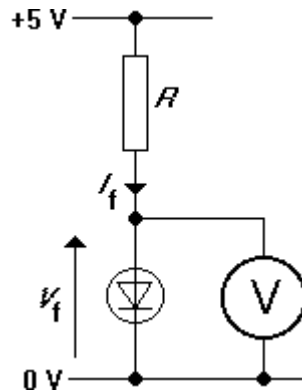


### Investigating the $I$ - $V$ characteristic of a diode

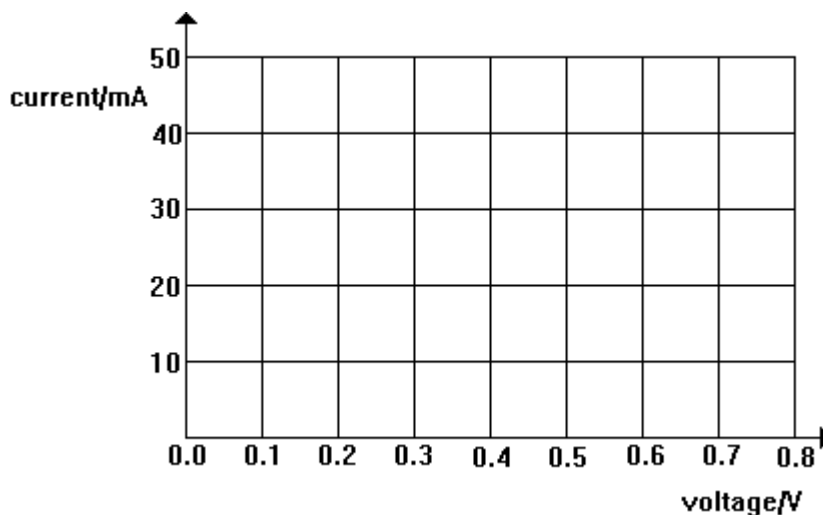
In the real world of electronics, the current in a component is often calculated from the voltage drop across a resistor in series with it. This is because it is usually not possible to break open a circuit to insert the ammeter!

1. Set up the circuit as shown, with  $4700\ \Omega$  for  $R$ . Use a 1N4148 signal diode.



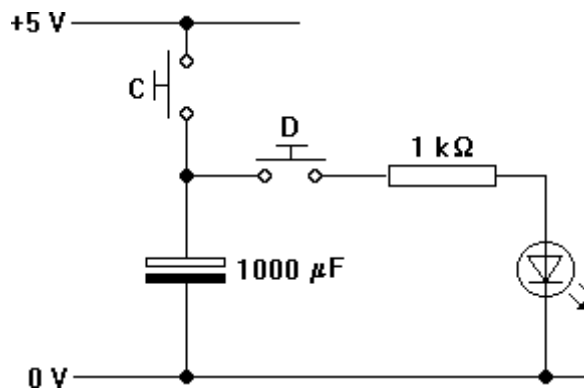
2. Measure the forward voltage  $V_f$  of the diode. Calculate the forward current  $I_f$  using Ohm's Law applied to the resistor. (You should get about 0.7 V and just under 1 mA.)
3. Repeat steps 1 and 2 with the following values of  $R$ .
 

2200  $\Omega$     1000  $\Omega$     470  $\Omega$     220  $\Omega$     100  $\Omega$
4. Use your results to plot a current–voltage graph for the diode. Use axes similar to the ones shown below.

