Section 1 Overview

Electronic components are used many appliances. Can you find ten appliances in the wordsearch below.

E	E	M	T	V	Y	S	A	A	R	Y	F	M	N
R	N	S	Q	R	T	D	Y	D	R	P	E	H	R
A	E	I	T	E	T	E	A	R	N	V	N	Y	E
F	C	D	H	E	S	V	L	Y	Z	L	H	V	T
I	R	N	R	C	R	A	B	E	K	G	C	G	U
R	K	Y	O	O	A	E	T	N	P	Y	T	W	P
E	I	G	A	I	C	M	O	E	L	H	N	U	M
A	L	N	C	R	S	E	G	S	L	M	O	X	O
L	S	H	O	B	E	I	R	N	Y	L	X	N	C
A	T	G	C	M	M	M	V	O	I	S	I	Q	E
R	F	F	V	M	N	S	A	E	E	H	T	T	L
M	Q	Q	L	Q	H	X	X	C	L	D	S	E	E
H	J	O	X	D	F	E	N	T	V	E	I	A	M
A	G	T	H	E	G	D	I	R	F	K	T	V	W

Section 2 - Output Devices

Identifying Output Devices

1. Which of the components in the list below are output devices?

   bulb thermistor relay thermocouple solenoid loudspeaker
   dynamo LED LDR buzzer motor microphone

2. Which output device could be used in a central locking system of a car?

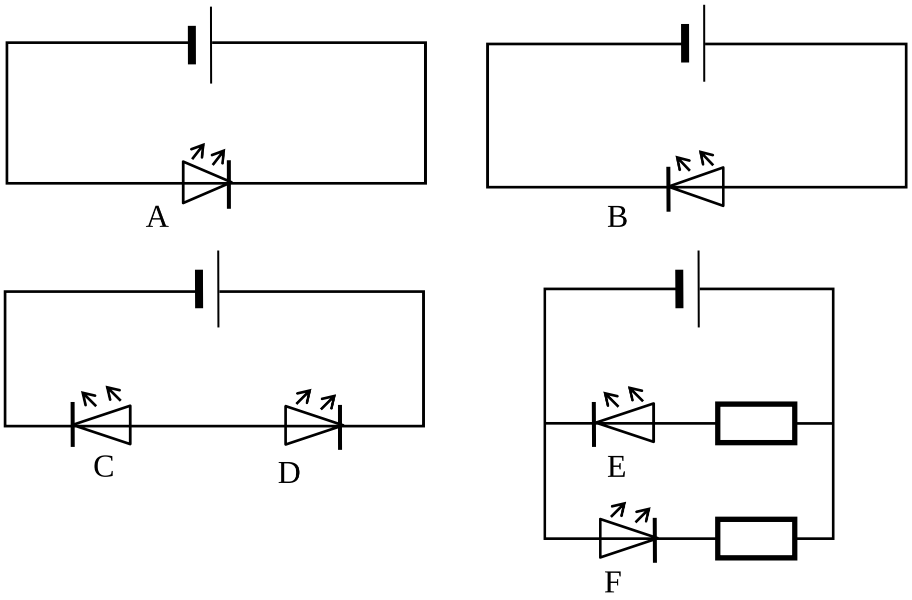
3. What would be an appropriate output device for a public address system?

4. Select an output device which could be used to raise and lower blinds automatically in a luxury flat.

5. Which output device is useful for digital displays on hi-fi systems?

The Light Emitting Diode (LED)

1. Which of the following LED's will light?



Helpful Hint

When working with LED circuits you can use the equation:

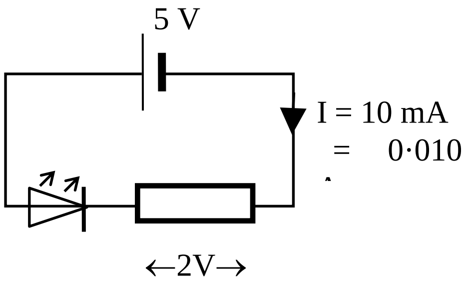
$$\mathbf{V = IR}$$

When applying this equation remember that the **supply voltage is shared** between the LED and the resistor.

Example

A certain LED takes a current of 10 mA and the voltage across it is 2 V. What should be the value of the series resistor when a supply voltage of 5 V is used?

1st. Sketch the circuit



2nd. Calculate the voltage across resistor R.

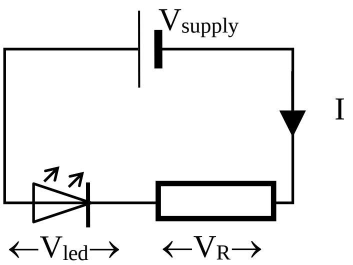
$$V_R = V_{supply} - V_{led}$$
$$= 5 - 2$$
$$= 3\ V$$

3rd. Apply V = IR to find the value of R

V_R = 3 V
I = 0·01 A
R = ?

V_R = I R
3 = 0·01 x R
R = 3 / 0·01
R = 300 Ω

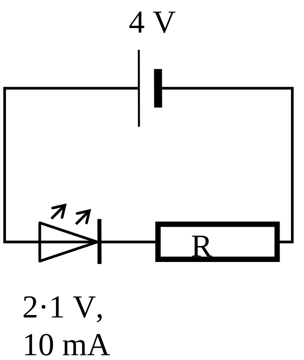
2. Use the stages outlined above to find the missing values in the following table.



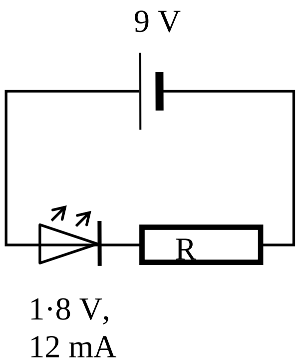
	V_{supply} (V)	*Voltage across LED* (V)	*Current* (A)	*Voltage across R* (V)	*Resistance of R* (Ω)
(*a*)	6	2·0	0·010		
(*b*)	12	2·0	0·010		
(*c*)	8	1·8	0·016		
(*d*)	20	1·6	0·008		
(*e*)	4	1·5	0·020		
(*f*)	11	2·0	0·012		

3. For each of the following circuits calculate the value of the series resistor which will enable the LED to operate at its ideal voltage and current.

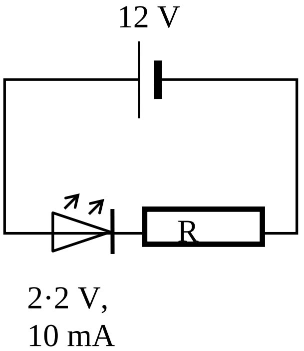
(*a*)



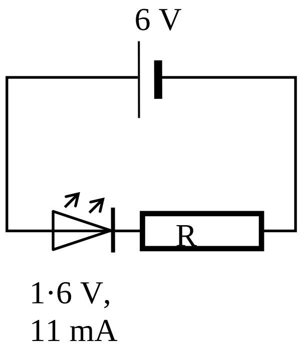
(*b*)



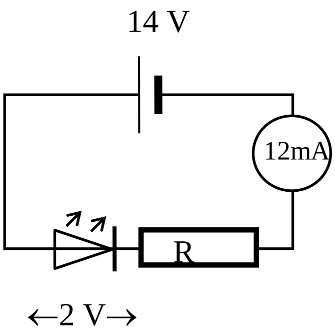
(*c*)



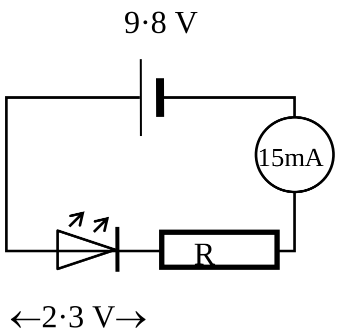
(*d*)



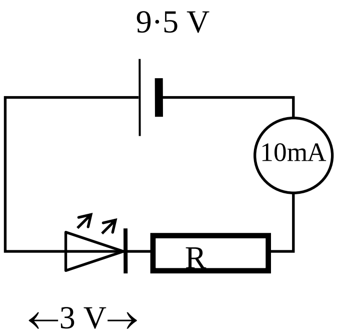
(*e*)



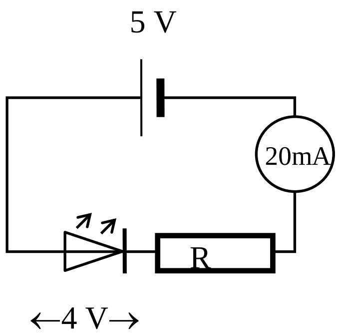
(*f*)



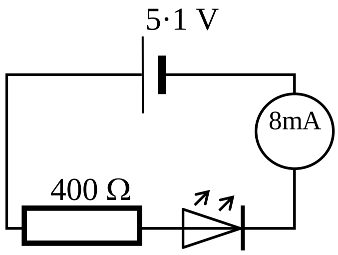
(*g*)



(*h*)



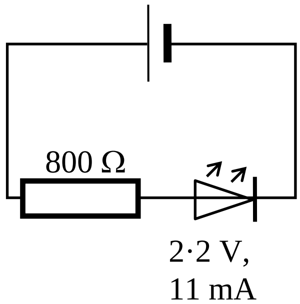
4. Consider the following circuit.



(*a*) Calculate the voltage across the 400 Ω resistor.

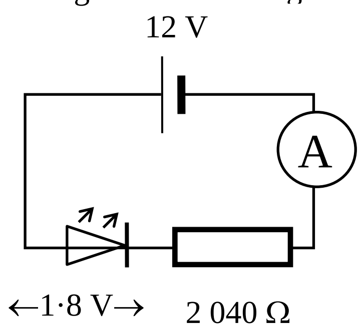
(*b*) Calculate the voltage across the LED.

5. For the circuit shown below work out the value of the supply voltage which will enable the LED to operate at it's stated rating.

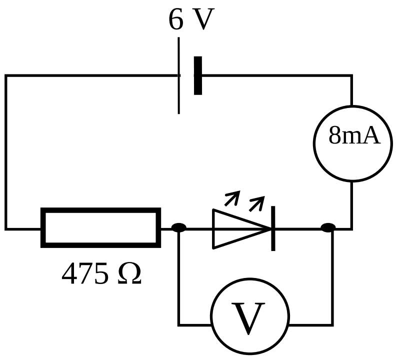


6. The voltage and current specifications for a certain LED are 1·75 V and 10 mA respectively. What should be the value of the series resistor if the LED is powered by a 6 V supply?

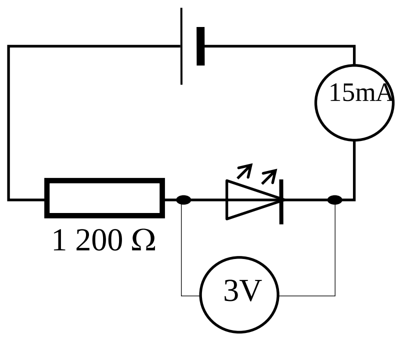
7. Calculate the ammeter reading in the following circuit.



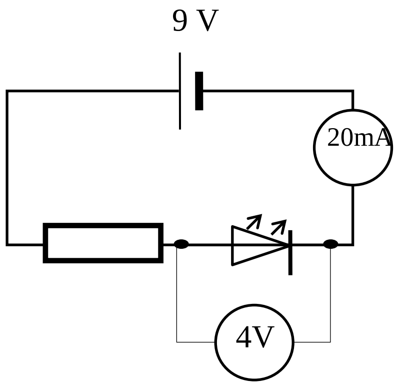
8. Calculate the voltmeter reading in the circuit shown below.



9. What is the supply voltage for the following circuit?



10. Calculate the value of resistor R in the circuit below.



Binary to Decimal Conversion

Helpful Hint

Digital systems use binary because this can be represented by a series of 1's and 0's unlike decimal which requires the numbers 1,2,3,4,5,6,7,8& 9.

Numbers in binary are made up in the same way as numbers in decimal.
For example consider the number **6752**. The position of each number gives its value.

1000	100	10	1
6	7	5	2

6752 ***means*** 6 thousands 7 hundreds 5 tens 2 units

The position of each number in binary also gives its value.
Consider the binary number 1111

8	4	2	1
1	1	1	1

1111 ***means*** 1 eight 1 four 1 two 1 one
We can convert this to a decimal number by simply adding up the numbers.

$$8 + 4 + 2 + 1 = 15$$

so **1111** in binary is **15** in decimal

1. Convert each of the following binary numbers into a decimal number:

   (*a*) 0101 (*b*) 1001 (*c*) 1010 (*d*) 0110

   (*e*) 1101 (*f*) 1011 (g) 0111 (h) 1000

2. In an electronic counter the output is a binary number represented by a series of Light Emitting Diodes.

   ○ ● ○ ●
   ON OFF ON OFF

   The decoder chip converts the binary number into a decimal number which is displayed on a seven segment display.
   For each of the following binary outputs give the decimal number which would appear on the seven segment display.

   (*a*) ○ ○ ● ○ (*d*) ○ ● ○ ○

   (*b*) ○ ○ ● ● (*e*) ● ● ● ●

   (*c*) ● ● ● ○ (*f*) ○ ● ● ○

Section 3 - Input Devices

In this section you can use the equation:

V = IR

where **V** = voltage in volts (V)
I = current in amps (*A*)
R = resistance in ohms (Ω).

Helpful Hint
When choosing an input device for an electronic system, think about what type of energy the device has to detect.

Capacitor microphone thermistor solar cell
light dependent resistor (LDR) thermocouple

1. Select from the list above a suitable input device for each of the following:

(*a*) Public address system in a railway station

(*b*) Digital thermometer

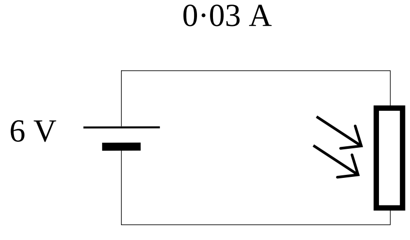
(*c*) Photographers light meter

(*d*) Time delay circuit for courtesy lights in a car

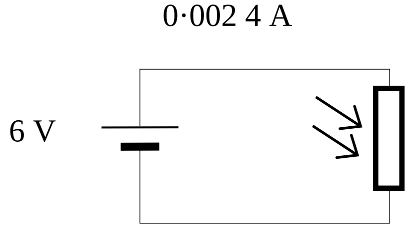
(*e*) Pilot light flame detector in a gas central heating system

(*f*) Sunlight hours recorder at a weather station.

2. The circuits below show two identical LDR's each connected to a 6 V supply.
One LDR is placed in a cupboard and the other is placed beside a window.



Circuit (i)

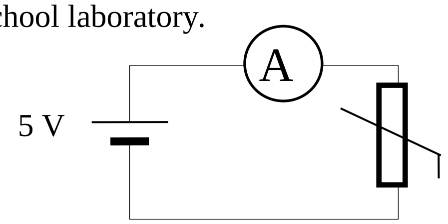


Circuit (ii)

(*a*) Calculate the resistance of each LDR.

(*b*) Which circuit shows the LDR in the cupboard?

3. The following circuit shows a thermistor connected to a 5 V supply and placed in a school laboratory.



In the morning the ammeter gave a reading of 1·25 mA. Later in the same day the reading had risen to 2·5 mA.

