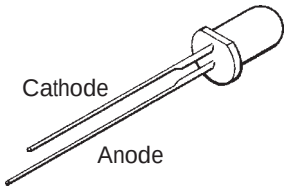
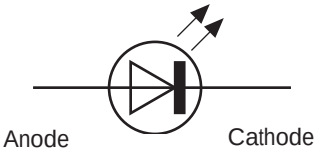
LIGHT EMITTING DIODES AND SEVEN SEGMENT DISPLAYS

A light emitting diode or LED is made from a semiconductor material, gallium arsenide phosphide, which emits light when a current of between 5 and 20 mA passes through it. Because the LED is a diode, it can only pass current in one direction - when it is forward biased. The LED emits no light when it is reverse biased. This is important as it means the anode must be connected to the positive side of the power supply to operate correctly. (An LED may be damaged if reverse biased.)



When a positive voltage is applied to the anode, the LED lights up. An external resistor **R** has to be connected in series with an LED to limit the current **I** through it to about 10 mA. The value of this resistance can be calculated from the formula:



$$R = \frac{V - V_f}{I}$$

V = supply voltage
Vf = forward voltage drop across LED

The voltage drop across the LED is typically 2 V.
So, for a supply voltage of V = 9 V,

$$R = \frac{9 - 2}{10 \times 10^{-3}} \qquad \left(\begin{array}{l} 10\ \text{mA} = 0.010\ \text{A} \\ = 10 \times 10^{-3}\ \text{A} \end{array} \right)$$

$= 700\ \Omega$

Choosing the nearest preferred value gives R = 680 Ω
(A table of preferred values is given at the end of study file 1)

Q1 The table below is the information given in a catalogue for a standard LED. Work out the value of the resistor needed if it is to be used with a 15 V power supply.

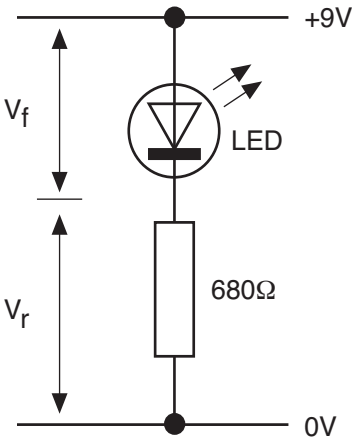
Technical specification (at 25°C)

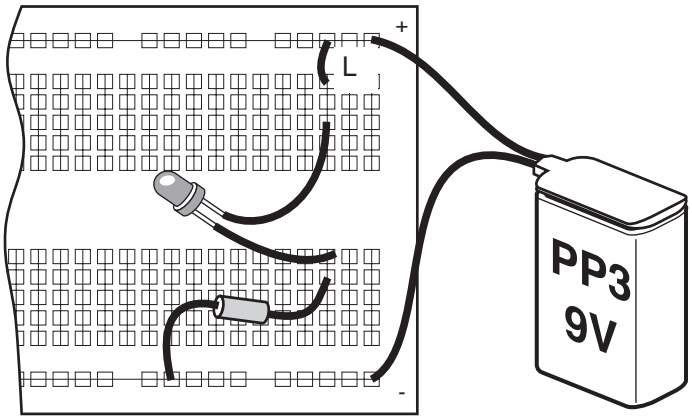
I_f max. mA	I_f typ. mA	V_f at I_f typ. V
30	10	2

I_f max. = maximum forward current.
I_f typ. = typical forward current.

INVESTIGATING A LED USING A PROTOTYPING BOARD

Set up the circuit below on the prototyping board as shown.
The flat side of the LED is nearest to the cathode and the longer leg shows the anode position.





Use a multimeter on the DC 10 V range to measure the voltage V_f across the LED, V_r the voltage across the resistance R, and V the voltage across the combination.

Q1 What is the sum of V_f and V_r?

Switch the multimeter to the DC 50 mA range and measure the current I_f through the LED. You will have to remove the link, (L), and connect the multimeter between the LED and the positive rail running along the top of the prototyping board.

Draw a table as shown and complete the first line.

