Higher
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Capacitors
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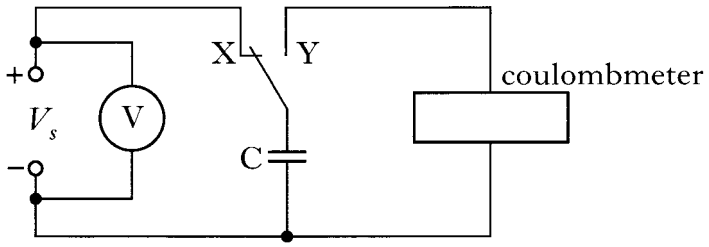
Past Paper questions
2000 - 2010

2000 Q24.

(a) In an experiment to measure the capacitance of a capacitor, a student sets up the following circuit.



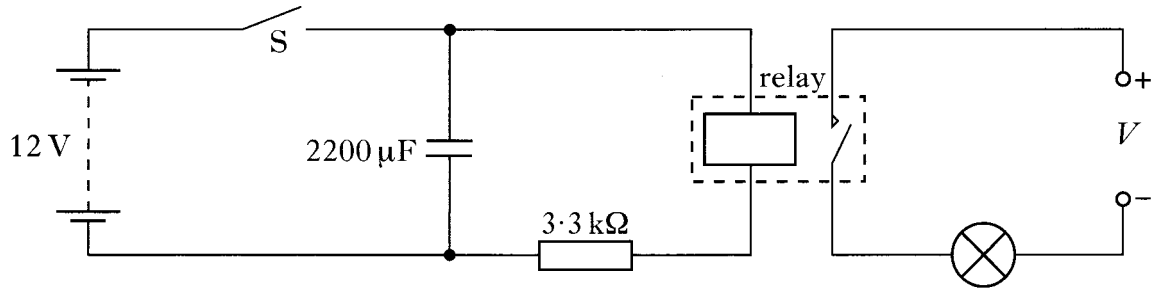
When the switch is in position X, the capacitor charges up to the supply voltage, V_S. When the switch is in position Y, the coulombmeter indicates the charge stored by the capacitor.
The student records the following measurements and uncertainties.

Reading on voltmeter = (2.56 ± 0.01)V
Reading on coulombmeter = (32 ± 1) μC

Calculate the value of the capacitance and the percentage uncertainty in this value.
You must give the answer in the form

value ± percentage uncertainty.

(b) The student designs the circuit shown below to switch off a lamp after a certain time.



The 12 V battery has negligible internal resistance. The relay contacts are normally open. When there is a current in the relay coil the contacts close and complete the lamp circuit.
Switch S is initially closed and the lamp is on.

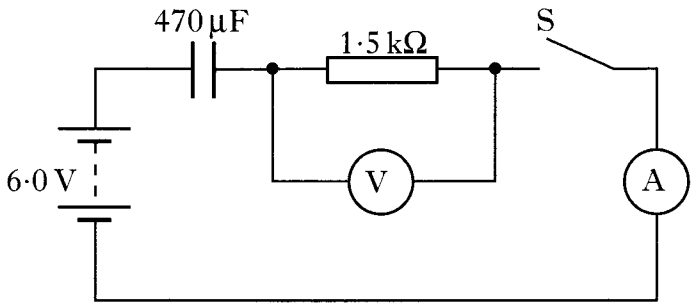
(i) What is the maximum energy stored in the capacitor?

(ii) (A) Switch S is now opened. Explain why the lamp stays lit for a few seconds.

(B) The 2200 μF capacitor is replaced with a 1000 μF capacitor.
Describe and explain the effect of this change on the operation of the circuit.

2001 Q25.

(a) The following diagram shows a circuit that is used to investigate the charging of a capacitor.



The capacitor is initially uncharged.
The capacitor has a capacitance of 470 μF and the resistor has a resistance of 1.5 kΩ.
The battery has an e.m.f. of 6.0 V and negligible internal resistance.

(i) Switch S is now closed. What is the initial current in the circuit?