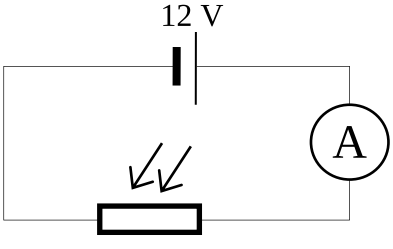
(*a*) Calculate the resistance of the thermistor in the morning.

(*b*) What happened to the temperature in the room during the day?
Explain your answer.

4. The following information for an LDR was found in a components catalogue.

Light Source	*Illumination* (lux)	*Resistance* (kΩ)
moonlight	0·1	10 000
60 W bulb at 1m	50	2·4
fluorescent light	500	0·2
bright sunlight	30 000	0·02

This LDR is connected to a 12 V supply with an ammeter in series with it as shown in the diagram.



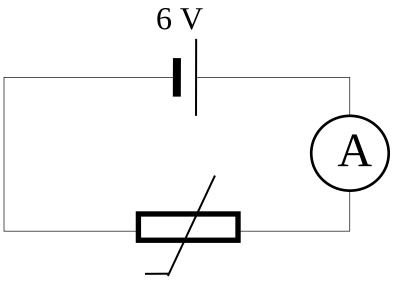
(*a*) What is the resistance in ohms of the LDR when exposed to fluorescent light?

(*b*) What would the ammeter read when a lamp with a 60 W bulb in it is placed 1 m away from the LDR?

(*c*) When the ammeter gives a reading of 0·6 A which light source is being used?

5. A pupil uses a thermistor as a simple electronic thermometer. She connects the thermistor to an ammeter and places the thermistor into a beaker of hot water. The ammeter gives a reading of 8 mA.

Temperature (°C)	*Resistance* (Ω)
20	3 750
40	198
60	750
80	350
100	200



(*a*) What is the temperature of the water in the beaker?

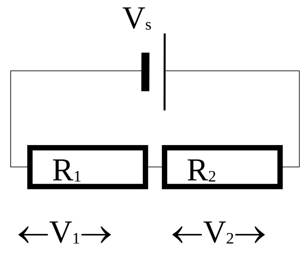
(*b*) The pupil adds some more water to the beaker and the ammeter gives a new reading of 1·6 mA. Did the pupil add hot or cold water to the beaker?

(*c*) What is the new temperature of the water?

(*d*) What will the ammeter read when the water is boiling?

Voltage Dividers

In a series circuit the voltage **divides up** between the components in the circuit i.e.

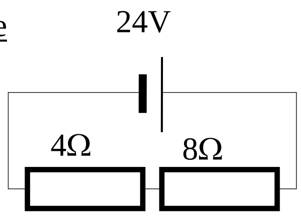


$V_s = V_1 + V_2$

where V_s = supply voltage
V_1 = voltage across R_1
V_2 = voltage across R_2

From Ohm's law we know that since current is constant in a series circuit, the higher the resistance of a component the greater the voltage across it.
This idea is used in the following example to calculate the voltage across components in a 'voltage divider' i.e. series circuit.

Example



Use the fact that the voltage 'split' across each component is in the same ratio as the resistance of each component.

$V_1 = \frac{R_1}{R_t} \times V_s$ $\quad V_2 = \frac{R_2}{R_t} \times V_s$ $\quad$ where R_t = total resistance

$= \frac{4}{12} \times 24$ $\quad = \frac{8}{12} \times 24$

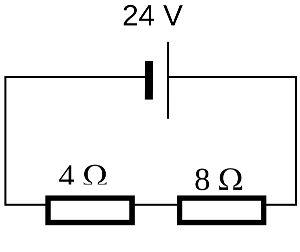
$= 8V$ $\quad = 16\ V$

(Remember to check your answer e.g. does $V_1 + V_2 = V_s$)

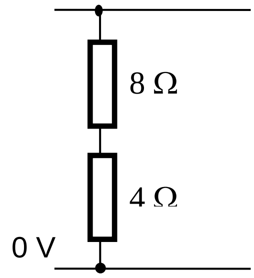
Lastly!

Circuit problems in electronics are usually drawn slightly differently than you are used to seeing.

e.g.

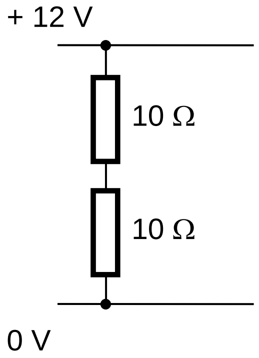


would be drawn as

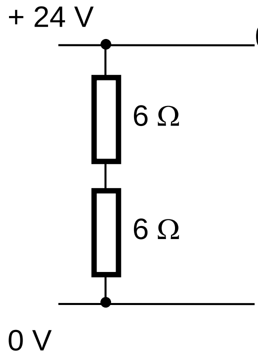


Find the voltage across each resistor in the following:

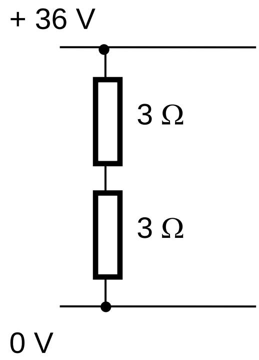
(1)



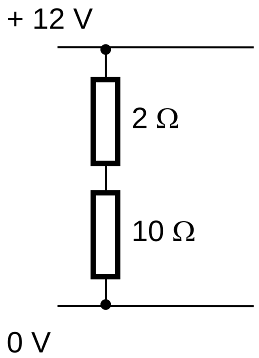
(2)



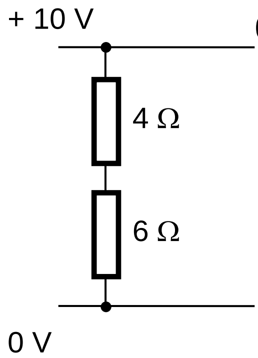
(3)



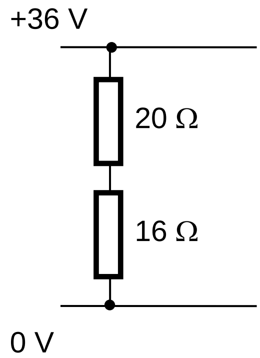
(4)



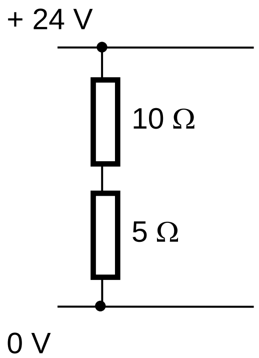
(5)



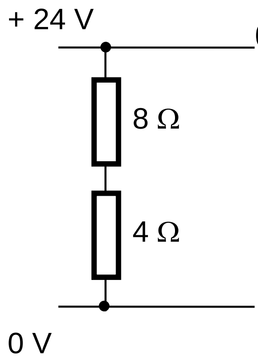
(6)



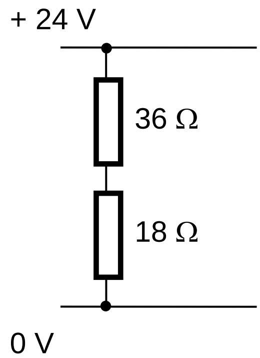
(7)



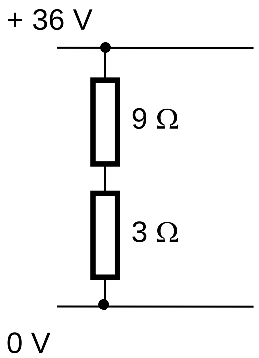
(8)



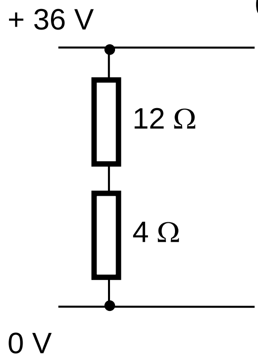
(9)



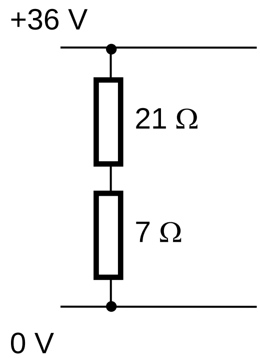
(10)



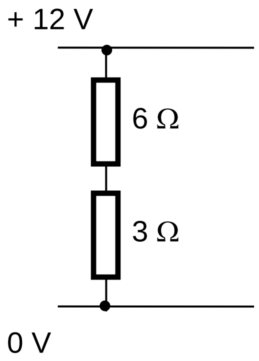
(11)



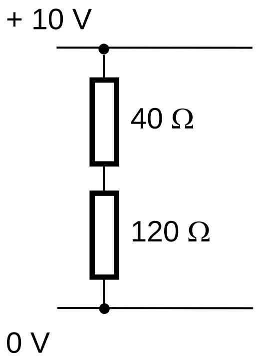
(12)



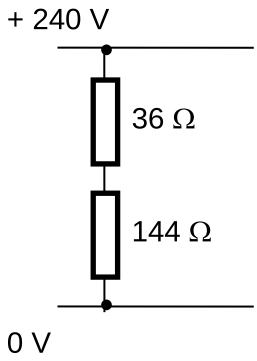
(13)



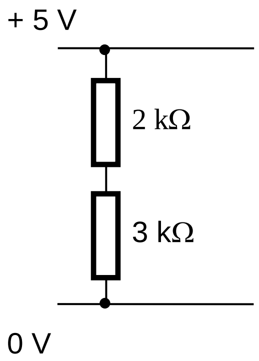
(14)



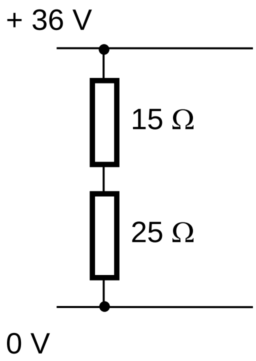
(15)



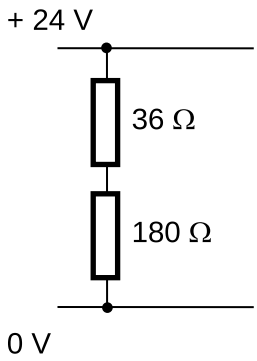
(16)



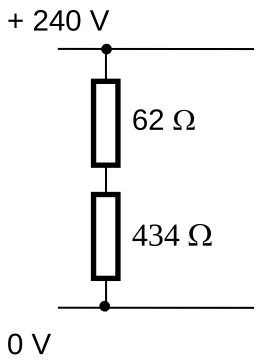
(17)



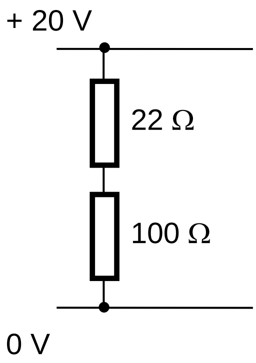
(18)



(19)



(20)



Helpful Hint
LDR's and thermistors often make up part of a voltage divider circuit in electronic systems.
It is important to remember that the **resistance** of these components varies with external conditions.

The following tables indicate how the resistance of an LDR and thermistor vary with external conditions.

LDR

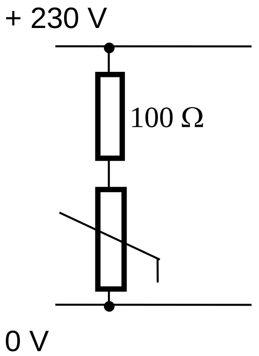
Light condition	*Resistance* (Ω)
dark	10 000
light	2 500
bright	20

Thermistor

Temperature (^{o} *C*)	*Resistance* (Ω)
10	4 000
40	1 980
100	200

Use the information above to solve questions 21 - 24.

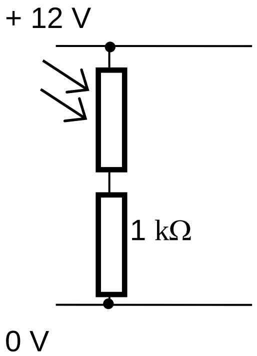
21. The following circuit is part of the input to an electronic frost alarm.



If the circuit operates from mains voltage calculate the voltage drop across the thermistor when it is

(a) 10 ^{o} C
(b) 40 ^{o} C

22. The following circuit could be part of a light meter for a camera.

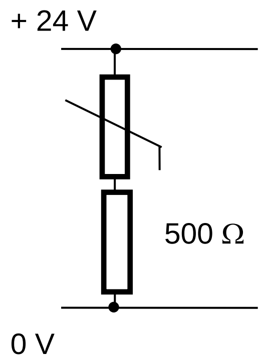


Use the information above to find the voltage drop across the LDR when it is:

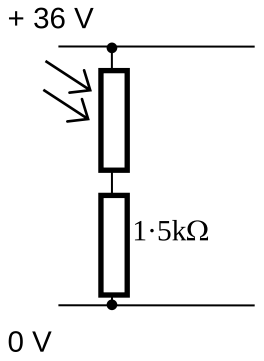
(*a*) dark
(*b*) light

23. Calculate the voltage across the **resistor** in the following circuit when the temperature is:

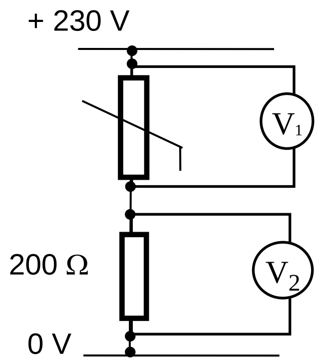
(*a*) 100 °C
(*b*) 40 °C



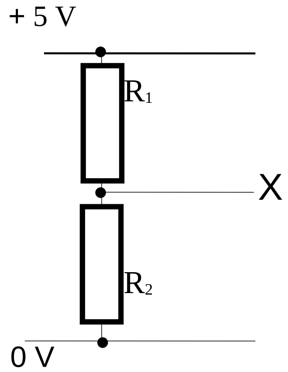
24. A young engineer designs part of an electronic system to trigger an alarm when it gets too bright.
What will the 'trigger voltage' across the resistor be in the following system when it is 'bright'?



25. At what temperature would the following circuit show equal readings on each voltmeter?



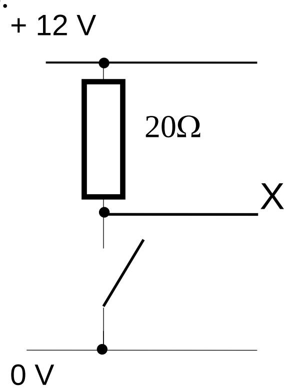
Helpful Hint
In a circuit like the following:



You are often required to calculate the voltage(or potential) at X
This is the same as asking for the voltage (or potential) across resistor R_2

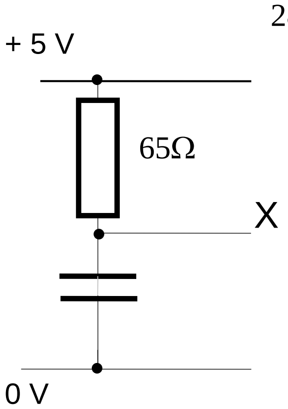
Calculate the voltage at X in questions 26 - 30.

