ENGLISH
FOR ELECTRICAL ENGINEERING

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FOREWORD

Penguasaan bahasa Inggris dalam komunikasi lisan dan tulisan merupakan hal yang mutlak di era digital. Bahasa Inggris sebagai bahasa internasional akan memudahkan siapa pun yang menguasainya untuk mengakses informasi yang berkualitas dari sumber yang akurat dan terpercaya. Buku Bahasa Inggris Teknik Listrik yang merupakan Bahasa Inggris yang didesain untuk mahasiswa Teknik Listrik akan memudahkan mahasiswa dalam mengasah kemampuan berbahasa Inggris sesuai dengan bidang keilmuannya. Bahasa Inggris Teknik Listrik berisi pengetahuan dan terminologi yang berhubungan dengan kelistrikan dimulai dari sirkuit listrik sederhana sampai dengan pembangkit listrik sehingga mahasiswa dapat menjelaskan referensi kelistrikan dengan baik.

Buku ini membahas mengenai *numerals, electrical circuit and electrical maintenance, telling process (how electrical machine works/how power plant works), safety at work, applying for a job,* dan *English presentation.* Materi yang disajikan berupa *language focus* yang disertai dengan materi teknik berupa *reading text,* dan *sentence construction* yang mengasah skill Bahasa Inggris mahasiswa.

Penulis mengucapkan terima kasih kepada PEDP ADB-LOAN atas pembiayaan. Penulis juga mengucapkan terima kasih kepada segenap dosen, staf, dan mahasiswa Program Studi Teknik Listrik dan Jurusan Teknik Elektro yang merupakan wadah bagi penulis dalam berkiprah sebagai dosen. Besar harapan penulis buku ini dapat memberikan sumbangsih bagi kemajuan dunia pendidikan vokasi di Indonesia ke arah yang lebih baik.

Makassar, Desember 2017

Penulis

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CHAPTER I
NUMERALS

1.1. Cardinal Numbers

Cardinal Numbers

1	**One**
10	**Ten**
11	**Eleven**
21	**Twenty one**
101	**One hundred and one**
1,564	**One thousand five hundred and sixty four**
10,000	**Ten thousand**
100,000	**One hundred thousand**
1,000,000	**One million**
1,000,000,000	**One billion/thousand million/one milliard**

1.1.1. Figures and words

Some examples of cardinal numbers in written English:

Free for ***10*** *days* ***450*** *million trees aged* ***2*** *to* ***11*** *inclusive*
35,000 *free air miles to be won an apartment for* ***6***

Sometimes numbers are written in words rather than figures. This happens especially with small numbers.

one *of* ***four*** *super prizes* ***two*** *bedrooms (****one*** *double and* ***one*** *single)*
ten *megabytes of data a child of* ***eight*** *the* ***Thirty*** *Years War*

Figure at the beginning of a sentence is not usuallly use.
Five hundred *and* ***seventy-one*** *people applied for the job.*

1.1.2. Numbers 1-100

1 *one*	11 *eleven*	21 *twenty-one*
2 *two*	12 *twelve*	22 *twenty-two*
3 *three*	13 *thirteen*	30 *thirty*
4 *four*	14 *fourteen*	40 *forty*
5 *five*	15 *fifteen*	50 *fifty*
6 *six*	16 *sixteen*	60 *sixty*
7 *seven*	17 *seventeen*	70 *seventy*
8 *eight*	18 *eighteen*	80 *eighty*
9 *nine*	19 *nineteen*	90 *ninety*
10 *ten*	20 *twenty*	100 *a/one hundred*

Be careful with these spellings: ***fifteen***, ***eighteen***, ***forty, fifty***, ***eighty***.

Hyphen (-) can be put in compound numbers below ***100***, e.g.

twenty-one *three hundred* and *sixty-five*

1.1.3. Numbers over 100

102	*a/one hundred and two*
164	*a/one hundred and sixty-four*
596	*five hundred and ninety-six*
7,832	*seven thousand eight hundred and thirty-two*
256,940	*two hundred and fifty-six thousand nine hundred and forty*
1,000,000	*a/one million*
8,330,000	*eight million three hundred and thirty thousand*
1,000,000,000	*a/one billion*

And can be put between hundred and the rest of the number for example:

*two hundred **and** fifty*

In American English ***and*** can be leave out

two hundred fifty

Hundred, thousand, million, etc do not have an ***-s*** when they are part of a number.

The flight costs six **hundred** *pounds*

But for phrases like ***hundreds of people***, It can be write a thousand in figures as ***1,000*** or ***1000*** or sometimes ***1 000***. Do not use ***1.000*** for a thousand because ***point (.)*** only use in decimals.

For the numbers ***1100***, ***1200***, etc. up to ***1900***, sometimes it says ***'eleven hundred'***, ***'twelve hundred'***, etc.

The hostages spent over **fourteen hundred** *days in captivity*

1.1.4. A and One

A or ***one*** can be used before hundred, thousand, million, etc.

We have got ***a hundred members / one hundred members***

A is more informal, and it is used when the number is not an exact figure.

I have told you ***a thousand times*** not to do that.

One is usual in longer numbers, e.g. when ***both million and thousand used together***.

Unemployment stands at ***one million four hundred thousand***

A or ***one*** cannot be leave out

We have got ***hundred members***

1.1.5. Informal Expressions for Numbers

In informal English ***a couple*** for ***two*** can be used.

I was carrying **a couple** *of suitcases*

Sometimes ***a couple*** of means ***'a few'***

Wait here. I will only be **a couple** *of minutes*

Sometimes ***a/one dozen for twelve*** and ***half a dozen for six*** can be used

I need **half a dozen** *eggs*

To express ***a large*** but not ***exact number***, we can use ***dozens of***, ***hundreds of***, ***thousands of***, ***millions of***, and ***billions of***

*There were **hundreds of** people in the square*

*A drop of water consists of **millions of** atoms*

A number with the ***of-pattern*** for part of a quantity can be used.

***Four of** the passengers were injured*

1.1.6. About, over, etc with Numbers

Words such as ***about*** can be used to show that a number is approximate.

***About** two years **around** a thousand pounds **approximately** four miles*

Some other ways of modifying a number are

***More** than 100 destinations* ***over** 5 metres long*

***Less** than ten miles* ***below** ten percent* *children **under** 3*

***only** £14.99* ***at least** 3 weeks* *sleeps **up to** 6 people*

1.1.7. Numbers used to Identify

Numbers are not only to express quantity but also to identify things. For example, a credit card, a passport, or a telephone has a number to identify it. Each figure must be read separately.

Express Card 4929 8063 1744

'four nine two nine, eight zero six three, one seven four four'

Call us on 01568 927 869

'oh one five six eight, nine two seven, eight six nine'

'Zero' or ***'oh'*** for ***0***. When a number is repeated it must be said e.g. ***'four four'*** or ***'double four'***.

The figure ***0***, can be called ***'nought' (British English)*** or ***'zero'***

*You have missed out **a nought / a zero** from this number*

1.2. Ordinal Numbers

Ordinal Numbers

1st	**First**
10th	**Tenth**
11th	**Eleventh**
21st	**Twenty first**
101st	**One hundred and first**
1,564th	**One thousand five hundred and sixty fourth**
10,000th	**Ten thousandth**
100,000th	**One hundred thousandth**
1,000,000th	**One millionth**
1,000,000,000th	**One billionth/thousand millionth/one milliardth**

1.2.1. Numbers

Ordinal numbers are ***first***, ***second,*** ***third***, ***fourth***, etc. First, second, and third are irregular, but to form the others it must by adding ***-th*** to the cardinal number, e.g. ***ten*** → ***tenth***, or changing the ending ***-ty*** to ***-tieth***, e.g. ***forty*** → ***fortieth***. When use figures, write the cardinal number and add the last two letters of the ordinal number, e.g. ***4 + th = 4th***.

Be careful with these spellings: ***fifth***, ***eighth***, ***ninth***, ***twelfth***, and ***twentieth***, ***thirtieth***, etc.

1st	*first*	8th	*eighth*	21st	*twenty-first*
2nd	*second*	9th	*ninth*	22nd	*twenty-second*
3rd	*third*	12th	*twelfth*	54th	*fifty-fourth*
4th	*fourth*	13th	*thirteenth*	100th	*(one) hundredth*
5th	*fifth*	20th	*twentieth*	347th	*three hundred and forty-seventh*

1.2.2. Figures and Numbers

Some examples of the use of ordinal numbers.

*Her **25th** birthday* *on the **83rd** floor* *in the **21st** century*

*The **third** and **fourth** adult passengers in your car can travel free*

An ordinal number usually comes before a cardinal number.

The ***first four*** runners were well ahead of the others.

Monarchs have Roman numerals spoken as ordinals.

*George V is **'George the fifth'***

1.3. Fractions, Decimals, and Percentages

1.3.1. Fractions

In fractions half, quarter, or an ordinal number are used.

$^1/_2$ *a half/ one half*	$1^1/_2$ *one and a half*
$^2/_3$ *two thirds*	$2^1/_3$ *two and a third*
$^1/_4$ *a quarter/ one quarter*	$6^3/_4$ *six and three quarters*
$^4/_5$ *four fifths*	$^{15}/_{16}$ *fifteen sixteenths*

With numbers less than one, ***of*** is used before a noun phrase

I waited ***three quarters of*** an hour

Two thirds of the field was under water

With ***numbers above one***, the ***noun is plural***

I waited ***one and a half hours***

The room is ***three and three quarter metres long***

Compare the fractions in these examples

Three quarters of a metre *(less than one metre)*

Three and three quarter metres *(more than one metre)*

With one and a half/quarter, etc + noun, there is an alternative pattern.

one and a half hour */an hour and a half*

one and a quarter pages*/a page and a quarter*

For the use of a singular or plural verb after a fraction

1.3.2. Decimals

Decimal is said ***point*** and used ***dot (.)***, (not a comma).

*0.2 '***point*** two'/'nought* **point** *two'/'zero* **point** *two'*

Zero is more typical of American English.

Each figure after the decimal point is spoken separately.

7.45 'seven **point** *four five'*

15.086 'fifteen **point** *oh/nought/zero eight six'*

Plural noun can be used after a decimal.

There was ***0.6 seconds*** *between the leaders*

3.25 metres *is the length of the wall*

1.3.3. Percentages

Look at these examples

Save ***25%! ('twenty-five per cent')***

A ***2 per cent*** *growth in population* ***('two per cent')***

Inflation of ***3.72 per cent*** *(****'three point seven two per cent')***

For the use of a singular or plural ***verb*** after a percentage

1.3.4. Numbers of Time

We can say ***once, twice, three times, four times***, etc to say ***how many times something happens***

I have only met your cousin ***once****, so I don't know him very well*

Peter goes to evening classes ***twice*** *a week*

I have run the New York Marathon ***three*** *times now*

Once also means ***'at a time in the past'***

Dinosaurs ***once*** walked the earth

For twice, three times, etc in expressions like twice as big

1.4. The Time of Day

Some examples of how referring to clock time

4.00	*four (o'clock)*	
8.05	*five (minutes) past eight*	*eight (oh) five*
2.10	*ten (minutes) past two*	*two ten*
5.12	*twelve minutes past five*	*five twelve*
11.15	*(a) quarter past eleven*	*eleven fifteen*
9.30	*half past nine*	*nine thirty*
1.35	*twenty-five (minutes) to two*	*one thirty-five*
10.45	*(a) quarter to eleven*	*ten forty-five*
7.52	*eight minutes to eight*	*seven fifty-two*

As well as past and to, Americans also use after and till

twenty-five minutes ***past/after*** *six*

five minutes ***to/till*** *four*

O'clock used only on the hour.