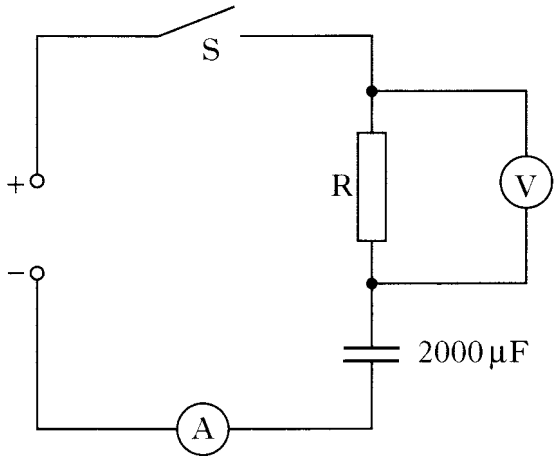
(ii) How much energy is stored in the capacitor when it is fully charged?

(iii) What change could be made to this circuit to ensure that the **same** capacitor stores **more** energy?

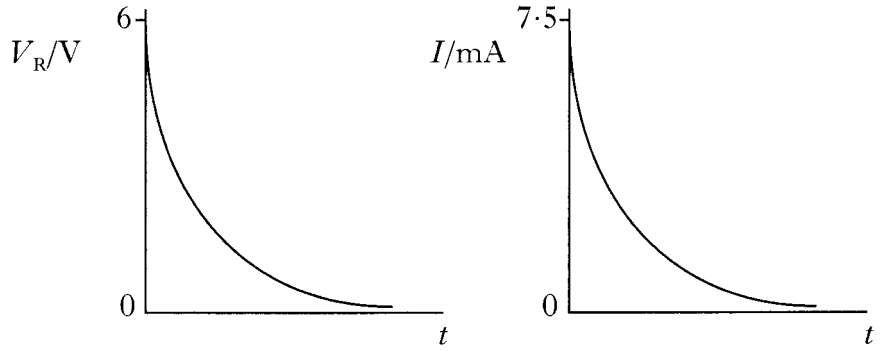
(b) A capacitor is used to provide the energy for an electronic flash in a camera. When the flash is fired, 6.35×10^{-3} J of the stored energy is emitted as light. The mean value of the frequency of photons of light from the flash is 5.80×10^{14} Hz.
Calculate the number of photons emitted in each flash of light.

2002 Q25.

(a) The circuit below is used to investigate the charging of a 2000 μF capacitor.
The d.c. supply has negligible internal resistance.

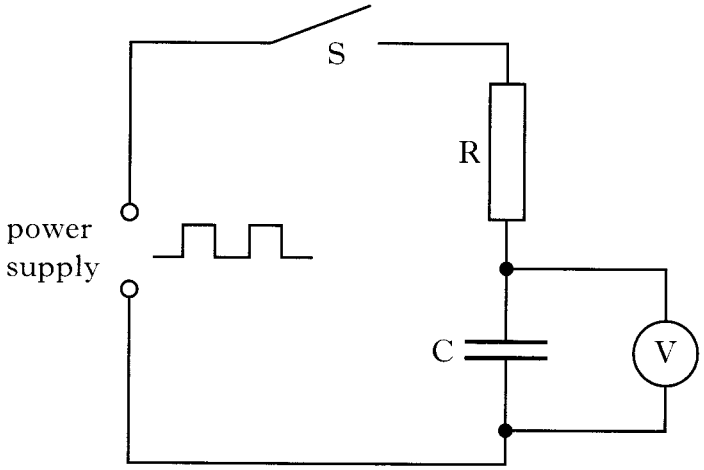


The graphs below show how the potential difference V_R across the **resistor** and the current I in the circuit vary with time from the instant switch S is closed.