26.



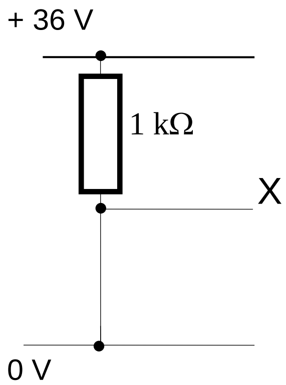
Switch S open

27.



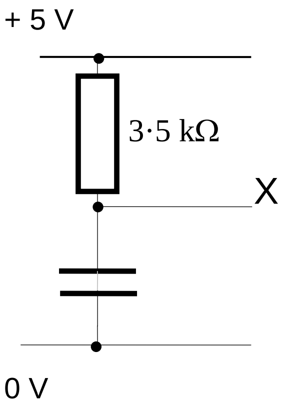
Capacitor C uncharged

28.



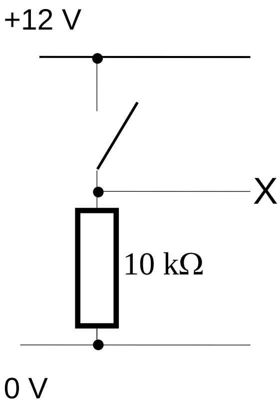
Switch S closed

29.



Capacitor C fully charged

30.

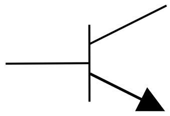


Switch S open.

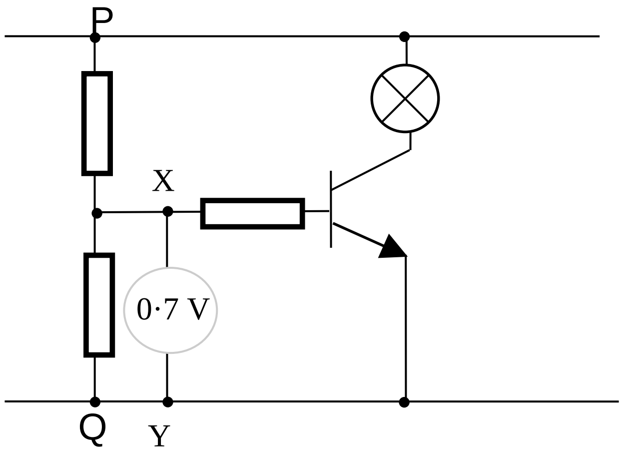
Section 4 - Digital Processes

Transistors in Circuits

Helpful Hint
The symbol for an NPN transistor is shown below.



The transistor operates as a switch in a circuit. It switches 'ON' when the voltage across XY, in the diagram below, is above approximately 0·7 V.

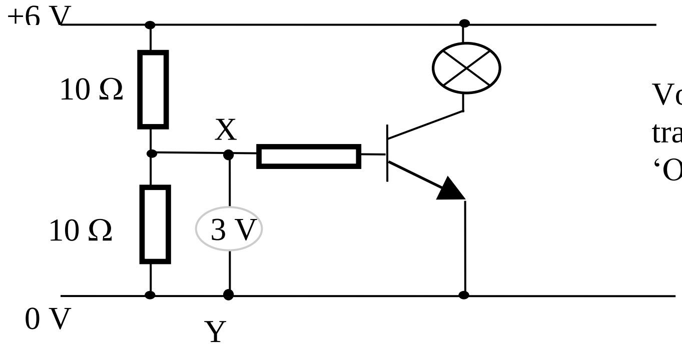


In the last section you studied voltage dividers. A voltage divider is usually placed between P and Q. Various components can be used to make up the voltage divider but it is always the voltage across XY which affects the transistor!

Some examples are shown on the next page.

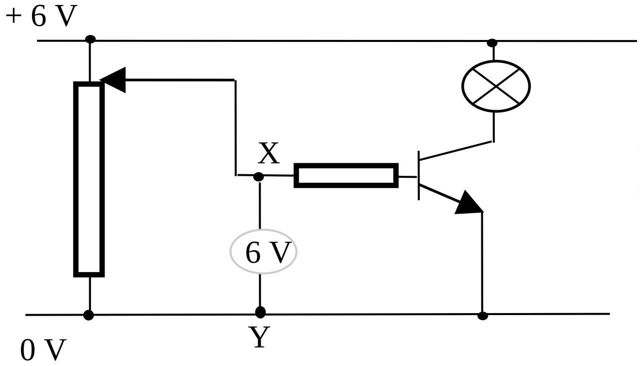
Examples

(*a*) The voltage divider can be two resistors in series

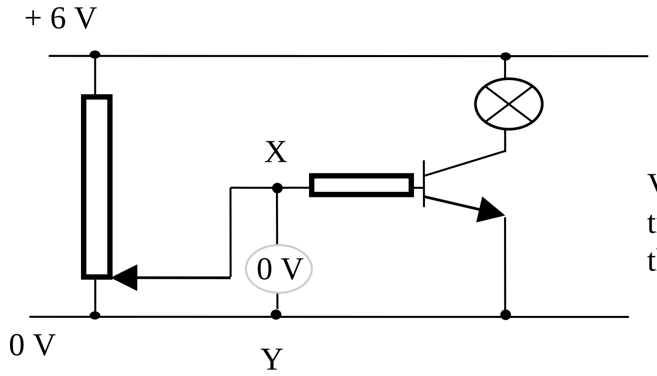


Voltage across XY is 3 V so transistor conducts (i.e. switches 'ON') and therefore bulb lights.

(*b*) The voltage divider can be a Potentiometer

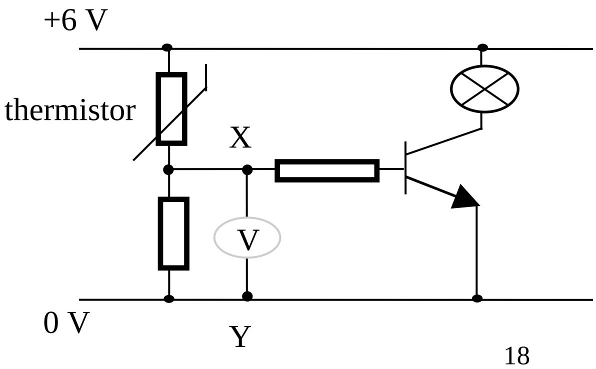


Voltage across XY is 6 V so transistor conducts and bulb lights.



Voltage across XY is 0 V so transistor does not conduct therefore bulb is OFF.

(*c*) The voltage divider may contain a variable resistor

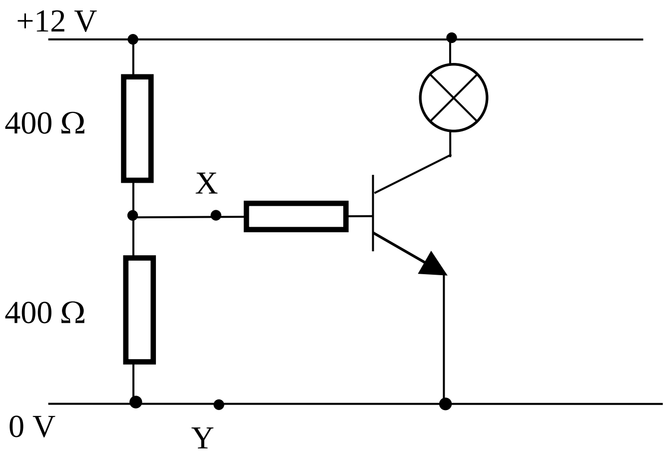


In **warm** conditions the **resistance** of the thermistor is **low** and so it takes only a small share of the supply voltage. Hence the voltage across XY is high i.e. transistor conducts and bulb is ON.

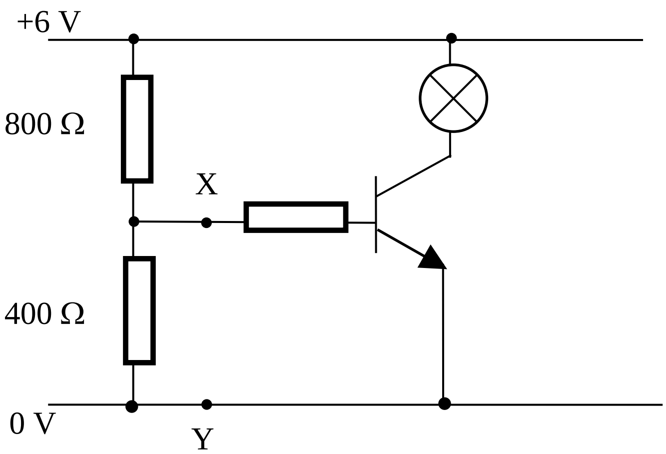
In **cold** conditions the **resistance** of thermistor is **high** and so it takes a large share of the supply voltage. This leaves only a small voltage across XY therefore the transistor does not conduct and the bulb remains OFF.

1. For each of the following circuits calculate the voltage across XY and then state whether the output device is ON or OFF.

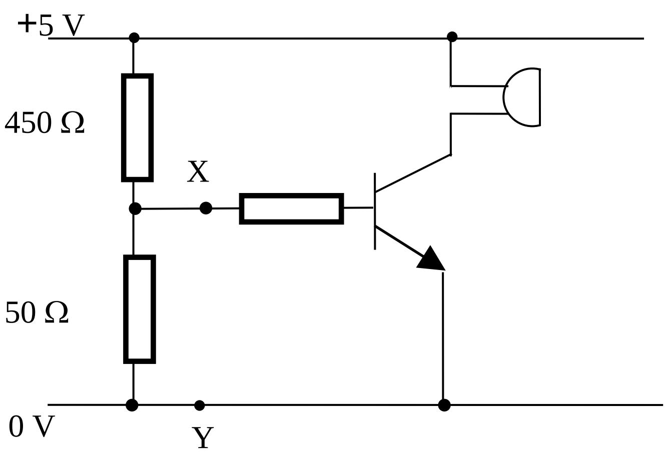
(*a*)



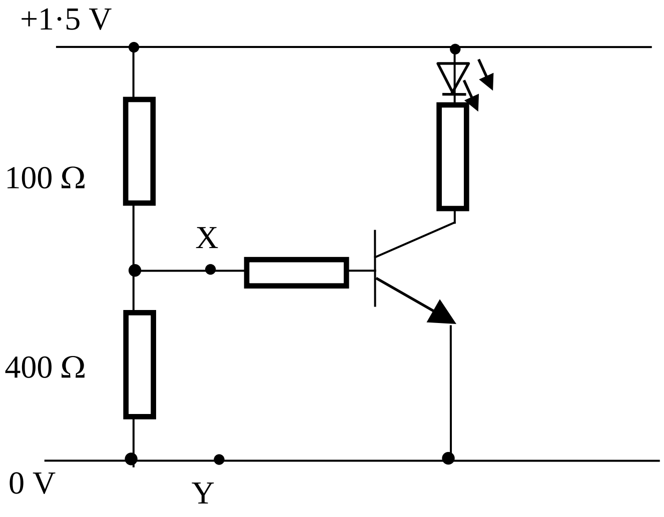
(*b*)



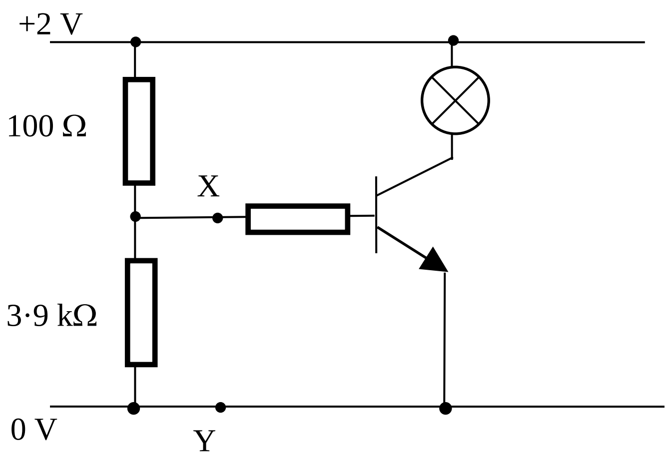
(*c*)



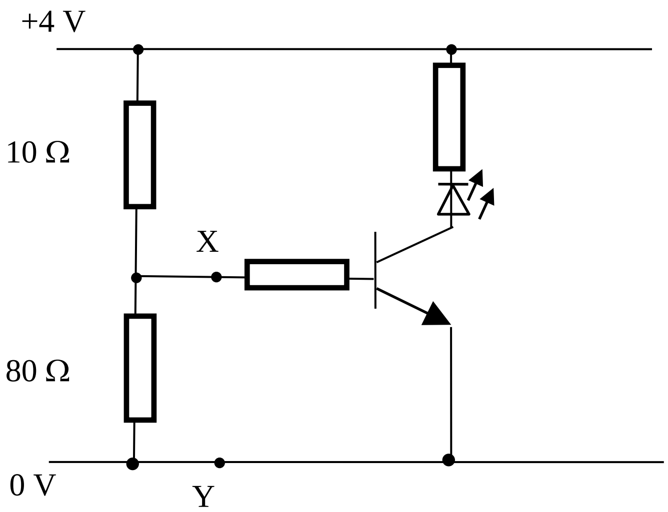
(*d*)



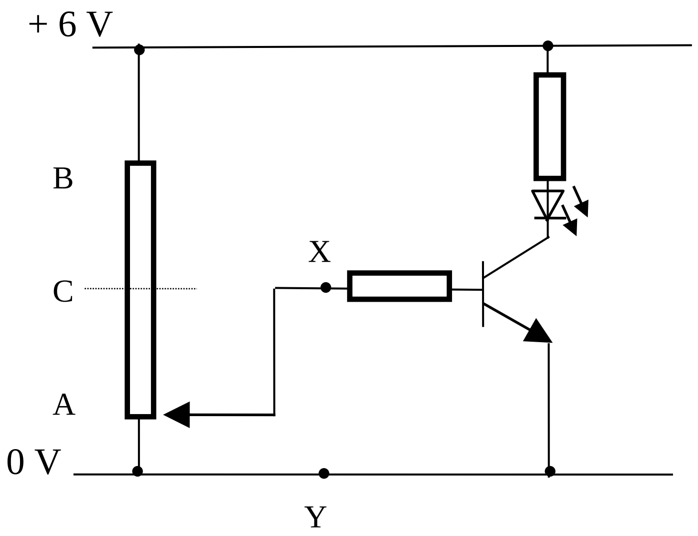
(*e*)



(*f*) (Hint! Think here!)



2. Consider the following circuit.



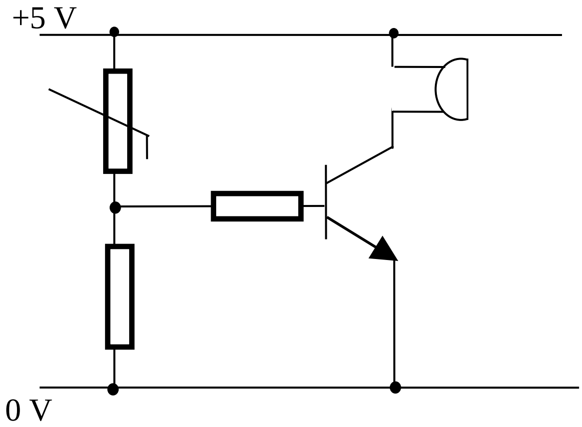
(*a*) What is the voltage across XY when the sliding connection is at point A?