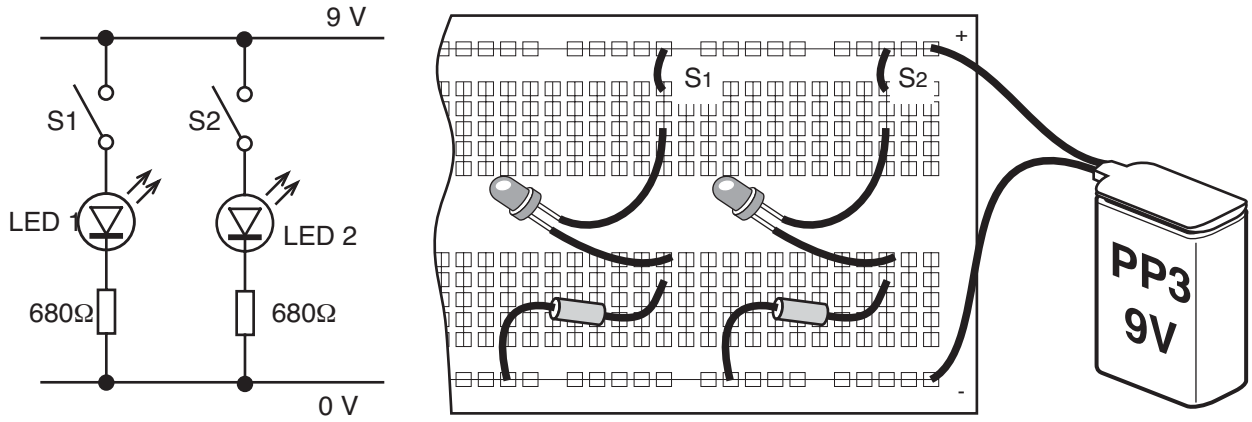
V	R	I_f	V_r	V_f
9V	680			
9V	1.2kΩ			
9V	3.9kΩ			
9V	10kΩ			

Use the three other values of R and enter these results in the table.

Q2 What happens to the current I as the value of R increases?

INVESTIGATING A CIRCUIT THAT CONTAINS MORE THAN ONE LED

Set up the circuit below on the protoboard board as shown. You can use wire links for S1 and S2.



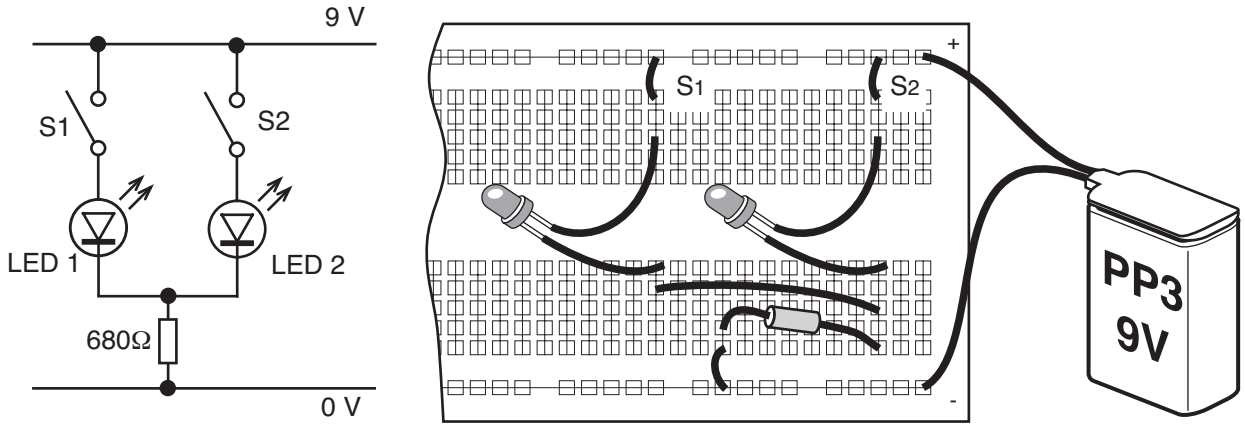
Close S_1 and note the brightness of LED1.

Close S_2 in addition to S_1 and again observe the brightness of the LEDs.

Is the brightness of the LEDs independent of one another ?

Can you give a reason to explain why?

Modify your circuit as follows:



Close S1 and note the brightness of LED1.

Close S2 in addition to S1 and observe the brightness of both the LEDs.