I got home at ***six o'clock***

In most contexts it can be used either way of saying the time: half past ten or ten thirty. It is prefer to say ten thirty when talking about a timetable

The ***24-hour clock*** *is used in timetables.*

The next train is at ***15 30. ('fifteen thirty')***

In official announcements, it may be heared times on the hour spoken as e.g. ***'(oh) nine hundred hours'*** or ***'thirteen hundred hours'*** rather than ***'nine o'clock'*** or ***'one o'clock'***.

am /eI "em/ meaning 'in the morning' (up to about midday) and ***pm /pi: "em/*** meaning 'in the afternoon or evening'. In writing ***am*** and ***pm*** are sometimes written with full stops: ***a.m./p.m***.

The match starts at ***3.00 pm***

It can also be said in the morning/afternoon/evening. ***Twelve o'clock*** in the day is ***midday or noon***. ***Twelve o'clock*** at ***night is midnight***.

The phone rang at ***half past four in the morning***

It is usually to leave out minutes ***after 5, 10, 20, and 25***, but it usually use after other numbers.

Seventeen minutes past/to six

In informal speech it can be leave out the hour if it is known.

It's nearly twenty past (four) already

Using half for half past is also informal.

What time is it? ***half nine/half past nine***

1.5. Fractions

$\boxed{a/b}$ a over b

$\boxed{ab/cd}$ a times b over c times d

$\boxed{1/n}$ one nth/ one over n

$\boxed{1/2}$ one half/one-half/a half

$\boxed{1/3}$ one third/one-third/a third

$\boxed{1/4}$ one quarter/one-quarter/a quarter

$\boxed{3/4}$ three quarters/three-quarters

$\boxed{1/5}$ one fifth/one-fifth/a fifth

$2/3$ two-thirds

$4/3$ four over three/four thirds/four-thirds

$1/10$ one tenth/a tenth/one-tenth

$3/7$ three sevenths/three-sevenths

$112/303$ a [one] hundred (and) twelve over three hundred (and) three

$5\frac{2}{5}$ five (and) two-fifths

$\frac{21}{311}$ twenty-one over three hundred (and) eleven

1.6. Suffices, Powers, Roots

$-x$ minus [negative] x

x' x prime[2]

$\bar{x}$ x bar

$\hat{x}$ x hat/ x wedge

x_i x sub i

x^i x super i

7^2 seven squared

5^3 five cubed / five to the third power

x^2 x squared

x^3 x cubed/ x to the third power

x^n x to the nth power/ x to the nth/ x to the power n/ x to the n

x^{-n} x to the minus nth power/ x to the power minus n/ x to the minus n

$x^{1/2}$ x to (the) half power/ the square root of x

$x^{1/3}$ the cube root of x

$x^{1/n}$ the nth root of x

$\sqrt{2}$ the square root of two

$\sqrt[3]{2}$ the cube root of two

$\sqrt[n]{x}$ the nth root of x

$\sqrt{x+y}$ the square root of the sum of x plus y

1.7. Addition, Subtraction, Multiplication, and Division

Addition

3 + 2 = 5	**Three plus two equals five**

Subtraction

3 - 2 = 1	**Three minus two equals one**

Multiplication

3 x 2 = 6	**Three times two equals six**

Division

6 : 2 = 3	**Six divided by two equals three**

NOTE

2, 4, 6	**are even numbers**
1, 3, 5	**are odd numbers**
3, 5, 7, 11	**are prime numbers**
$3^2 = 9$	**three squared equals nine**
$\sqrt{64} = 8$	**the square root of sixty four is eight**
$3^3 = 27$	**three cubed equals twenty seven**
$\sqrt[3]{64} = 4$	**the cube root of sixty four is four**
3^{12}	**three to the power twelve**

$x - y$ x minus y

x • •y x plus y

$x \pm y$ x plus minus y/ x plus or minus y

$x \mp y$ x minus or plus y

$xy, x \times y$ x times y / x multiplied by y

$x \cdot y$ x dot y

x • •y x divided by y

x/y x over y

$x : y$ the ratio of x to y

$n!$ n factorial / factorial n

$\binom{n}{a}$ binomial n over a / binominal coefficient n over a

$1 \cdots 5$ one to five

$1 + 3 + 5 + \cdots$ one plus three plus five dot dot dot

$x(y + z)$ x times the sum of y plus z / x open parenthesis y plus z close parenthesis[3]

(x • •y)z open parenthesis x plus y close parenthesis multiplied by z/ (initial) parenthesis x plus y (final) parenthesis multiplied by z [3]

$[x]$ x in brackets

$\frac{1}{2}\{x[y + (z - w)]\}$ one half times open brace x open bracket y plus open parenthesis z minus w close parenthesis close bracket close brace

$x'y''$ x prime times y double prime/ x prime times y second prime

$|z|$ modulus of z/ absolute value of z

• •A angle A

∟A right angle A

1.8. Tasks

Express the following numerals in the written form.

1. 2,187
2. 4.03187
3. 412,397 km^2
4. 0.001%
5. 1.602192×10^{-19}
6. 20/09/1904
7. 7/8
8. 1.380622×10^{-23} J K^{-1}

Express the following equations in words.

1. $(x - a)^2 + (y - b)^2 = r^2$
2. $d(e^u) = e^u du$
3. $x + iy = r(\cos\theta + i\sin\theta) = re^{i\theta}$
4. $a^b = e^{b \ln a}$
5. $\frac{d}{dx}\int_{u(x)}^{v(x)} f(t)dt = f(v)\frac{dv}{dx} - f(u)\frac{du}{dx}$

Complete the calculations using the words in the box. Sometimes there is more than one possible answer. Look at B opposite to help you.

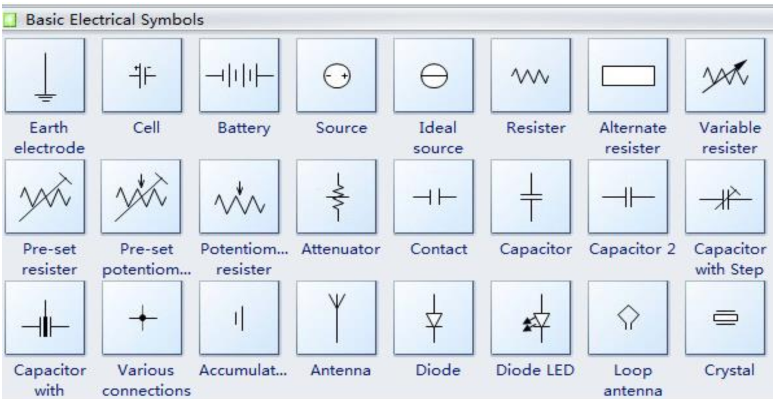
divided	minus	plus	square root	subtract	times
less	multiplied	square	squared	sum	

1 $14 + 8 = 22$	Fourteen .... eight equals twenty-two.
2 $100 \times 20 = 2{,}000$	One hundred .... twenty is two thousand.
3 $7 \times 11 = 77$	Seven .... by eleven equals seventy-seven.
4 $400 \div 8 = 50$	Four hundred .... by eight equals fifty.
5 $95 + 2 = 97$	The .... of ninety-five and two is ninety-seven.
6 $8^2 = 64$	The .... of eight is sixty-four.
7 $50 - 30 = 20$	If you .... thirty from fifty, it equals twenty.
8 $\sqrt{100} = 10$	The .... of a hundred is ten.
9 $11^2 = 121$	Eleven .... is a hundred and twenty-one.
10 $48 - 12 = 36$	Forty-eight .... twelve equals thirty-six.

CHAPTER II
ELECTRICAL CIRCUIT AND ELECTRICAL MAINTENANCE

2.1. Electrical Symbols

Basic electrical symbols represent earth electrode, cell, battery, source, ideal source, resister, etc. These symbols help create accurate diagrams and documentation. Electric circuits, whether simple or complex, can be described in a variety of ways. An electric circuit can be described with mere words; however, a simple and visual way to describe an electrical circuit should be diagramming it using basic electrical symbols.



Earth electrode is a metal plate, water pipe, or other conductor of electricity partially buried in the earth so as to constitute and provide a reliable conductive path to the ground

Cell is a device containing electrodes immersed in an electrolyte, used for generating current or for electrolysis.

Battery is a container consisting of one or more cells, in which chemical energy is converted into electricity and used as a source of power.

Source is a part of a field-effect transistor from which carriers flow into the inter-electrode channel.

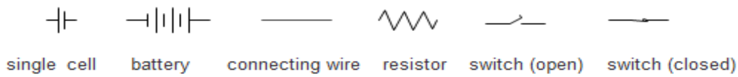
Ideal source includes ideal voltage source and ideal current source. An ideal source is a theoretical concept of an electric current or voltage supply (such as a battery) that has no losses and is a perfect voltage or current supply. Ideal sources are used for analytical purposes only since they cannot occur in nature.

Resistor is a device having resistance to the passage of an electric current.

Capacitor is a device used to store an electric charge, consisting of one or more pairs of conductors separated by an insulator.

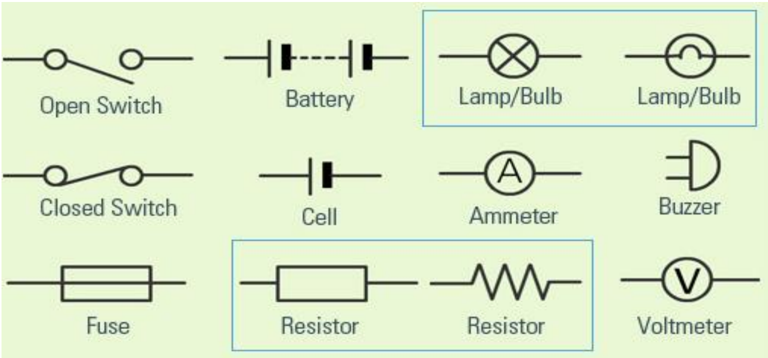
Antenna is an electrical device which converts electric power into radio waves, and vice versa.

Some most commonly-used basic electrical symbols used in schematic diagrams are shown below:



2.2. Electrical Circuit

An electrical circuit is a path or line through which an electrical current flows. The path may be closed (joined at both ends), making it a loop. A closed circuit makes electrical current flow possible. It may also be an open circuit where the electron flow is cut short because the path is broken. An open circuit does not allow electrical current to flow. Below is a basic set of symbols that you may find on circuit diagrams:



It is very important to know the basic parts of a simple circuit and the symbols that relate to them. A simple circuit has conductors, a switch, a load and a power source. Here are the functions of each part:

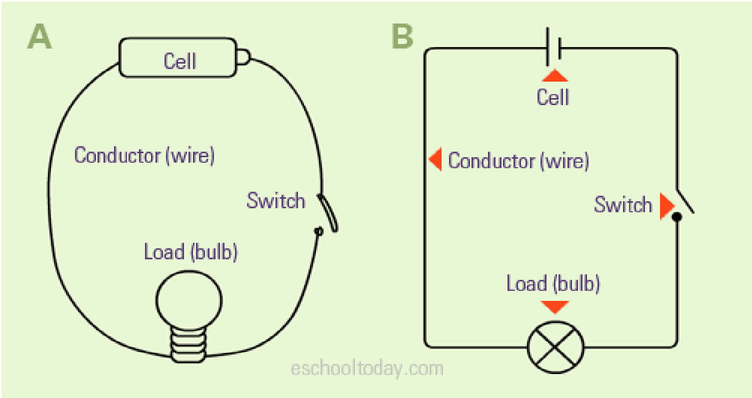
Conductors are usually copper wires with no insulation. They make the path through which the electricity flows. One piece of the wire connects the current from the power source (cell) to the load. The other piece connects the load back to the power source.

