LEDfun

Introduction to Hand Soldering Technology and Electronics

Practical Exercises

Incorporating elabtronics ledfun

Teacher Resource Booklet

Name:

elabtronics
INNOVATIVE CONTROL SOLUTIONS

Office: 51 Byron Place, Adelaide, South Australia 5000 ABN 64 405 458 383
Email: edu@elabtronics.com Web: http://www.elabtronics.com
Telephone: (08) 8231 5966 Fax: (08) 8231 5266

Acknowledgements

This manual is a compilation of materials from several sources and authors.

Miroslav Kostecki

Chief Engineer for elabtronics

Derek M Fuller

Gleeson College, South Australia

Stephen B Fribbins

Training Consultant, South Australia

Other Sources

The Microchip Technology Inc (USA) website http://www.microchip.com

Disclaimer

elabtronics reserves the right to make changes to the product described. The manufacturer accepts no liability for any consequential loss, injury or damage resulting from the use of this product or from any errors or omissions in it. The specifications presented in this product are not to be deemed as forming a contract either in full or in part.

Electronic Pathways for Year 9 Students

Information for students

Aim
To introduce students to a "current" blend of science and technology, systems and processes via electronics, whilst developing a knowledge of components, circuit board manufacture and hand soldering skills to allow an informed choice in Year 10 when students are able to undertake both SACE and TAFE courses in this field of study.

Prerequisites
Students should have some **basic** understanding of the following topics:
- Charge and statics
- Voltage and current *(AC and DC)*
- Resistance/"Load" on a circuit
- Power sources *(cells, batteries, power packs, mains)*
- Types of circuits *(open, closed, short, series, parallel)*
- Effects of placing globes in series/parallel
- Effects of placing cells in series/parallel
- Conductors and insulators
- Switches, fuses and safety with electricity

Teaching Objectives
- Introduce basic skills and terminology associated with hand tools, soldering irons, tip care and soldering techniques.
- Component recognition, awareness of the existence of value codes and the importance of component polarity.
- Printed circuit board – purpose, recognition of layout, footprints of components and relationship to circuit diagrams.
- Basic debugging involving the simple use of multimeters.
- Develop safe working practices with electricity.
- Enhance problem-solving skills, fine motor skills, cooperative learning practices.
- Introduce female students to a wider range of science/technical experiences than has previously been available.
- Prepare students for Integrated Circuit programming in Year 10.

Where does this unit lead?

Students who **successfully** complete this unit *(they need to score at least 65%)* may apply to undertake a TAFE Hand Soldering course *(NE29)* that is run one evening a week after school for one semester, in a bus, on the Gleeson Campus. In conjunction with this the College offers a VET course *(which is SACE and TAFE courses combined to give dual accreditation – two qualifications for the one unit of work)* in electronics. This is begun in Year 10 and, if passed in Year 11, will give them formal recognition of their skills and open up many job, apprenticeship and further education opportunities in the electronics industry. South Australia will require 7,500 trained personnel by 2005 and a quarter of all University courses will be in the electronics field by 2010!

Requirements:

Consumables *(2 students' work goes in one labelled plastic lunchbox)*

Each student will need access to the following:
- Solder practice board *(in a resealable bank coin bag labelled with student's name)*
- 12 x ¼ watt resistors
- 10 cm of 0.7 – 0.9 mm tinned copper wire for staples
- 80 cm of 0.71 mm 60 / 40 multi core solder
- 5 cm of 2.0 – 2.5 mm desoldering wick
- 3 cm piece of lollipop stick
- ledfun kit *(to be kept in a resealable bag labelled with student name)*

Tools

One set between 2 students **in a pencil case** *(16 sets)*
- Soldering iron and appropriate tip *(2 types – 8 red pencil cases for white soldering irons and 8 blue pencil cases for blue soldering irons)*
- *(The tips for the blue irons have a '7' stamped on the flat inner end)*
- Sponge in a polythene bag *(larger sponge for blue irons)*
- 3 x 90 mm pliers – flat nosed, needle nosed, side cutters

One set per bench **in a large bucket** *(8 sets)*
- 4 sets of Helping hands *(with magnifying lens if required)*
- 2 multimeters
- 1 set of tweezers
- 1 set of desoldering tools *(1 solder syringe and set of hand tools in red plastic case)*
- 1 mini screwdriver set
- Soft toothbrush for cleaning circuit boards
- Chemwipes

On the trolley – as required

- 120 mm side cutters for heavy gauge wire cutting *(16 pairs)*
- Wire strippers for removing plastic coating on leads
- Distilled water for sponges
- Ethyl alcohol *(ethanol)* for cleaning flux off boards
- RMA flux for desoldering
- Magnifying lenses for helping hands *(18 with adapters fitted)*

This unit should be completed in 4-5 weeks. So don't waste time, there's a lot to do!

Getting started

Students need to be aware of the following procedures and safety matters:

WARNING

No solder, wire, links, resistors, plastic sleeving or any other *materials (especially metals)* used in connection with this unit of electronics must be allowed to go into the sink. Chemicals poured down the drain after them could result in dangerous reactions and maybe even poisonous gases being given off.
*(**Remember:** acid + metal = **hydrogen gas**)*

Cutting any wire other than soft copper, tinned copper wire, component leads or solder with the small 90 mm side cutters will ruin them instantly. Staples and paper clips are made from hardened spring steel and they must NOT be cut with these pliers.

Mains electricity *(240 volt)* will not be connected to any electronic components *(normally they run on 0 – 6 volt. More than this can cause them to explode!)*
Burning holes in the soldering stations is mega-dangerous – there are 240 volts inside!

Learn how to wind power cords around power packs and soldering irons, hold them correctly and store them safely in the correct location.
Select the appropriate pencil case of tools for the soldering iron being used. The BLUE pencil cases contain the correct larger sponge and tips for the BLUE soldering irons. If in doubt the blue soldering iron tips have a '7' stamped on the end of the tip – indicating an operating temperature of 700°F**.**

Learn how to insert the correct tip in the soldering iron, tin it when new, select correct heat setting *(on the white soldering irons this is critical and must be set at only 365°C/700°F)* and keep it clean during use. **Very importantly – remember to tin it at the end of the session just after switching off**, otherwise the casing will be damaged and the tip will go rusty and not solder properly – if at all.

Identify each of the pieces of equipment and the tools by their proper names.
Identify your own work with a permanent marker pen on the printed circuit board.
Use only distilled/demineralised water on the *sponges (sponges must be kept in sealed/folded polythene bags).*

Leave time at the end of a soldering session to cool the tip down before removing it and replacing it in the wooden block on the trolley. *(The damp sponge can do this if ou are pushed for time).*

You should try to gain experience on both types of soldering irons – remembering that they must use the correct tip for each type.

Look at the project kit at this stage and observe each of the 8 different "functions" and circuit plans. Start thinking carefully about the sort of device/game you are going to make around the kit and what resources you are going to have to gather in readiness to make it. Use homework time to gather resources well before production dates and ensure that it is not overly complex or difficult with the possibility of missing the due date.

Your choice of function/mode can be altered if you don't like the end result just by using the de-soldering procedures you are about to learn and then changing some of the components *(resistors)* to those on another circuit plan. Consequently you should keep all the spare components issued with the kit.

In the final project make sure that all the components are correctly fitted before soldering and then check that all solder joints are sound with no sign of bridging *(short circuits)* before fitting the IC. IC's are easily damaged by reverse polarity.

Knowing how to set up and connect a multimeter safely to read current *(in series)*, voltage *(in parallel)* and resistance *(across component when disconnected from circuit and all power is off)* can be useful in fault finding, i.e. looking for open circuits, short circuits and checking battery condition.

Your work will be marked as you go. **Take careful note of the points in the instructions where work needs to be presented.** You should bring the booklet with the appropriate marks page opened and ready when you present work for assessment. Please be patient and listen carefully to the feedback. Good feedback from the teacher will help you gain extra marks!

Pre-reading the instructions is a useful homework task and adds value to the time spent on practical tasks.

For more interesting facts: *Internet electronics* – www.iserve.net/~alex/lib/tutorial

Year 9 Science – Work Practices during Electronics Unit

Name	Kit	Iron	Prompt cleanup	Clean workspace	Return equipment	Free of damage	Worked Co-op

CHECK UP

Question 1

Karen and Marty wanted to set up the circuit shown in figure 1. Write a list of the equipment they would need.

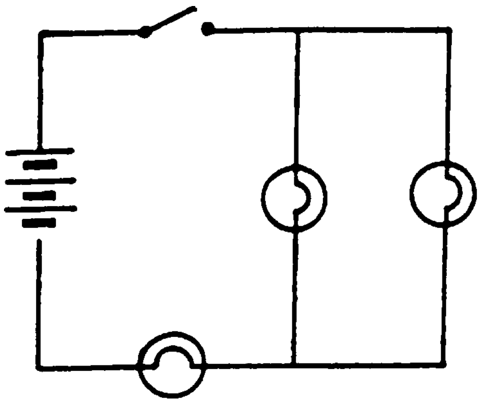


Figure 1

Question 2

Karen and Marty then set up the circuit shown in figure 2. They wanted to test different materials to see if they were conductors or insulators. They connected the materials in the circuit between x and y, and noted the glow in the light bulb. Which materials are conductors and which are insulators?

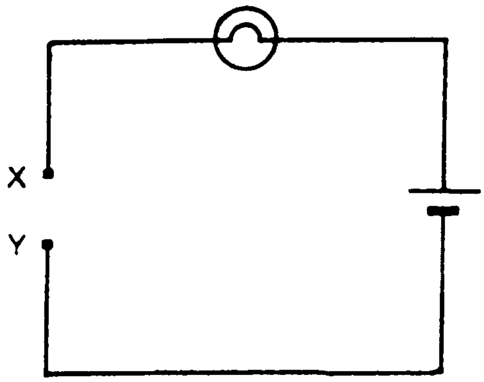


Figure 2

MATERIAL	GLOW IN BULB
Iron nail	Glowed brightly
Glass rod	Did not glow
Rock	Did not glow
Graphite	Dull glow
Paper clip	Glowed brightly
Copper screw	Glowed brightly

Question 3

In Question 2, which materials had:

- High resistance?
- Medium resistance?
- Low resistance?

Question 4

Which circuit diagram represents the circuit shown in figure 3?

