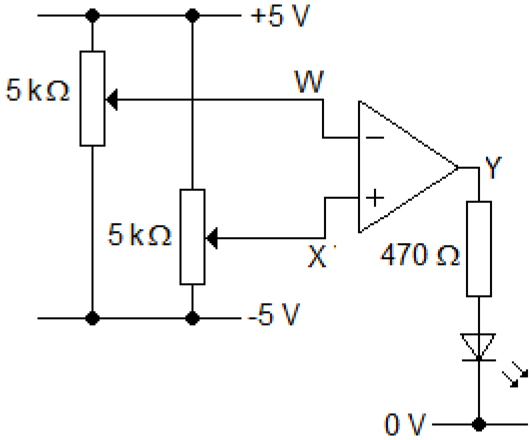
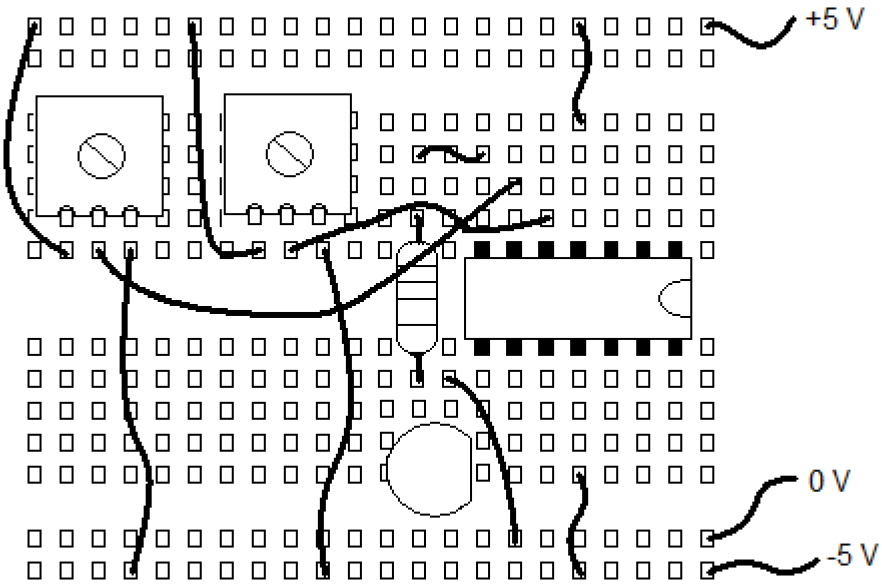
Op-amp transfer characteristic

You are going to investigate the transfer characteristic of an op-amp.

1 Assemble the circuit shown opposite. Use one op-amp in a TL084 i.c., as shown below. Notice that the i.c. has been inserted upside down to make the supply connections to +5 V and -5 V easier.



2 Use a voltmeter to check that the signals at W and X can be varied from +5 V to -5 V by rotating the potentiometer shafts with a screwdriver.



3 Set the signal at W to +2.0 V. Set the signal at X to +3 V. If all is well, the LED should be glowing. Measure the voltage at Y, the op-amp output.

4 With the voltmeter connected to X, very slowly lower its voltage to - 3 V. Verify that the LED goes off when X goes below +2.0 V. Measure the voltage at Y when the LED is off.

5 Now set X to -2 V. Investigate the effect on the LED of sweeping W from -3 V to +3 V.

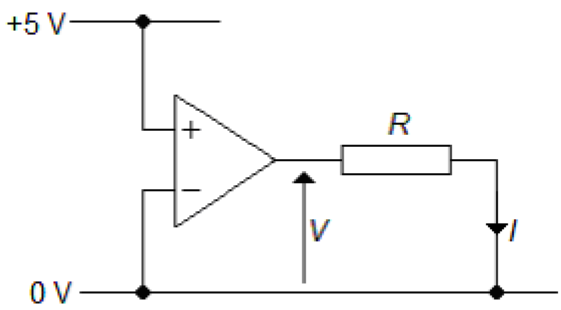
6 Write down a prediction of the behaviour of the LED when X is swept from +3 V to -3 V while X is set to 0 V. Then use the circuit to see if your prediction was correct.

Loading an op-amp

You are going to find out how the voltage at the output of an op-amp depends on the current it sources.