Switch is simply a small gap in the conductor where you can close or open the circuit. When the switch is closed, the circuit is closed and electricity flows.

The load is a small light bulb or buzzer that lights when the circuit is turned on. The load is also known as a resistor.

Cell is the power source. Note that more than one cell put together is known as a battery.

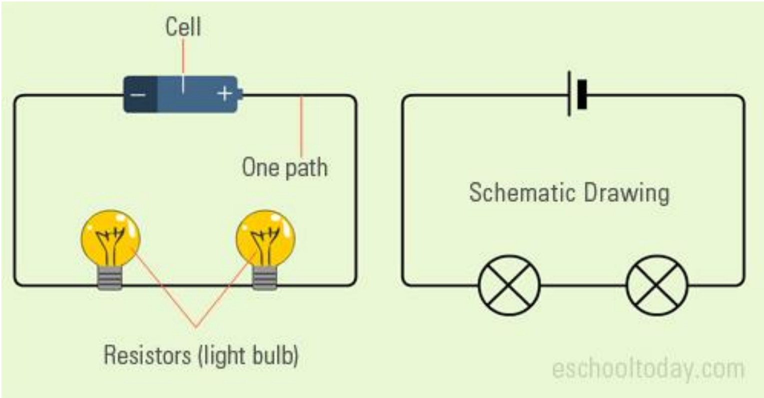
The diagram below shows how a basic circuit looks like.



It is important to draw circuits with clean straight lines, as shown in diagram B. Avoid realistic sketches. It is important to know that a circuit can have more than the basic components in the diagram. It can have two or more batteries or two or more bulbs. There are two types of circuits namely Series Circuit and Parallel Circuit.

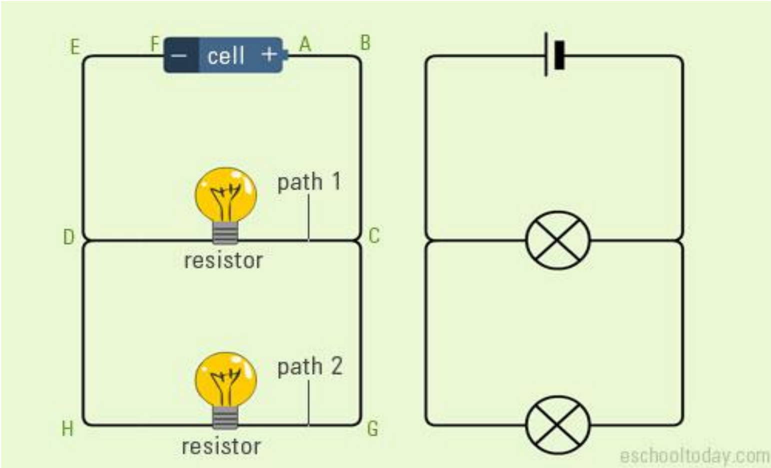
Series circuits

A series circuit is one that has more than one resistor, but only one path through which the electricity (electrons) flows. From one end of the cell (battery), the electrons move along one path with no branches, through the resistors, to the other end of the cell. All the components in a series circuit are connected end-to-end. A resistor in a circuit is anything that uses some of the power from the cell. In the example below, the resistors are the bulbs. In a series circuit, the components are arranged in a line, one after the other. The schematic drawing is a better way to draw a series circuit. Take a look at the diagram below:



Each time there is damage (break) in any one of the resistors the entire circuit will not function. For example, if one light bulb goes out, all the other lights will go off because the electricity path in the broken bulb is cut off. The example is in Christmas lights on the trees at home during Christmas. If the lights are in a series circuit, one burned out bulb will keep all the lights off. That is one disadvantage of series circuits. One advantage though is that you will always know if there is a break in a series circuit. If there are many bulbs in a circuit with a battery (cell), it is very likely that the light will be dimmer because many resistors are acting on the same voltage of power from the battery.

Parallel circuits In a parallel circuit, there is more than one resistor (bulb) and they are arranged on many paths. This means electricity (electrons) can travel from one end of the cell through many branches to the other end of the cell. The illustration below involving two resistors in a parallel circuit



From the parallel circuit there is more than one path namely

PATH 1: A-B-C-D-E-F and back to A.

PATH 2: A-B-C-G-H-D-E-F and back to A.

It is clear that electricity from the cell can take either path A or Path B to return to the cell. The great thing about parallel circuits is that, even when one resistor (bulb) burns out, the other bulbs will work because the electricity is not flowing through one path.

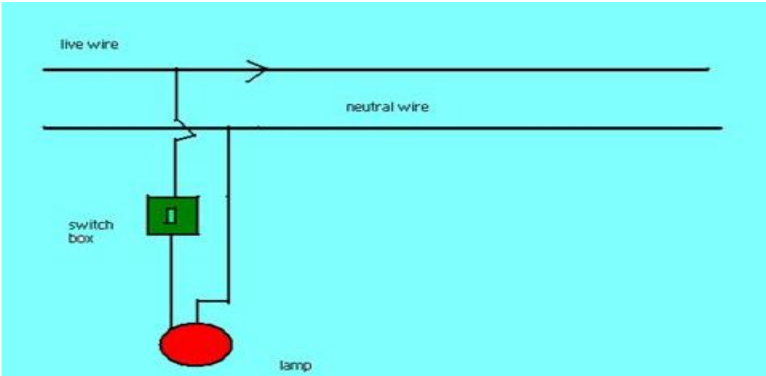
Think of all the light bulbs in your home. If one bulb burns out, the other bulbs in the rooms still work. Another great thing is that the bulbs in a parallel circuit do not dim out like the case in series circuits. This is because the voltage across one branch is the same as the voltage across all other branches.

10 Simple Electrical Circuits

An electrical circuit diagram is a simplified schematic representation of an electric circuit. It uses standard symbols for the components in the circuit and does not show the physical arrangements of the components. From homes to big industries, it all depend on electricity. An electrical circuit is a closed loop in which continuous electrical current goes from the supply to the load. If you are trying to describe an electrical circuit to your friend or neighbor, it is likely that you have to draw the connection. For example, if you want to explain a lighting circuit, it can take more time to draw the bulb, battery, and wires because different people draw various components of the circuit in different ways and this may take a long time to explain. Therefore, a better way is to learn how to show simple electrical circuits by some simple electric circuits.

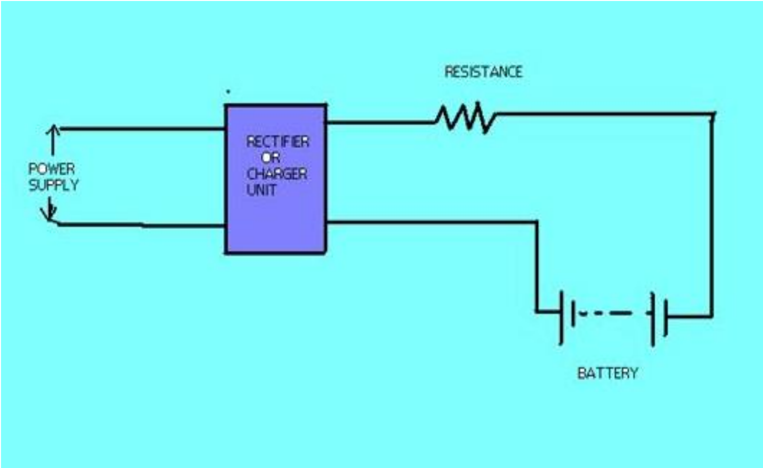
AC Circuit for Lamp

For a lamp it need two wires; one is the neutral wire and the other is the live wire. These two wires are connected from the lamp to the main supply panel. It is advisable to use different colours for live wires and neutral wires. The universal practice is to use the colour red for live wires and a black colour for the neutral wire. For switching ON and OFF the lamp we need a control called a switch - provided in the live wire between the main supply and lamp. If the switch is ON, the electric circuit is closed and the lamp glows, and if the switch is OFF, it will disconnect the power supply to the lamp. For safe operation this wiring is placed in a box called a switch box. The switch wire and live wire are a single wire; it is just cut in between to connect the switch. In case you want to change the lamp, don’t forget to switch OFF the lamp and if possible disconnect the power supply to the circuit.



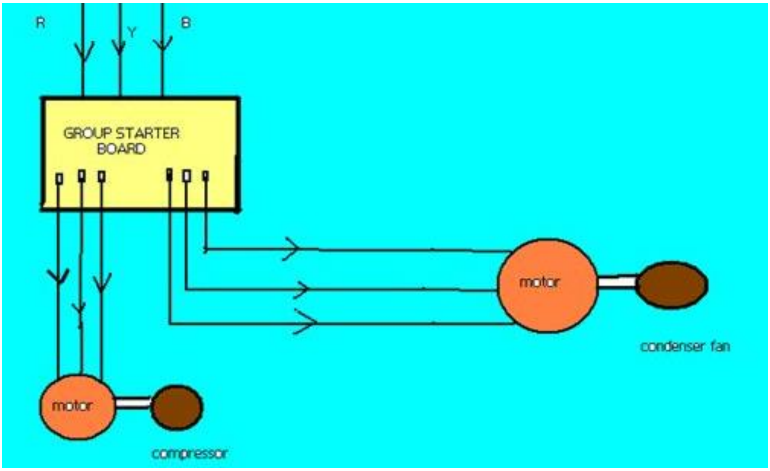
Battery Charging Circuit

Battery charging is done by means of a rectifier. The main function of the rectifier is to convert AC (Alternating Current) into DC (Direct Current). The rectifier shown in the diagram is the bridge rectifier, which has four diodes connected in the form of a bridge. Resistance is added in the circuit to limit the flow of current. When the supply is given to the rectifier through a step down transformer, it converts the AC supply into DC supply and this flows to the battery, thereby charging it. Usually this circuit is enclosed in a battery charger unit or inverter and only the terminals emerge out of the charger unit to be connected to the battery for charging.



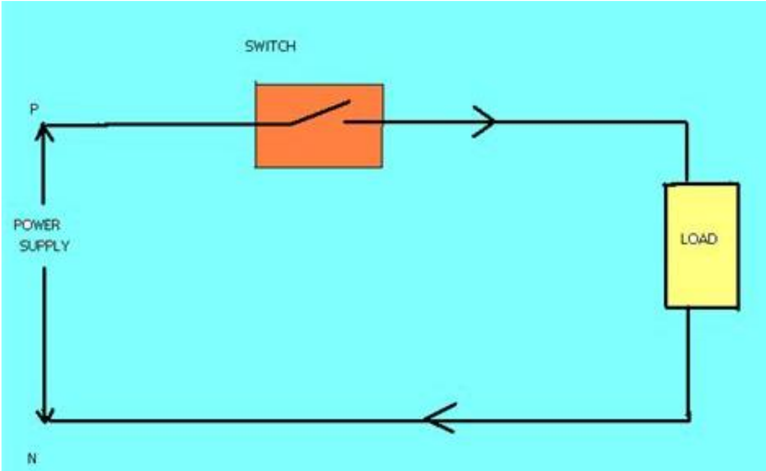
Air Conditioning Electric Circuit

Air conditioning is a process that heats, cools, cleans, and circulates air together with the control of its moisture content. The electric aspect of AC comprises the power equipment for motors and starters for the compressor and condenser fans. Associated electric equipment includes solenoid valves, high and low pressure switch, and high and low temperature switch, together with the safety cut-outs for over current, under voltage etc. The compressor and condenser fans are driven by a simple fixed speed 3 phase AC induction motor, each with its own starter and supplied from a distribution board. Routine electric maintenance and fault finding on the motor and starters involves cleaning, checking of connections, insulation tests, etc.