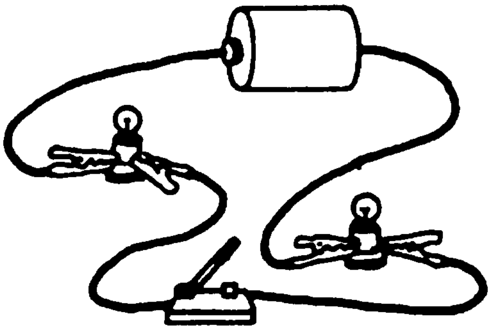
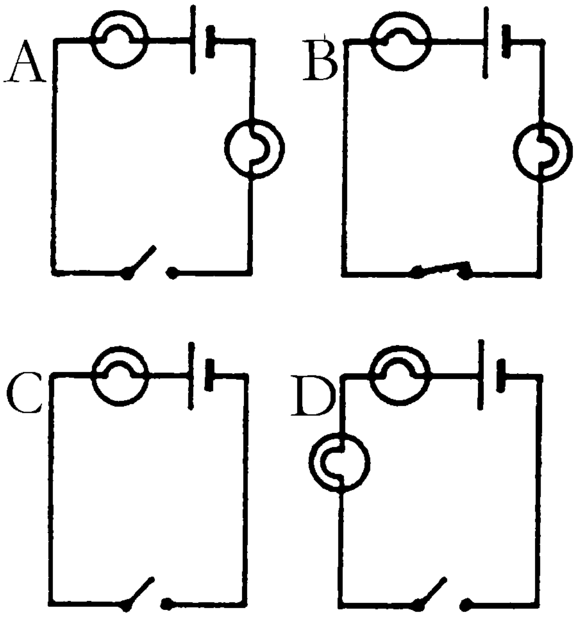


Figure 3



Question 5

Are the bulbs shown in figure 4 in series or in parallel?

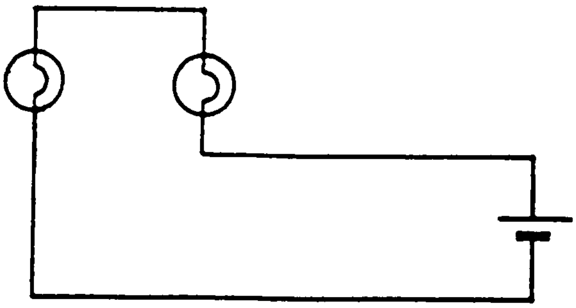


Figure 4

Question 6

State Ohms Law.

Question 7

What is the resistance of a 12-volt circuit carrying an electric current of 2 Amperes?

Question 8

In the electrical circuit shown in figure 4, each of the light bulbs in the circuit is of the same resistance. When S1 is closed and S2 is open,

- None of the bulbs light up
- Only G1 lights up
- Only G1 and G2 light up
- All the bulbs light up

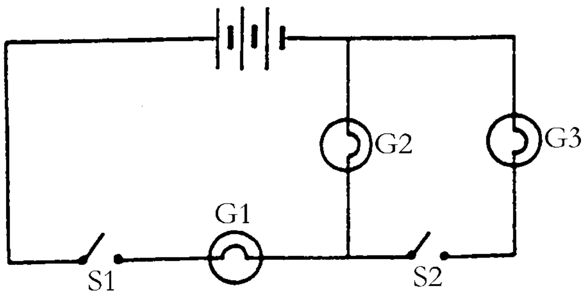


Figure 5

Question 9

The circuit diagram in figure 6 is part of a caravan's electrical circuit. If all the lights are turned on, and then the light over the bed is turned out, all the other globes will:

- Go out
- Glow a little more brightly
- Glow a little less brightly
- Remain the same.

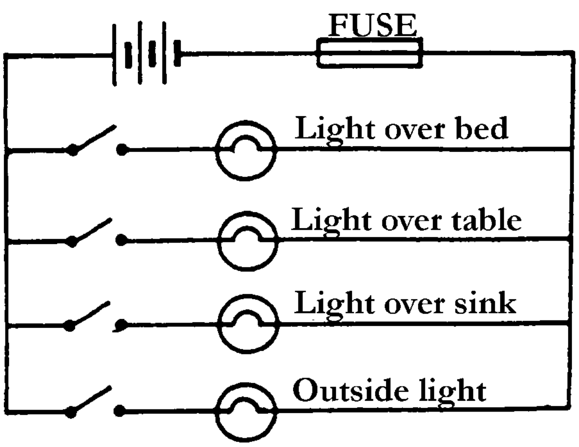


Figure 6

ANSWERS

Question 1

1 battery, the torch bulbs, 1 switch, 6 pieces of connecting wire plus alligator clips.

Question 2

Conductors	**Insulators**
Iron nail	Glass rod
Paper clip	Rock
Copper screw	
Piece of graphite	

Question 3

Iron nail	low resistance
Glass rod	high resistance
Rock	high resistance
Piece of graphite	medium resistance
Paper clip	low resistance
Copper screw	low resistance

Question 4

Answer: A.
B: Switch is open instead of closed
C: Bulb missing
D: Switch in wrong position

Question 5

In series.

Question 6

The electric current in a circuit depends on the electrical resistance in the circuit and the voltage. **V=IR**

Question 7

R =V/I
=12 volts / 2 amperes
=6 ohms

Question 8

Only G1 and G2 light up. When S1 is closed and S2 is open, current flows through the left hand part of the circuit *(G1 and G2)*, but not the right hand part *(G3)*.

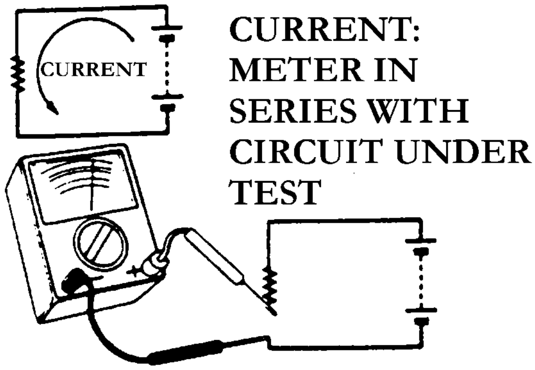
Question 9

They remain the same. Because the lights are connected in parallel, the voltage drop is the same across all the lights, no matter how many are turned on. Therefore each bulb will glow with the same brightness. *(They would glow less brightly only if the lights were in series.)*

How to use your multimeter

Setting it up

When you buy a multimeter, it is seldom ready for use. Almost always, batteries must be fitted, and in some cases, there is a protective wire link across the meter to remove. Read the instruction manual carefully, and carry out any steps described. A word of caution: most meters are supplied with batteries, but sometimes these are not the best. As a meter is left unused for long periods, it is a wise investment to buy some fresh, well-known brand batteries.
Your multimeter will have a large scale area, a knob surrounded by figures, a small



knob marked ‘Ohms adjustment’ or similar, and at least two terminals. If there are more than two terminals, look for the ones marked ‘+’ and ‘-‘, or ‘V-A-OHMS’ and ‘common’. In many meters, these terminals will be coloured red and black respectively.
Plug your test leads into the terminals: red into the red or ‘+’ terminal, black into the black or ‘-‘ terminal. Turn the knob to one of the ‘Ohms’ ranges and short the ends of the test leads *(or ‘probes’)* together. The pointer should move at least part way up the dial, perhaps right to the end and past it. If it does, your meter is ready for work

What scales have you?

Most multimeters *(even the real budget models)* give you at least four different measurement options: DC voltage, DC current, AC voltage, and Ohms. These are further divided into different ranges, to give more flexibility. The more expensive meters may also offer AC current measurement and possibly other functions too.
Each of the ranges is represented by a scale shown on the meter face, although many of the scales may be shared. For example, you might read 0 – 2.5 mA on the same scale as you read 0 – 250 mA and 0 – 250 volts. These scales are linear and thus the divisions between markings remain constant. All you have to do is apply the right ‘units’ to the scales to work out the exact figure: these units are given to you alongside the pointer on the ‘range’ switch.
There might also be a strip of mirror on the scales. The purpose of this is the allow you to line up the pointer with its reflection, thus eliminating ‘parallax’ errors (errors caused by reading the pointer from an angle.)
There may also be other ranges marked on the scale, which are obtained by using different terminals from the normal ones. An example would be a 0.1V *(50 uA)* DC terminal and a 1000V AC terminal, which are not affected by the ‘range’ switch. These special terminals are connected directly to the meter in some cases, and must be used with extreme care.

Measuring DC current

The important thing to remember when measuring current is that the meter must be placed in **series** with the circuit. This means that the circuit must be broken, with the meter leads connecting the two sections together.
Normally a circuit is broken by unsoldering a wire or component. Unfortunately, this is not always possible. For instance, if you want to know the current flowing through a certain PCB track, you must break the track *(shudder!)* to include the meter in series. This can usually be done by cutting the track at a narrow point with a very sharp blade. When the measurement is finished, solder can be flowed over the knife to restore the connection. *(You might even need to put in a small piece of hookup wire to assist the connection.)*
When measuring current, start with your meter on the highest range and work down. Stop when the pointer moves reasonably high up the scale.
It is also important that the probes are connected in the correct polarity. The red probe is connected to the more positive side of the circuit and the black probe is connected to the more negative side.
If you find the pointer swings the wrong way, reverse the probes.

Measuring AC current

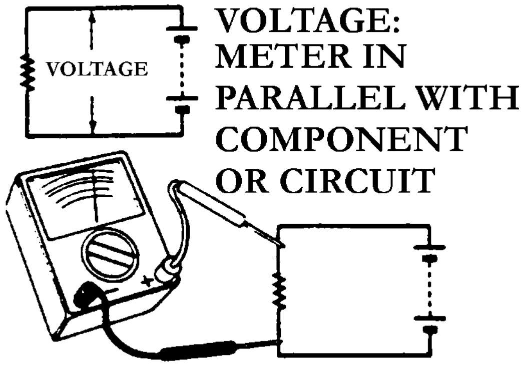
Your meter may not have provision for AC current measurement, particularly if it is an economy type. If it does, measurement is basically the same as for DC except there is no need to worry about polarity. Once again, start with a high range and work down to the correct one.

Measuring unknown current

If you don't know whether AC or DC is flowing in the circuit, don't worry. If the meter is set on DC, and you have AC flowing, both halves of the cycle will tend to cancel each other out. Your pointer may 'shudder' a little. If you are trying to measure DC on an AC scale, nothing will happen if the current is steady. If the current is varying, there will be some reading, but it will be erroneous.

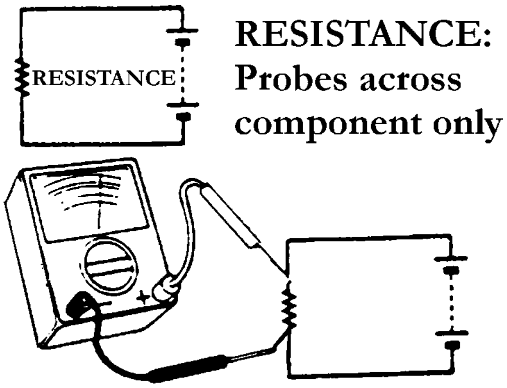
Measuring DC Voltages

Measuring voltages is exactly the opposite to measuring current: the meter is placed in parallel with the circuit or component being measured. Once again, however, polarity must be observed, with red *(positive)* to the positive side of the circuit and black *(negative)* to the negative.
Again, if you don't know the voltage, start on the highest and work down.