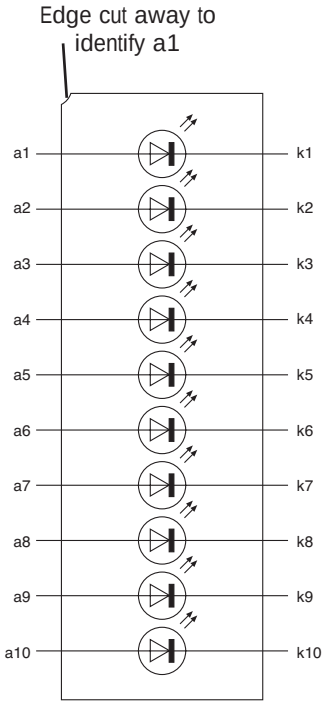
Are the brightness of the LEDs independent of one another?

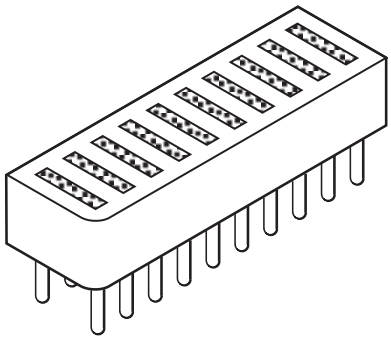
Can you give a reason to explain why?

If you wished to control a set of LEDs with switches, what would be the advantage of using a separate current limiting resistor for each LED.

MULTI-LED ARRAYS

A ten-segment bargraph array contains 10 LEDs encapsulated in a 20 pin package to form a neat compact display. Each LED is completely seperate from the others in the package and light leakage between adjacent LEDs is minimal. Both a sketch and a pinout diagram for a bargraph LED are shown below.





End stackable LED arrays are also available in which different combinations of 1, 2, 3 and 5 way arrays may be assembled.

SEVEN SEGMENT DISPLAYS

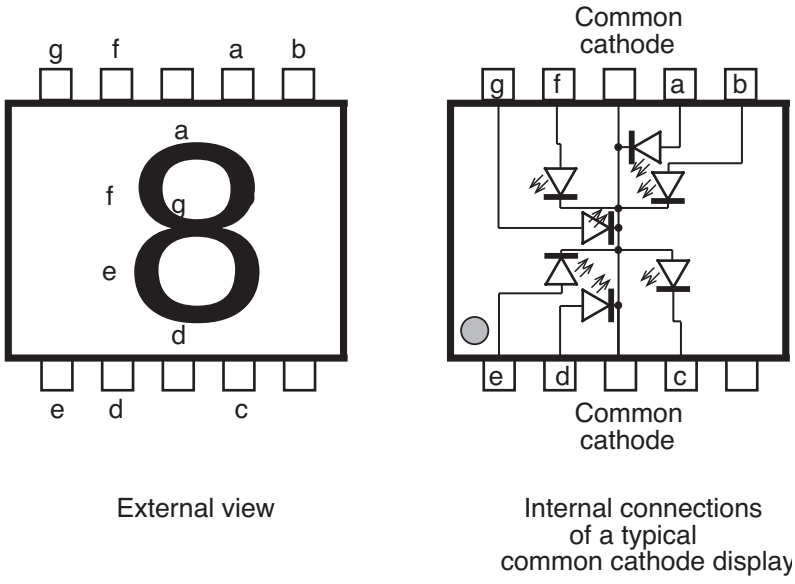
A seven segment display contains seven LEDs encapsulated in a single package such that the numbers 0 to 9 can be displayed by illuminating different combinations of the seven LEDs as shown below.

7 segment display

Segments illuminated for each of the 10 digits

If the seven segment display is manufactured with all seven anodes connected together then the display is referred to as a common anode display. Common anode displays are used with devices that sink current.

If the display is manufactured with all seven cathodes connected together then the display is referred to as a common cathode display. Common cathode displays are used with devices that source current. A pinout diagram showing how the seven LEDs are typically arranged is shown below.



External view

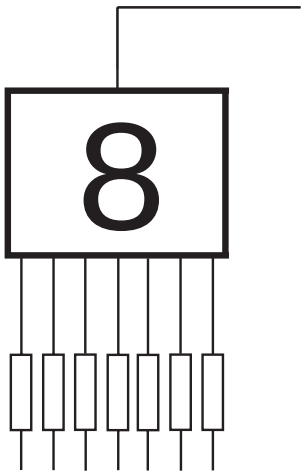
Internal connections of a typical common cathode display

In the diagram above, the pins are arranged along the top and bottom of the display. Seven segment displays are also available with the pins arranged along the sides.