1 Set up the circuit opposite on breadboard. Start off with *R* = 10 kΩ.

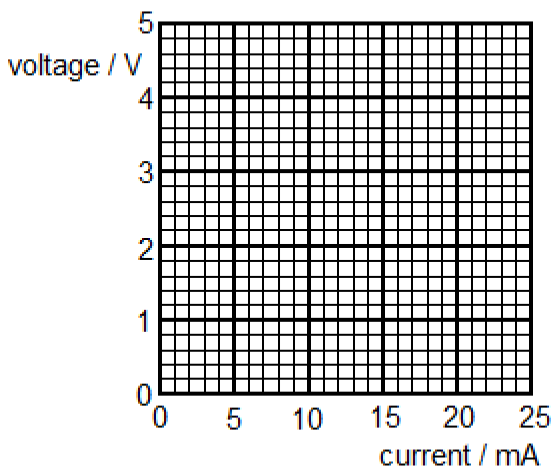
2 Use a voltmeter to measure the voltage at the output of the op-amp. If all is well, it should be about +4 V.



3 Repeat for the values of *R* shown in the table. For each value of *R*, use the value of *V* to calculate the current in the resistor *I*.

R	***V***	***I***
10 kΩ		
4.7 kΩ		
2.2 kΩ		
1 kΩ		
470 Ω		
220 Ω		
100 Ω		

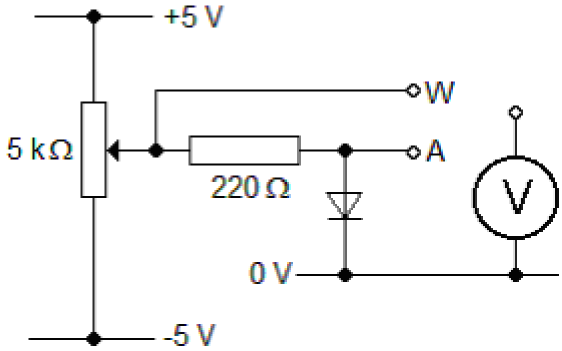
4 Use your results to plot a voltage-current graph for the op-amp output.



Transfer characteristic for a silicon diode

You are going to find out how the current in a diode depends on the voltage across it.

1 Set up the circuit shown opposite. Use a 1N4148 silicon diode.



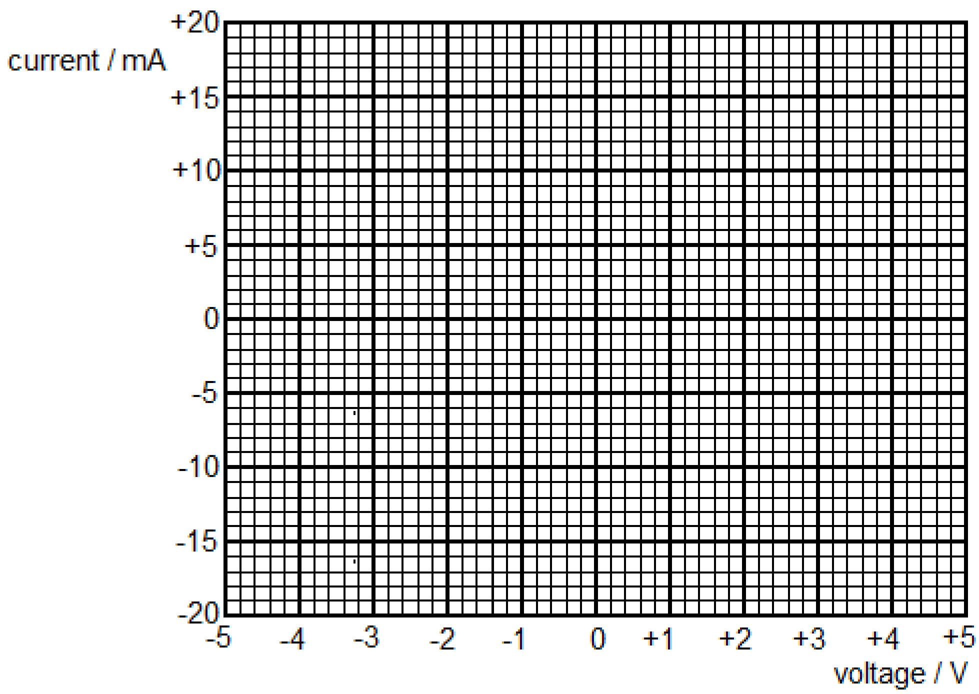
2 Connect the voltmeter to W. Rotate the potentiometer shaft to set W at +5 V. Measure the voltage at A, the diode anode. If all is well, it should be about +0.7 V.

3 Use the voltage drop $V_W - V_A$ across the 220 Ω resistor to calculate the current *I* in the diode. It should be about +20 mA. Calculate the resistance of the diode.