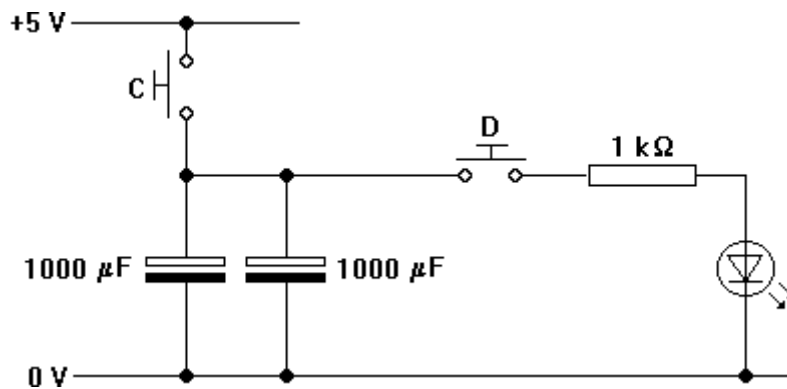


### Charging and discharging a capacitor

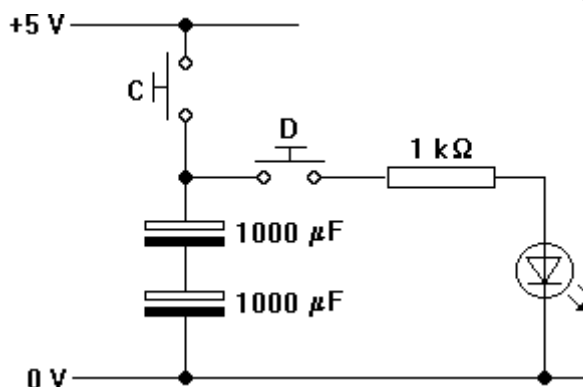
1. Assemble the circuit shown below. Be careful to get the capacitor connected round the right way.



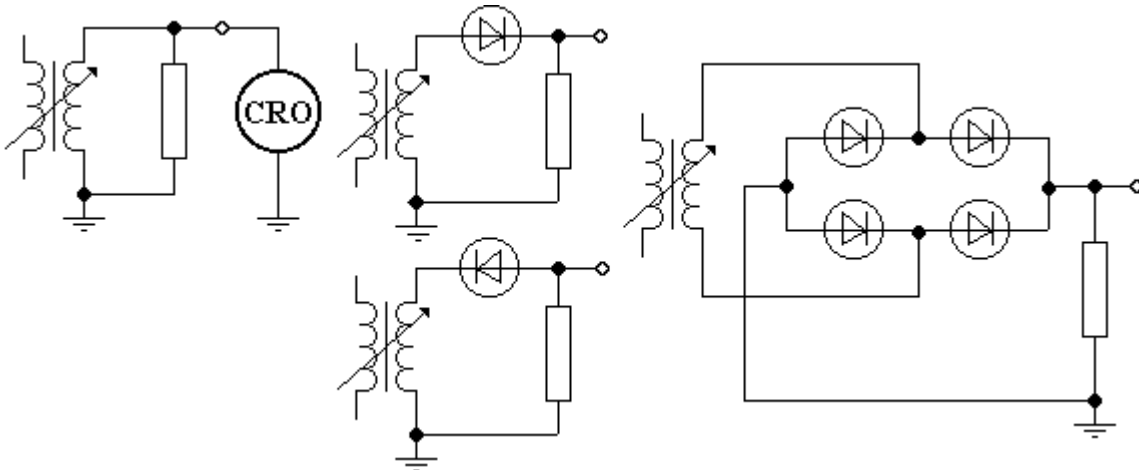
2. Press C and release it; then press D. There should be a brief flash of light from the LED. Explain why.
3. Insert a second 1000 µF capacitor in parallel with the one already there. Investigate what difference this makes.



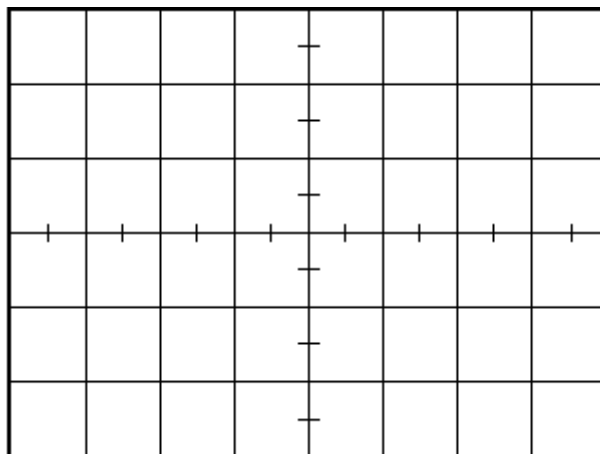
4. Now place the capacitors in series with each other. What happens?