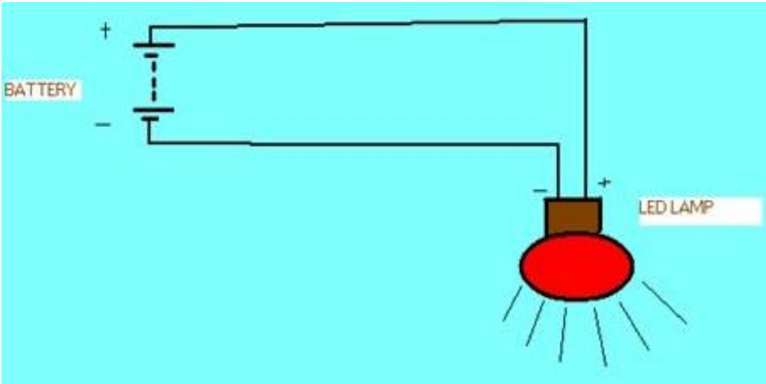
Switch Circuit

Switches are used for operating lights, fans etc. many times a day but we usually do not try to see the connection made inside the switch. The function of the switch is to connect or complete the circuit going to the load from the supply. It has moving contacts which are normally open. As shown in the diagram, the power supply to the load is through the switching circuit, and therefore the power supply can be cut by keeping the switch open.



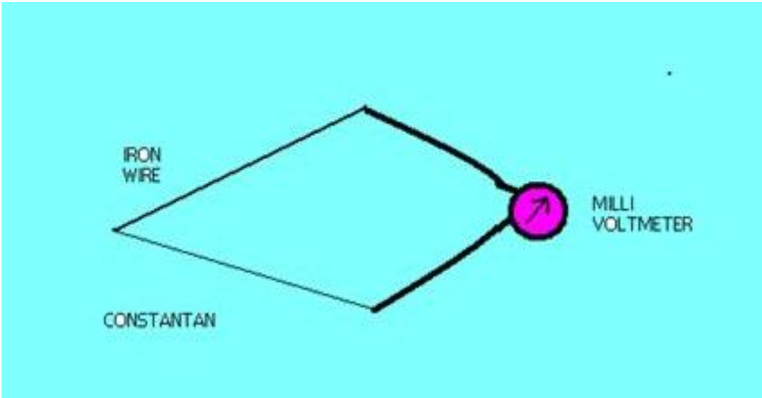
DC Lighting Circuit

For a small LED (Light Emitted Diode) lamp, normally a DC supply (battery) is used. This circuit is very simple. The battery has two points, anode and cathode. The anode is positive and cathode is negative. A lamp has two terminals - one is positive and the other is negative. The positive terminal of the lamp is connected to the anode and the negative terminal of the lamp is connected to the cathode of the battery. Once the connection is made the lamp will glow. To enable switching ON or OFF, connect a switch in between any one wire that will cut off or supply DC voltage to the LED bulb.



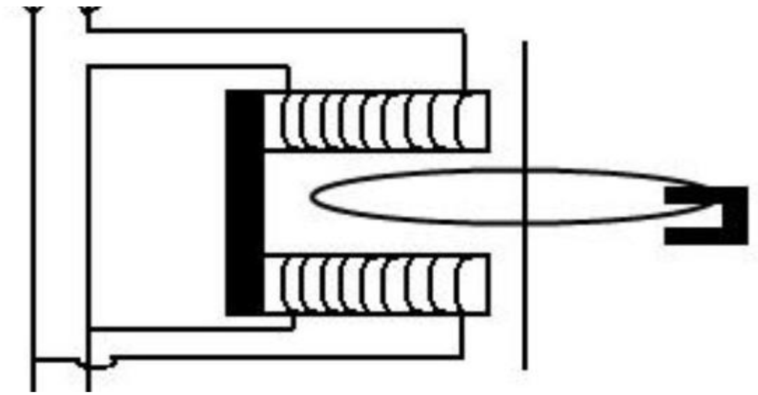
Thermocouple Circuit

When the junctions formed from two dissimilar homogenous materials are exposed to the temperature difference, an EMF (Electromotive Force) is generated. This is called the Seebeck effect. The figure shows a thermocouple, which consists of two wires, one iron and the other made of constantan, with a voltmeter. This voltmeter will measure the EMF generated and this can be calibrated to measure the temperature. The temperature difference between the hot and cold junction will produce an EMF proportional to it. If the cold junction temperature is kept constant, then the EMF is proportional to the temperature of the hot junction.



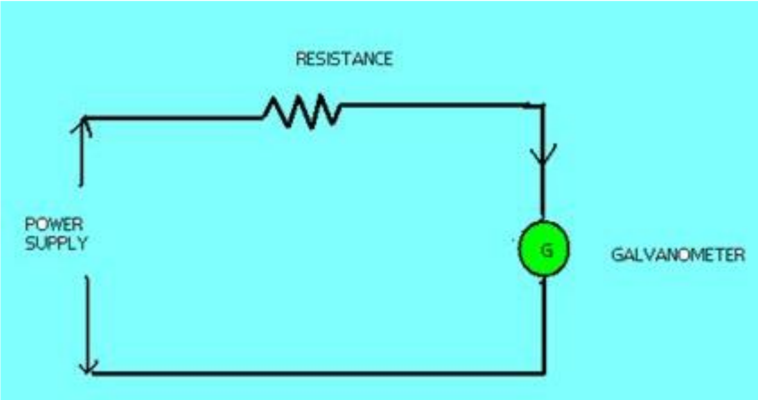
Energy Meter or Motor Meter

Energy is the total power consumed over a time interval. The power consumed over a period of time can be measured by a motor meter or energy meter. Energy meters are used in all power supply lines to every house in order to measure the power consumed in both DC and AC circuits. It is measured in watt-hour or kilowatt hour. For DC circuits, the meter may be an ampere hour or a watt-hour meter. There is an aluminium disc which rotates continuously when power is consumed. The speed of rotation is proportional to the power consumed (in watt-hour) by the load. Energy meters have a pressure coil and a current coil. When the voltage is applied across the pressure coil, current flows through the coil and produces a flux which exerts torque on the disc. Load current flows through the current coil and produces another flux which exerts an opposite torque on the aluminium disc. The resultant torque acts on the disc and results in a rotation on the disc which is proportional to the energy utilized and which is recorded in the energy meter.



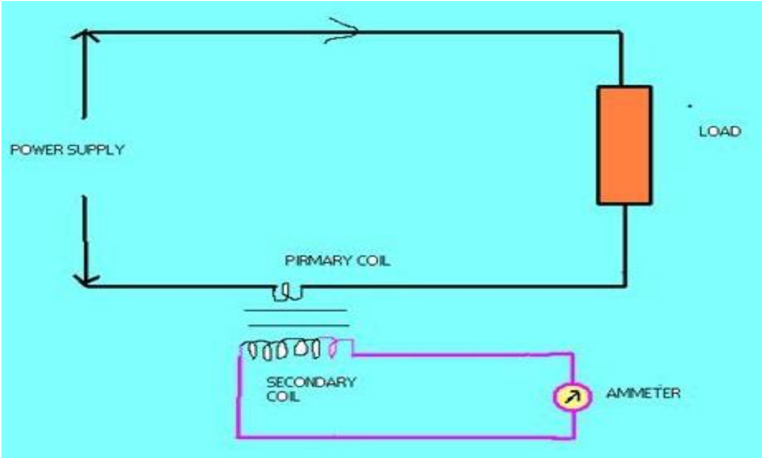
Multimeter Circuit

A multimeter is probably one of the most simpe electrical devices which can measure resistance, currents and voltage. It is an indispensable instrument and can be used for measuring DC as well as AC voltage and currents. It is used for checking the continuity of a circuit (by ohm meter scale, for measuring DC current flow, DC voltage across the circuit and also for measuring the AC voltage across power supply transformer. It consists of a galvanometer connected in series with a resistance. The current flow in a circuit, that is, voltage across the circuit can be measured by connecting the terminals of the multimeter across the circuit. It is mainly used to test the continuity of the windings in a motor.



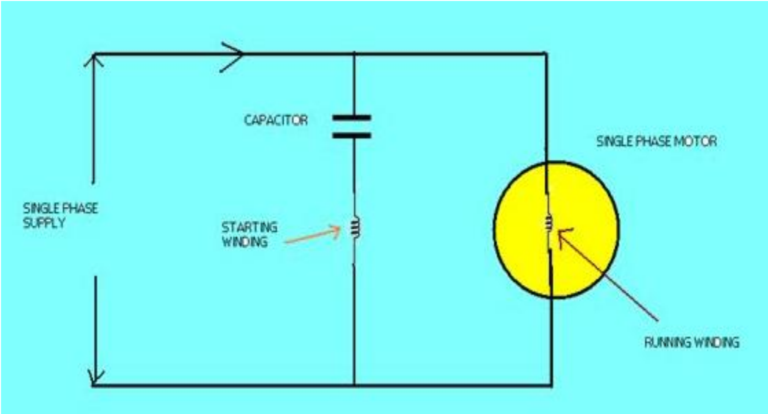
Current Transformer Circuit

The current transformer is used to measure the current flow in a circuit, with the help of a low range ammeter. Actually, it steps down the current to the level of ammeter range. It has a primary winding and a secondary winding. The primary winding is connected to the power circuit so that the current being measured passes through it. The secondary winding of the transformer is connected to an ammeter. The transformer will step down the current to a value that can be measured by the connected ammeter.



Single Phase Motor Circuit

Single phase motors are designed to operate from a single phase supply and can perform a wide variety of useful services in homes, offices, factories, and workshops, and in other business establishments. A single phase motor has two terminals in the terminal box of the outer casing. One of these terminals is connected with the live wire of the power circuit and the other is connected with the neutral wire. When the electrical supply goes to the motor, the motor will run until the power supply is cut. Even a fan works on this single phase motor. Sometimes the fan will not start when we switch it ON. The reason is that the capacitor employed for making the single phase motor self starting is not functioning. The best way to solve this problem is to replace the capacitor.



2.3. Electrical Maintenance

Electrical accidents commonly occur whilst equipment is being maintained. This may be electrical equipment such as switchgear or equipment that uses electrical power. Most accidents happen because workers have not been adequately trained, are being poorly supervised, or because the risks of the work have not been properly assessed. The incidents are real. Below are the case regarding to electrical maintenance and also the comment on how to minimize the risk of electrical maintenance.

Unsafe system of work

An employee was killed by 86 Volts when changing a welding electrode whilst working in a metal silo. An employee received a fatal electric shock whilst changing a welding rod during arc-welding work inside a metal silo. It was found that there was a voltage of no more than 86 Volts ac between the welding rod and the silo metalwork when no welding was taking place. There was an unsafe system of work in this hazardous environment. It was found during the investigation that the electrical equipment in use at the time of the accident was damaged but this was found not to be contributory to the accident

Comment

This incident shows that even relatively low voltages can deliver a fatal electric shock, particularly where a person cannot easily escape the shock, and that arc welding equipment should be switched off when rods are being changed. Electrical work in hazardous environments should not be carried out until a risk assessment has been done and control measures identified and implemented. Every country has published guidance covering many of the common hazardous environments such as confined spaces, where there is a hazard from earthed surfaces, wet places, explosive atmospheres, deep trenches, near sewage etc. Work should not commence where there is doubt regarding the effectiveness of any control measure.