(*b*) Does the LED light when the sliding connection is at point A?

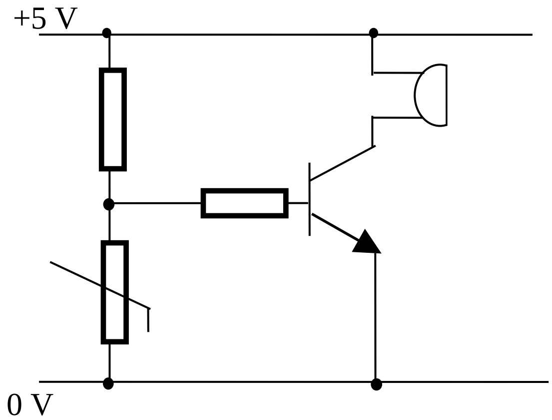
(*c*) Does the LED light when the sliding connection is at point B? Explain your answer.

(*d*) Does the LED light when the sliding connection is at point C? Explain your answer.

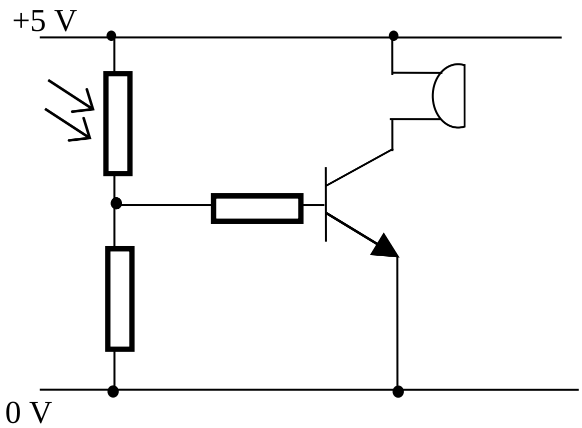
3. Study the four circuits shown below.



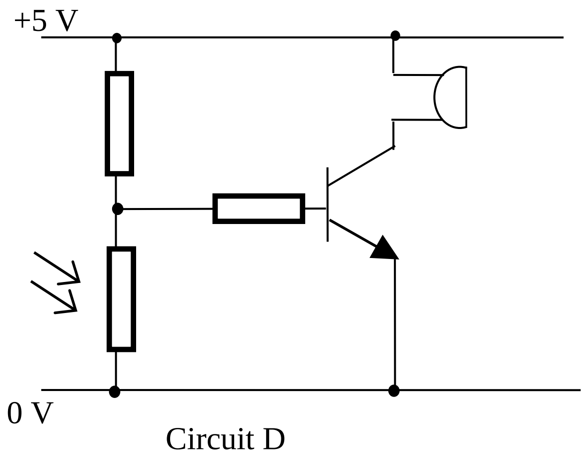
Circuit A



Circuit B



Circuit C



Circuit D

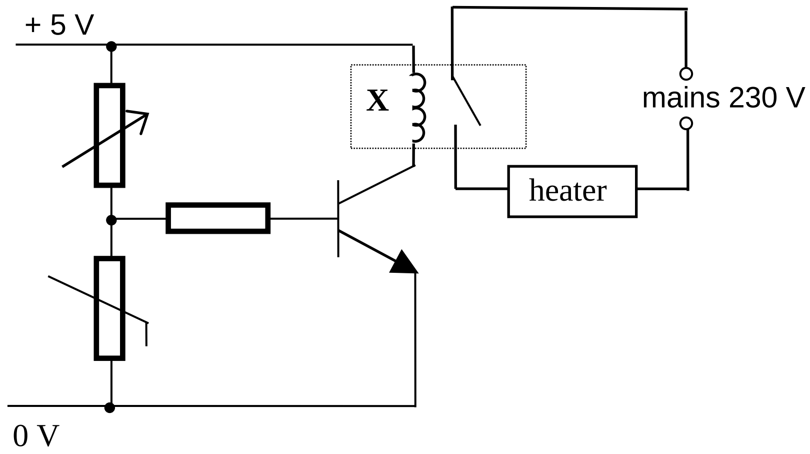
(*a*) Which circuit could be used to remind drivers at night to put on their headlamps? Explain your answer.

(*b*) Which circuit would be useful as a warning indicator of low temperature in an elderly person's house? Explain your answer.

(*c*) Which circuit could be used to waken campers when daylight arrives? Explain your answer.

(*d*) Which circuit would be most suitable as a fire alarm?

4. The following circuit is used to switch on an electric heater automatically when the temperature in a room falls below a certain value.



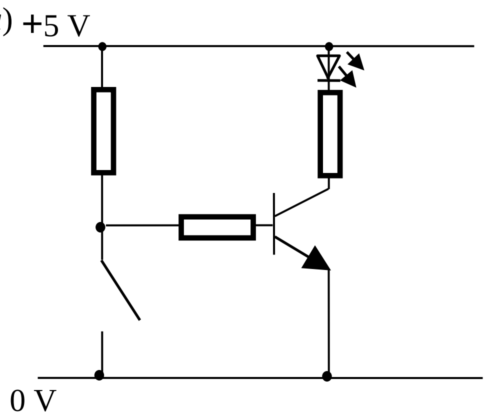
(*a*) Explain how the circuit operates.

(*b*) What would be the effect of decreasing the resistance of the variable resistor?

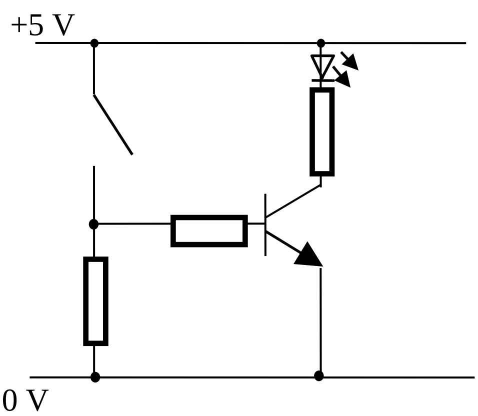
(*c*) Why would it be unsuitable to put the heater at point X instead of the relay?

5. For each of the following circuits state whether the output device is ON or OFF and explain your answer.

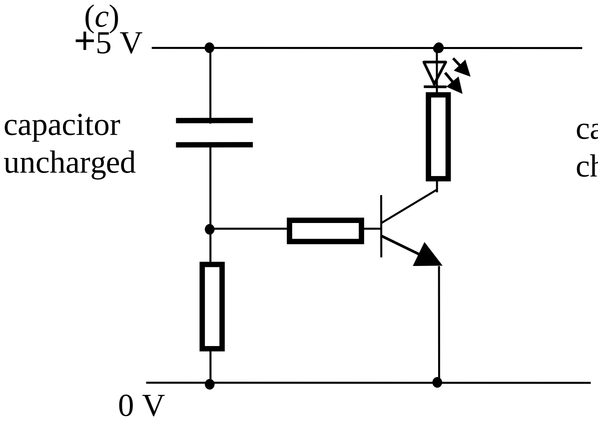
(*a*)



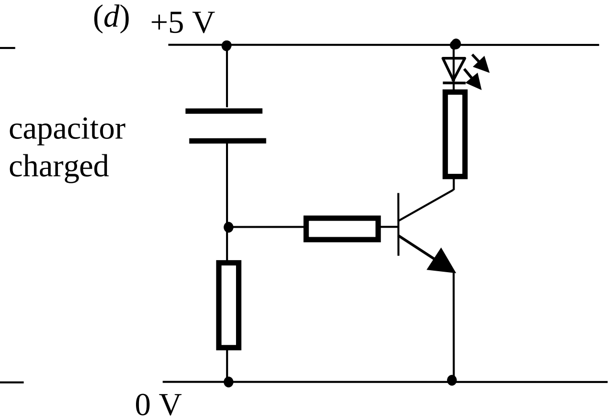
(*b*)



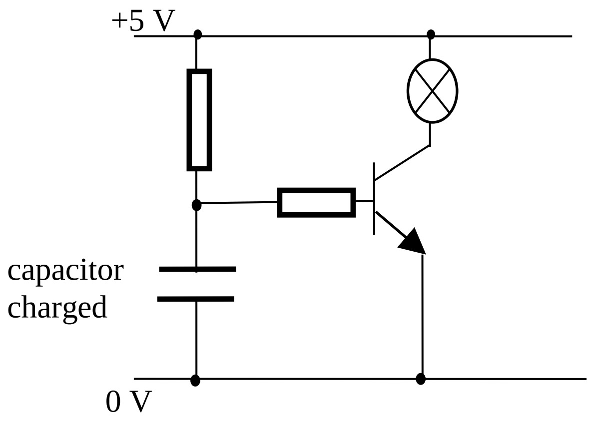
(*c*)



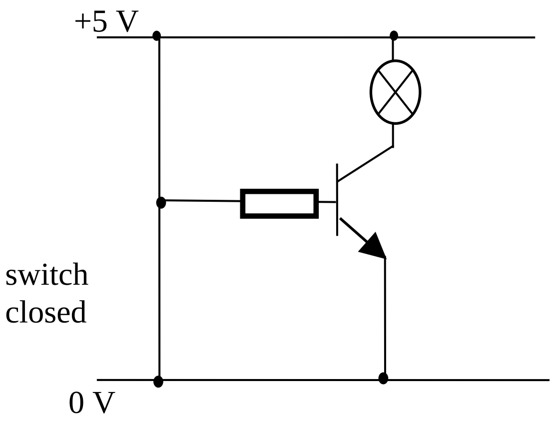
(*d*)



(*e*)



(*f*)



Logic Gates

1. Identify the logic gate represented by each of the following truth tables.

(*a*)

Input	Output
0	1
1	0

(*b*)

Input 1	Input 2	Output
0	0	0
0	1	1
1	0	1
1	1	1

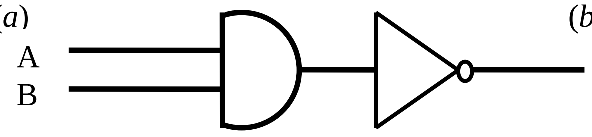
(*c*)

Input 1	Input 2	Output
0	0	0
0	1	0
1	0	0
1	1	1

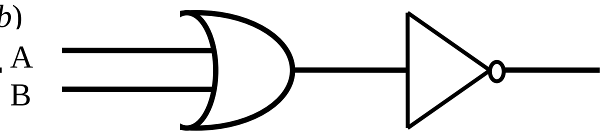
2. For each of the following combinations of logic gates complete a truth table of the form:

Input A	Input B	Output
0	0	
0	1	
1	0	
1	1	

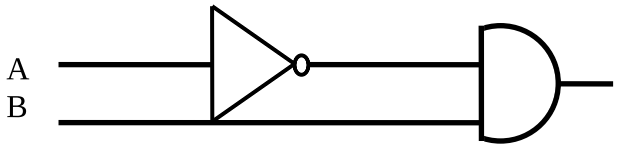
(*a*)



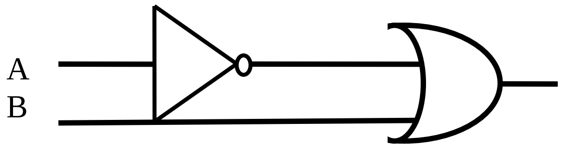
(*b*)



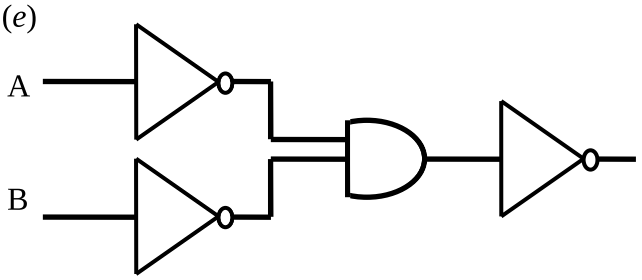
(*c*)



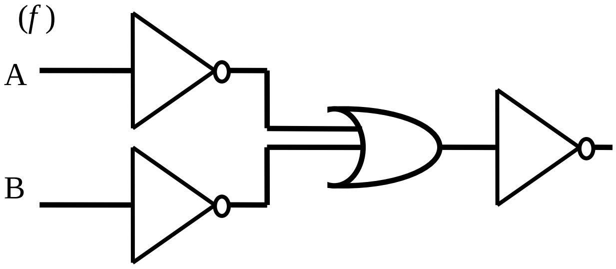
(*d*)



(*e*)



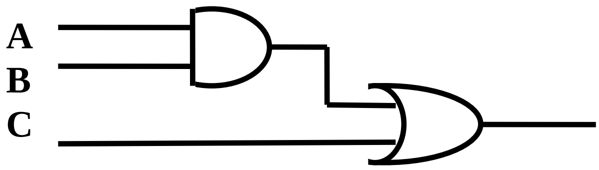
(*f*)



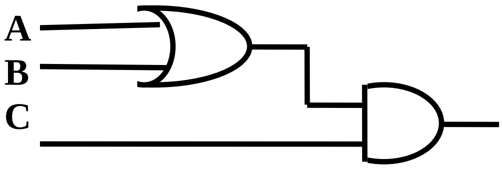
3. Each of the following combinations of logic gates has three inputs. For each combination complete a truth table of the form:

Input A	Input B	Input C	Output
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

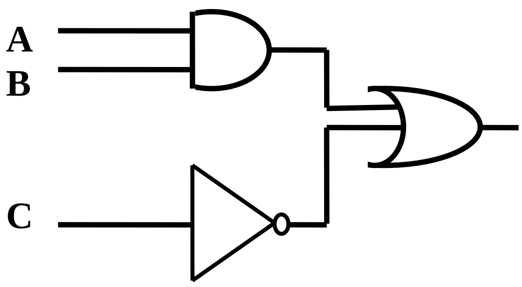
(a)



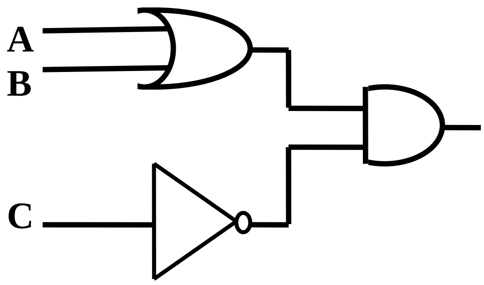
(*b*)



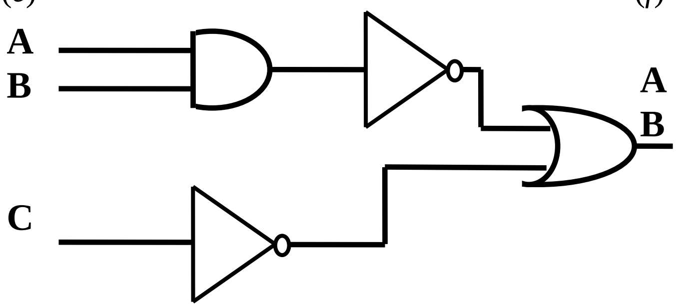
(*c*)