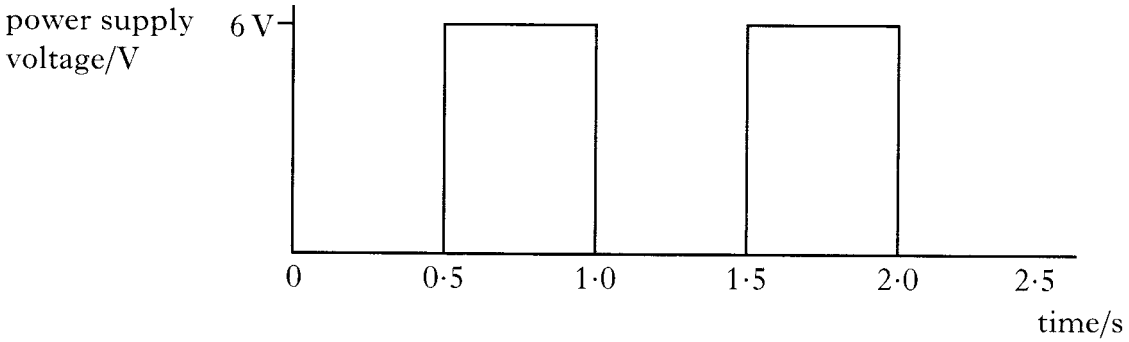


(i) What is the potential difference across the capacitor when it is fully charged?
(ii) Calculate the energy stored in the capacitor when it is fully charged.
(iii) Calculate the resistance of R in the circuit above.

(b) The circuit below is used to investigate the charging and discharging of a capacitor.



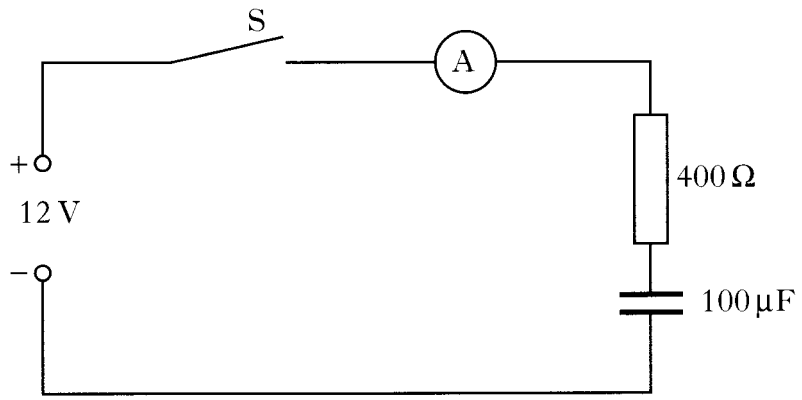
The graph below shows how the power supply voltage varies with time after switch S is closed.
The capacitor is initially uncharged.
The capacitor charges fully in 0.3 s and discharges fully in 0.3 s.
Sketch a graph of the reading on the voltmeter for the first 2.5 s after switch S is closed.



The axes on your graph must have the same numerical values as those in the above graph.

2004 Q25.

In an experiment, the circuit shown is used to investigate the charging of a capacitor.



The power supply has an e.m.f. of 12V and negligible internal resistance.
The capacitor is initially uncharged.
Switch S is closed and the current measured during charging.
The graph of charging current against time is shown in figure 1.

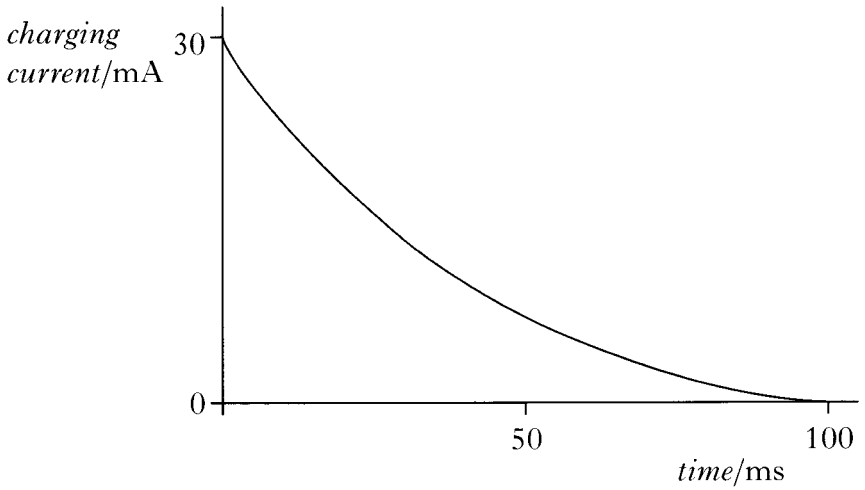


figure 1

(a) Sketch a graph of the voltage across the capacitor against time until the capacitor is fully charged. Numerical values are required on both axes.