Measuring AC Voltages

It's just the same as measuring DC voltages just follow the same steps and remember that the meter must be placed in parallel.
A word of explanation here about what the meter actually reads. As you know an AC wave starts at zero, rises to a peak, falls back to zero, and then does the same thing in the other direction during one cycle.
A moving coil meter *(as 99% of multimeters are)* indicates what is called the 'rms.' value of the voltage. This value, which stands for 'root mean square' is more or less an average, taking into account the fact that the voltage is always changing.
The 'rms.' voltage has exactly the same 'work value' as a DC voltage of the same magnitude. In other words, if you supplied an electric heater with 240 volts rms, and then 240 volts DC, the heater would give out the same heat in both cases.
If you want to convert the 'rms.' value your meter reads to the 'peak' value *(the maximum voltage reached in the cycle)* you have to multiply by 1.4142. Conversely, the rms. voltage is 0.7071 of the peak voltage.



Measuring resistance

When measuring resistance, it is important that the component you are reading is not affected by other components in the circuit. There is no point measuring a resistor when there is another resistor in parallel that is interfering with the reading.
Therefore it is normal practice to remove one end of the component under test from the circuit to avoid any possible influence. Another wise move, even if you disconnect one end of the component, is to make sure power to the circuit is turned off.

Before commencing measurement *(and each time you change resistance ranges)* you must ‘zero’ the meter. This involves adjusting the knob on the meter so that the pointer reads exactly zero Ohms when the probes are shorted together.
Select the lowest resistance range and zero the meter. Then place your probes across the resistor *(or other component you are testing)*. If the pointer doesn’t move *(or barely moves)* switch up to the next range, and the next, until the pointer is in the last third of the scale. This is the area where the best reading accuracy is obtained.
If the pointer reaches, or over-shoots zero, back off one range. Re-zero the meter and then read the value from the ‘Ohms’ scale. Multiply the reading from the scale by the multiplier indicated by the knob. For example, if you read 15 on the scale and the knob points to ‘x100’ then the actual resistance is 15 x 100 or 1.5k.

Checking transistors and diodes

While not a perfect check, a multimeter can usually give you a ‘go/no go’ test on most diodes and small signal transistors. Testing power transistors is not quite so simple as the results can be misleading.

Checking diodes

This is very easy. A diode should conduct in one direction only. Set your multimeter to a low Ohms range *(say x10)* and place your probes on each end of the diode, take the reading, then reverse the probes. In one direction the reading will be high and in the other it will be low. If this is the case, then basically the diode is ok.
Zener diodes can also be checked the same way. You can’t tell their voltage, but you will at least have a go/no go indication.

Testing transistors

Because transistors are basically two diodes in one package, we can check them in a similar way to diodes. We can also check for ‘punch through’ from collector to emitter.
Switch to a low Ohms range *(e.g. x10)* and connect the probes to the emitter and collector. Read the meter, reverse the probes, and read the meter again. Both should be high. If so, continue. If not, you should probably throw the transistor away!
Switch to a high *(x1000)* range, and connect one of the probes to the transistor’s base. Connect the other probe to the emitter, then collector, noting the readings. Both readings should be roughly the same; high or low, it doesn’t matter, but remember which.
Now swap the probe on the base with the other, and do the same check. The readings should still be roughly the same, but opposite to the last check. If the last readings were both high, these should both be low, and vice versa.
If these tests are ok, the transistor is also probably OK. By the way, you can work out whether your transistor is NPN or PNP with these checks: with the black lead on the base and the readings low, the transistor is NPN type. With the red lead on the base and both readings low, the transistor is PNP type.

Point to remember

- Meter in series for current
- Meter in parallel for voltage
- Meter across component only when measuring resistance
- Start on the highest range and work down
- Zero the pointer when changing to any resistance range.
- Replace the batteries if you cannot zero pointer
- Use the mirrored scale to avoid parallax errors
- Swap the probes if the pointer swings backwards
- Take care of your meter!

What's inside a multimeter?

As you can see, the multimeter is very versatile. But do you know how it performs all those functions?
The heart of the multimeter itself is the meter movement itself. This consists of a coil of wire, suspended on an axle, in a magnetic field from a permanent magnet. If a current passes through the coil, another magnetic field is set up. The two fields repel each other, *(just like two magnets can repel each other)*, and the coil tries to move.
The only way a coil can move is to rotate on its axle. Attached to the axle are a spring, and a pointer that can move over a scale. Because of the spring, the amount of rotation of the coil will vary precisely with the amount of current flowing through the coil. So the scale can be graduated directly in units of current.
The current through a coil is, however, very small. In a modern multimeter it takes just 50uA to make the pointer travel from one end of the scale to the other. This is called the full scale deflection, or 'fsd.'
Obviously, a multimeter can measure a lot more than 50 uA. Many meters measure up to 10A – 200,000 times as much.
Remember, if two resistors are connected in parallel, the current divides up in inverse proportion to their resistance. Exactly the same happens in a multimeter. The switch connects various resistors in parallel with the coil so that the current between the coil and resistors divides. An average multimeter has a coil resistance of 2000 Ohms. If a 2000 Ohm resistor was connected in parallel, the meter would read full scale when 100uA was flowing. If a 0.1005 Ohm resistor was connected in parallel, the meter would read full scale with a current of 1 amp flowing.
The resistors switched in parallel with a meter are called 'shunts' – they shunt most of the current past the meter.
How about voltage? A meter measures current, but the coil has a certain resistance, so from Ohm's law we know that to make this current flow a certain voltage has to be applied to the coil. With a 2000 ohm movement, it takes just 0.1V to make 50uA flow *(for fsd).*
It follows that if we add more resistors in series, it will take more and more voltage to maintain that same 50uA current.
If we added a 2000 ohm resistor in series, the voltage would divide across each 'resistance' so that there was still 0.1 volts across the movement with 0.2 volts applied. So the meter would read full scale. If we connected a 1,998,000 ohm

resistor in series, we could apply 100 volts to the meter, and it would still only read full scale.
Of course, the pointer doesn't have to swing all the way; a lesser voltage will give us a lesser swing. So we can calibrate the scale directly in volts, with the maximum voltage being what that series resistor will allow for exactly full scale deflection.
The resistor in series is called a 'multiplier' as it obviously multiplies the voltage required for full scale deflection.

Measuring resistance

A meter switched to the 'Ohms' scale is basically still a voltmeter, the difference being that the voltage which drives the movement comes from internal batteries rather then the circuit under test. *(Note that a multimeter needs batteries only for resistance measurement – they can be removed completely for current and voltage.)*
As the battery voltage remains constant, any resistance that is introduced in series with the meter will reduce the current flowing, thus reducing the reading. The scale is calibrated directly in Ohms, and must be multiplied by the figure indicated by the switch pointer. The switch selects different multipliers so that very wide ranges of resistance can be measured.
We mentioned previously the 'zero Ohms' adjustment. All this does is 'fine tune' the multiplier so that effects of battery voltage and component aging can be countered. If the 'zero Ohms' control cannot bring the pointer to the zero mark, then the battery should be replaced.

Meter sensitivity

All meters 'load' the circuit being measured. By this we mean that the circuit or component is affected by the current taken from the circuit to drive the meter movement – small though it is. For minimum loading, the 'sensitivity' of the meter should be as high as possible.
Sensitivity is quoted in 'Ohms per volt': in general, the higher the better. A modern multimeter would have a sensitivity of around 20,000 ohms per volt DC *(more than enough for the average hobbyist use)*.
What this means is that on each DC voltage range, the circuit 'sees' the meter as a resistor having a value of 20,000 times the full scale voltage of the range. On a 1 volt range it would be equivalent to a 20,000 ohm resistor; on a 100 volt range it would be equal to a 2,000,000 ohm resistor, over the entire range.
AC sensitivity is always lower than DC: 7 to 10 thousand Ohms per volt is typical. This is adequate for the hobbyist.

Understanding component values:

The decimal point has almost been abolished from electronic assembly documentation, as the dot was so small it often disappeared during printing. It has been replaced by a letter,

e.g.	5V	-	5 volts
	5A	-	5 amps
	5W	-	5 watts
	5V6	-	5.6 volts
	5A6	-	5.6 amps
	5W6	-	5.6 watts

Unfortunately, there is not a letter in our alphabet that stands for Ohm, but we're all quite used to seeing a capital R for resistance. In the past, and still sometimes today, the Greek letter omega *(Ω)* was used, but due to problems of printing, the capital R is used for resistance as well as for ohms.

4R7	-	4.7 ohms
3R2	-	3.2 ohms
100R	-	100 ohms

Resistors often have values of thousands and millions of ohms. Therefore there are a number of letters that stand for multiples of the basic unit.

They are:

T (Tera) = 1,000,000,000,000 (10^{12})

G (Giga) = 1,000,000,000 (10^{9})

M (Mega) = 1,000,000 (10^{6})

k (kilo) = 1,000 (10^{3})

m (milli) = 1/1,000 (10^{-3})

μ or u (micro) = 1/1,000,000 (10^{-6})

n (nano) = 1/1,000,000,000 (10-9)

p (pico) = 1/1,000,000,000,000 (10^{-12})

Basic colour codes

It is often impractical to write the value of a resistor on the outside of its case. Therefore coloured bands around the case of the resistor are often used to indicate the value of resistance. These bands are easy to read and can be seen from virtually any angle. Each colour represents a particular number. The basic colour codes are:

Black band	0	Green band	5
Brown band	1	Blue band	6
Red band	2	Violet band	7
Orange band	3	Grey band	8
Yellow band	4	White band	9

The first two coloured bands will give the first figures in the resistance value. For example:

Red band – violet band gives 27

Green band – blue band gives 56

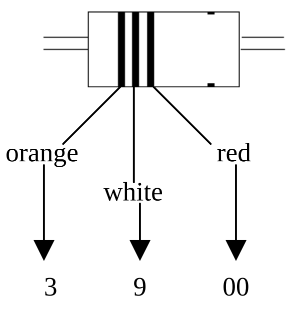
The third coloured band will give the number of zeros to be counted after the second colour. It must be noted that gold and silver are sometimes used as the third colour. Gold multiplies the first two numbers by 0.1 and silver by 0.01. For example:

Red band – violet band – brown band gives 270 Ohms

Green band – blue band – yellow band gives 560000 Ohms

Brown band – grey band – gold band gives 1.8 Ohms

The value of a resistor can now be determined from its coloured bands. An example is shown below:



giving 3900 Ohms or 3.9kΩ.

You may have noticed a 3.9 kΩ resistor written as 3k9. This abbreviation is now widely used in electronics. The engineering prefix symbol is used to replace the decimal point. For example:

2.2 MΩ = 2M2

3.3 kΩ = 3k3

4.7Ω = 4R3

A fourth band, if present, will indicate the maximum error tolerance that can be expected for that value of resistor. The main fourth band colours are:

Brown ± 1%

Red ± 2%

Gold ± 5%

Silver ± 10%

None ± 20%

The colour codes above are found on the most common series of resistors known as the E12 series. The name of the series takes its name from the number of possible values the first two colours can have.
For the E12 series, values are: 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82.

