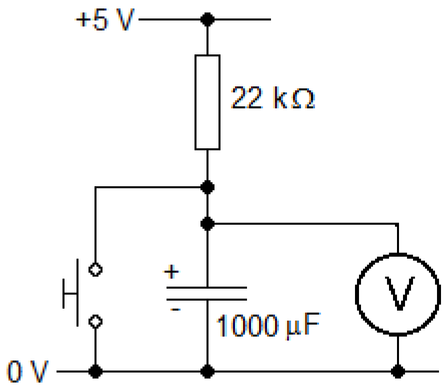
Charging and discharging capacitors

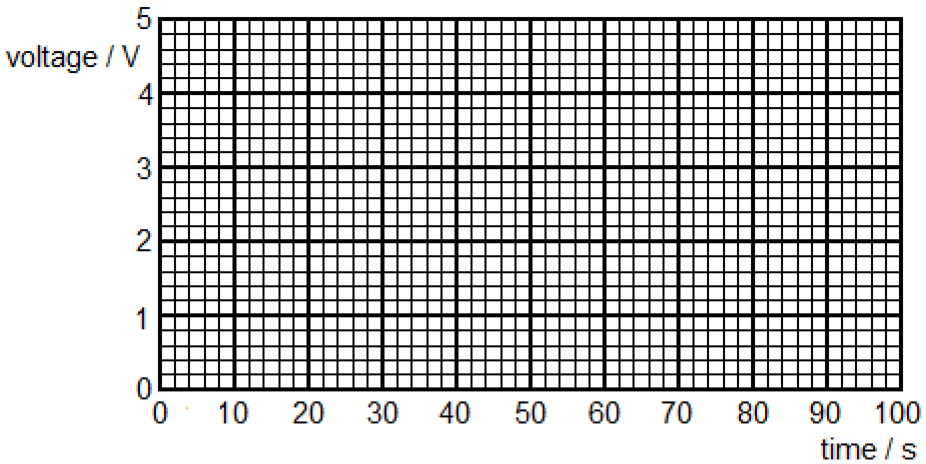
You are going to find out how the voltage across a capacitor changes with time as it is charged and discharged through a resistor.

1 Assemble the circuit shown opposite. The capacitor has a polarity, so be careful to get it round the right way.



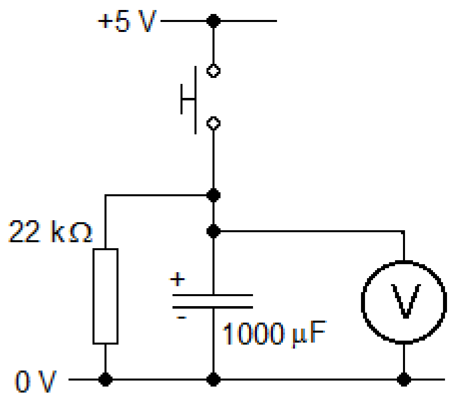
2 Close the switch and open it again. If all is well, the voltmeter reading should drop quickly to 0 V and then rise very slowly back up to +5 V.

3 Close the switch again. Start a stopwatch as you open the switch. Record the voltmeter reading every 10 s for the next 100 s. Plot the readings on the voltage-time graph below.



4 Join up the points with the best curve. Label it **charging**.

5 Now assemble the circuit shown opposite. Closing the switch should quickly charge up the capacitor. When the switch is open the capacitor discharges slowly through the resistor.

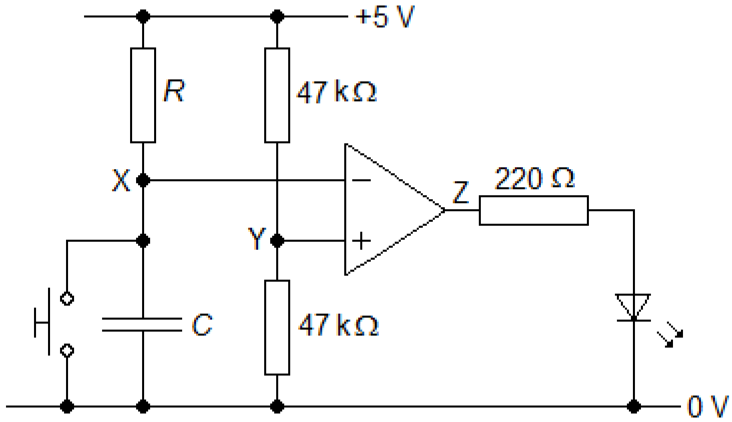


6 Close the switch and open it again. Record the voltmeter reading every 10s, plotting it on the graph above. Join up the points with the best curve. Label it **discharging**.