(b) (i) Calculate the voltage across the capacitor when the charging current is 20 mA.

(ii) How much energy is stored in the capacitor when the charging current is 20 mA?

(c) The capacitor has a maximum working voltage of 12 V.
Suggest **one** change to this circuit which would allow an initial charging current of greater than 30 mA.

(d) The 100 μF capacitor is now replaced by an uncharged capacitor of unknown capacitance and the experiment is repeated.
The graph of charging current against time for this capacitor is shown in figure 2.

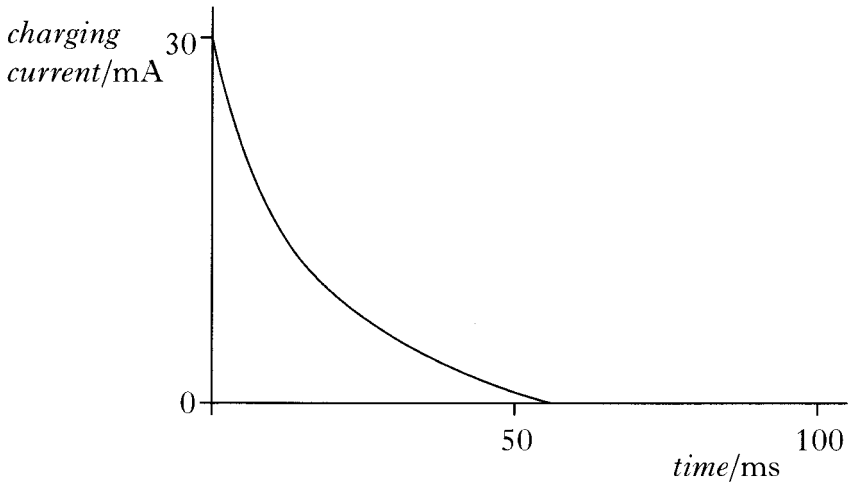
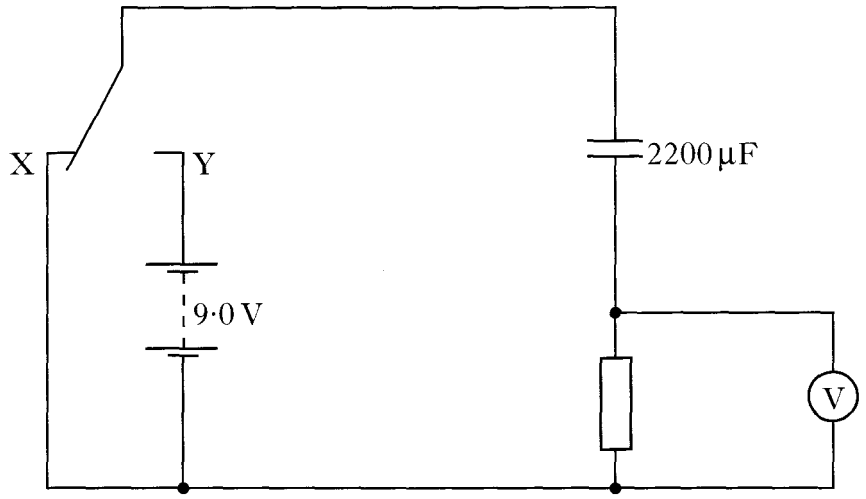


figure 2

By comparing figure 2 with figure 1, determine whether the capacitance of this capacitor is greater than, equal to or less than 100 μF.
You must justify your answer.

2005 Q26.

A student investigates the charging and discharging of a 2200 μF capacitor using the circuit shown.



The 9.0V battery has negligible internal resistance. Initially the capacitor is uncharged and the switch is at position X. The switch is then moved to position Y and the capacitor charges fully in 1.5 s.

(a) (i) Sketch a graph of the p.d. across the **resistor** against time while the capacitor charges. Appropriate numerical values are required on both axes.