Philips film resistors

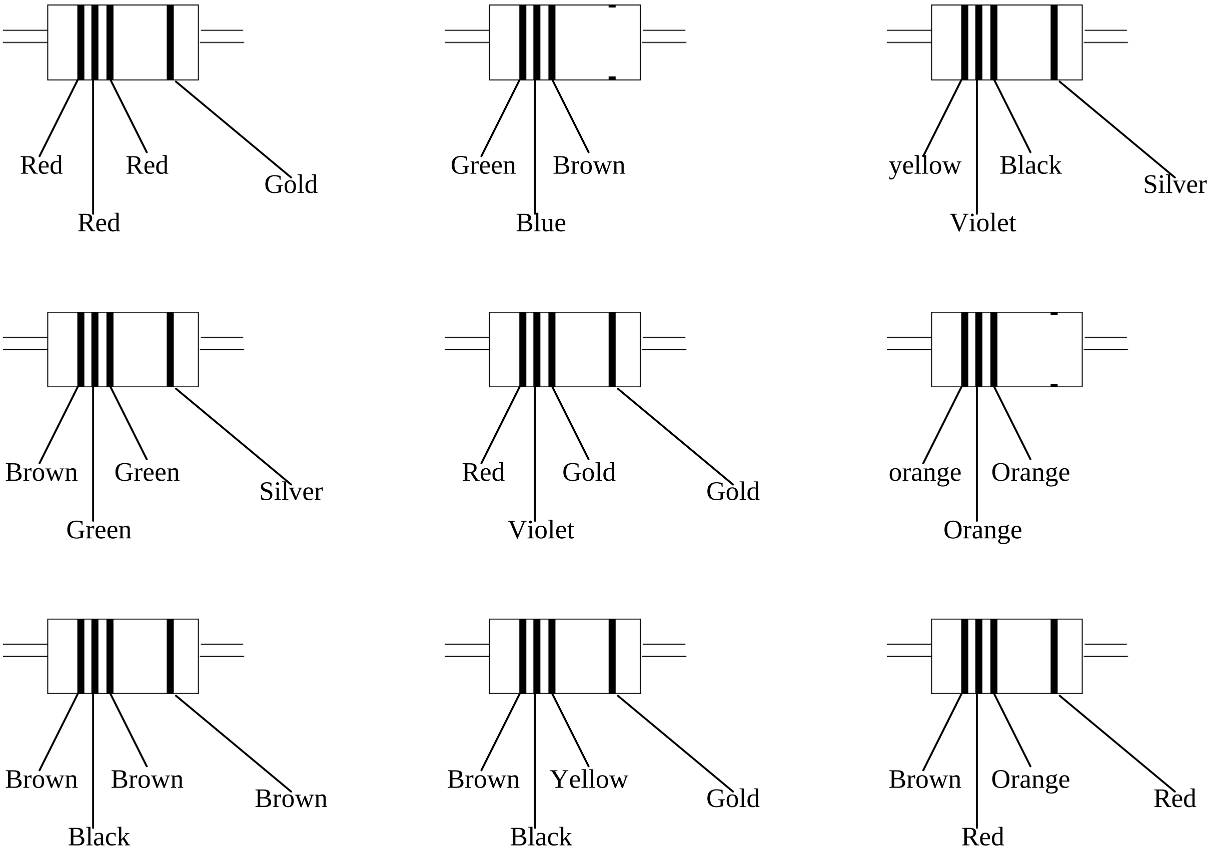
Philips offer a range of high precision film resistors with tolerances as low as 0.1%. In these cases the third coloured band gives a third value, the fourth band gives the multiplier or number of zeros, and a fifth band gives the tolerance. A sixth band, in precision metal film resistors, will give the temperature coefficient. For example, a Philips resistor has the colour coding:

Brown	red	yellow	brown	brown
1	2	4	0	1%

Or 1240 Ω ± 1% ≡ 1.24 kΩ ± 1%

Exercise

Determine the values of resistance and tolerance for the resistors below.

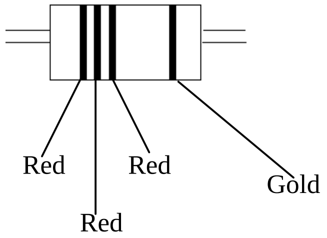


Complete the following table:

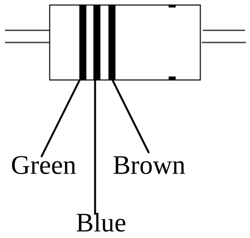
1st colour	2nd colour	3rd colour	4th colour	Value
Red	Violet	Red	Gold	2k7 ± 5%
				330k ± 10%
				47R ± 2%
				15k ± 20%

Answers

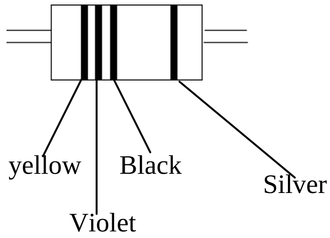
Determine the values of resistance and tolerance for the resistors below.



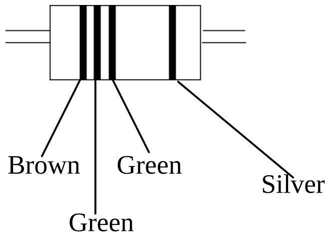
2,200 R or 2k2 ± 5%



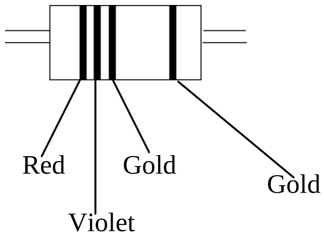
560 R ± 20%



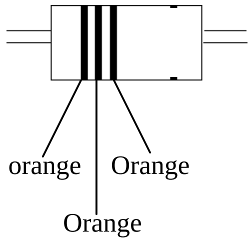
47 R ± 10%



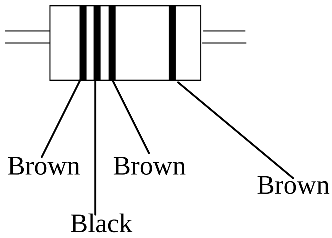
1500000 R or 1M5 ± 10%



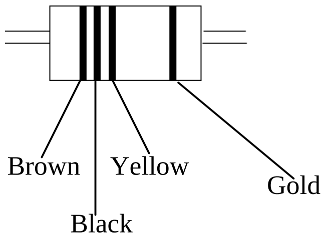
2.7R or 2R7 ± 5%



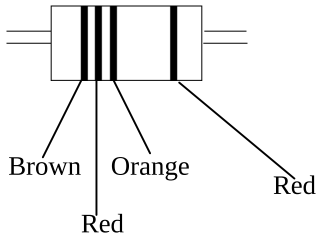
33000 R or 33k ± 20%



100 R ± 1%



100,000 R or 100k ± 5%



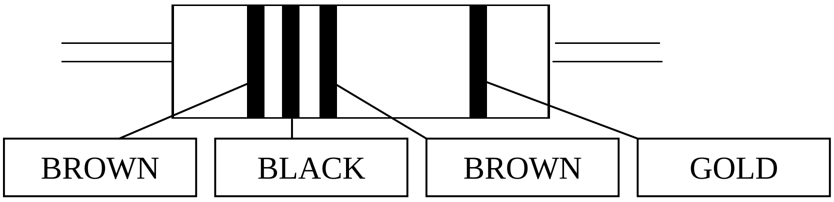
12000 R or 12k ± 2%

Complete the following table:

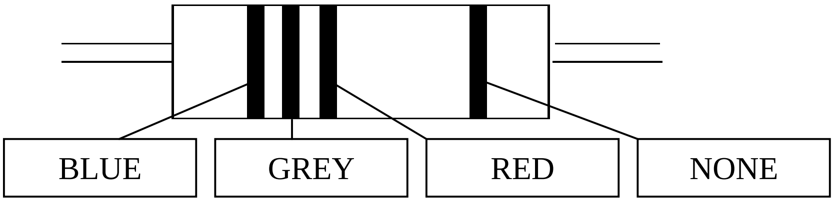
1st colour	2nd colour	3rd colour	4th colour	Value
Red	Violet	Red	Gold	2k7 ± 5%
Orange	**Orange**	**Yellow**	**Silver**	330k ± 10%
Yellow	**Violet**	**Gold**	**Red**	47R ± 2%
Brown	**Green**	**Orange**	**None**	15k ± 20%

Resistor Colour Code Practice

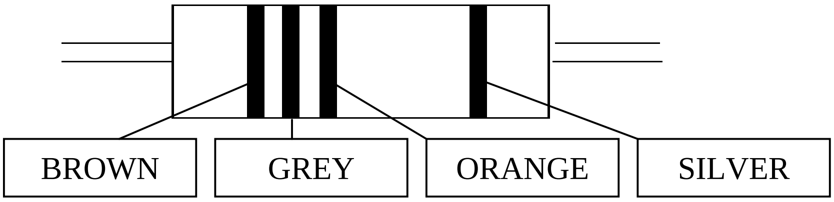
To learn the resistor colour code, there's no substitute for practice. Shown below are the codes for common resistors you'll be using in the laboratory. When you can write any resistor's value from its code without looking at your chart, you'll have achieved a major objective of this lesson.