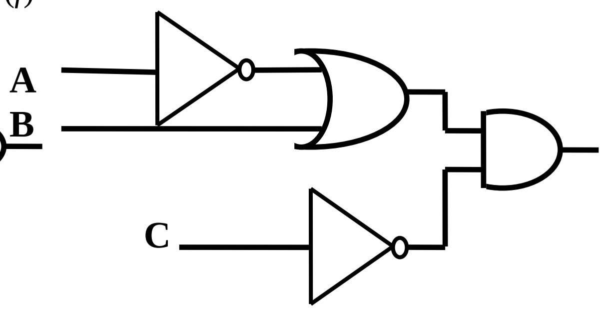
(*d*)



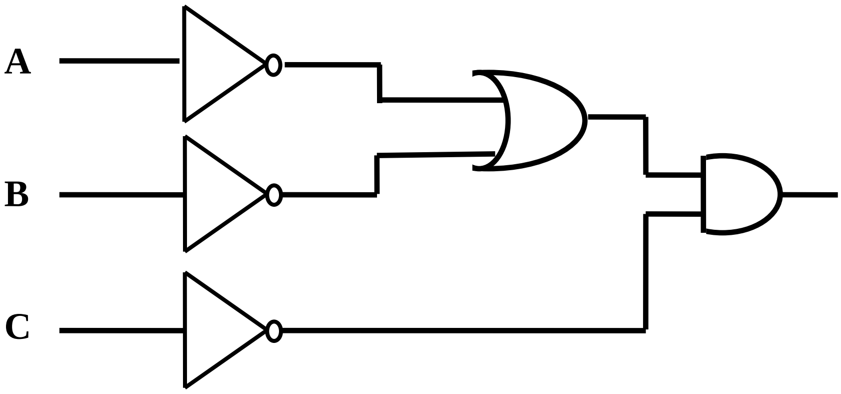
(*e*)



(*f*)



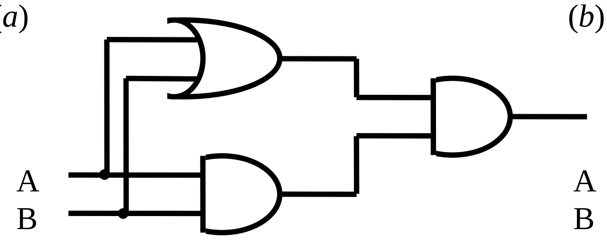
(*g*)



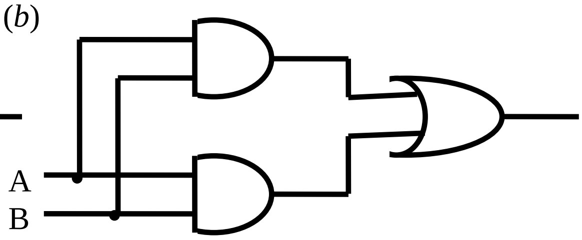
4. Each of the following combinations of logic gates involve linked inputs, that is two inputs being fed into different gates. For each combination complete a truth table of the form:

Input A	Input B	Output
0	0	
0	1	
1	0	
1	1	

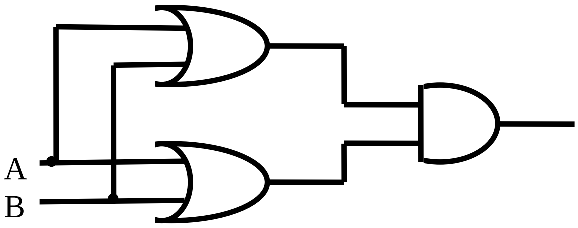
(*a*)



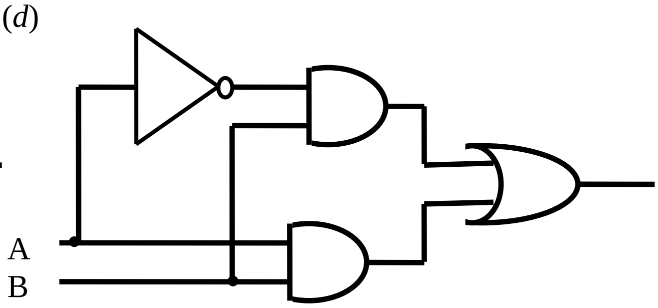
(*b*)



(*c*)

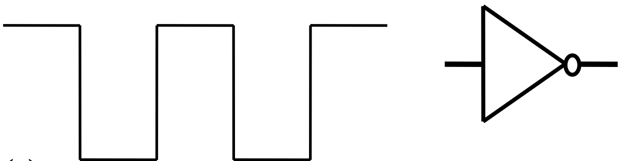


(*d*)

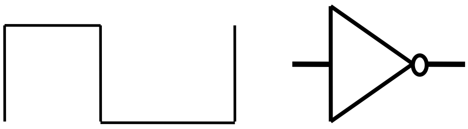


5. Show the pattern of pulses that would appear at the output of each of the following gates as a result of the input pulses shown.

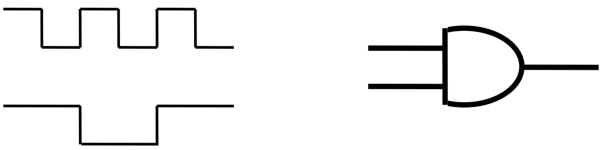
(*a*)



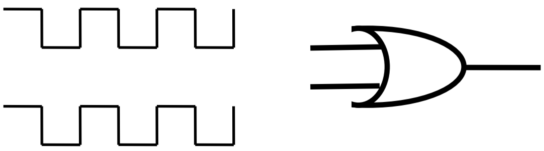
(*b*)



(*c*)



(*d*)



Section 5 - Analogue Processes

Devices containing amplifiers

(1) In which of the following systems do amplifiers play an important part?

radio capacitor TV loudspeaker LED solenoid
stereo remote control car public address system.

Voltage Gain

In this section you can use the equation:

$$\textbf{voltage gain} = \frac{\textbf{output voltage}}{\textbf{input voltage}}$$

also written as:

$$\textbf{voltage gain} = \frac{V_{out}}{V_{in}}$$

where **V_{out}** = Output voltage in volts (V)
V_{in} = Input voltage in volts (V).

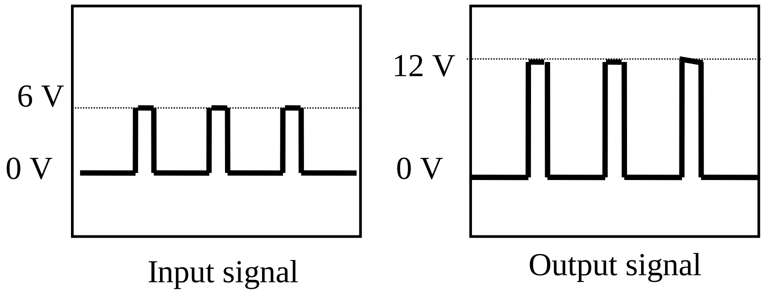
(Note: Voltage gain has no unit since it is a ratio of input to output voltages.)

1. Find the missing values in the following table.

	Input voltage (V)	*Output voltage* (V)	*Voltage Gain*
(*a*)	2	10	
(*b*)	24	96	
(*c*)	3		10
(*d*)	15		5
(*e*)		100	20
(*f*)		16	2

2. Calculate the gain of a guitar amplifier if the input signal is 2·3 V and the output signal is 46 V.

3. A student studies the input and output traces from an amplifier and displays the results on an oscilloscope.
Use the trace to find the gain of the amplifier.



4. A hearing aid amplifies an input signal by a factor of 20. What would be the voltage of an output signal if the input signal was 0·12 V?

5. Televisions use amplifiers to boost the signal received after transmission. The output voltage of an amplifier is 2·3 mV and its gain is 15. Calculate the size of the input voltage collected at the aerial.

6. A pick up cartridge can produce a 0·2 mV signal which is then amplified. What is the gain of an amplifier which increases this signal to 15 V?

7. If the voltage gain of a pre-amp is 4 000 and the input signal is 3 mV, calculate the output voltage.

8. A signal generator connected to a loudspeaker is used to investigate the range of human hearing. The output from the loudspeaker is 20 V and the gain is 1 000. Calculate the size of the input signal.

9. A CD sends signals of approximately 0·25 mV to a pre-amplifier which produces an output voltage of 15 V. Use this data to find the gain of the pre-amplifier.

10. Calculate the output voltage of a personal stereo amplifier if it has a gain of 2 500 and the input voltage is 3·5 mV.

Power Gain

In this section you can use the equation:

$$\textbf{power gain} = \frac{\textbf{output power}}{\textbf{input power}}$$

also written as:

$$\textbf{power gain} = \frac{P_{out}}{P_{in}}$$

where **P_{out}** = Output power in Watts (W)
P_{in} = Input power in Watts (W).

(Note: Power gain has no unit since it is a ratio of input to output powers.)

1. Find the missing values in the following table:

	Input Power (W)	*Output Power* (W)	*Power Gain*
(*a*)	0·006	60	
(*b*)		40	5 000
(*c*)	4×10^{-3}	80	
(*d*)		50	100
(*e*)	0·002		3 000
(*f*)	5×10^{-3}		200

2. An amplifier delivers an output of 60 W when the input power is 1·8 W. What is the power gain of the amplifier?

3. What would be the input power to an amplifier with a power gain of 400, if it delivers an output of 40 W?

4. The signal from a compact disc player has a power of 6 mW. The attached amplifier has a gain of 5 000. What is the power delivered to the speaker?

Helpful Hint
In this section you can also use the equation

$$P = \frac{V^2}{R}$$

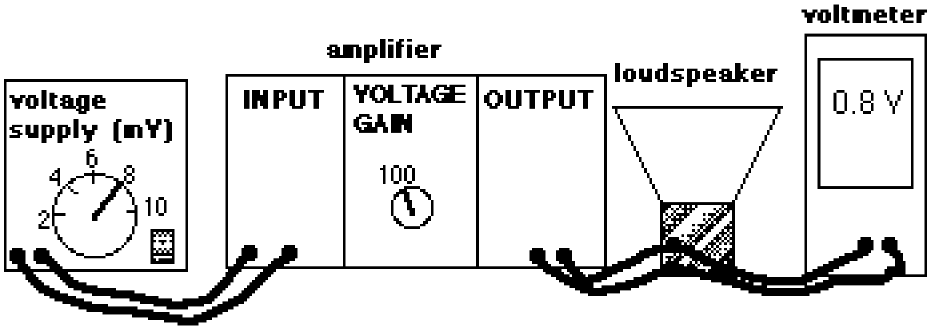
where **P**= power in watts (W)
V= voltage in volts (V)
R= resistance in ohms (Ω).

5. Find the missing values in the following table:

	Power (W)	*Voltage* (V)	*Resistance* (Ω)
(*a*)		9	16·2
(*b*)		20	100
(*c*)	3 000	230	
(*d*)	4·8	6	
(*e*)	3		48
(*f*)	48		1 200

6. An amplifier is fed with an input voltage of 12 mV. Calculate the input power of the amplifier given that the input resistance is 15 kΩ.

7. An experiment is set up in a laboratory to investigate the input and output voltages of an amplifier. The apparatus is shown below.



The input voltage is 8 mV and the input resistance of the amplifier is 220 kΩ. An output signal of 0·8 V, 0·016 W is fed to a loudspeaker.

(*a*) What is the input power to the amplifier?

(*b*) What is the resistance of the loudspeaker?

8. The pick-up cartridge in a record deck delivers a 10 mV signal to the amplifier which has an input resistance of 20 kΩ.

   (*a*) What is the input power to the amplifier?

   (*b*) The maximum power output from the amplifier is 40 W. Calculate the power gain of the amplifier.

   (*c*) The output from the amplifier is delivered to a loudspeaker with an input resistance of 6 Ω. What is the voltage across this speaker?

9. 3 mV is fed into an amplifier whose input resistance is 50 kΩ.

   (*a*) Calculate the power delivered to the amplifier.

   (*b*) If the amplifier has a power gain of $2{\cdot}5 \times 10^{9}$, what is the output power produced by the amplifier?

   (*c*) This output signal is sent to a loudspeaker which has a resistance of 20 Ω. What is the voltage across the loudspeaker?

10. The tape deck of a hi-fi system produces a signal of 3 mV, $1{\cdot}6 \times 10^{-10}$ W. This signal is passed through an amplifier to a loudspeaker. The loudspeaker has a resistance of 6 Ω and the voltage across it is 6 V.

   (*a*) What is the power output of the loudspeaker?

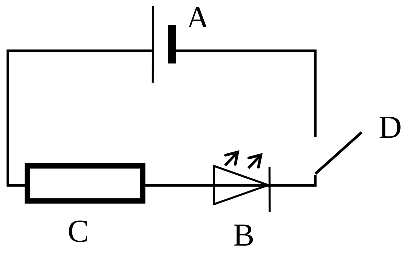
   (*b*) Calculate the power gain of this amplifier.

   (*c*) What is the input resistance of the amplifier?

Electronics Revision Questions

General Level

1. The circuit below is set up in a laboratory.

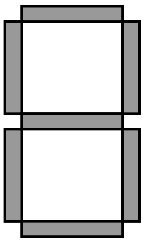


(*a*) Name components A, B, C and D.

(*b*) Explain why component C is necessary in this circuit.

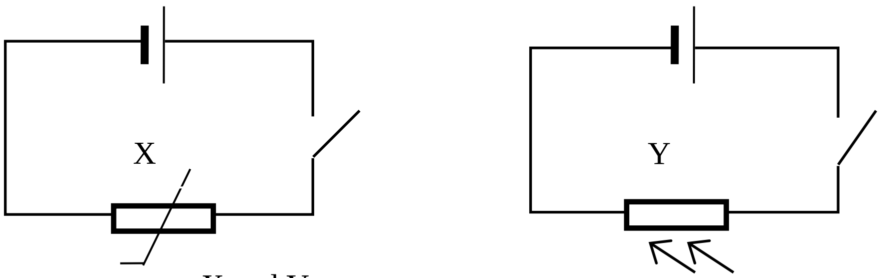
(*c*) Why is it important that component B is connected the right way round?

(*d*) Light emitting diodes can be arranged as follows to produce different numbers:



What is the name given to this arrangement of LED's?

2. Look at the following circuits:



(*a*) Name components X and Y.

(*b*) What will happen to the resistance of component X as the temperature increases?

(*c*) What will happen to the current flowing in X as the temperature increases?

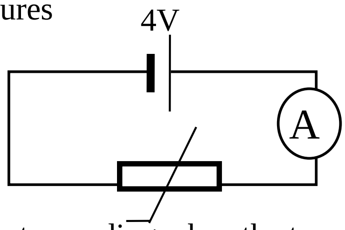
(*d*) What will happen to the resistance of component Y as it gets dark?

(*e*) What will happen to the current flowing in Y as it gets dark?

3. The resistance of a certain thermistor was recorded at various temperatures. The results are shown in the table below.