**Different types of rectifier**



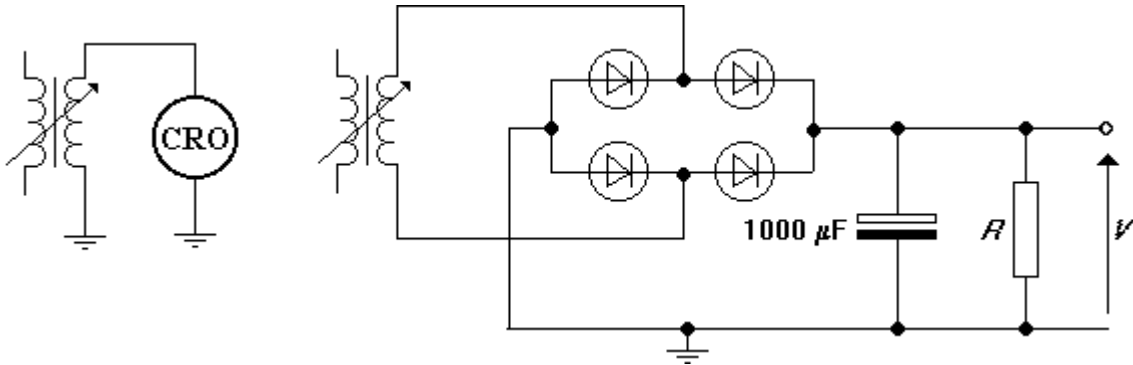
1. The circuit at the left-hand end shows a variable transformer (a.c. power pack) supplying current to a 1 kΩ resistor. An oscilloscope (CRO) is connected to the output terminal. Notice that one terminal of the transformer has been earthed. Construct the circuit.
2. Set up the CRO so that its vertical amplifier is 2 V/cm and the timebase is 5 ms/cm. Adjust the Y-shift so that the trace is in the centre of the screen for 0 V. Don't adjust these settings from now on. You should only need to alter the trigger setting to stabilise the trace.
3. Adjust the transformer until the peak voltage on the CRO screen is +5 V. Don't adjust the transformer from now on.
4. Sketch the trace on the screen. A copy of the grid below might help. Don't forget to show the settings of the timebase and vertical amplifier.



5. Assemble the remaining circuits in turn. Use 1 kΩ resistors each time. For each circuit, use the CRO to sketch the the time variation of the voltage at the output terminal. Note the different earthing arrangements for the diode bridge circuit!

### Investigating ripple in a simple power supply

1. Use a CRO to set the peak voltage of a variable transformer (a.c. power pack) to +6.0 V. Settings of 2 V/cm and 5 ms/cm, with d.c. input should work well. Do not adjust the setting of the transformer from now on.



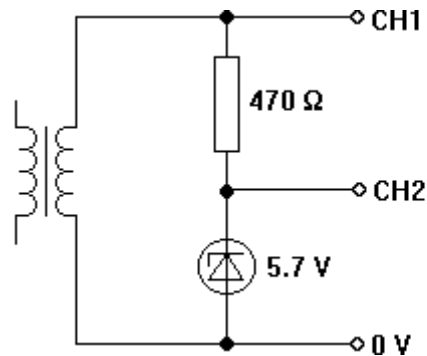
Warning! Capacitors can explode if reverse biased.  
Wear eye protection when doing this experiment.