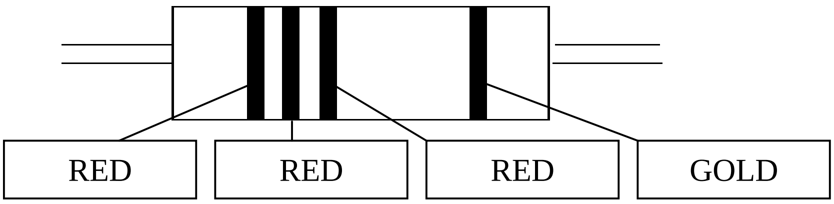
A) __________±___



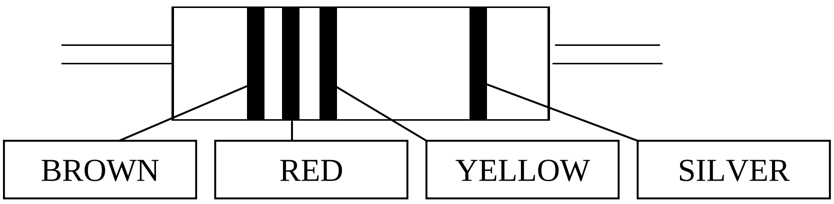
B) __________±___



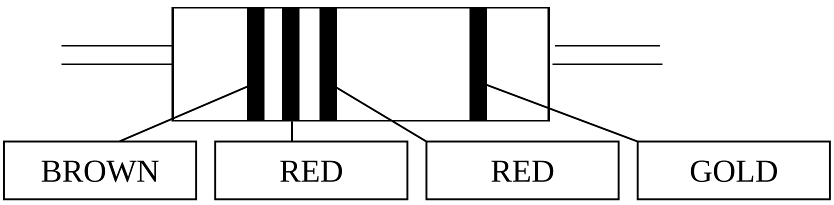
C) __________±___



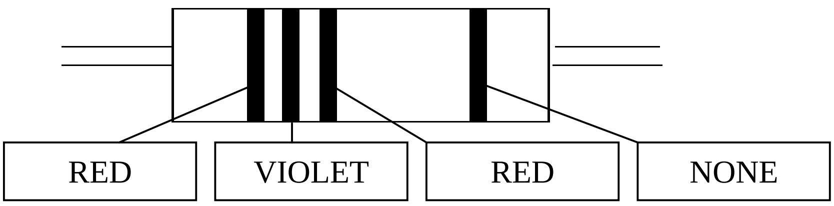
D) __________±___



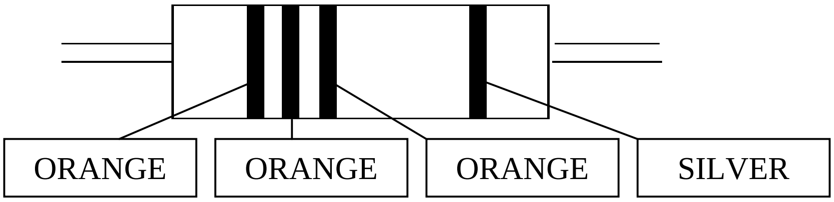
E) __________±___



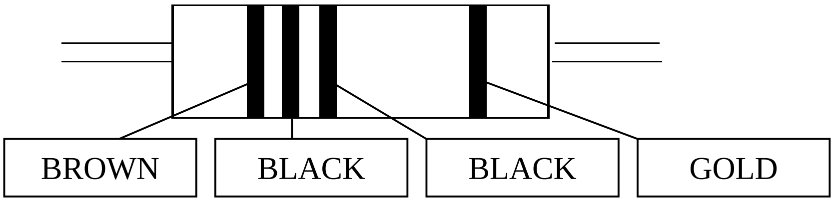
F) __________±___



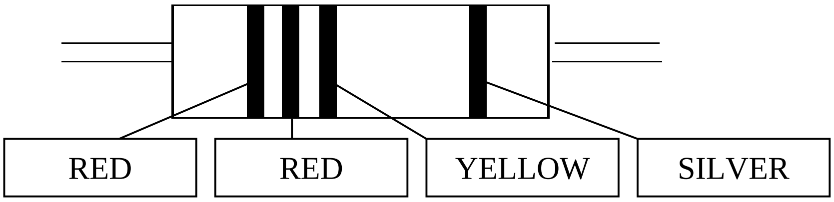
G) __________±___


ORANGE
ORANGE
ORANGE
SILVER

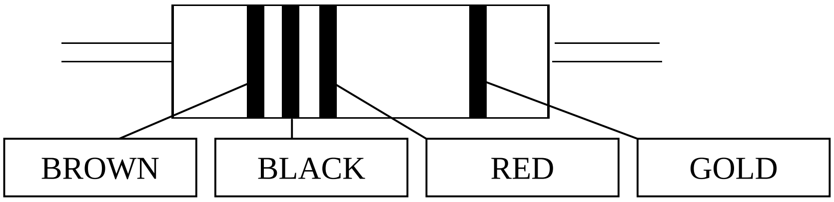
H) __________±___


BROWN
BLACK
BLACK
GOLD

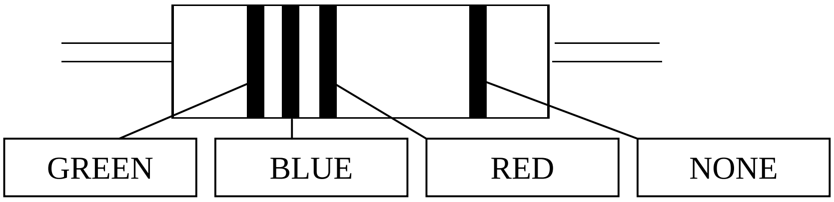
I) __________±___


RED
RED
YELLOW
SILVER

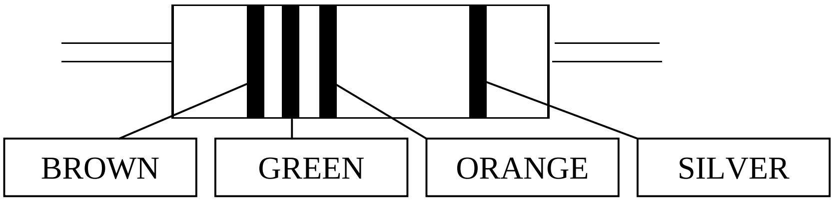
J) __________±___


BROWN
BLACK
RED
GOLD

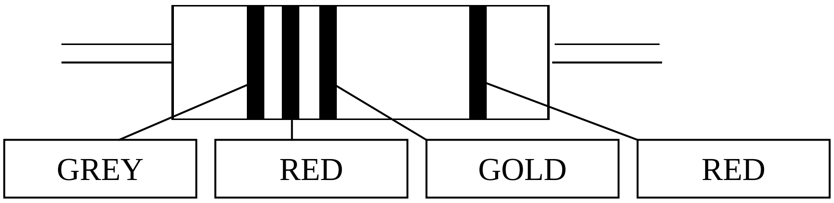
K) __________±___


GREEN
BLUE
RED
NONE

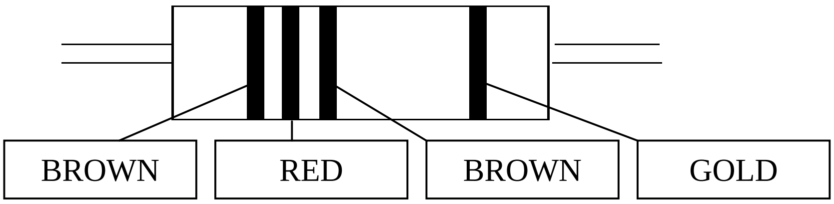
L) __________±___


BROWN
GREEN
ORANGE
SILVER

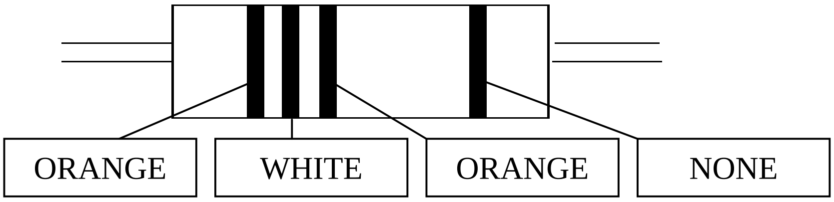
M) __________±___


GREY
RED
GOLD
RED

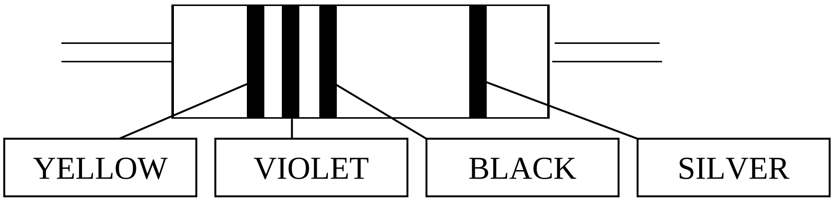
N) __________±___


BROWN
RED
BROWN
GOLD

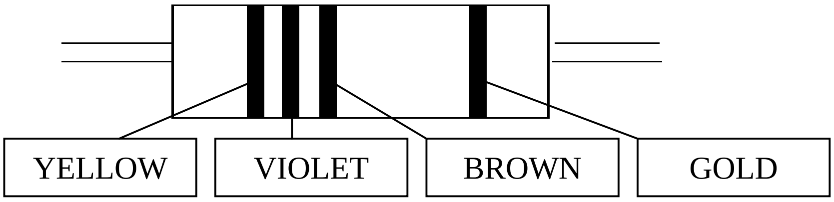
O) __________±___


ORANGE
WHITE
ORANGE
NONE

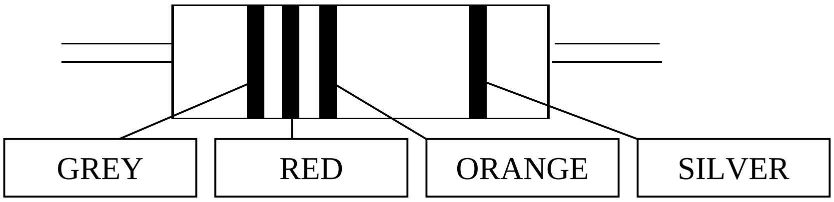
P) __________ ± ___


YELLOW
VIOLET
BLACK
SILVER

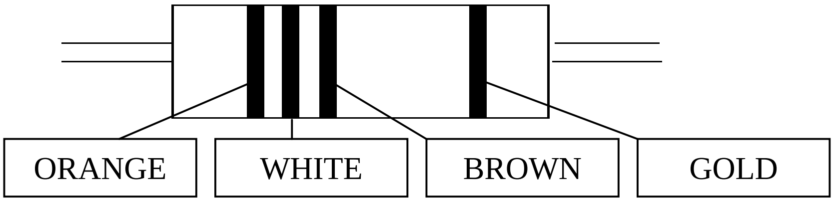
Q) __________ ± ___


YELLOW
VIOLET
BROWN
GOLD

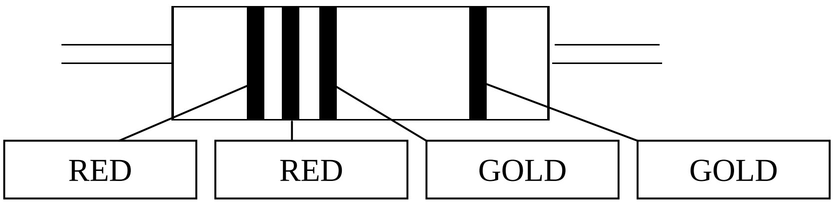
R) __________ ± ___


GREY
RED
ORANGE
SILVER

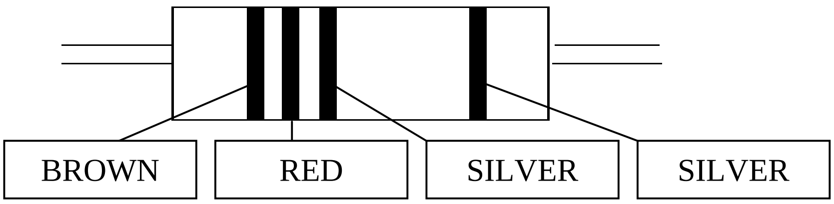
S) __________ ± ___


ORANGE
WHITE
BROWN
GOLD

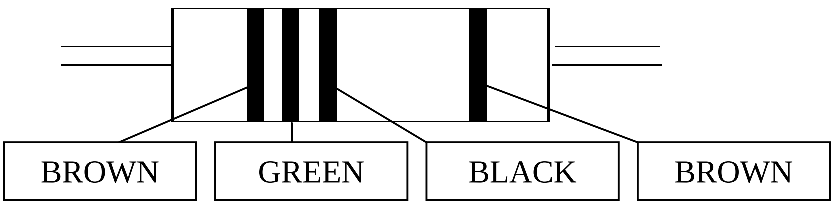
T) __________ ± ___


RED
RED
GOLD
GOLD

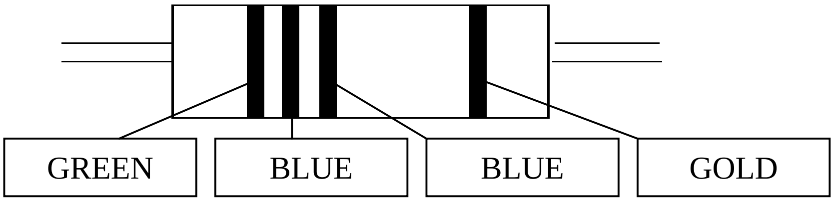
U) __________ ± ___


BROWN
RED
SILVER
SILVER

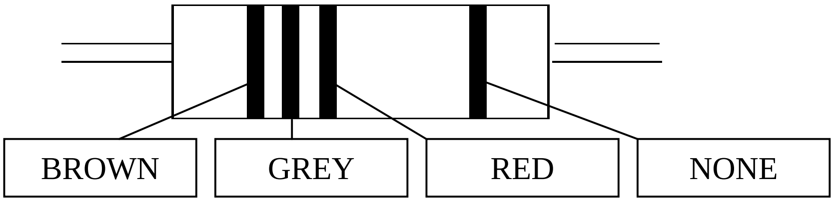
V) __________ ± ___


BROWN
GREEN
BLACK
BROWN

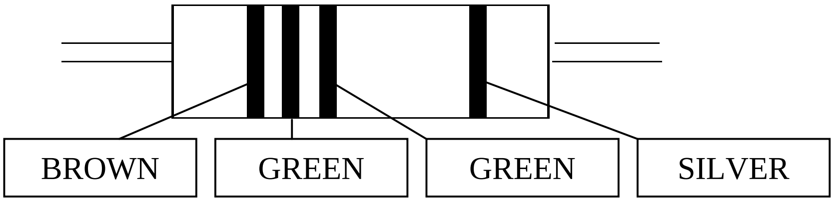
W) __________ ± ___



X) __________±___



Y) __________±___



Z) __________±___

Which of these resistors are NOT part of the E12 series?

1.	3k3	2.	2k9	3.	16k	4.	150k
5.	2R5	6.	22R	7.	1M8	8.	140k
9.	3R9	10.	8k2	11.	5k6	12.	68k
13.	4k5	14.	120k	15.	27k	16.	3R5

Answers

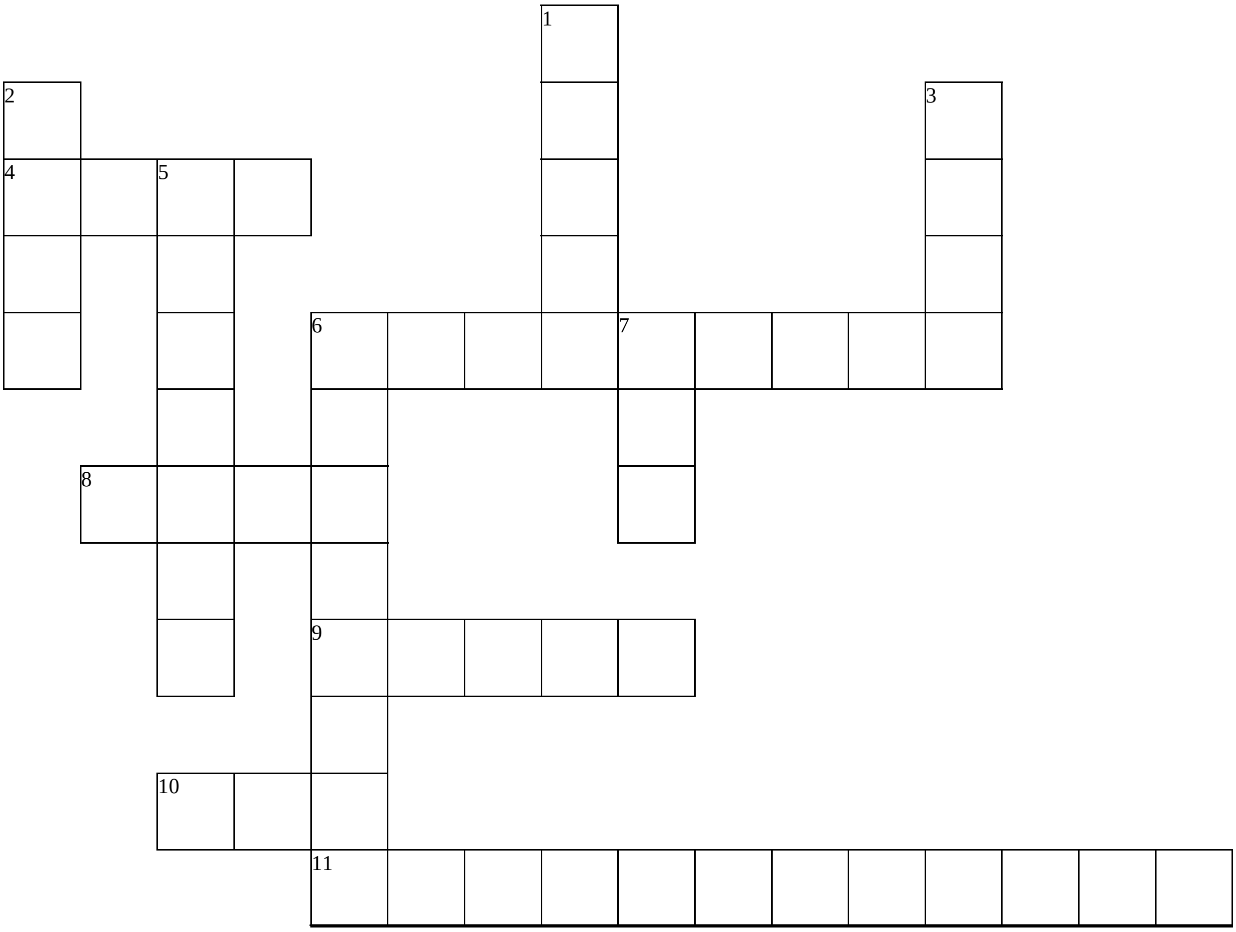
	Value	Standard Notation	
A.	100 R ± 5%	100 R	
B.	6,800 R ± 20%	6k8	
C.	18,000 R ± 10%	18k	R = single units
D.	2,200 R ± 5%	2k2	k = thousands
E.	120,000 R ± 10%	120k	M = millions
F.	1,200 R ± 5%	2k2	
G.	2,700 R ± 20%	2k7	
H.	33,000 R ± 10%	33k	
I.	10 R ± 10%	10 R	
J.	220,000 R ± 10%	220k	A letter always replaces
K.	1,000 R ± 5%	1k	the decimal point or,
L.	5,600 R ± 20%	5k6	where appropriate, the
M.	15,000 R ± 10%	15k	first comma. All zeros
N.	8.2 R ± 2%	8R2	after that comma are
O.	120 R ± 5%	120 R	dropped.
P.	39,000 R ± 20%	39k	