Temperature (°C)	Resistance (Ω)
10	4 000
40	1 980
100	200

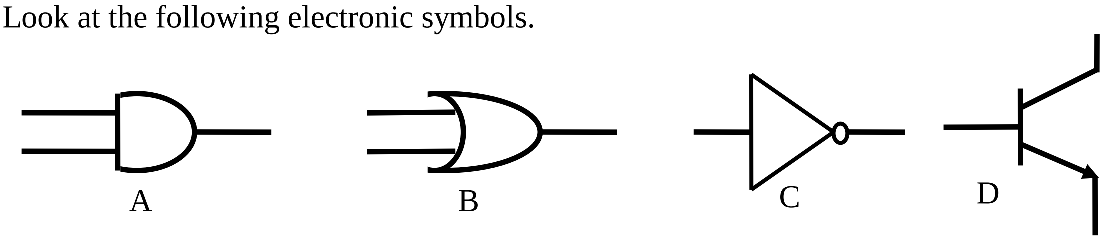
The thermistor was then connected to a 4 V battery and ammeter and exposed to the same range of temperatures



(*a*) What was the ammeter reading when the temperature was 10 °C?

(*b*) What temperature is indicated by an ammeter reading of 0·02 A?

4. Look at the following electronic symbols.



(*a*) Name the device represented by each symbol.

(*b*) Which device can be used as a switch?

(*c*) Which device is represented by the following truth table?

A	B	output
1	1	1
1	0	0
0	1	0
0	0	0

5. Amplifiers play an important part in many electronic systems.

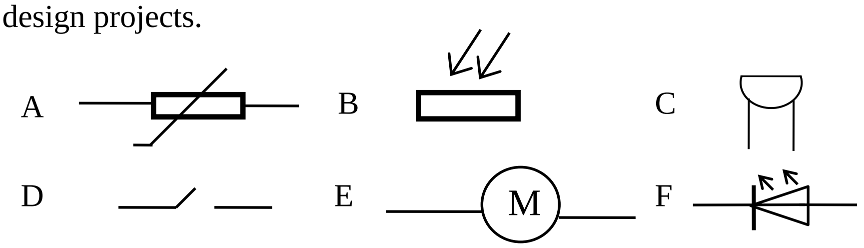
(*a*) Calculate the voltage gain of a guitar amplifier which has an input voltage of 0·8 V and an output voltage of 20 V.

(*b*) A personal stereo amplifier has a voltage gain of 1 800 to produce an output voltage of 9 V. What is the input voltage for the amplifier?

(*c*) An input voltage of 2 mV is sent to an amplifier which has a voltage gain of 2 000. Calculate the output voltage produced.

Credit Level

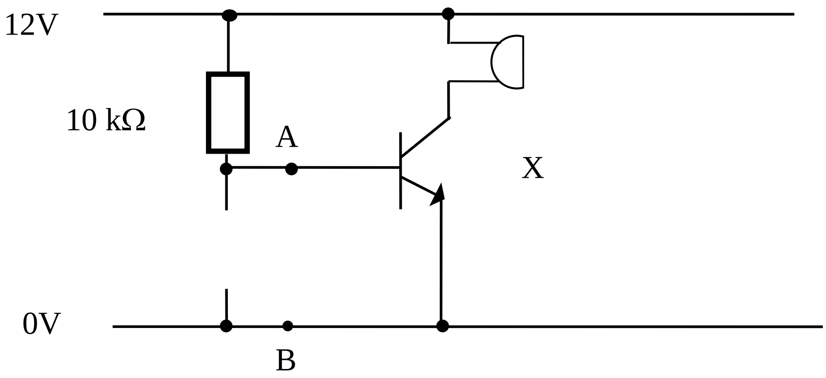
1. Some students are given the electronic components shown below to use in their school design projects.



(*a*) Name each of the components.

(*b*) Which of the components would be **most** suitable to use as the input device for a gardeners frost alarm?

(*c*) Copy and complete the following circuit showing how the input device would be connected. Explain fully how the system operates.

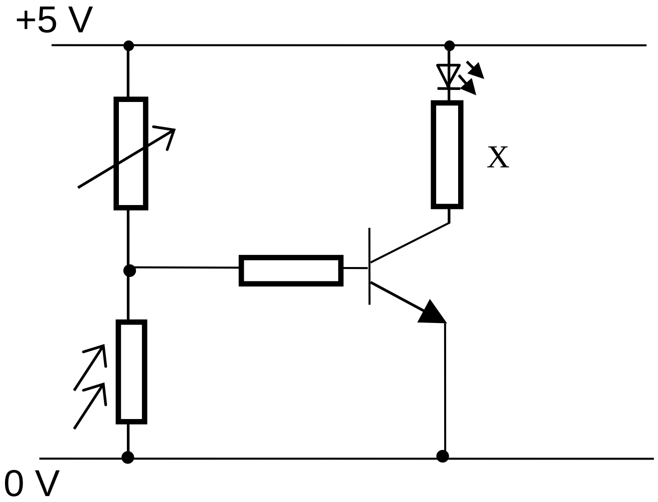


(*d*) Use the information in the table below to calculate the voltage across AB at each temperature in the table below.

Temperature (°C)	*Resistance* (Ω)
-10	800
-5	620
0	600
5	550

(*e*) The output device will 'switch on' when the voltage across AB is 0·7 V or more. At what temperature does this happen?

2. The following circuit is used to indicate when the light level in a room is too low.



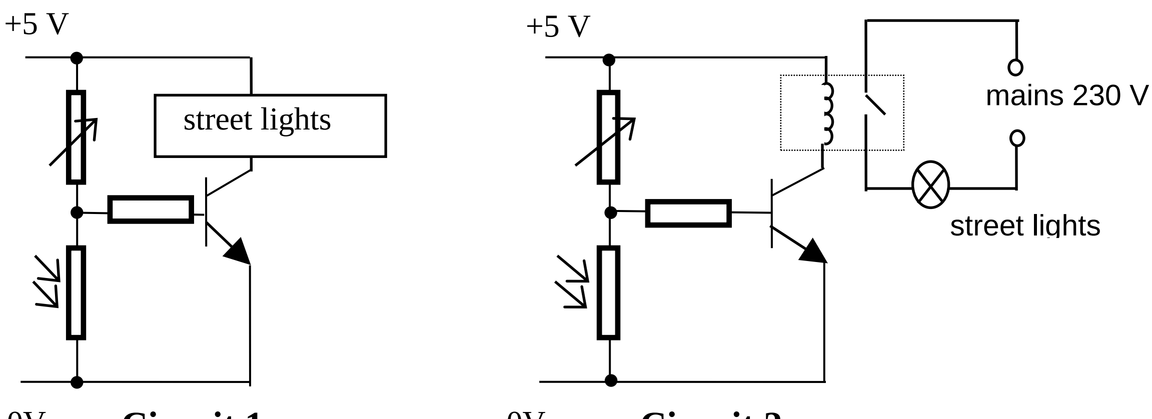
(*a*) Why has a variable resistor been used instead of a fixed value resistor at the input?

(*b*) What is the purpose of resistor X in the circuit?

(*c*) Calculate the size of resistor X if the LED is designed to operate at 3 V, 10 mA.

(*d*) Explain how the circuit works.

It is suggested that the circuit be adapted slightly and used as part of an automatic street lighting system .Two of the possible "adapted" circuits are shown below.



Circuit 1 **Circuit 2**

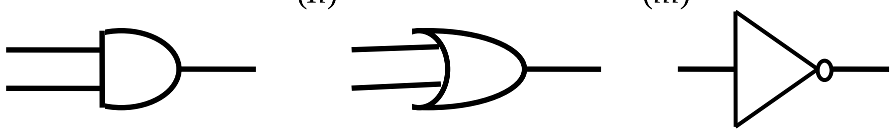
(*e*) Circuit 1 was described as 'unsuitable for the purpose'. By looking at the circuits, can you suggest what was wrong with circuit 1 and how Circuit 2 is better.

(f) Explain the function of the relay in circuit 2.

3. Logic gates are used widely in electronic systems.

(*a*) Name each of the following logic gates:

(*I*) (*Ii*) (*iii*)



(*b*) For each logic gate draw the corresponding truth table.

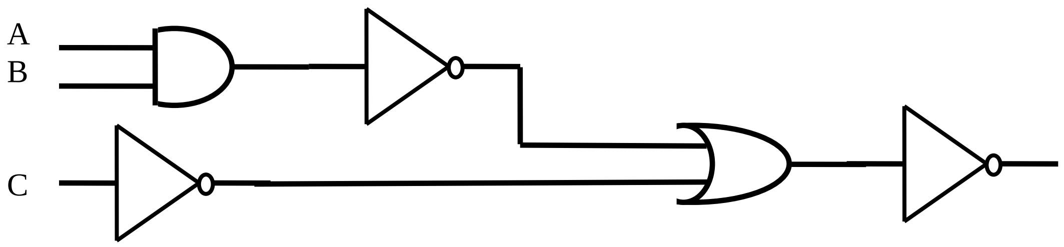
For each of the following applications name the logic gate that would be most suitable.

(*c*) The courtesy lights in a car should come when either of the front doors of the car are opened.

(*d*) A frost alarm is designed to operate only at night.

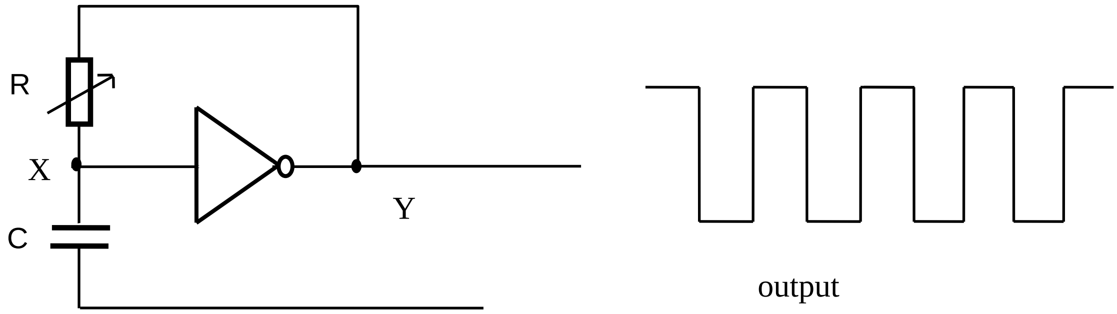
(*e*) An alarm system in a bank must be able to be operated from two different positions behind the counter.

(*f*) Look at the combination of logic gates shown below. Copy and complete the truth table for this system.



Input A	Input B	Input C	Output
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

4. The diagram below shows a clock pulse generator circuit with its output.



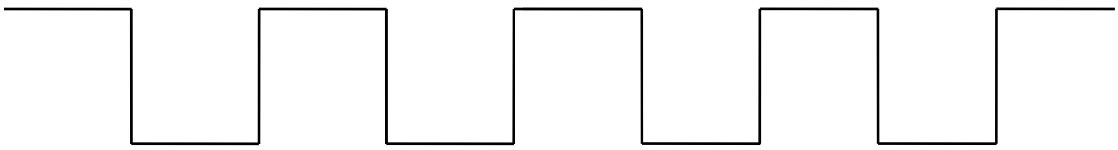
(*a*) Name the logic gate used in this circuit.

(*b*) When the capacitor is uncharged what are the logic levels at X and Y?

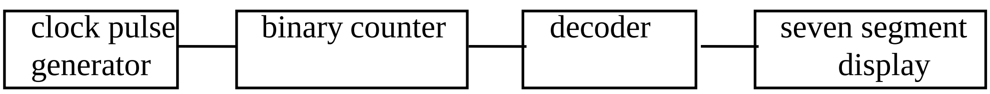
(*c*) When the capacitor charges up what happens to the logic levels at X and Y?

(*d*) Use your answers to part (*a*) and (*b*) to explain how this circuit produces a series of pulses as shown at the output.

(*e*) The output from this circuit can be altered by adjusting R and / or C. Look at the output shown below and explain how R and / or C have been altered to produce it.

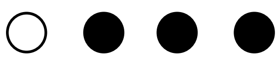


The clock pulse generator is connected to a binary counter a decoder and a seven segment display as shown below.

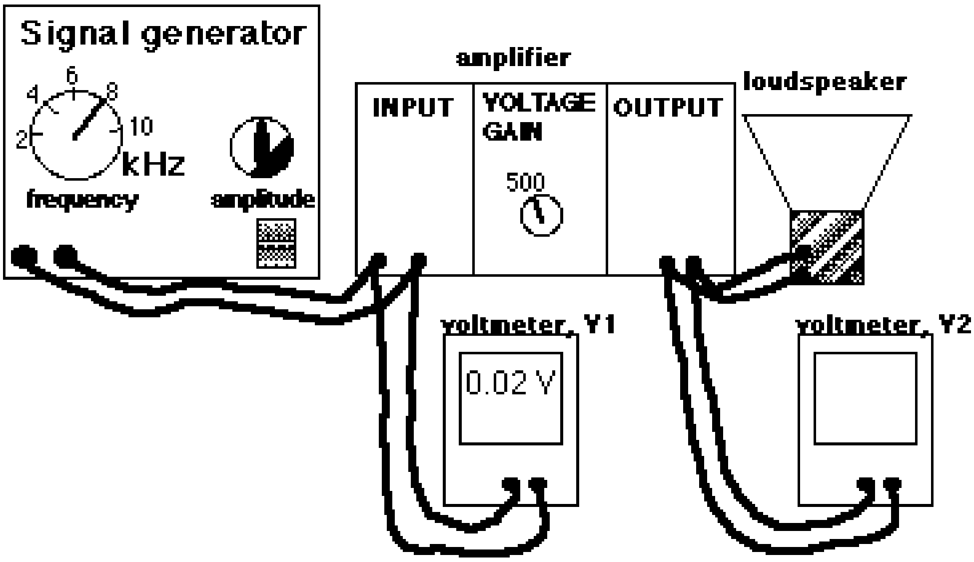


(*f*) The output from the binary counter is displayed as a series of LED's as shown:

What number would appear on the seven segment display when the following output was produced by the binary counter?



5. A signal is fed into an amplifier from a signal generator, as shown below



(*a*) If the voltage gain of the amplifier is set at 500 what should be the reading on voltmeter V_2?

(*b*) The input resistance of the amplifier is 100 kΩ and the resistance of the loudspeaker is 8 Ω. Calculate the power gain of the amplifier.

(*c*) Describe what would happen to each voltmeter reading if the amplitude of the input signal was increased slightly.

(*d*) Describe what would happen to each voltmeter reading if the voltage gain of the amplifier was halved.

(*e*) Describe what would happen to each voltmeter reading if the frequency of the input signal was increased.