2. Assemble the power supply circuit shown on the right. Have a load  $R$  of  $10\text{ k}\Omega$  ( $10\,000\ \Omega$ ). Be careful about where you earth the circuit, and which way round you have the capacitor. Connect the CRO so that it measures the voltage  $V$  across the load.
3. Switch on the transformer. If all is well, the screen trace should be a horizontal line at +4.6 V.
4. Now copy this table. Do calculations to complete it – don't do any measurements yet! You can assume that the a.c. supply has a frequency of 50 Hz. The current  $I = 4.6/R$ .

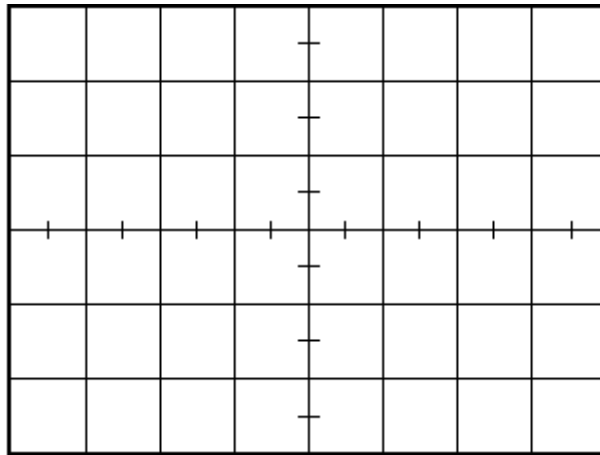
load/ $\Omega$	current/A	ripple/V
100		
220		
470		
1000		

5. Replace the load with the values shown in the table, one after the other. Measure the size of the ripple each time. You might need to switch the CRO input to a.c.

### Exploring a zener diode characteristic



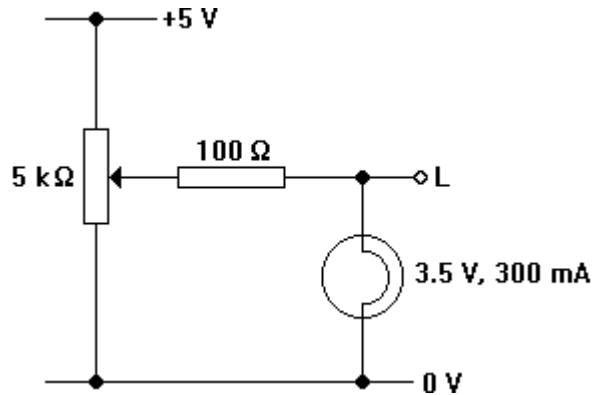
1. Assemble the circuit as shown. Use a variable transformer (a.c. power pack) set to 9 V r.m.s. Connect CH1 and CH2 to separate channels of a dual-beam oscilloscope.
2. Set the timebase to 5 ms/cm and the vertical amplifier to 5 V/cm, with 0 V at the centre of the screen. Trigger on CH1.
3. Switch on the variable power pack. Check that the signal at CH1 is a sine wave with a peak value of about 12.5 V. If all is well, the signal at CH2 should not go above +5.7 V or below  $-0.7$  V.
4. Sketch the waveforms at CH1 and CH2. A copy of the grid below might help. Don't forget to show the settings of the timebase and vertical amplifier.



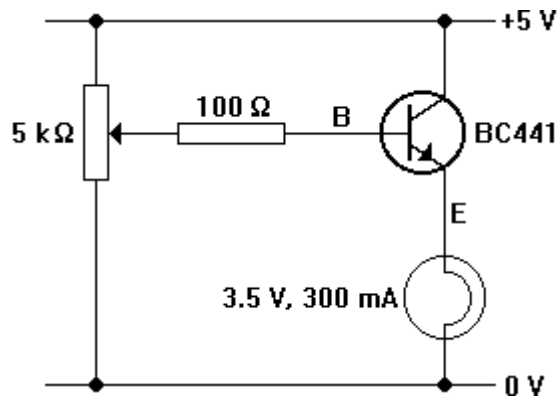
5. Explain the shape of the signal at CH2 by referring to the properties of the zener diode.