Q.	47 R ± 10%	47 R	
R.	470 R ± 10%	470 R	
S.	82,000 R ±10%	82k	
T.	390 R ± 5%	390 R	
U.	2.2 R ± 5%	2R2	
V.	0.12 R ± 10%	R12	
W.	15 R ± 1%	15 R	
X.	56,000,000 R ±5%	56M	
Y.	1,800 R ± 20%	1k8	
Z.	1,500,000 R ± 10%	1M5	

Which of these resistors are NOT part of the E12 series?

1.	3k3	**2.**	**2k9**	**3.**	**16k**	4.	150k
5.	**2R5**	6.	22R	7.	1M8	**8.**	**140k**
9.	3R9	10.	8k2	11.	5k6	12.	68k
13.	**4k5**	14.	120k	15.	27k	**16.**	**3R5**

E12 series resistors begin with: 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82. If a known E12 series resistor does not begin with one of these numbers, it is being read back to front or incorrectly.

How’s your resistance to Crossword Puzzles???



Across
4. Resistors are measured in ………..
6. The fourth band measures ……….
8. ‘k’ stands for ……..
9. The number value for violet is…..
1. A silver fourth band is ……..%
2. ‘M', ‘k’, ‘R', or ‘V' replaces the …………. / …….. (two words) for imperfect numbers

Down
1. The colour value for nine is……
2. The 5% tolerance colour is……
3. The number value for green is….
5. ‘M' stands for……..
6. ‘k’ stands for…..
7. Two is the number for this colour.

ANSWERS

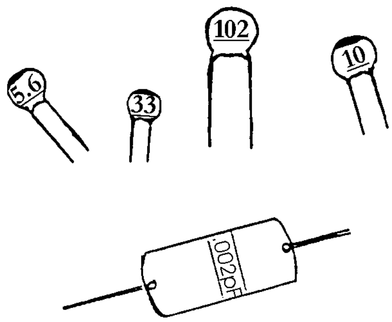
							[1]W								
[2]G							H					[3]F			
[4]O	H	[5]M	S				I					I			
L		I					T					V			
D		L		[6]T	O	L	E	[7]R	A	N	C	E			
		L		H				E							
	[8]K	I	L	O				D							
		O		U											
		N		[9]S	E	V	E	N							
				A											
		[10]T	E	N											
				[11]D	E	C	I	M	A	L	P	O	I	N	T

Capacitor Values

Large capacitors are marked in microFarads and indicate this by the abbreviations ‘uF’, ‘u’, or even the obsolete ‘MFD’. Smaller capacitors are marked in nanoFarads or picoFarads and may be abbreviated by ‘n' or ‘p'. If the value contains a decimal point the ‘u’, ‘n’ or ‘p’ is sometimes put in the place of the decimal point. Therefore a 4.7 pF capacitor can be marked as 4p7.
If no unit is given, a judgement based on the capacitor’s size must be made to determine which unit is intended. For example, a small ceramic capacitor marked ‘4.7’ is probably 4.7 pF, whereas a large plastic capacitor marked ‘4.7’ is more likely to be 4.7 uF. If the value is in ‘nF’ then this is invariably shown.
Another marking system uses two numeric digits to indicate the value in picoFarads. The first two digits represent the first two digits of the value, and the third digit is the multiplier or number of zeros. For example, a capacitor marked 104 would be read as 10 0,000. This would be formatted as 100,000 pF and would commonly be known as 100 nF or 0.1 uF. Likewise, a capacitor marked 472 would be 4700 pF, also known as 4.7 nF or .0047 uF.