Appendix (i) Data Sheet

Speed of light in materials	
Material	*Speed in m/s*
Air	3×10^8
Carbon dioxide	3×10^8
Diamond	$1{\cdot}2 \times 10^8$
Glass	$2{\cdot}0 \times 10^8$
Glycerol	2.1×10^8
Water	$2{\cdot}3 \times 10^8$

Speed of sound in materials	
Material	*Speed in m/s*
Aluminium	5 200
Air	340
Bone	4 100
Carbon dioxide	270
Glycerol	1 900
Muscle	1 600
Steel	5 200
Tissue	1 500
Water	1 500

Gravitational field strengths	
	Gravitational field strength on the surface in N/kg
Earth	10
Jupiter	26
Mars	4
Mercury	4
Moon	1·6
Neptune	12
Saturn	11
Sun	270
Venus	9
Uranus	11·7
Pluto	4·2

Specific heat capacity of materials	
Material	*Specific heat capacity in J/kg°C*
Alcohol	2 350
Aluminium	902
Copper	386
Glass	500
Glycerol	2 400
Ice	2 100
Lead	128
Silica	1 033
Water	4 180
Steel	500

Specific latent heat of fusion of materials	
Material	*Specific latent heat of fusion in J/kg*
Alcohol	$0{\cdot}99 \times 10^5$
Aluminium	$3{\cdot}95 \times 10^5$
Carbon dioxide	$1{\cdot}80 \times 10^5$
Copper	$2{\cdot}05 \times 10^5$
Glycerol	$1{\cdot}81 \times 10^5$
Lead	$0{\cdot}25 \times 10^5$
Water	$3{\cdot}34 \times 10^5$

Melting and boiling points of materials		
Material	*Melting point in °C*	*Boiling point in °C*
Alcohol	-98	65
Aluminium	660	2470
Copper	1 077	2 567
Glycerol	18	290
Lead	328	1 737
Turpentine	-10	156

Specific latent heat of vaporisation of materials	
|*Material*	*Sp.l.ht vap(J/kg)*
Alcohol	$11{\cdot}2 \times 10^5$
Carbon dioxide	$3{\cdot}77 \times 10^5$
Glycerol	$8{\cdot}30 \times 10^5$
Turpentine	$2{\cdot}90 \times 10^5$
Water	$22{\cdot}6 \times 10^5$

SI Prefixes and Multiplication Factors		
Prefix	*Symbol*	*Factor*
giga	G	$1\ 000\ 000\ 000 = 10^9$
mega	M	$1\ 000\ 000 = 10^6$
kilo	k	$1\ 000 = 10^3$
milli	m	$0{\cdot}001 = 10^{-3}$
micro	μ	$0{\cdot}000\ 001 = 10^{-6}$
nano	n	$0{\cdot}000\ 000\ 001 = 10^{-9}$

Appendix (ii) Answers to Numerical Problems

Section 2 - Output Devices

The L.E.D.(p.3)

1. B and E
2.
(a) 4 V, 400 Ω
(b) 10 V, 1 000 Ω
(c) 6·2 V, 387·5 Ω
(d) 18·4 V, 2 300 Ω
(e) 2·5 V, 125 Ω
(f) 9 V, 750 Ω
3.
(a) 190 Ω
(b) 600 Ω
(c) 980 Ω
(d) 400 Ω
(e) 1 000 Ω
(f) 500 Ω
(g) 650 Ω
(h) 50 Ω
4.
(a) 3·2 V
(b) 1·9 V
5. 11 V
6. 425 Ω
7. 0·005 A
8. 2·2 V
9. 21 V
10. 250 Ω

Binary to Decimal Conversion(p.8)

1.
(a) 5
(b) 9
(c) 10
(d) 6
(e) 13
(f) 11
(g) 7
(h) 8
2.
(a) 13
(b) 12
(c) 1
(d) 11
(e) 0
(f) 9

Section 3 - Input Devices

Using V = I R(p.9)

2.
(a) (i) 200 Ω
(ii) 2500 Ω
(b) circuit (ii)
3.
(a) 4 000 Ω
4.
(a) 0·2 kΩ
(b) 0·005 A
(c) bright sunlight
5.
(a) 60 ^{0}C
(b) cold
(c) 20 ^{0}C
(d) 0·03 A

Voltage Dividers(p.13)

1. 6 V, 6 V
2. 12 V, 12 V
3. 18 V, 18 V
4. 2 V, 10 V
5. 4 V, 6 V
6. 20 V, 16 V
7. 16 V, 8 V
8. 16 V, 8 V
9. 16 V, 8 V
10. 27 V, 9 V
11. 27 V, 9 V
12. 27 V, 9 V
13. 8 V, 4 V
14. 2·5 V, 7·5 V
15. 48 V, 192 V
16. 2 V, 3 V
17. 13·5 V, 22·5 V
18. 4 V, 20 V
19. 30 V, 210 V
20. 3·6 V, 16·4 V
21.
(a) 224·39 V
(b) 218·94 V
22.
(a) 10·91 V
(b) 8·57 V
23.
(a) 17·14 V
(b) 4·84 V
24. 35·53 V
25. 100 ^{0}C
26. 12 V
27. 0 V
28. 0 V
29. 5 V
30. 0 V

Section 4 - Digital Processes

Transistors(p.20)

1.
(a) 6 V, bulb ON
(b) 2 V, bulb ON
(c) 0·5 V,Buzzer OFF
(d) 1·2 V, L.E.D. ON
(e) 1·95 V, bulb ON
(f) 3·56 V, L.E.D. OFF as it is wrongly connected.
2.
(a) 0 V
(b) No
(c) Yes
(d) Yes
3.
(a) D
(b) B
(c) C
(d) A
5.
(a) ON
(b) OFF
(c) ON
(d) OFF
(e) ON
(f) OFF

Logic Gates(p.26)

1.
(a) NOT
(b) OR
(c) AND
2.

(a)	(b	(c)	(d)	(e)	(f)
1	1	0	1	0	0
1	0	1	1	1	0
1	0	0	0	1	0
0	0	0	1	1	1

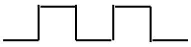
3.

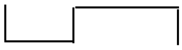
(a)	(b)	(c)	(d)
0	0	1	0
1	0	0	0
0	0	1	1
1	1	0	0
0	0	1	1
1	1	0	0
1	0	1	1
1	1	1	0

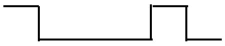
(e)	(f)	(g)
1	1	1
1	0	0
1	1	1
1	0	0
1	0	1
1	0	0
1	1	0
0	0	0

4.

(a)	(b)	(c)	(d)
0	0	0	0
0	0	1	1
0	0	1	0
1	1	1	1

5. (a) 

(b) 

(c) 

(d) 

Section 5 - Analogue Processes

Voltage Gain (p.29)

1.
(a) 5
(b) 4
(c) 30 V
(d) 75 V
(e) 5 V
(f) 8 V

2. 20
3. 2
4. 2·4 V
5. 1·53 x 10^{-4} V
6. 75 000
7. 12 V
8. 0·02 V
9. 60 000
10. 8·75 V

Power Gain (p.31)

1.
(a) 10 000
(b) 8 x 10^{-3} W
(c) 20 000
(d) 0·5 W
(e) 6 W
(f) 1 W

2. 33·33
3. 0·1 W
4. 30 W
5.
(a) 5 W
(b) 4 W
(c) 17·6 Ω
(d) 7·5 Ω
(e) 12 V
(f) 240 V

6. 9·6 x 10^{-9} W
7.
(a) 2·91 x 10^{-10} W
(b) 40 Ω

8.
(a) 5 x 10^{-9} W
(b) 8 x 10^{9}
(c) 15·49 V

9.
(a) 1·8 x 10^{-10} W
(b) 0·45 W
(c) 3 V

10.
(a) 6 W
(b) 3·75 x 10^{10}
(c) 56 250 Ω

Revision Questions

General Level (p.34)

3.
(a) 0·001 A
(b) 100 ^{0}C

4.
(b) D
(c) A

5.
(a) 25
(b) 0·005
(c) 4 V

Credit Level (p.36)

1.
(b) A
(d) -10 ^{0}C : 0·89 V
-5 ^{0}C : 0·7 V
0 ^{0}C : 0·68 V
5 ^{0}C : 0·63 V
(e) -5 ^{0}C

2.
(c) 200 Ω

3.
(a) (i) AND
(ii) OR
(iii) NOT
(c) OR
(d) AND
(e) AND
(f) 0
0
0
0
0
0
0
1

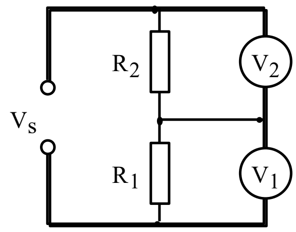
4.
(a) NOT
(b) logic 0, logic 1
(c) becomes logic 1, becomes logic 0.
(e) R and/or C have been increased
(f) 8

5.
(a) 10 V
(b) 3·125 x 10^{9}
(c) both increase
(d) no change to V1 ; V2 would half.
(e) no change to either reading.

Analogue Electronics

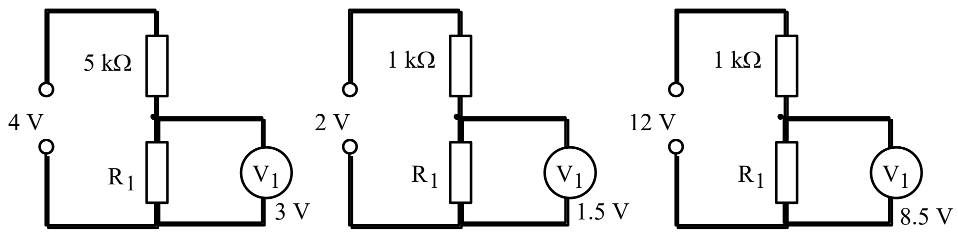
1. Calculate the values of V_1 and V_2 in the circuit shown for the following situations.

   (a) V_S = 12 V R_1 = 40 kΩ R_2 = 20 kΩ
   (b) V_S = 6 V R_1 = 150 kΩ R_2 = 30 kΩ
   (c) V_S = 10 V R_1 = 3 kΩ R_2 = 5 kΩ



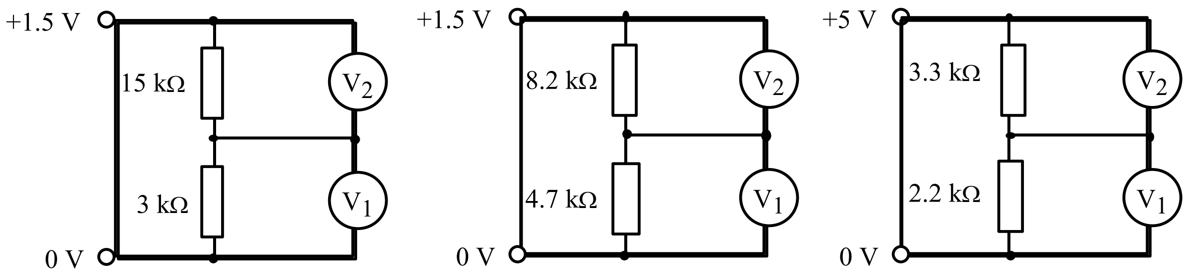
2. Calculate the values of R_1 in the following circuits.

   (a) (b) (c)



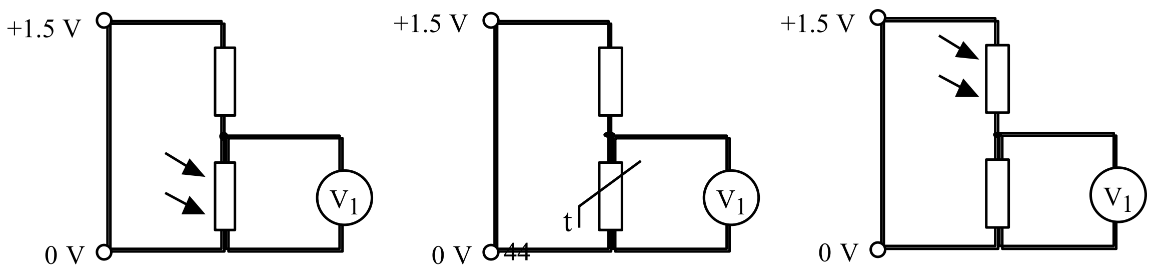
3. Calculate the values of V_1 and V_2 in the circuits shown.

   (a) (b) (c)

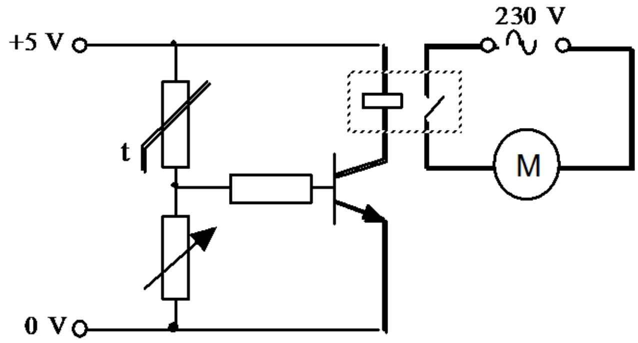


4. Explain what happens to the value of V_1 in each of the following situations -

   (a) brightness increasing (b) temperature increasing (c) brightness decreasing.



5. The thermistor shown has a resistance of 31 kΩ at 30 °C and 35 kΩ at 25 °C.



(a) If the variable resistor is set at 5 kΩ, calculate the input voltage to the transistor **in each case**.

(b) Hence, explain how the circuit shown works.

(c) Explain the purpose of the variable resistor.

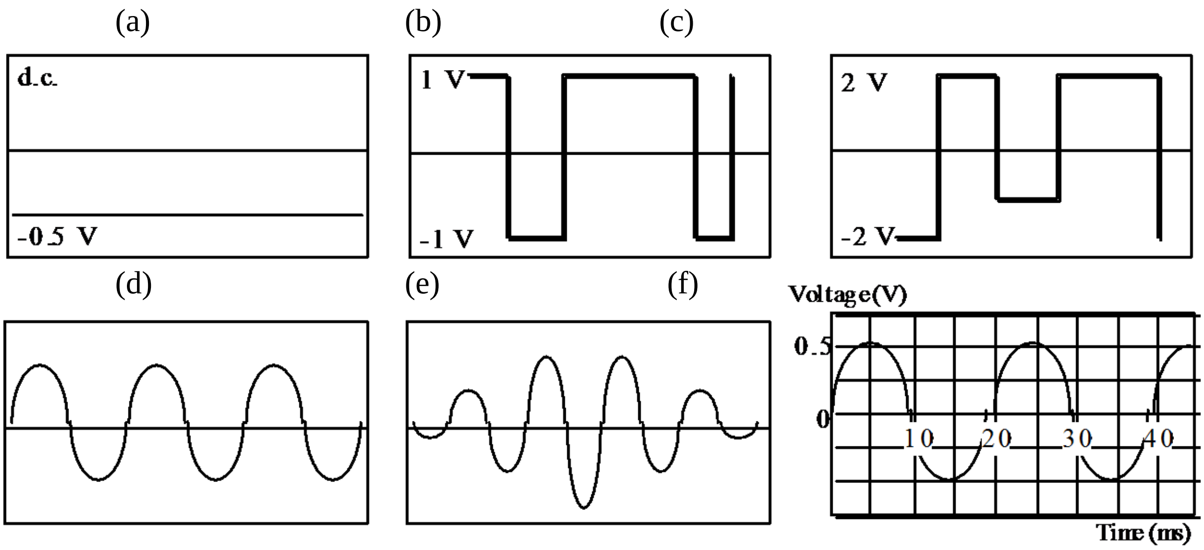
(d) Suggest a possible use for the circuit.

(e) Why is the relay switch necessary?