### The emitter follower

1. Set up the circuit as shown. Make sure that you identify the wiper of the 5 k $\Omega$  potentiometer correctly. The lamp will need to be external to your breadboard.



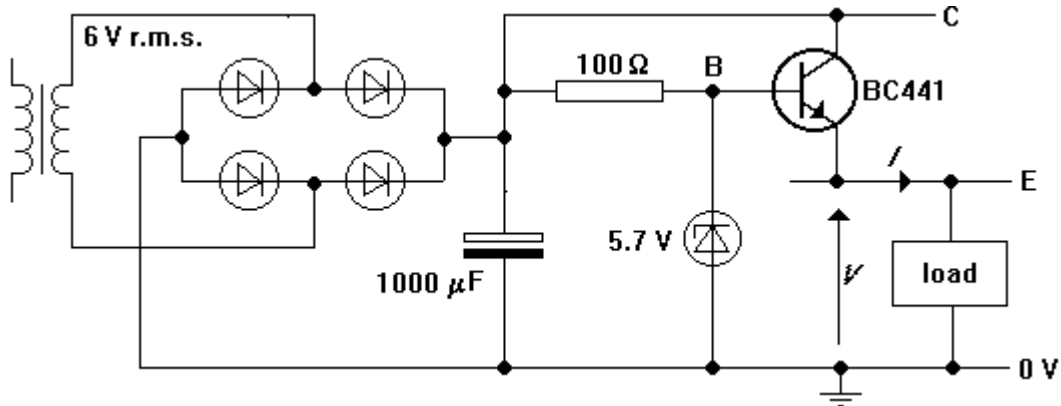
2. Remove the lamp. Connect a voltmeter between L and 0 V. If all is well, you should be able to alter the voltage at L smoothly between 0 V and +5 V by adjusting the knob on the potentiometer.
3. Replace the lamp. Verify that whatever the setting of the potentiometer, the lamp doesn't get enough voltage to glow.
4. Add a power transistor as shown below. Be careful to identify the base, emitter and collector terminals correctly.



5. Verify that the brightness of the lamp can be varied smoothly from full on to full off by adjusting the potentiometer.
6. Connect a voltmeter between B and 0 V. Set B to 0.0 V. Use the same voltmeter to measure the voltage at E (also 0.0 V).
7. Connect the voltmeter to B and increase it by 0.5 V.
8. Repeat steps 6 and 7 until you reach the maximum voltage at B.
9. Use your results to plot a graph which shows how the voltage at the emitter depends on the voltage at the base of the transistor.

### Investigating a stabilised power supply

1. Assemble the circuit shown below. Use power diodes and a power transistor. Start off with a load of  $100\ \Omega$ . The variable transformer (a.c. power pack) will need to be set at  $6\ \text{V r.m.s.}$



2. Switch on. Use an oscilloscope to check that the peak voltage at C is  $+7\ \text{V}$ . Adjust the setting of the variable transformer (a.c. power pack) if necessary.
3. Verify that B is a steady  $+5.7\ \text{V}$  with very little ripple. E should be a steady  $+5.0\ \text{V}$ .
4. The  $100\ \Omega$  load draws a current of  $I = 5/100 = 0.05\ \text{A}$  or  $50\ \text{mA}$  from the circuit. Sketch the appearance of the signals at C and E for this load current. Measure the ripple at C and E.
5. Use two  $100\ \Omega$  resistors in parallel as the load. This should draw a current of  $100\ \text{mA}$  from the circuit. Sketch the appearance of the signals at C and E for this load current. Measure the ripple at C and E.
6. Repeat stage 5 for three, four and five  $100\ \Omega$  resistors in parallel as the load.
7. Use your results to plot graphs showing how the ripple at C and E depend on the load current. Explain their shapes, with the help of some calculations.