For the second type of display there are numerous variations in the pin out arrangement of the segments. It is important that a data sheet is consulted when connecting a particular display in a circuit.

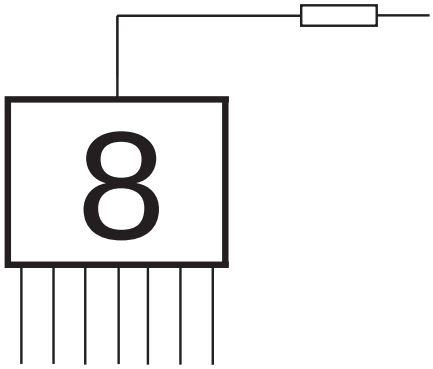
CURENT LIMITING RESISTORS

The best method of limiting the current through a seven segment display is to use a current limiting resistor in series with each of the seven LED's.



From your investigation of a circuit containing two LEDs, you will probably have concluded that the current through each LED is independent of the total number of LEDs illuminated if individual limiting resistors are used. For example, if each individual LED current of a seven segment display were limited to 10mA then a total current of 20mA would flow when the number "1" was displayed and 70mA would flow when the number "8" was displayed. The brightness of a particular LED would be constant when illuminated irrespective of the state of the other six LEDs.

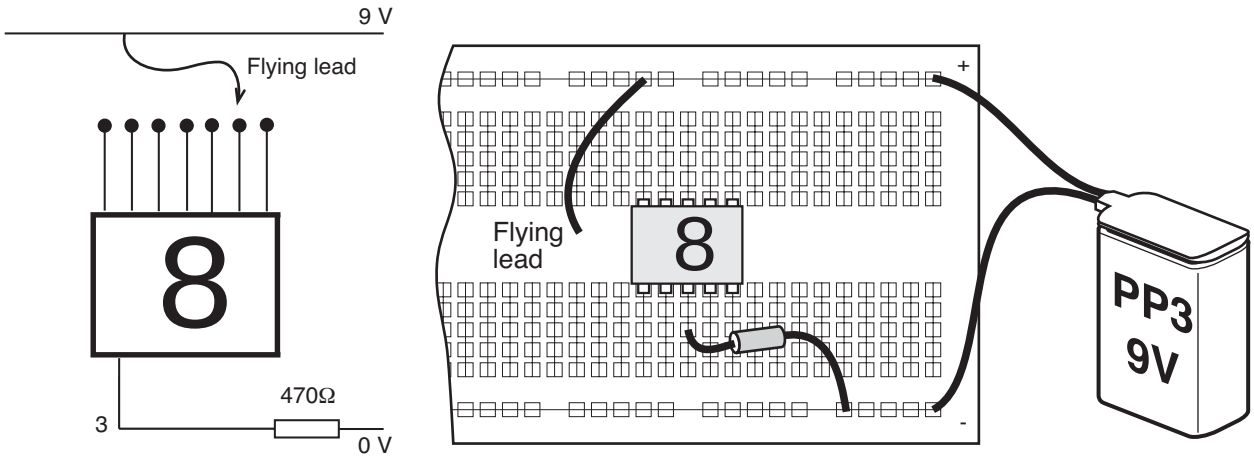
If you were not particularly concerned with a constant level of illumination then a single limiting resistor could be used.



The brightness of the illuminated segments would depend on how many segments were illuminated. For example, if the total current was limited to 20mA then 10mA would flow through each of the illuminated segments when the number "1" was displayed. If the number "8" was displayed then approximately 2.9mA would flow through each segment and the display would be much dimmer.

INVESTIGATING A SEVEN SEGMENT DISPLAY

Connect a common cathode seven segment display to the prototyping board as shown below. The cathode is connected to pin 3 and 8.



Touch the flying lead on each of the other eight pins in turn and label the pin out diagram below with the letters a to g to indicate which segment corresponds to each pin.

Pin number	1	2	3	4	5	6	7	8	9	10
Segment										