A brief guide to controlling risks in the workplace are

1. Identify the hazards

One of the most important aspects of your risk assessment is accurately identifying the potential hazards in your workplace. A good starting point is to walk around your workplace and think about any hazards. In other words, what is it about the activities, processes or substances used that could injure your employees or harm their health? When you work in a place every day it is easy to overlook some hazards, so here are some tips to help you identify the ones that matter:

a. Check manufacturers' instructions or data sheets for chemicals and equipment as they can be very helpful in explaining the hazards and putting them in their true perspective.
b. Look back at your accident and ill-health records – these often help to identify the less obvious hazards.
c. Take account of non-routine operations (e.g. maintenance, cleaning operations or changes in production cycles).
d. Remember to think about long-term hazards to health (e.g. high levels of noise or exposure to harmful substances).

There are some hazards with a recognised risk of harm, for example working at height, working with chemicals, machinery, and asbestos. Depending on the type of work you do, there may be other risks that are relevant to your business.

2. Who might be harmed?

Think how employees (or others who may be present, such as contractors or visitors) might be harmed. Ask the employees or seniors what they think the hazards are, as they may notice things that are not obvious to you and may have some good ideas on how to control the risks. For each hazard you need to be clear about who might be harmed – it will help you identify the best way of controlling the risk. That does not mean listing everyone by name, but rather identifying groups of people (e.g. people working in the storeroom or passers-by). Remember:

a. Some workers may have particular requirements, e.g. new and young workers, migrant workers, new or expectant mothers, people with disabilities, temporary workers, contractors, homeworkers and lone workers.
b. Think about people who might not be in the workplace all the time, such as visitors, contractors and maintenance workers.
c. Take members of the public into account if they could be harmed by your work activities.
d. If you share a workplace with another business, consider how your work affects others and how their work affects you and your workers. Talk to each other and make sure controls are in place.
e. Ask some other workers if there is anyone you may have missed.

3. Evaluate the risks

Having identified the hazards, you then have to decide how likely it is that harm will occur, ie the level of risk and what to do about it. Risk is a part of everyday life and you are not expected to eliminate all risks. What you must do is make sure you know about the main risks and the things you need to do to manage them responsibly. Generally, you need to do everything 'reasonably practicable' to protect people from harm. This means balancing the level of risk against the measures needed to control the real risk in terms of money, time or trouble. However, you do not need to take action if it would be grossly disproportionate to the level of risk. Your risk assessment should only include what you could reasonably be expected to know – you are not expected to anticipate unforeseeable risks. Look at what you're already doing and the control measures you already have in place. Ask yourself:

a. Can I get rid of the hazard altogether?
b. If not, how can I control the risks so that harm is unlikely?

Some practical steps you could take include:

a. trying a less risky option;
b. preventing access to the hazards;
c. organising your work to reduce exposure to the hazard;
d. issuing protective equipment;
e. providing welfare facilities such as first aid and washing facilities;
f. involving and consulting with workers.

Improving health and safety need not cost a lot. For instance, placing a mirror on a blind corner to help prevent vehicle accidents is a low-cost precaution, considering the risks. Failure to take simple precautions can cost you a lot more if an accident does happen. Involve every workers, so you can be sure that what you propose to do will work in practice and will not introduce any new hazards. If you control a number of similar workplaces containing similar activities, you can produce a model risk assessment reflecting the common hazards and risks associated with these activities. You may also come across model assessments developed by trade associations, employers' bodies or other organisations concerned with a particular activity. You may decide to apply these model assessments at each workplace, but you can only do so if you:

a. satisfy yourself that the model assessment is appropriate to your type of work;
b. adapt the model to the detail of your own work situations, including any extension necessary to cover hazards and risks not referred to in the model.

4. Record your significant findings

Make a record of your significant findings – the hazards, how people might be harmed by them and what you have in place to control the risks. Any record produced should be simple and focused on controls. If you have fewer than five employees you do not have to write anything down. But it is useful to do this so you can review it at a later date, for example if something changes. If you have five or more employees you are required by law to write it down. Any paperwork you produce should help you to communicate and manage the risks in your business. For most people this does not need to be a big exercise – just note the main points down about the significant risks and what you concluded.

When writing down your results keep it simple, for example 'fume from welding – local exhaust ventilation used and regularly checked'.

A risk assessment must be suitable and sufficient, i.e. it should show that:

a. a proper check was made;
b. you asked who might be affected;
c. you dealt with all the obvious significant hazards, taking into account the number of people who could be involved;
d. the precautions are reasonable, and the remaining risk is low;

e. you involved your employees or their representatives in the process.

Where the nature of your work changes fairly frequently or the workplace changes and develops (eg a construction site), or where your workers move from site to site, your risk assessment may have to concentrate more on a broad range of risks that can be anticipated. Take a look at the selection of example risk assessments via website they show you what a completed risk assessment might look like for your type of workplace. You can use these as a guide when doing your own. The site also has online risk assessment tools, to help employers complete and print off their own records. If your risk assessment identifies a number of hazards, you need to put them in order of importance and address the most serious risks first. Identify long-term solutions for the risks with the biggest consequences, as well as those risks most likely to cause accidents or ill health. You should also establish whether there are improvements that can be implemented quickly, even temporarily, until more reliable controls can be put in place. Remember, the greater the hazard the more robust and reliable the measures to control the risk of an injury occurring will need to be.

5. Regularly review your risk assessment

Make sure your risk assessment stays up to date. Few workplaces stay the same. Sooner or later, you will bring in new equipment, substances and procedures that could lead to new hazards. So it makes sense to review what you are doing on an ongoing basis, look at your risk assessment again and ask yourself:

a. Have there been any significant changes?
b. Are there improvements you still need to make?
c. Have your workers spotted a problem?
d. Have you learnt anything from accidents or near misses?

An apprentice electrician was severely injured from contact with live equipment in a substation. An apprentice electrician was severely injured when he touched live equipment whilst doing work to install ceiling fans in a substation. His employer failed to adequately control the system of work where there were exposed live bus bars. There was no safe system of work, the supervision was inadequate, and the management of the activity was left to an electrician who had insufficient experience to do the job safely. No attempt was made to get the electricity distribution company to screen the live equipment.

Comment

Before allowing work to start, those in control should identify the hazards present, the risks posed by the hazards, and the control measures needed to reduce the risks so far as is reasonably practicable. They should implement the control measures in the system of work and communicate this with the workers. The continuing effectiveness of the control measures should be assessed throughout the work and the work should be stopped if the control measures fail to control the risk. Those in control of work activities should ensure that workers have suitable competence to do the work safely.

An employee received an electric shock that broke both shoulders. Employee sustained broken shoulders when testing a incorrectly wired appliance. An employee sustained a 240 volt electric shock that broke both shoulders whilst attempting to test a newly manufactured appliance that had been incorrectly wired to the mains lead. Suitable precautions had not been taken to prevent electrical injury to employees engaged in testing work on electrical appliances. Employees were exposed to live wires at 240 Volts ac, there was exposed metal in the test area, there was no test of mains lead prior to live test and no risk assessment for electrical testing work.

Comment

The correct procedures should be used when powering up electrical equipment for the first time so that the risks arising from incorrect assembly are minimised. The procedures should be based on an assessment of the foreseeable faults and the actions necessary to prevent faults from giving rise to danger. Employees should be instructed how to use the procedures, and the effectiveness of the procedures should be reassessed regularly, or where there is a change that could give rise to additional risks.

An employee was trying to apply insulating tape to a live electrical cable but received an electric shock. Employee received a shock whilst insulating live wires.An employee received a 650 Volt ac. electric shock when he picked up a cable lying on the ground that was connected to a generator and began to apply insulating tape to exposed wires.

Comment

People who undertake work on electrical equipment or installations should be competent to do so. Those in control of work should instruct workers only to undertake work they are competent for, and workers should ensure they do likewise.

Inadequate information

An employee received a fatal electric shock whilst examining a faulty air conditioning unit. Electrical contractor killed whilst examining faulty air conditioning unit. An electrical contractor received a fatal electric shock whilst examining a faulty air conditioning unit at premises owned and controlled by a Metropolitan Borough Council. Investigation found that the Council had failed to maintain the air conditioning unit in a safe condition, despite having had knowledge of its condition for some time. Also, this was the second electrocution on premises under control of the council in 5 years.

Comment

Those in control of work activities have a responsibility to maintain equipment in such a state that it is safe. They should also provide such information and instruction as is necessary to ensure that workers are able to work safely. The health and safety toolbox gives basic guidance on general health and safety issues. Diagnosing faults with electrical equipment is covered by Safety in electrical.

No training

A worker was injured when working in a live electrical panel. He had not been trained. A worker was injured when working in a live electrical panel**.** An employee was instructed to carry out work on an electrical control panel to reverse the phases and reverse the conveyor that had blocked. The panel was still live and electrical shorting resulted in arcing and caused burns to his face and arms. He had not received training in electrical work.

Comment

People who work on electrical equipment or installation must be competent to do the tasks required of them. Competence can normally be demonstrated by an individual who has successfully completed a suitable training course, has experience in the area of work, and is able to appreciate how to reduce the risks posed by the work activity.

Inadequate isolation

An electrician received a severe electric shock because he had not properly isolated the supply. Electrician suffered shock when electrical supply had not been properly isolated. An electrician received a severe electric shock whilst carrying out building refurbishment and fitting out work in a new estates office. The electrical supply had not been properly isolated. Investigation revealed there was no management system in place to check precautions for electrical work.

Comment

It is the responsibility of those in control of work activities to direct those work activities such that the risks are reduced 'so far as is reasonably practicable'. This requires, amongst other things, that work is properly planned and that safety precautions are taken. Electricity supplies should be made dead and proved to be dead before work is commenced, and the method of isolation should prevent inadvertent or deliberate re-energisation of the electrical system.

Unsafe rules

An electrical fitter had to have both arms amputated after receiving burns from a 33,000 Volt supply. Electrical fitters injuries result in amputation when he believed he was working in a safe zone. The employee, an electrical fitter received 33,000 Volt burns when he climbed live apparatus in a substation when he believed it to be within a safe working zone. His injuries resulted in amputation of both arms. The company were found not to have adequate arrangements for the demarcation of safe working zones and the monitoring of zones once established was not adequately practiced. The training of staff in the setting out of zones was poor. Company had used national distribution rules as the basis of their procedures but failed to elaborate on the guidance of those rules.

Comment

Employers should ensure that working methods, materials, equipment and worker training meet the standards set out in good practice guidelines. Guidelines for many common tasks are generally readily available, but often need to be modified so that they are suitable for particular tasks.

Poor control of work activities

An electrical contractor was injured by live 11,000 Volt switchgear. Contractor receives injuries when switchgear was not isolated. The company employed contract workers to undertake repairs and improvements to their paper manufacturing plant when production was stopped. During this time, an employee of an electrical contractor undertook an inspection of 11,000 Volt switchgear with the authorisation of the company. The switchgear had not been isolated and this resulted in him receiving injuries from the live equipment. Following this incident, employees of the factory occupier entered and worked on and in close proximity to this live, exposed 11,000 Volt equipment without the competence to do so.

Comment

Workers should be given enough information to allow them to work safely. This may take the form of a toolbox talk before work commences for lower risk activities, or may require a formal permit to work system for higher risk activities. Workers should also be assessed to identify if they are competent to do the work.