Some common values and their possible markings:

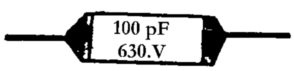
MicroFarads	**nanoFarads**	**picoFarads**	**EIA code**
0.0001 uF*	0.1 n*	100 pF	101
0.00022 uF*	0.22 n (n22)	220 pF	221
0.001 uF	1 n (1n0)	1,000 pF	102
0.0033 uF	3.3 n (3n3)	3,300 pF	332
0.01 uF	10 n	10,000 pF*	103
0.047 uF	47 n	47,000 pF*	473
0.1 uF (u1)	100 n	100,000 pF*	104
0.82 uF (u82)	820 n	820,000 pF*	824
1.0 uF	1,000 n*	1,000,000 pF*	105



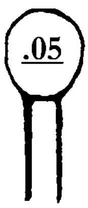
* not normally expressed in this form.

Typical disk ceramic capacitor marking:

P68	0.68 pF
1p2	1.2 pF
4p7	4.7 pF
10p	10 pF
22p	22 pF
82p	82 pF
n10	100 pF (1 nF)



Polystyrene



Ceramic

Capacitor Codes — Worksheet

The capacitor scale: 1 Farad = 1,000,000,000,000 picoFarads.
Or, 1 picoFarad is one million millionth of a Farad!

Farads	MilliFarads	MicroFarads	NanoFarads	PicoFarads
Decimal point .	000	000	000	000
	10-3	10-6	10-9	10-12
Symbol	mF	uF	nF	pF
Equivalents	1 mF =1000 uF = 1,000,000,000 pF	1 uF = 1000 nF = 1,000,000 pF	1 nF = 1000 pF	Basic units

Reading the codes

Number of picoFarads (value)	Usually written as MicroFarads	Standard notation on capacitor
1,000,000,000,000 pF 1,000,000,000 pF 1,000,000 pF 1,000 pF 1 pF	1 Farads 1,000 uF 1 uF 0.001 uF pF	1 F 108 (ten with eight zeros) 105 (ten electron five zeros) 102 (ten with two zeros) 1 pF
Examples 330,000 pF 20,000,000 pF 4,700 pF 680 pF 10 pF	 0.33 uF 20 uF 0.0047 uF 680 pF 10 pF	 334 (33 with four zeros) 206 (20 with six zeros) 472 (47 with two zeros) 681 (68 with one zero) 10 pF
You try 1 5,600,000 pF 2 ………….pF 3 12,000 pF 4 ……………. 5 …………….	 1 5.6 uF 2 0.022 uF 3 ……………. 4 ……………. 5 15 uF	 1. ……………. 2. 223 3. 123 4. 222 5. …………….

Answers

You try 1. 5,600,000 pF 2. **22,000 pF** 3. 12,000 pF 4. **22,000 pF** 5. **15,000,000 pF**	 1. 5.6 uF 2. 0.022 uF 3. **0.012 uF** 4. **0.0022 uF** 5. 15 uF	 1. **565** 2. 223 3. 123 4. 222 5. **156**

Applied electricity

A German scientist George Simon OHM discovered the relationship between applied voltage, current flow, and circuit resistance in 1827.
This is stated as OHMS LAW.

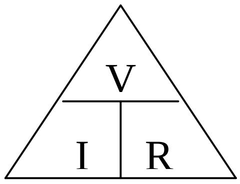
- the current (I) flowing in a circuit is directly proportional to the applied voltage *(V)*
- the current *(I)* flowing in a circuit is inversely proportional to its resistance.

i.e. Double the voltage and the current flow doubles.
Double the resistance and the current flow halves

This may be written:

$$I\ \textit{(Amps)} = \frac{V\ \textit{(Volts)}}{R\ \textit{(Ohms)}}$$

and $$R\ \textit{(Ohms)} = \frac{V\ \textit{(Volts)}}{I\ \textit{(Amps)}}$$



and $$V\ \textit{(Volts)} = I\ \textit{(Amps)} \times R\ \textit{(Ohms)}$$

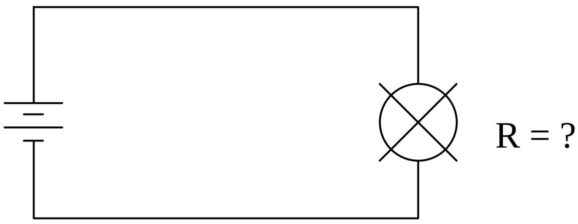
Example calculation

Problem: when a 1.5 V cell is connected to a bulb a current of 0.5 A flows.

What is the resistance of the bulb?

I = 0.5 A
V = 1.5 V
R = ?

$$R = \frac{V\ \text{(volts)}}{I\ \text{(amps)}} = \frac{1.5\ V}{0.5\ A} = 3\Omega$$



Research – learning about Ohm's Law

Question 1

In an electrical circuit that is connected to a 6 V battery powering a bulb of 0.5 ohms resistance, find out how much current is flowing. 2 marks

Question 2

When a heater is operating, 2 amps flows through the element. The unit is connected to 240 V. Find the resistance of the element. 2 marks

Question 3

Total resistance of a portable radio's circuit is 24 ohms. Current flowing through it is 0.25 amps. What voltage is required to operate the radio? 2 marks

Question 4

A 240 V appliance has an internal resistance of 12 ohms. What is the current? 2 marks

Question 5

In the country, a 32 V bulb uses a current of 0.4 of an amp. What is the resistance of the bulb? 2 marks

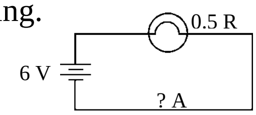
Draw a circuit diagram for each problem. Show all calculations. 10 marks total

Answers

Question 1

In an electrical circuit that is connected to a 6 V battery powering a bulb of 0.5 ohms resistance, find out how much current is flowing.

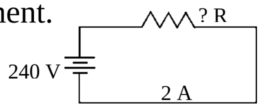
I = V / R = 6 / 0.5 = 12 amps



Question 2

When a heater is operating, 2 amps flows through the element. The unit is connected to 240 V. Find the resistance of the element.

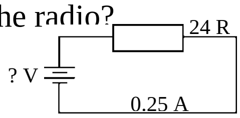
R = V / I = 240 / 2 = 120 R



Question 3

Total resistance of a portable radio's circuit is 24 ohms. Current flowing through it is 0.25 amps. What voltage is required to operate the radio?

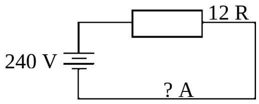
V = IR = 0.25 x 24 = 6 volts



Question 4

A 240 V appliance has an internal resistance of 12 ohms. What is the current?

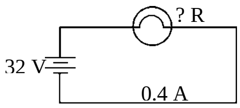
I = V / R = 240 / 12 = 20 amps



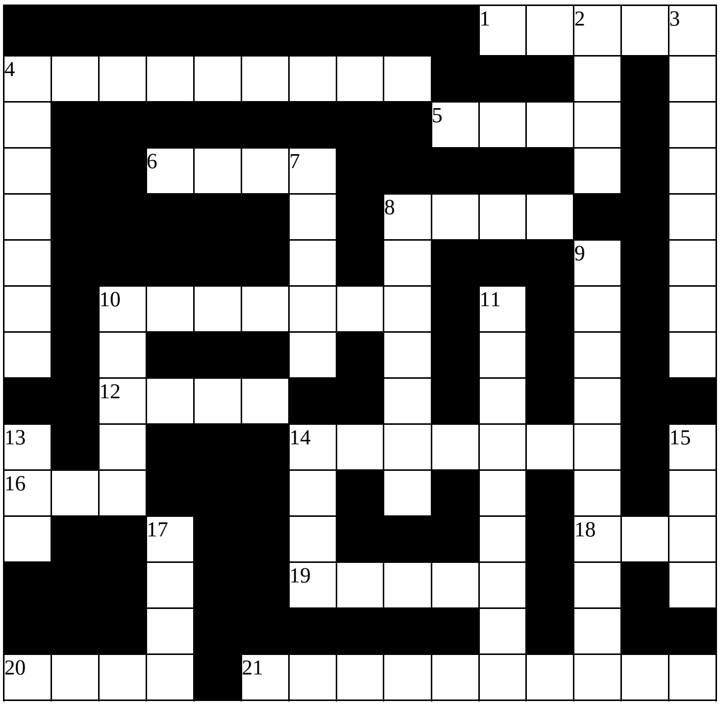
Question 5

In the country, a 32 V bulb uses a current of 0.4 of an amp. What is the resistance of the bulb?

R = V / I = 32 / 0.4 = 80 R



Crossword



Across

1. If you ………. the switch in a circuit, current will flow. (5)
4. This kind of material will allow current to flow through it. (9)
5. A switch could simply be a piece of …… (4)
6. A ………glows more brightly as more current flows through it. (4)
8. The value of a resistor is shown by coloured bands. Each one is called a …….. (4)
10. Unlike charges ……….. (7)
12. Current flow is measured in ……. (4)
14. A complete path for electrons to flow around is called a ……….. (7)
16. If the current flowing through a 6 across is reduced it becomes …….. (3)
18. Unit of electrical resistance. (3)
19. The amount of ……….. from a 6 across depends upon how much current is flowing through it. (5)
20. A 6 across will ……… when current flows through it (4)
21. Any …….. Device uses electricity (10)

Down

2. If you …….. the switch in a circuit, no current can flow. (4)
3. A tiny particle with a negative charge. (8)
4. An object with too many or too few electrons is said to be ……… (7)
7. If we create a ……. in a circuit, current will cease to flow. (5)
8. More than one 14 down connected together form a ……… (7)
9. Items such as calculators and digital watches are known as ……… devices (10)
10. An important application of a thermistor is in its use as a fire ……… (5)
11. An ………. will not allow current to flow through it (9)
13. A special kind of resistor whose value changes when light shines on it. (3)
14. This pushes charges around a circuit. (4)
15. A 14 down can be considered to be a kind of …… (4)
17. An electric current is a ……… of charge (4)

Answers

										[1]C	L	[2]O	S	[3]E
[4]C	O	N	D	U	C	T	O	R				P		L
H									[5]W	I	R	E		E
A			[6]B	U	L	[7]B						N		C
R						R		[8]B	A	N	D			T
G						E		A				[9]E		R
E		[10]A	T	T	R	A	C	T		[11]I		L		O
D		L				K		T		N		E		N
		[12]A	M	P	S			E		S		C		
[13]L		R				[14]C	I	R	C	U	I	T		[15]P
[16]D	I	M				E		Y		L		R		U
R			[17]F			L				A		[18]O	H	M
			L			[19]L	I	G	H	T		N		P
			O							O		I		
[20]G	L	O	W		[21]E	L	E	C	T	R	I	C	A	L

Mini Dictionary

Amp. Short for Ampère. The unit of electrical current named after a French mathematician and physicist.