(ii) The resistor is replaced with one of higher resistance. Explain how this affects the time taken to fully charge the capacitor.

(iii) At one instant during the charging of the capacitor the reading on the voltmeter is 4.0 V. Calculate the charge stored by the capacitor at this instant.

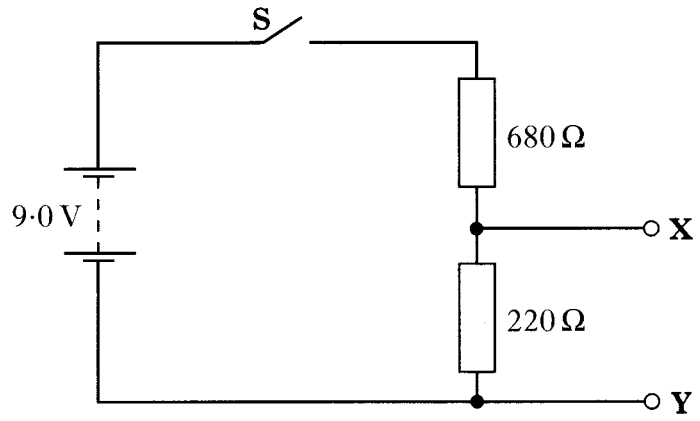
(b) Using the same circuit in a later investigation the resistor has a resistance of 100 kΩ. The switch is in **position Y** and the capacitor is fully charged.

(i) Calculate the maximum energy stored in the capacitor.

(ii) The switch is moved to position X. Calculate the maximum current in the resistor.

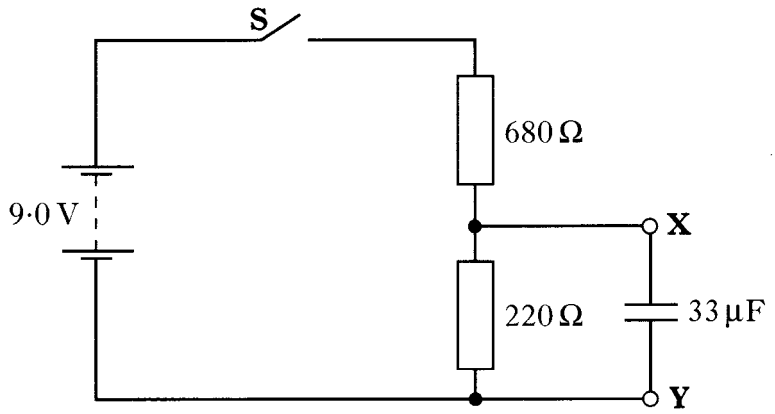
2006 Q25.

The 9.0 V battery in the circuit shown below has negligible internal resistance.



(a) Switch **S** is closed.
Calculate the potential difference between **X** and **Y**.

(b) Switch **S** is opened.
An uncharged 33 μF capacitor is connected between **X** and **Y** as shown.



Switch S is then closed.

(i) Explain why work is done in charging the capacitor.

(ii) State the value of the maximum potential difference across the capacitor in this circuit.

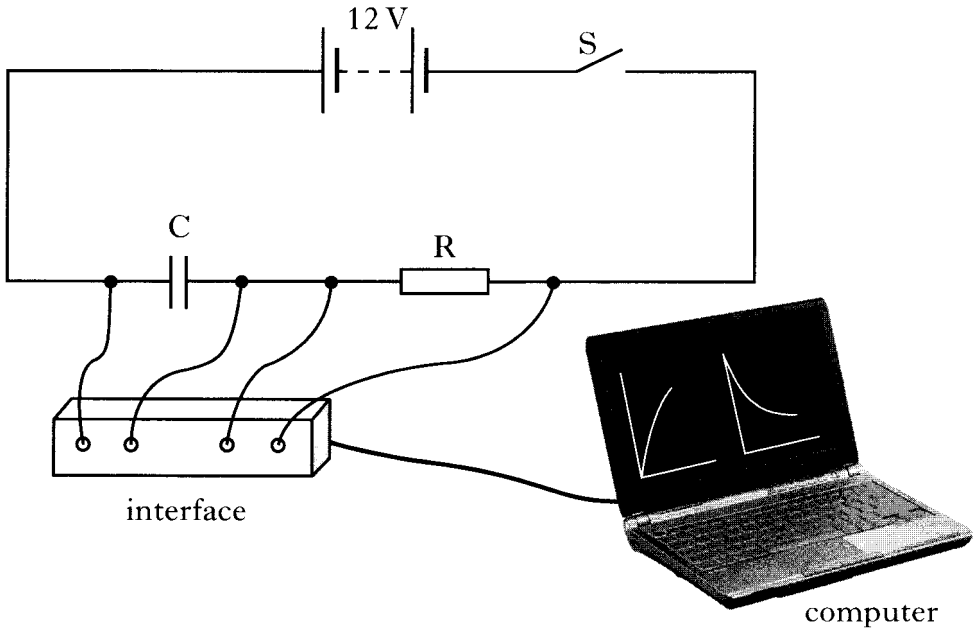
(iii) Calculate the maximum energy stored in the capacitor.