Live working

An employee suffered brain damage following an electric shock he received whilst live working. Employee's heart stopped while maintaining an induction heat treatment machine. An engineering factory employee sustained an electric shock that stopped his heart while maintaining an induction heat treatment machine that was live. The equipment should have been made dead and it was found he was not competent to undertake such work. Although he was resuscitated, he suffered oxygen starvation resulting in a serious brain injury.

Comment

Electrical equipment and machinery should be securely isolated before any work is undertaken on it that will give rise to risks arising from the electricity or other risk such as those caused by an unintended start up. People who perform the isolation and work should be competent to do so. A formal permit to work system may be required where the risks are higher.

Unsuitable test equipment

Employee was killed while working with poorly constructed equipment. An employee was killed by a 415 volt electric shock whilst setting up equipment to test printed circuit boards. The test equipment was poorly constructed, resulting in the employee working in close proximity to live connectors at the ends of test leads.

Comment

Equipment should be designed so that it does not give rise to electrical or other risks, and a safe system of work employed to ensure the equipment is used correctly. A risk assessment should be done to identify the hazards, the risks arising from the hazards, and the control measures needed to control the risks. The control measures should be incorporated into the safe system of work. Workers should be instructed to use the safe system of work, and the effectiveness of the safe system of work monitored. It is very beneficial for all staff to have knowledge of emergency procedures.

Poor maintenance

A worker received a 240 Volt electric shock whilst using a pressure washer. Worker received shock whilst using a pressure water washing machine. A worker received a 240 Volt electric shock whilst using a pressure water washing machine. An investigation found the company had failed to: a) maintain the washer, b) provide a safe system of work and c) notify the existence of the factory to the standard organization. There was a high potential for serious injury from contact with 240 Volt electricity supply when using water washing equipment.

Comment

All work equipment should be regularly checked to ensure it is safe to use. A visual check each day, or each time the equipment is used is likely to identify many of the potential electrical faults. Work equipment should also be thoroughly tested regularly. This should be done frequently enough that there is little chance a fault will develop that will lead to danger. In general, equipment used in harsh environments such as building sites or outdoors will need more regular testing than equipment used in an office environment. It is a good idea to note down your decision on the frequency of testing for each item of equipment and then ensure the tests are carried out. It is also a good idea to note down the results of each test so that deterioration can be spotted as early as possible.

You should regularly review your frequency of testing and change it according to the number and type of defects found. It is possible to do simple checks on your installation using an electrical socket tester. This is a device that can be plugged into a socket outlet, and can identify if there is a wiring fault. However, be aware that many types of socket tester cannot detect certain types of fault, and could indicate the socket is safe when it is not.

Failure to manage work

A contractor's employee received an electric shock after confusion over isolation. Employee received a shock whilst touching a metal fence. A contractor's employee touched a metal mesh fence against which a live cable end was resting and received a 415 Volt electric shock. This occurred after a Permit to Work irregularity by the host company, inadequate isolation of the job by an electrical contractor's electrician, and re-energising of the circuit by the host company. Investigation of the incident revealed a failure to properly manage the permit to work system over a period of 14 months.

Comment

Those in control of work on electrical equipment or installations should ensure it is carried out in a manner that, so far as is reasonably practicable, does not lead to danger. Precautions should be taken to ensure that equipment that has been electrically isolated cannot be reenergised if danger will result.

Person not competent

Person received a severe electric shock after he incorrectly wired a machine. Shock received after incorrectly wiring a machine. A person received severe electric shock injuries after incorrectly wiring a machine, which resulted in the machine frame becoming live. The injured person was not competent to undertake such work, yet competent persons were available.

Comment

Those in control of work activities should ensure that workers are competent to undertake them.

Uninsulated electrical wiring

A worker was killed whilst attempting to clear a blockage in a wrapping machine. Machine operator killed whilst clearing blockage from a mail wrapping machine. A machine operator was killed by an electric shock whilst attempting to clear a blockage from a mail wrapping machine. He pressed the emergency stop, lifted a guard, and reached into the open back panel. Whilst freeing packages, he touched the exposed wires on a transformer powering the machine. The electrical wires were not insulated and no risk assessment had been done.

Comment

Electrical conductors should be insulated or positioned in such a way as to prevent, so far as is reasonably practicable, danger. Those in control of work activities should ensure that electrical machinery, equipment and installations are maintained in a state that minimises, so far as is reasonably practicable, the risks arising from electricity.

2.4. Solar Panel

Solar panels are fast becoming a very attractive renewable energy option, which could end up being incredibly beneficial to the environment. The process of converting sunlight to electrical energy is one that has improved dramatically over the last few decades, and is now more efficient than ever. The use of solar energy has been around for years in small devices such as calculators, but now many are talking about powering houses and businesses off of these panels.

Solar is one of the most promising renewable energy sources currently available, due to the fact that solar power is abundant. The rays that emanate from the sun can produce nearly

1,000 watts of energy for every square meter of the earth's surface. By collecting that energy, we would never have to rely upon damaging fossil fuels again. A solar PV system uses sunlight to generate electricity which you can use to power your home or office that can reduce your carbon footprint and impact on the environment.

Solar energy is created using the energy which has been generated by the sun. A solar power panel is able to function using the solar energy which is derived from the sun. Every solar power panel contains many different silicon cells or solar cells. They are building blocks of solar panels. The energy from the sun is absorbed by these solar cells. The solar energy derived from the sun is converted into electricity with the help of a solar power panel.

For this reason, it is important to understand exactly how solar panels work, and how they can be used to produce electricity for the average home.

1. The solar panels installed on the rooftops absorb sun's light (photons) from the sun.
2. The silicon and the conductors in the panel convert the sunlight into Direct Current (DC) electricity which then flow into the inverter.
3. The inverter then converts DC to AC (Alternating Current) electrical power which you can use at house.
4. Excess electricity that is not used by you can be fed back to the grid.
5. When your solar panels produce less power than what is required by you at home, you can always buy electricity from the utility.

The Process of Converting Solar Power to Electricity

1. Solar panels use a special process of converting photons to electrons to generate a current by making use of a special type of cell known as a photovoltaic cell. These cells are commonly found on the front of calculators and small gadgets. When a bank of them is connected together, they are collectively known as a solar panel.
2. Photovoltaic cells are made up of semi conductive materials such as silicon. The semiconductor absorbs the light from the sun. When this happens, the photons in the sunlight knock some of the electrons in the semi conductive material loose which allows them to flow in an electrical current.
3. Within each cell, there is an electric field which is used to streamline this flow of electrons in a particular direction. When these electrons meet a metal contact placed on the photovoltaic cell, it can be used to power devices.

Solar (or photovoltaic) cells convert the sun's energy into electricity. Whether they're adorning your calculator or orbiting our planet on satellites, they rely on the the photoelectric effect: the ability of matter to emit electrons when a light is shone on it. Silicon is what is known as a semi-conductor, meaning that it shares some of the properties of metals and some of those of an electrical insulator, making it a key ingredient in solar cells. When the sun shines onto a solar cell. Sunlight is composed of miniscule particles called photons, which radiate from the sun.

As these hit the silicon atoms of the solar cell, they transfer their energy to loose electrons, knocking them clean off the atoms. The photons could be compared to the white ball in a game of pool, which passes on its energy to the coloured balls it strikes.

Freeing up electrons is however only half the work of a solar cell: it then needs to herd these stray electrons into an electric current. This involves creating an electrical imbalance within the cell, which acts a bit like a slope down which the electrons will flow in the same direction. Creating this imbalance is made possible by the internal organisation of silicon. Silicon atoms are arranged together in a tightly bound structure. By squeezing small quantities of other elements into this structure, two different types of silicon are created: n-type, which has spare electrons, and p-type, which is missing electrons, leaving ‘holes’ in their place. When these two materials are placed side by side inside a solar cell, the n-type silicon’s spare electrons jump over to fill the gaps in the p-type silicon. This means that the n-type silicon becomes positively charged, and the p-type silicon is negatively charged, creating an electric field across the cell. Because silicon is a semi-conductor, it can act like an insulator, maintaining this imbalance.

As the photons smash the electrons off the silicon atoms, this field drives them along in an orderly manner, providing the electric current to power calculators, satellites and everything in between.

The Use of Silicon

1. Silicon is made up in a crystalline form, with each atom of silicon holding fourteen electrons in a specialized setup of three different shells. Two of these shells are full, and hold two and eight electrons respectively. The third shell, which holds the last four electrons, is only half full. In order to fill the last shell, the silicon will

share electrons with four nearby atoms. This is what gives it its crystalline structure.

2. In its natural form, silicon is not a particularly good conductive material due to the fact that it has no free electrons, in contrast to other conductive materials such as copper. In order to free up the movement of these electrons, the silicon found in solar panels is a special, impure form of silicon. By mixing in other atoms with the silicon atoms, an uneven number of free electrons are created. These electrons form no bonds, and so are free to move when hit by light.
3. Silicon is naturally very shiny and reflective, so in order to stop photons from bouncing away from the material, an anti-reflective coating is applied to the cells. Quite often, a glass cover will be laid over the top in order to protect the silicon from outside elements.

The Electric Field

1. When positive and negative silicon come into contact with one another, the free electrons on one side will be drawn to the other. When the two mix, they create a form of barrier known as an electric field. This field pushes electrons from the positive silicon to the negative, but not allowing them to flow the other way.

2. When photons hit the photovoltaic cell, electron-hole pairs are broken apart. When this happens, the electron is freed and a space becomes available to be filled by another electron. The electron will move to the negative side while the hole moves to the positive side, creating an imbalance in the electrical neutrality of the cell. By inserting conductors, we can use this movement of electrons creates a current while the electric field creates a voltage. The product of these two is power.

Potential Energy Loss

One of the major problems facing solar energy is the fact that it is often less efficient than other forms of energy production, yielding low amounts of power compared to counterparts such as the burning of fossil fuels. There are many reasons for this loss of energy.

1. The main causes of energy loss is the fact that the light from the sun comes in many different wavelengths. Some of these wavelengths work exactly as expected, with photons separating electron-hole pairs. However, some of them do not have the energy to separate these pairs, and pass harmlessly through them. Others still have too much energy, which means that a great deal of the energy is lost due to the fact that there is more energy than is required to knock free an electron, but not enough to knock any more free.
2. While another material would require less energy to knock their electrons free, this would mean that the voltage of the material would be far lower. In order to increase efficiency, there needs to be a balance between

the voltage and current produced by the solar cell. Without that balance, the efficiency is lost.

3. Metal is usually placed at the bottom of the cells in order to conduct the electrons. However, these plates will not collect all of the energy being produced, as some will be lost through the top. Covering the top would mean losing the sunlight, while putting conductors around the outside of the cell would require the electrons to travel much further. For this reason, the cells are often covered by a thin grid of metal to help reduce the distance the electrons need to travel.

The Uses of Solar Power

1. By affixing solar panels to the roof of a house, photovoltaic cells can be used to produce electricity which can be used directly by the power supply of the house or, increasingly, stored in large batteries which can be used to power the house like a generator. Of course, if you live in a darker region of the world, the efficiency of these solar panels will be greatly reduced.
2. Solar energy can also be sold to power grids when an excess of electricity is produced. This means that should the sun be shining brightly, you can make use of solar cells to power your devices and even make some money should you generate an excess of energy. Similarly, should the sun not be shining, you will still be hooked up to the main utility grid which would allow you to buy energy from them should you not want to rely on batteries or generators.
3. Solar panels are also common in spacecraft to generate electricity for on-board computers and other electrical

appliances. This is due largely to the fact that the effectiveness of solar panels is not diminished in space, and the sun is always shining which means that the craft have a reliable source of energy without needing to carry heavy fuels or batteries with them. These panels are often found on satellites and discovery craft such as shuttles and crafts such as the Mars rovers.

