.

The pupil wants to change the design of this circuit in order to double the resonant frequency.

(c) Describe an exact change the pupil could make to achieve this.