4 Complete the table for values of the wiper voltage V_W from +5 V to -5 V in steps of 0.5 V.

V_W	V_A	$V_W - V_A$	*I*	*R*
+5.0 V				
+4.5 V				
...				
-5 V				

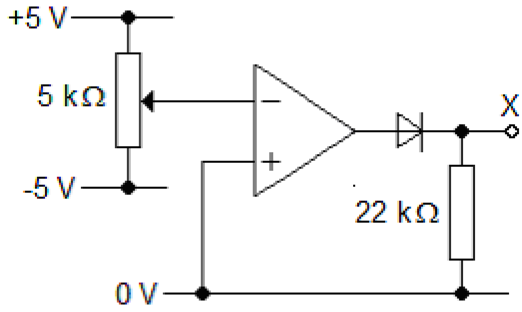
5 Use your results for *I* and V_A to draw a current-voltage graph for the diode.



Conversion to digital

You are going to evaluate three different ways of converting the bipolar output signal of an op-amp into a digital signal.

1 Assemble the circuit shown opposite. Use a 1N4148 silicon diode.

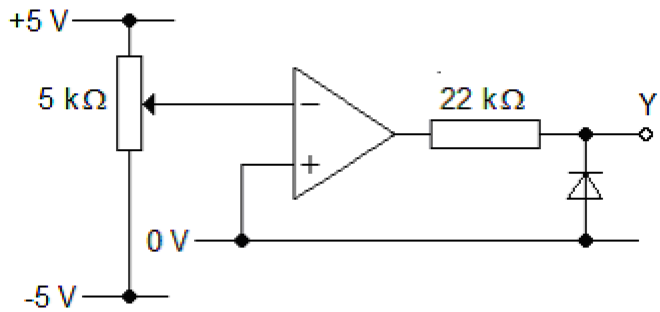


2 Use a voltmeter to find out how the signal at X depends on the signal at the op-amp inverting input.

3 Record your observations in the table below.

inverting input	X	Y	Z
above 0 V			
below 0 V			

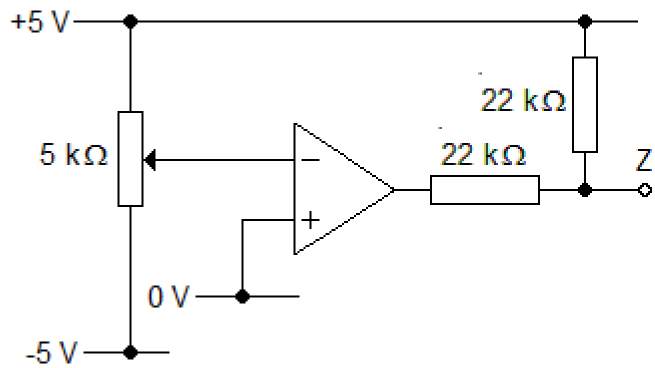
4 Rearrange the components to make the circuit opposite.



5 Use a voltmeter to find out how the signal at Y depends on the signal at the op-amp inverting input.

6 Record your observations in the table.

7 Remove the diode and add a resistor to make the circuit opposite.



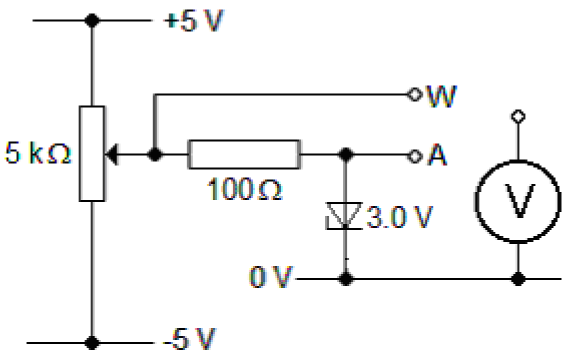
8 Use a voltmeter to find out how the signal at Z depends on the signal at the op-amp inverting input.

9 Record your observations in the table.

10 Digital signals should always be above +3 V or below +2 V. Which circuit has the best way of generating a digital signal from an op-amp? Give reasons for your choice.

Transfer characteristic for a zener diode

You are going to find out how the current in a zener diode depends on the voltage across it.