Every solar power panel contains many different silicon cells or solar cells. Each solar cell generates a few volts of electricity. Photons will strike the surface of these solar cells and then generate an electrical current. The roof is the usual place where solar power panels are installed at homes or offices so that it gets the required amount of exposure from the sun. The photovoltaic panels on the solar power panel convert the solar energy into electrical energy. The electricity which is generated through these panels is mostly DC which will be converted into AC with the help of an inverter. Silicon is one of the main material that is usually used for making a solar power panel.

Solar panels absorb the sunlight as a source of energy to generate electricity or heat. A photovoltaic (PV) module is a packaged, connect assembly of typically 6x10 photovoltaic solar cells. Photovoltaic modules constitute the photovoltaic array of a photovoltaic system that generates and supplies solar electricity in commercial and residential applications. Each module is rated by its DC output power under standard test conditions (STC), and typically ranges from 100 to 365 Watts (W). The efficiency of a module determines the area of a module given the same rated output – an 8% efficient 230 W module will have twice the area of a 16% efficient 230 W module. There are a few commercially available solar modules that exceed efficiency of

22% and reportedly also exceeding 24%. A single solar module can produce only a limited amount of power; most installations contain multiple modules. A photovoltaic system typically includes an array of photovoltaic modules, an inverter, a battery pack for storage, interconnection wiring, and optionally a solar tracking mechanism. The most common application of solar panels is solar water heating systems. The price of solar power has continued to fall so that in many countries it is cheaper than ordinary fossil fuel electricity from the grid (there is "grid parity").

Photovoltaic modules use light energy (photons) from the Sun to generate electricity through the photovoltaic effect. The majority of modules use wafer-based crystalline silicon cells or thin-film cells. The structural (load carrying) member of a module can either be the top layer or the back layer. Cells must also be protected from mechanical damage and moisture. Most modules are rigid, but semi-flexible ones are available, based on thin-film cells. The cells must be connected electrically in series, one to another. Externally, most of photovoltaic modules use MC4 connectors type to facilitate easy weatherproof connections to the rest of the system.

Modules electrical connections are made in series to achieve a desired output voltage or in parallel to provide a desired current capability. The conducting wires that take the current off the modules may contain silver, copper or other non-magnetic conductive transition metals. Bypass diodes may be incorporated or used externally, in case of partial module shading, to maximize the output of module sections still illuminated. Some special solar PV modules include concentrators in which light is focused by lenses or mirrors onto smaller cells. This enables the use of cells with a high cost per unit area (such as gallium arsenide) in a cost-effective way.

Depending on construction, photovoltaic modules can produce electricity from a range of frequencies of light, but usually cannot cover the entire solar range (specifically, ultraviolet, infrared and low or diffused light). Hence, much of the incident sunlight energy is wasted by solar modules, and they can give far higher efficiencies if illuminated with monochromatic light. Therefore, another design concept is to split the light into different wavelength ranges and direct the beams onto different cells tuned to those ranges. This has been projected to be capable of raising efficiency by 50%. Scientists from Spectrolab, a subsidiary of Boeing, have reported development of multi-junction solar cells with an efficiency of more than 40%, a new world record for solar photovoltaic cells. The Spectrolab scientists also predict that concentrator solar cells could achieve efficiencies of more than 45% or even 50% in the future, with theoretical efficiencies being about 58% in cells with more than three junctions.

Currently, the best achieved sunlight conversion rate (solar module efficiency) is around 21.5% in new commercial products typically lower than the efficiencies of their cells in isolation. The most efficient mass-produced solar modules have power density values of up to 175 W/m^2 (16.22 W/ft^2). Research by Imperial College, London has shown that the efficiency of a solar panel can be improved by studding the light-receiving semiconductor surface with aluminum nanocylinders similar to the ridges on Lego blocks. The scattered light then travels along a longer path in the semiconductor which means that more photons can be absorbed and converted into current. Although these nanocylinders have been used previously (aluminum was preceded by gold and silver), the light scattering occurred in the near infrared region and visible light was absorbed strongly. Aluminum was found to have absorbed the ultraviolet part of the spectrum, while the visible and near infrared parts of the spectrum were found to be scattered by the aluminum surface. This, the research argued, could bring down the cost significantly and improve the efficiency as aluminum is more abundant and less costly than gold and silver. The research also noted that the increase in current makes thinner film solar panels technically feasible without "compromising power conversion efficiencies, thus reducing material consumption.

2.5. Cooling System

The picture is A fluid-cooling panel designed at Stanford being tested on the roof of the Packard Electrical Engineering Building. It looks like a regular roof, but the top of the Packard Electrical Engineering Building at Stanford University has been the setting of many milestones in the development of an innovative cooling technology that could someday be part of our everyday lives.

Since 2013, Shanhui Fan, professor of Electrical Engineering, and his students and research associates have employed this roof as a test bed for a high-tech mirror-like optical surface that could be the future of lower-energy air conditioning and refrigeration.

Research published in 2014 first showed the cooling capabilities of the optical surface on its own. Now, Fan and former research associates Aaswath Raman and Eli Goldstein, have shown that a system involving these surfaces can cool flowing water to a temperature below that of the surrounding air. The entire cooling process is done without electricity.

Radiative sky cooling is a natural process that everyone and everything does, resulting from the moments of molecules releasing heat. This phenomenon is particularly noticeable on a cloudless night because, without clouds, the heat and everything around radiates can more easily make it through Earth's atmosphere, all the way to the vast, cold reaches of space. Although our own bodies release heat through radiative cooling to both the sky and our surroundings, we all know that on a hot, sunny day, radiative sky cooling isn't going to live up to its name. This is because the sunlight will warm you more than radiative sky cooling will cool you. To overcome this problem, the team's surface uses a multilayer optical film that reflects about 97 percent of the sunlight while simultaneously being able to emit the surface's thermal energy through the atmosphere. Without heat from sunlight, the radiative sky cooling effect can enable cooling below the air temperature even on a sunny day.

Putting Radiative Sky Cooling to Work

For their latest paper, the researchers created a system where panels covered in the specialized optical surfaces sat atop pipes of running water and tested it on the roof of the Packard Building in September 2015. These panels were slightly more than 2 feet in length on each side and the researchers ran as many as four at a time. With the water moving at a relatively fast rate, they found the panels were able to consistently reduce the temperature of the water 3 to 5 degrees Celsius below ambient air temperature over a period of three days.

The researchers also applied data from this experiment to a simulation where their panels covered the roof of a two-story commercial office building in Las Vegas – a hot, dry location where their panels would work best – and contributed to its cooling system. They calculated how much electricity they could save if, in place of a conventional air-cooled chiller, they used vapor-compression system with a condenser cooled by their panels. They found that, in the summer months, the panel-cooled system would save 14.3 megawatt-hours of electricity, a 21 percent reduction in the electricity used to cool the building. Over the entire period, the daily electricity savings fluctuated from 18 percent to 50 percent. The researchers are focused on making their panels integrate easily with standard air conditioning and refrigeration systems and they are particularly excited at the prospect of applying their technology to the serious task of cooling data centres.

Transformer Cooling System and Methods

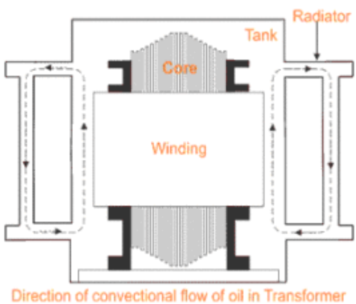
The main source of heat generation in transformer is its copper loss or I^2R loss. Although there are other factors contribute heat in transformer such as hysteresis and eddy current losses but contribution of I^2R loss dominate them. If this heat is not dissipated properly, the temperature of the transformer will rise continually which may cause damages in paper insulation and liquid insulation medium of transformer. Therefore, it is essential to control the temperature with in permissible limit to ensure the long life of transformer by reducing thermal degradation of its insulation system. Electrical power transformer use external transformer cooling system to accelerate the dissipation rate of heat of transformer. There are different transformers cooling methods available for transformer.

Different Transformer Cooling Methods

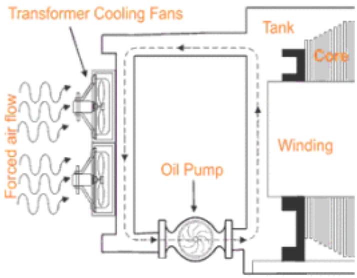
For accelerating cooling different transformer cooling methods are used depending upon their size and ratings.

ONAF Cooling of Transformer

Heat dissipation can obviously be increased, if dissipating surface is increased but it can be make further faster by applying forced air flow on that dissipating surface. Fans blowing air on cooling surface is employed. Forced air takes away the heat from the surface of radiator and provides better cooling than natural air. The full form of ONAF is "Oil Natural Air Forced". As the heat dissipation rate is faster and more in ONAF transformer cooling method than ONAN cooling system, electrical power transformer can be put into more load without crossing the permissible temperature limits.



OFAF Cooling of Transformer



Oil Forced Air Forced or OFAF Cooling of Transformer

In oil forced air natural cooling system of transformer, the heat dissipation is accelerated by using forced air on the dissipating surface but circulation of the hot oil in transformer tank is natural convectional flow. The heat dissipation rate can be still increased further if this oil circulation is accelerated by applying some force. In OFAF cooling system the oil is forced to circulate within the closed loop of transformer tank by means of oil pumps. OFAF means "Oil Forced Air Forced" cooling methods of transformer. The main advantage of this system is that it is compact system and for same cooling capacity OFAF occupies much less space than farmer two systems of transformer cooling. Actually in oil natural cooling system, the heat comes out from conducting part of the transformer is displaced from its position, in slower rate due to convectional flow of oil but in forced oil cooling system the heat is displaced from its origin as soon as it comes out in the oil, hence rate of cooling becomes faster.

OFWF Cooling of Transformer

Ambient temperature of water is much less than the atmospheric air in same weather condition. So water may be used as better heat exchanger media than air. In OFWF cooling system of transformer, the hot oil is sent to a oil to water heat exchanger by means of oil pump and there the oil is cooled by applying sowers of cold water on the heat exchanger's oil pipes. OFWF means "Oil Forced Water Forced" cooling in transformer.

ODAF Cooling of Transformer

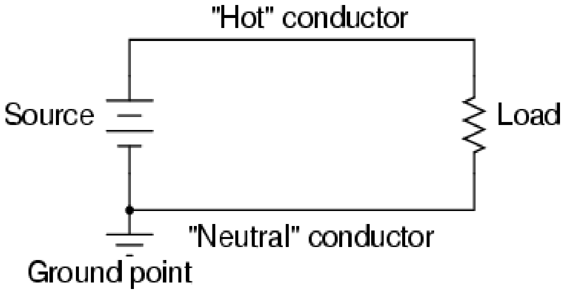
ODAF or oil directed air forced cooling of transformer can be considered as the improved version of OFAF. Here forced circulation of oil directed to flow through predetermined paths in transformer winding. The cool oil entering the transformer tank from cooler or radiator is passed through the winding where gaps for oil flow or pre-decided oil flowing paths between insulated conductor are provided for ensuring faster rate of heat transfer. ODAF or oil directed air forced cooling of transformer is generally used in very high rating transformer.