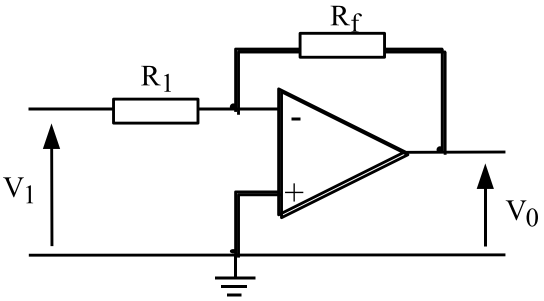
1. Draw a circuit diagram similar to the circuit of Question 5 that would switch on a mains voltage lamp when the ambient light level drops below a certain level.

7. The circuits shown in questions 5 & 6 could use a different type of transistor called an n-channel enhancement MOSFET. Draw the symbol for this transistor and label each terminal.

8. The following signals are fed into an inverting amplifier with a gain of 5. Draw the expected output trace.

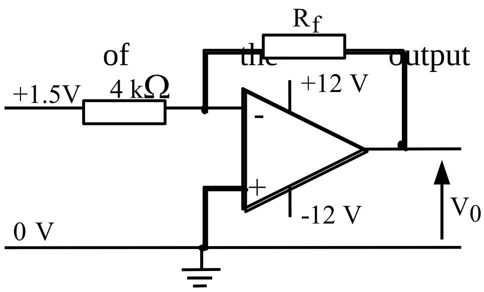


9. (a) In what mode is the op-amp being used in the circuit below.
   (b) State the relationship between V_1, R_1, R_f, and V_0.
   (c) Find the unknown values in the table shown. All calculations should be set out clearly.

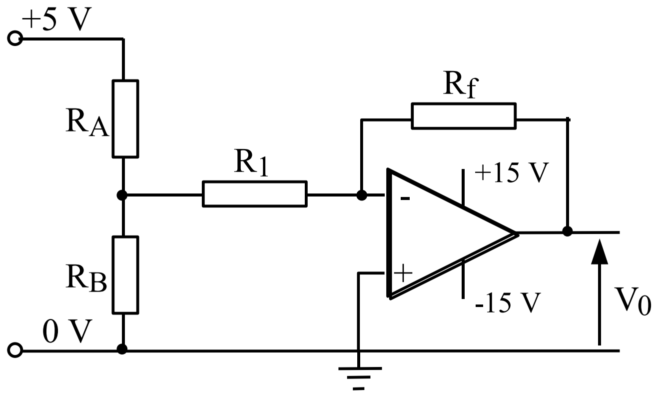


	R_1(kΩ)	R_f(kΩ)	V_1(V)	V_0(V)
(i)	10	100	0.5	
(ii)	5	8	-1.4	
(iii)		5.4	0.4	-1.8
(iv)	1000		1.5	-0.6

10. (a) Which of the following values of Rf will produce saturation of the output voltage?
   (i) 15 kΩ (ii) 25 kΩ (iii) 35 kΩ
   (b) What is the approximate value of the saturation voltage?

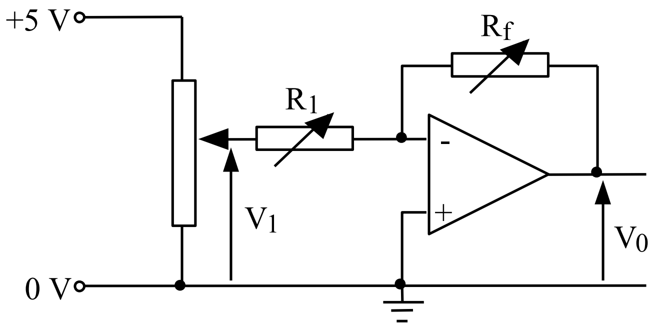


11. Calculate the value of VO for the following situations.

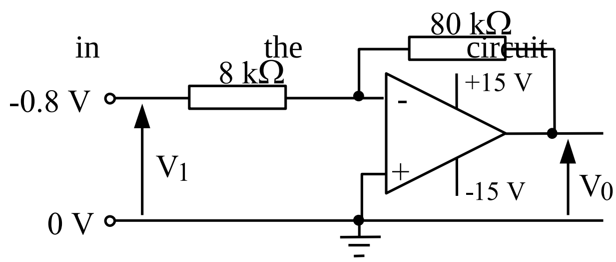


	R_A(kΩ)	R_B(kΩ)	R_1(kΩ)	R_f(kΩ)
(a)	1	4	10	20
(b)	1.2	4.7	1.5	10
(c)	5	2	8.2	27
(d)	5	1	1	4

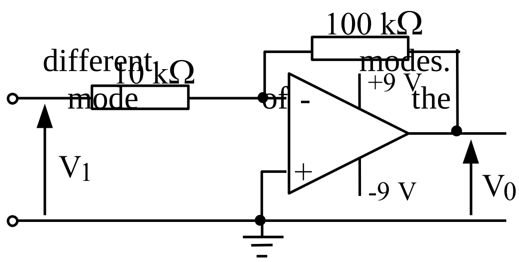
12. Describe 3 ways to **increase** the magnitude of the output voltage in the circuit shown.



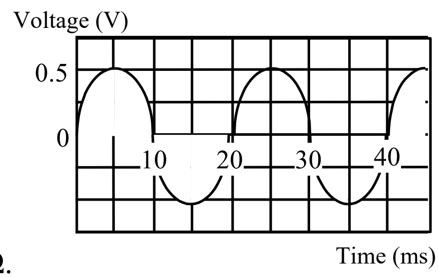
13. (a) Calculate the value of the output voltage in the circuit shown.
(b) If the value of R_f is doubled, what would be the output voltage?



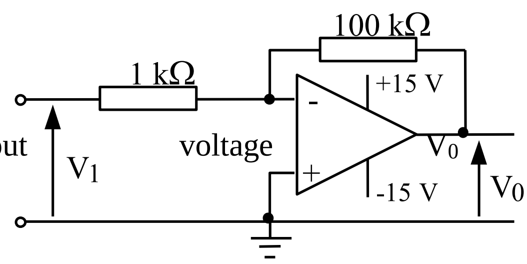
14. (a) An operational amplifier can be connected in different modes. State the operating mode of the amplifier shown.
(b) Calculate the gain of the circuit.



The graph shows how the voltage applied to the input of the circuit varies with time.
(c) Using square ruled paper, draw a graph showing how the **output** voltage varies with time.
(d) Describe the output signal if the input voltage is increased to 2 V.
(e) Both resistors have an uncertainty of ± 0.01 kΩ. Which resistor will introduce the greatest uncertainty into the gain calculation?
(f) What is the uncertainty in the gain?



15. (a) Calculate the gain of the circuit shown.
(b) Calculate the output voltage for an input voltage of 15 mV.
(c) What happens to the gain of the circuit if the feedback resistor is reduced.

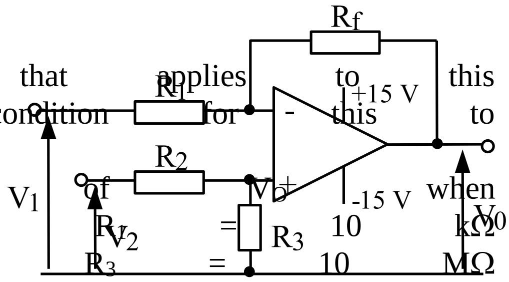


16. The circuit below shows an operational amplifier in the differential mode.

(a) What is the function of this circuit ?

(b) State the relationship that applies to this circuit, giving the condition for this to hold.

(c) Find the value of V_0 when R_f = 10 MΩ, R_1 = 10 kΩ, R_2 = 10 kΩ, R_3 = 10 MΩ, V_1 = 480 mV V_2 = 500 mV.



17. Calculate the unknown values in the table for a differential amplifier circuit.

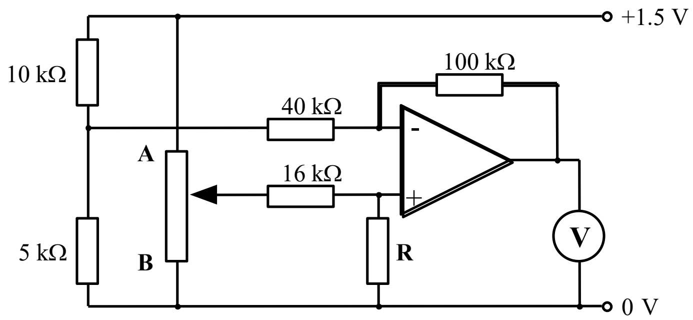
	V_1 (V)	V_2 (V)	$R_f = R_3$ (kΩ)	$R_1 = R_2$ (kΩ)	V_0 (V)
(a)	2.5	3.0	100	10	
(b)	1.5	1.3	30	5	
(c)	0.4	0.4	10	100	
(d)	6.0	7.2		3	6.6
(e)	4.5		40	5	-8.0

18. (a) In the circuit below, what value should be chosen for R for it to operate as a differential amplifier?

(b) Determine the reading on the voltmeter with the slider at position A.

(c) If the contact is moved to a position midway between A and B calculate the voltmeter reading.

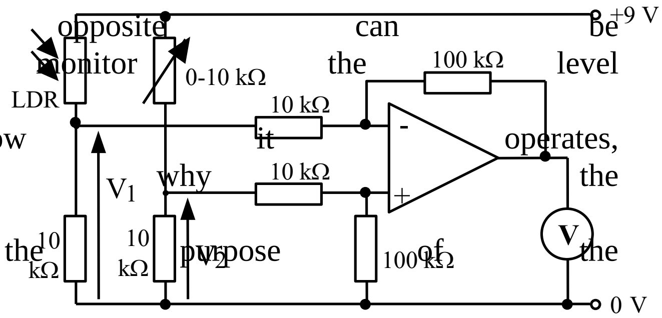
(d) Where should the contact be to produce an output voltage of (i) -1.25 V (ii) 0 V.



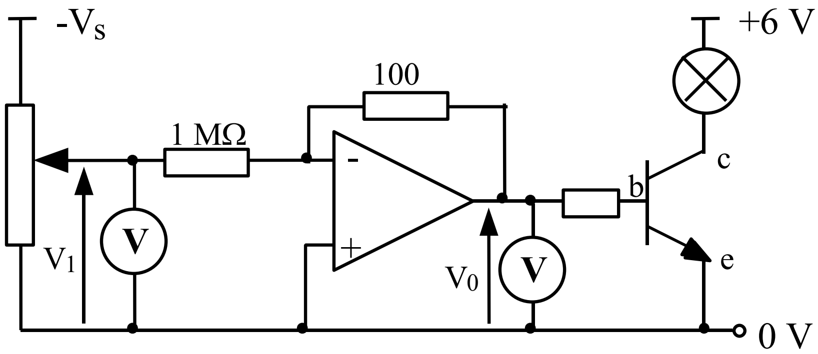
19. The circuit opposite can be shown to monitor the level of brightness.

(a) Explain how it operates, mentioning why the voltmeter reading changes.

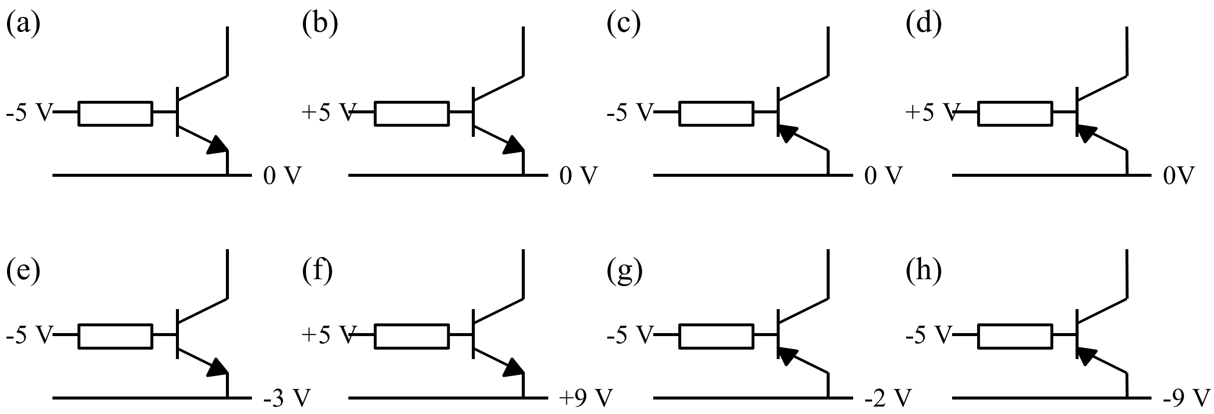
(b) What is the purpose of the variable resistor?



20. (a) Calculate the gain of the circuit shown.
    (b) At what value of (i) V_0 (ii) V_1 will the transistor switch on ?
    (c) Write down a rule which will allow you to predict whether a transistor is on or off. Remember the polarity of the base-emitter voltage is important.



21. State if the transistors below are switched on or off.



NUMERICAL ANSWERS

Analogue Electronics

1. (a) $V_1 = 8$ V $V_2 = 4$ V
   (b) $V_1 = 5$ V $V_2 = 1$ V
   (c) $V_1 = 3.75$ V $V_2 = 6.25$ V
2. (a) $R_1 = 15$ kΩ (b) $R_1 = 3$ kΩ (c) $R_1 = 2.43$ kΩ
3. (a) $V_1 = 0.25$ V $V_2 = 1.25$ V
   (b) $V_1 = 0.55$ V $V_2 = 0.95$ V
   (c) $V_1 = 2$ V $V_2 = 3$ V
4. (a) V_1 decreases (b) V_1 decreases (c) V_1 increases
5. (a) When T = 25 °C, V = 0.625 V. T = 30 °C, V = 0.7 V.
6. -
8. -
9. (a) Inverting mode
   (b) $V_0 = -(R_f / R_1)\ V_1$
   (c) (i) $V_0 = -5$ V (ii) $V_0 = 2.24$ V (iii) $R_1 = 1.2$ kΩ (iv) $R_f = 0.4$ MΩ
10. (a) $R_f = 35$ kΩ (b) 10 V
11. (a) $V_0 = -8$ V (b) $V_0 = -13$ V (satuaration) (c) $V_0 = -4.7$ V (d) $V_0 = -3.32$ V
12. Increase R_f, decrease R_1, increase V_1.
13. (a) $V_0 = -8$ V (b) $V_0 = -13$ V (saturation).
14. (a) Inverting mode (b) Gain = 10 (f) ±0.01
15. (a) Gain = 100 (b) V0 = -1.5 V (c) Gain will be reduced.
16. (a) Amplifies the difference between V_1 and V_2.
    (b) $V_0 = -(R_f / R_1)\ (V_2 - V_1)$
    (c) $V_0 = 20$ V (saturates to 13 V).
17. (a) $V_0 = 5$ V (b)$V_0 = -1.2$ V (c) $V_0 = 0$ V (d) $R_f = 16.5$ kΩ (e) $V_2 = 3.5$ V.
18. (a) 40 kΩ (b) $V_0 = 2.5$ V (c) $V_0 = 0.625$ V
    (d) (i) Position B (ii) $^1/_3$ distance from bottom.
19. -
20. (a) Gain = 0.1 (b) (i) 0.7 V approx. (ii) $V_1 = 7$ V
21. (a) Off (b) On (c) On (d) Off (e) Off
    (f) Off (g) On (h) Off