(iv) Switch **S** is now opened.
Sketch a graph to show how the current through the 220 Ω resistor varies with time from the moment the switch is opened.
Numerical values are required only on the current axis.

2008 Q25.

(a) State what is meant by the term *capacitance*.

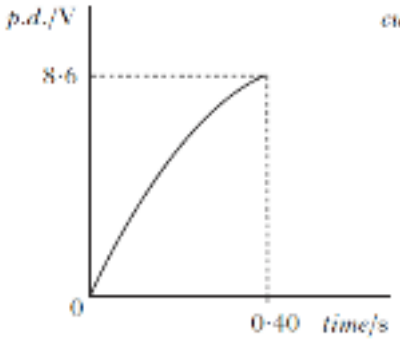
(b) An uncharged capacitor, C, is connected in a circuit as shown.



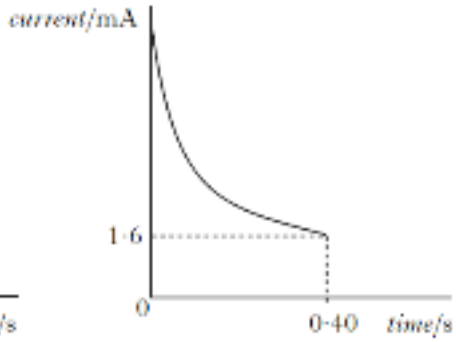
The 12 V battery has negligible internal resistance. Switch S is closed and the capacitor begins to charge. The interface measures the current in the circuit and the potential difference (p.d.) across the capacitor. These measurements are displayed as graphs on the computer.

Graph 1 shows the p.d. across the capacitor for the first 0.40 s of charging.

Graph 2 shows the current in the circuit for the first 0.40 s of charging.



Graph 1



Graph 2

(i) Determine the p.d. across resistor R at 040 s.

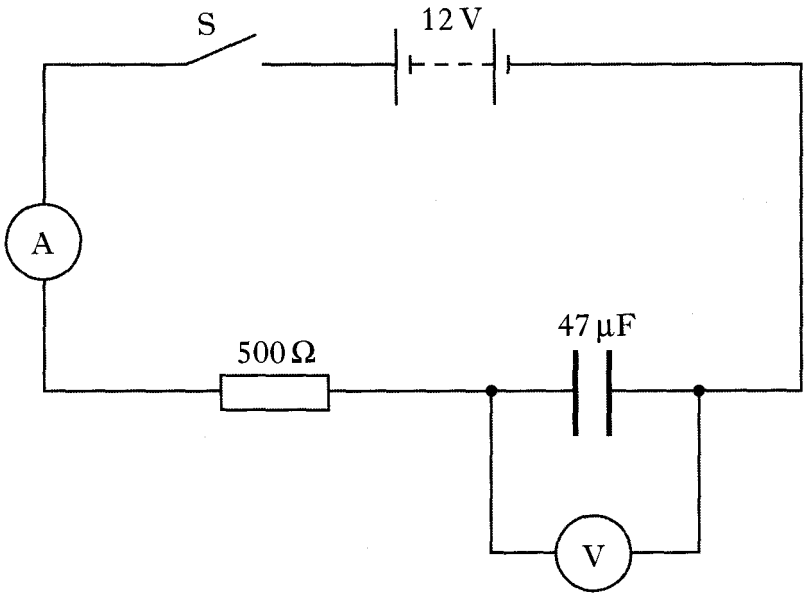
(ii) Calculate the resistance of R.