Amplify. To make larger.

Battery. A number of cells (*see* Dry Cell) added together to produce a higher voltage.

Capacitor. A component which can be used as a small store or reservoir for current.

Carbon. A very common material used in making resistors. It is mixed with other materials to let more or less current pass through it.

Ceramics. Materials, like most china cups and saucers, which are excellent insulators, especially for high voltages.

Circuit. A combination of conductors and components that conduct and control current.

Components. The parts making up a circuit.

Conductor. A material that passes current with very little resistance.

Conventional Current Flow. The opposite to electron flow in a circuit. It was originally believed that a 'fluid' flowed from *(+)* to *(-)*. This idea was found to be incorrect when the electron was discovered. But it was too late to change the way we spoke about and described current flow. When talking about current flow, you must make it clear that you mean either electron flow *(-)* to *(+)* or conventional current flow: the assumption that something is flowing the other way.

Diode. A component that allows current to pass through it in only one direction.

Dry Cell. A chemical device for producing current. The chemicals are not really dry but in paste form. Where several are put together in series we have a battery.

Electron. Materials are made up of atoms and these in turn contain one or more electrons. When moving through conductors as electric current, you might think of electrons as dodgem cars bumping each other along.

Electronics. The subject concerned with the control of electrons in circuits.

Farad. The unit of capacitance. One Farad is too large a unit to use in electronics, so we use microFarads *(one millionth of a Farad)*, picoFarads *(one thousand millionth of a Farad)* and nanoFarads *(one million millionth of a Farad)*. Abbreviations uF, pF and nF respectively.

Flux. *See* Solder.

Graphite. A form of carbon which conducts current and behaves just like a resistor.

Heat Sink. Something for taking away unwanted heat. Pliers, for example, can be used as a heat sink during a soldering operation.

Insulator. A material that does not normally pass current. Glass and ceramic materials are excellent insulators and were used as such before plastics were developed.

LED. Short for Light Emitting Diode, a device that emits light when current flows through it in the right direction.

Matrix Board. A plastic board with regularly spaced holes to hold pins on which components are soldered. A matrix board can also be used as a drill jig for model making.

Membrane Panel. A type of switch made up of a sandwich of thin plastic layers, at least two of which are printed with conductors. When these very thin switches are pressed in the right place, conductors in different layers meet.

Ohm. The unit of resistance, named after the German, George Ohm.

Ohm's Law. The law of physics that states the relationship between current, voltage and resistance. If two of these are known, the third can be worked out using Ohm's Law.

Parallel. A method of connecting components together. When connected in parallel, two or more components are connected identically between the same points of a circuit. Two resistors connected in parallel, for example, can be placed side by side and their legs joined together at either end. These give two routes for the current to take and the total resistance they offer is less than either one alone.

PCB. Short for printed circuit board, a printed board having thin copper tracks for connecting components.

Polystyrene. A plastic material often used in sheet form for vacuum forming.

Resistor. A device which acts against current flowing freely. The wire element of an electric fire resists the flow of current and gets hot – as does the filament of a light bulb.

SCR. Short for Silicon Controlled Rectifier, a member of the thyristor family of components, generally used for controlling large currents. When triggered with a small current, the SCR turns on and continues to conduct until its current supply is interrupted.

Series. A method of connecting components together. They are connected in a line, like the carriages of a train. Resistors are often connected in series to reduce current flow. Two light bulbs connected in series to a battery will glow dimmer than just one, since two present more resistance to current than just one.

Snap. The clip that attaches to the top of some batteries.

Solder. The solder used in electronics work is usually an alloy, or mixture, of tin and lead, which has a low melting-point. As well as melting at a low temperature, it is made to go solid again after melting. It normally has a resin flux as fine threads in its centre *(multi-core solder)* which flows out over the hot joint to assist the solder fusing.

Surface Mounting (SM). A method of mounting components on PCBs. Both the copper connecting tracks and the components are placed on the same side of the board.

Switch. A component used in circuits for controlling current flow by allowing it to pass or preventing it, or altering the course it takes.

Symbol. In electronics a symbol is a 'picture' on paper that stands for a component.

Tinning. The application of a thin film of solder to metal surfaces to be joined by soldering. Tinning ensures all surfaces are coated and makes joining easier.

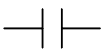
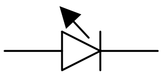
Transistor. A component, invented only in 1948, that can be used as an amplifier of current or as a switch. A small current to its base makes a larger current flow between collector and emitter.

Volt. The unit of voltage named after the Italian Volta. Until quite recently, voltage was often referred to as pressure.

Wire. A conductor, usually made of copper and wrapped with a PVC insulating sleeve. Two types are common in electronics. Stranded wire contains a number of fine copper wires which makes it flexible, and this is used for flying leads, battery connections, leads on appliances, etc. Single core wire has only one conductor. It is usually used for connections where the wire will not be moved.

Year 9 Science Electronics Test Home Room:_____ Name_______________________

TOTAL MARKS /40

1) Which two metals are always used to make solder? (2)
2) State the correct temperature setting for solder operations (1)
3) How long should it take to complete a good solder joint? (1)
4) Describe the solder process in three simple steps
   a) ____
   b) ____
   c) ____ (3)
5) Draw a diagram to show that you recognise the appearance of the following: (2)
   a) Camel back mounting
   b) Semi-clinched termination.
6) Why are ‘camel backs’ used to mount components? (1)
7) Which pliers would you use to bend a standard 90° mounted resistor? (1)
8) Identify the following component outlines:
   a) 
   b) 
   c)  (3)
9) identify the following circuit symbols:
   a) 
   b) 
   a)
   c) 
   (3)
10) What does the term ‘polarised’ mean when referring to electronics components? (1)
11) How do you recognise the polarity of the following components?
   a) An LED
   b) An electrolytic capacitor
   c) A diode
   d) A resistor (4)
12) What is an LED? (1)
13) What is the main function of a capacitor? (1)

14) What are the units of:

a) Resistance

b) capacitance

c) voltage

d) current (4)

15) Name one function of an integrated circuit (IC) (1)

16) What values would the following resistor codes stand for?

a) Red, red, red, gold.

b) Yellow, violet, orange, silver.

c) Brown, black, black, none.

d) Green, grey, gold, gold. (4)

17) Give the colour code for the following resistors:

a) 3k3 ± 10%

b) 100R ± 5%

c) 56k ± 20% (3)

18) What value would the following capacitor codes stand for (give units)?

a) 104

b) 222 (2)

19) Give the correct code for the following capacitor values;

a) 1 microFarad

b) 33000 picoFarads (2)

20) How well do you think you went in this test? (score yourself between 1 and 10)

Answers TOTAL MARKS /40

1) Which two metals are always used to make solder? **Tin, Lead** (2)

2) State the correct temperature setting for solder operations **365°C / 700°F** (1)

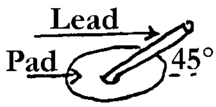
3) How long should it take to complete a good solder joint? **4 seconds** (1)

4) Describe the solder process in three simple steps

   a) **Heat the pad and lead – 1 sec**
   b) **Feed ½ cm solder onto joint – 1 sec**
   c) **Remove solder, hold soldering iron on for 2 secs** (3)

5) Draw a diagram to show that you recognise the appearance of the following: (2)

   a) Camel back mounting 

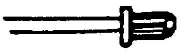
   b) Semi-clinched termination. 

6) Why are 'camel backs' used to mount components?

   To relieve stress where the lead enters the component <u>OR</u> to relieve stress on the bends in the lead.

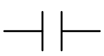
7) Which pliers would you use to bend a standard 90° mounted resistor? **Flat nosed pliers.** (1)

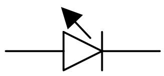
8) Identify the following component outlines:

   a) **Resistor** 
   b) **Diode** 
   c) **LED**  (3)

9) identify the following circuit symbols:

   a) **Battery** 

   b) **Capacitor** 

   c) **LED** 

(3)

10) What does the term 'polarised' mean when referring to electronics components? (1)

    The component has positive and negative leads.

11) How do you recognise the polarity of the following components?

    a) An LED **Short lead or flat on rim is negative.**
    b) An electrolytic capacitor **An arrow points to negative.**
    c) A diode **A white / silver / black band at the negative end.**
    d) A resistor **Does not have any polarity.** (4)

12) What is an LED? **A light emitting diode.** (1)

13) What is the main function of a capacitor? **To store charge (electricity)** (1)

14) What are the units of:

a. Resistance **Ohms**
b. Capacitance **Farads**
c. Voltage **Volts**
d. Current **Amps** (4)

15) Name one function of an integrated circuit (IC) (1)

Amplifying, timing, switching, counting, rectifying, thousands more

16) What values would the following resistor codes stand for?

a. Red, red, red, gold. **2,200R ± 5% or 2k2 ± 5%**
b. Yellow, violet, orange, silver. **47,000R ± 10% or 47k ± 10%**
c. Brown, black, black, none. **10R ± 20%**
d. Green, grey, gold, gold. **5.8R ± 5% or 5R8 ± 5%** (4)

17) Give the colour code for the following resistors:

a. 3k3 ± 10% **orange, orange, red, silver.**
b. 100R ± 5% **brown, black, brown, gold.**
c. 56k ± 20% **green, blue, orange, none.** (3)

18) What value would the following capacitor codes stand for (give units)?

a. 104 **100,000 pF or 0.1 uF**
b. 222 **2,200 pF or 2.2 nF or 0.0022 uF** (2)

19) Give the correct code for the following capacitor values;

a. 1 microFarad **105**
b. 33000 picoFarads **333** (2)

20) How well do you think you went in this test? (score yourself between 1 and 10)

Ten, of course (no marks for this one!).

Year 9 post electronics survey No name is required on this form.

Please answer the following questions as best you can to help us evaluate the unit and try to improve it for future students. Please start by telling us if you're male or female.

Where Y/N is used, please circle the preferred answer. Gender M / F

1) Did you enjoy the electronics unit? Y / N

   Give it an interest rating between 1 and 10. ____

2) Did you learn anything useful from it? Y / N

   Give it an educational value between 1 and 10. ____

3) Name another science unit you have completed that you felt was more valuable / interesting to you.

4) Do you feel you accomplished some learning that could be useful to you in the future? Y / N

   Tick any of the following that might apply to you in the future.

   - I am serious and I would like to do the TAFE VET / SACE course in year 10 ☐
   - I enjoy electronics, and would like to do it in year 10 – but not the VET / SACE course ☐
   - I would like to continue with electronics as a hobby ☐
   - I am not really interested ☐

5) Did you find the unit booklet adequate to understand what to do? Y / N

   Rate it from 1 to 10. ____

6) If you gave it a score less than 6, how would you improve it?

7) Do you have a better idea for the project than using the ledfun kit?

   Rate it from 1 to 10 ____

8) Did you think the final project at the end was worthwhile? Y / N

   Rate it from 1 to 10. ____