Halving-time

You are going to find out how the halving-time of an RC network depends on its component values.

1 Assemble the circuit shown below. Start with R = 100 kΩ and C = 100 μF.



2 Use a voltmeter to check that point Y is at +2.5 V, halfway between 0 V and +5.0 V.

3 Check that X goes to 0 V when the switch is pressed. This should make the LED glow. Releasing the switch allows the voltage at X to rise slowly as the capacitor charges through the resistor. The LED should suddenly stop glowing when X gets to +2.5 V.

4 Use a stopwatch to measure the time $T_{1/2}$ between the release of the switch and the LED going off. Enter the result in the table below. Compare it with the calculated value of 0.7RC.

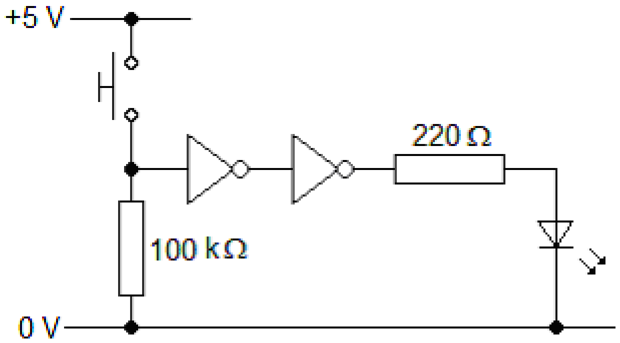
R	***C***	**0.7*RC***	$T_{1/2}$
100 kΩ	100 μF		
220 kΩ	100 μF		
22 kΩ	1000 μF		
47 kΩ	1000 μF		
10 kΩ	1000 μF		

5 Repeat step 4 for the other combinations of R and C given in the table.

Digital signal delay

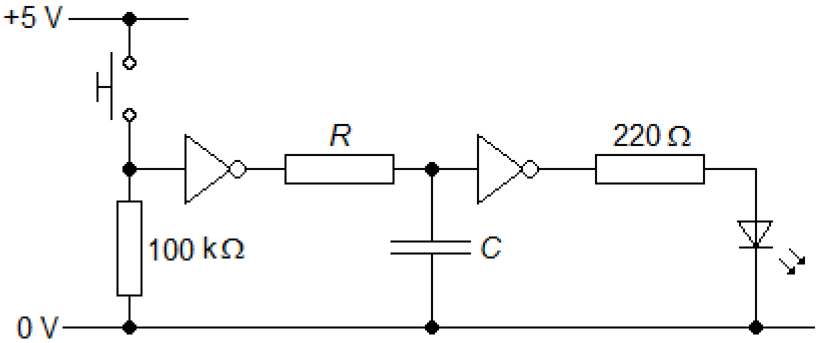
You are going to use an RC network to delay changes of a digital signal by 15 seconds.

1 Construct the circuit shown opposite.



2 Press the switch and release it. If all is well, the LED should start and stop glowing as soon as the switch is closed and opened.

3 Now add an RC network, as shown below. Let R = 47 kΩ and C = 100 µF. Verify that this introduces a time delay of about 3 s between changes of the switch and the LED.



4 Use the rule $T_{1/2} = 0.7RC$ to select component values for RC which result in a time delay of 15 s. Try them out - remember that the signal has to remain stable for a few time constants between changes.

5 You may have noticed that the change of signal at the output of the second logic gate is not very crisp. The LED does not change state very quickly. Verify that replacing the 4069 NOT gate i.c. with a 40106 Schmitt trigger NOT gate i.c. solves this problem, but also increases the time delay to $0.8RC$.