(iii) The capacitor takes 2.2 seconds to charge fully.
At that time it stores 10.8 mJ of energy.
Calculate the capacitance of the capacitor.

(c) The capacitor is now discharged.
A second, identical resistor is connected in the circuit as shown.
Switch S is closed. Is the time taken for the capacitor to fully charge less than, equal to, or greater than the time taken to fully charge in part (b)?
Justify your answer.

2009 Q26.

A 12 volt battery of negligible internal resistance is connected in a circuit as shown.



The capacitor is initially uncharged. Switch S is then closed and the capacitor starts to charge.

(a) Sketch a graph of the current against time from the instant switch S is closed.
Numerical values are not required.

(b) At one instant during the charging of the capacitor the reading on the ammeter is 5.0 mA.
Calculate the reading on the voltmeter at this instant.

(c) Calculate the **maximum** energy stored in the capacitor in this circuit.

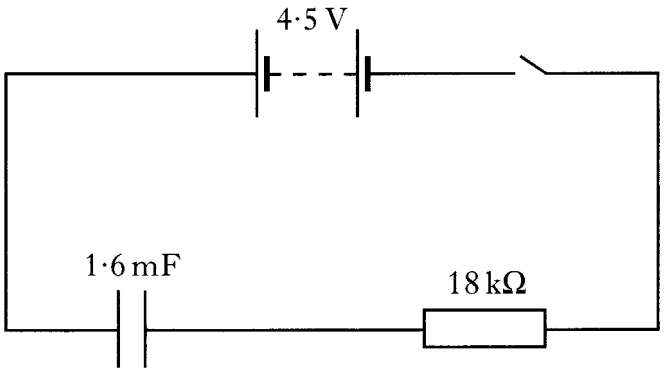
(d) The 500 Ω resistor is now replaced with a 2.0 kΩ resistor.
What effect, if any, does this have on the maximum energy stored in the capacitor?
Justify your answer.

2010 Q24.

An experiment is carried out to measure the time taken for a steel ball to fall vertically through a fixed distance using an electronic timer.

(a) The experiment is repeated and the following values for time recorded.
0.49s, 0.53s, 050s, 0.50s, 0.55s, 0.51s.
Calculate:
(i) the mean value of the time;
(ii) the approximate random uncertainty in the mean value of the time.

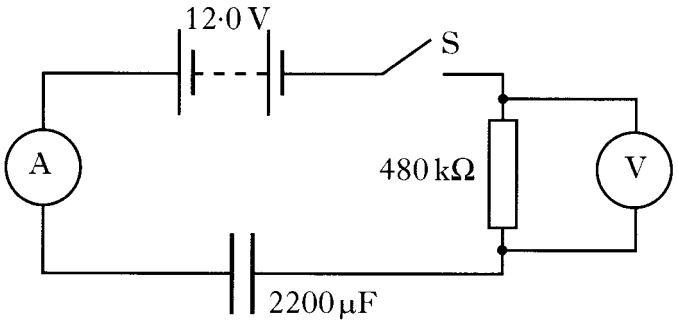
(b) Part of the circuit in the electronic timer consists of a 1.6 mF capacitor and an 18 kΩ resistor connected to a switch and a 4.5 V supply.



(i) Calculate the charge on the capacitor when it is fully charged.
(ii) Sketch the graph of the current in the resistor against time as the capacitor charges. Numerical values are required on the current axis.

2007 Q26.

An uncharged 2200 μF capacitor is connected in a circuit as shown.



The battery has negligible internal resistance.

(a) Switch S is closed. Calculate the initial charging current.

(b) At one instant during the charging process the potential difference **across the resistor** is 3.8 V.
Calculate the charge stored in the capacitor at this instant.

(c) Calculate the **maximum** energy the capacitor stores in this circuit.