1 Set up the circuit shown opposite. Use a BZX55C30 zener diode.

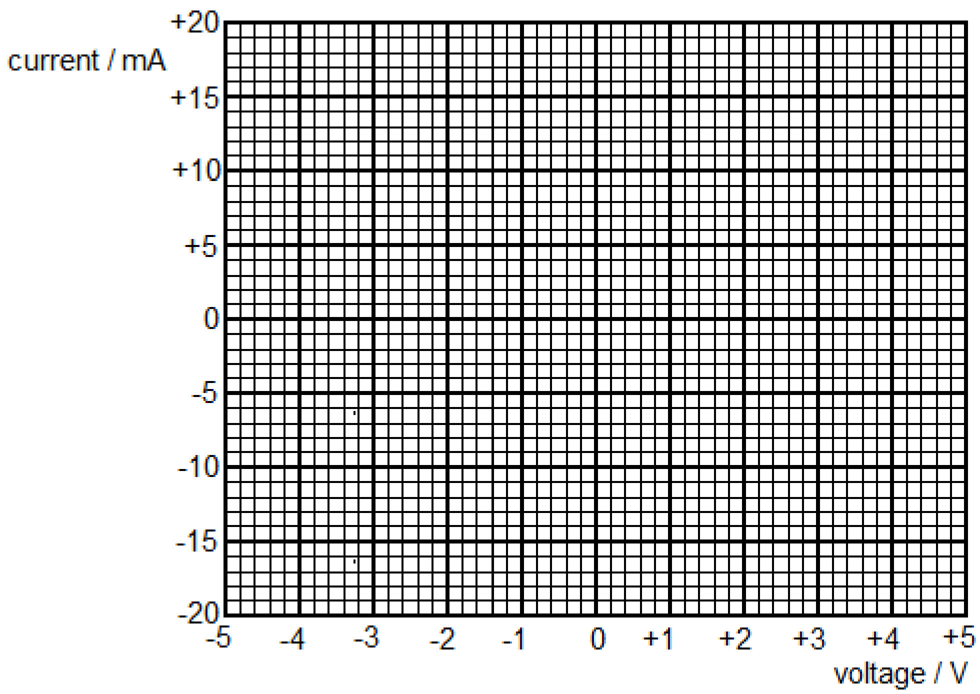
2 Connect the voltmeter to W. Rotate the potentiometer shaft to set W at -5 V. Measure the voltage at A, the diode anode. If all is well, it should be about -3 V.

3 Use the voltage drop V_W - V_A across the 100 Ω resistor to calculate the current I in the diode. It should be about -20 mA.

4 Complete the table for values of the wiper voltage V_W from -5 V to +5 V in steps of 0.5 V. Stop when the current exceeds +20 mA.

V_W	V_A	V_W - V_A	I
-5.0 V			
-4.5 V			
...			

5 Use your results for I and V_A to draw a current-voltage graph for the zener diode.



Light sensor

You are going to design and test a light sensor system whose output is a three-bit digital signal.

1 Use an LDR, a 4.7 kΩ resistor and the supply rails at +5 V and 0 V to make a light sensor whose output voltage rises with increasing illumination. Test your circuit with a voltmeter.

2 Next to your light sensor, use a 22 kΩ and 47 kΩ resistor to generate a fixed voltage of about +1.6 V.

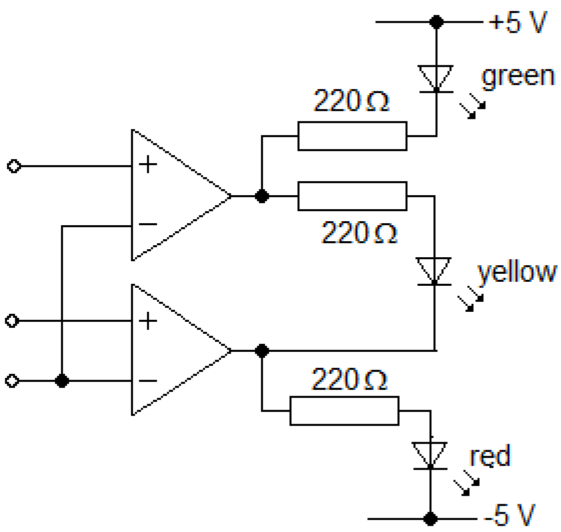
3 Use 100 kΩ and 220 kΩ resistors to generate another fixed voltage of about +3.4 V.

4 Use one of the op-amps in a TL084 i.c. to compare the output of the light sensor with the fixed +1.6 V. Add a red LED and 220 Ω series resistor, such that it only glows when the LDR is illuminated.

5 Use another op-amp, 220 Ω resistor and a green LED to compare the output of the light sensor with the fixed +3.4 V - the LED must only glow when the LDR is illuminated.

6 Add a third op-amp and voltage divider to make a yellow LED glow whenever the output of the light sensor goes above +2.5 V.

7 The circuit you have built uses the number of glowing LEDs to tell you about the level of illumination of the LDR. Study the circuit opposite and use it to make a circuit which behaves as shown in the table below.



LDR illumination	glowing LED
dark	red
dim	yellow
bright	green