ODWF Cooling of Transformer

ODAF or oil directed water forced cooling of transformer is just like ODAF only difference is that here the hot oil is cooled in cooler by means of forced water instead of air. Both of these transformer cooling methods are called forced directed oil cooling of transformer.

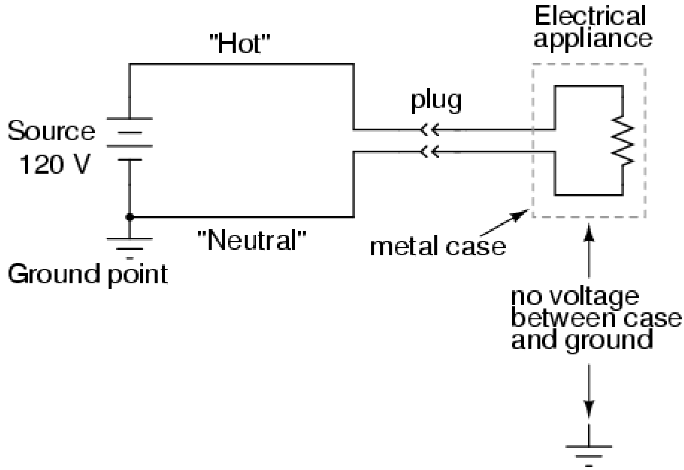
2.6. Safe Electrical Circuit Design

A power system with no secure connection to earth ground is unpredictable from a safety perspective: there is no way to guarantee how much or how little voltage will exist between any point in the circuit and earth ground. By grounding one side of the power system’s voltage source, at least one point in the circuit can be assured to be electrically common with the earth and therefore present no shock hazard. In a simple two-wire electrical power system, the conductor connected to ground is called the neutral, and the other conductor is called the hot, also known as the live or the active:

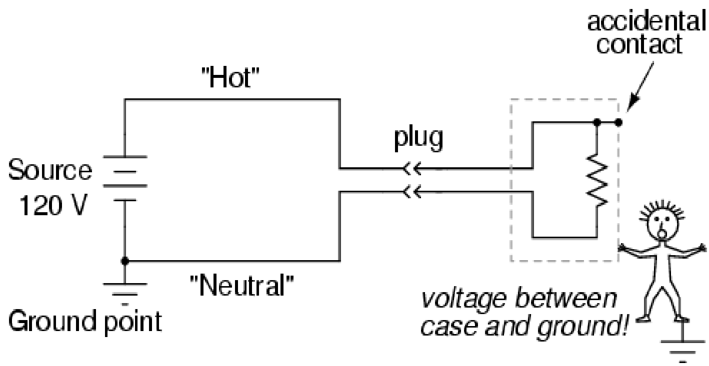


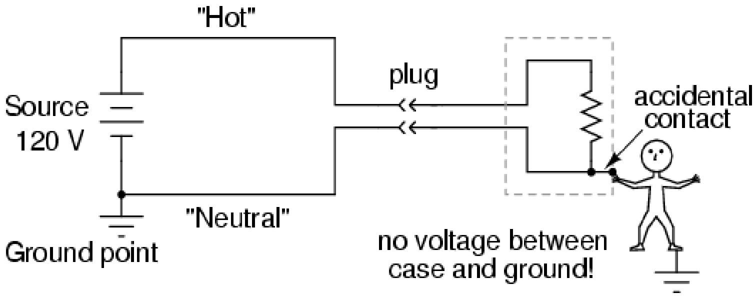
As far as the voltage source and load are concerned, grounding makes no difference at all. It exists purely for the sake of personnel safety, by guaranteeing that at least one point in the circuit will be safe to touch (zero voltage to ground). The “Hot” side of the circuit, named for its potential for shock hazard, will be dangerous to touch unless voltage is secured by proper disconnection from the source (ideally, using a systematic lock-out/tag-out procedure).

This imbalance of hazard between the two conductors in a simple power circuit is important to understand. The following series of illustrations are based on common household wiring systems (using DC voltage sources rather than AC for simplicity). If take a look at a simple, household electrical appliance such as a toaster with a conductive metal case, we can see that there should be no shock hazard when it is operating properly. The wires conducting power to the toaster’s heating element are insulated from touching the metal case (and each other) by rubber or plastic.



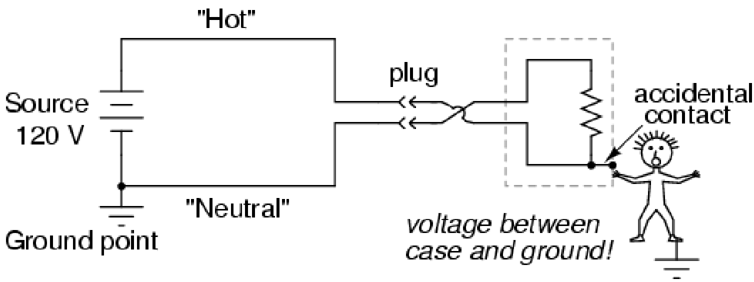
However, if one of the wires inside the toaster were to accidentally come in contact with the metal case, the case will be made electrically common to the wire, and touching the case will be just as hazardous as touching the wire bare. Whether or not this presents a shock hazard depends on which wire accidentally touches:





If the "hot" wire contacts the case, it places the user of the toaster in danger. On the other hand, if the neutral wire contacts the case, there is no danger of shock:

To help ensure that the former failure is less likely than the latter, engineers try to design appliances in such a way as to minimize hot conductor contact with the case. Ideally, of course, you do not want either wire accidentally coming in contact with the conductive case of the appliance, but there are usually ways to design the layout of the parts to make

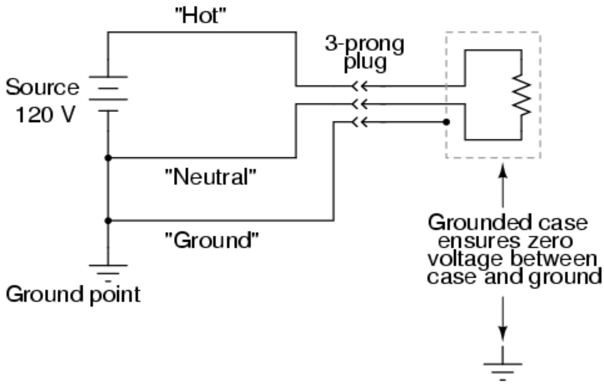


accidental contact less likely for one wire than for the other. However, this preventative measure is effective only if power plug polarity can be guaranteed. If the plug can be reversed, then the conductor more likely to contact the case might very well be the “hot” one:

Appliances designed this way usually come with “polarized” plugs, one prong of the plug being slightly narrower than the other. Power receptacles are also designed like this, one slot being narrower than the other. Consequently, the plug cannot be inserted “backwards,” and conductor identity inside the appliance can be guaranteed. Remember that this has no effect whatsoever on the basic function of the appliance: its strictly for the sake of user safety.

Some engineers address the safety issue simply by making the outside case of the appliance nonconductive. Such appliances are called double-insulated, since the insulating case serves as a second layer of insulation above and beyond that of the conductors themselves. If a wire inside the appliance accidently comes in contact with the case, there is no danger presented to the user of the appliance.

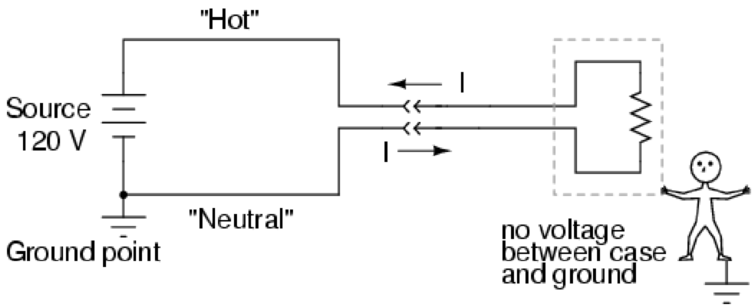
Other engineers tackle the problem of safety by maintaining a conductive case, but using a third conductor to firmly connect that case to ground:



The third prong on the power cord provides a direct electrical connection from the appliance case to earth ground, making the two points electrically common with each other. If they are electrically common, then there cannot be any voltage dropped between them. At least, that is how it is supposed to work. If the hot conductor accidently touches the metal appliance case, it will create a direct short-circuit back to the voltage source through the ground wire, tripping any over current protection devices. The user of the appliance will remain safe.

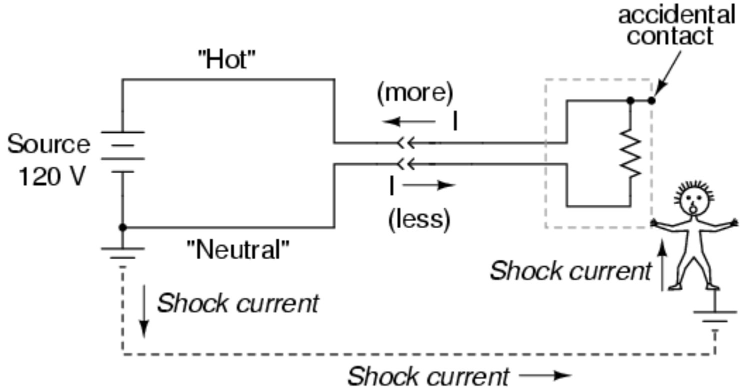
Therefore, it is so important never to cut the third prong off a power plug when trying to fit it into a two-prong receptacle. If this is done, there will be no grounding of the appliance case to keep the user(s) safe. The appliance will still function properly, but if there is an internal fault bringing the hot wire in contact with the case, the results can be deadly. If a two-prong receptacle must be used, a two- to three-prong receptacle adapter can be installed with a grounding wire attached to the receptacle's grounded cover screw. This will maintain the safety of the grounded appliance while plugged in to this type of receptacle.

Electrically safe engineering does not necessarily end at the load, however. A final safeguard against electrical shock can be arranged on the power supply side of the circuit rather than the appliance itself. This safeguard is called ground-fault detection, and it works like this:

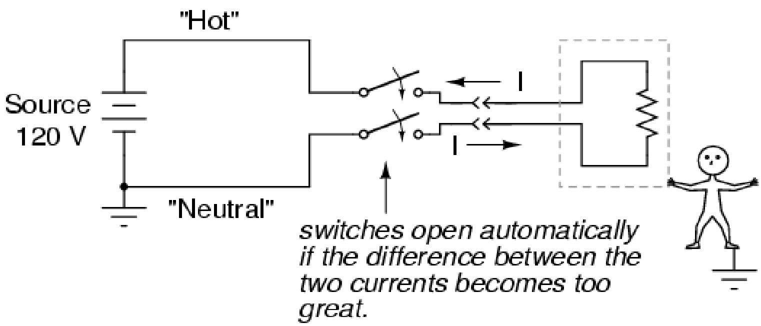


In a properly functioning appliance (shown above), the current measured through the hot conductor should be exactly equal to the current through the neutral conductor, because there's only one path for electrons to flow in the circuit. With no fault inside the appliance, there is no connection between circuit conductors and the person touching the case, and therefore no shock.

If, however, the hot wire accidentally contacts the metal case, there will be current through the person touching the case. The presence of a shock current will be manifested as a *difference* of current between the two power conductors at the receptacle:



This difference in current between the “hot” and “neutral” conductors will only exist if there is current through the ground connection, meaning that there is a fault in the system. Therefore, such a current difference can be used as a way to *detect* a fault condition. If a device is set up to measure this difference of current between the two power conductors, a detection of current imbalance can be used to trigger the opening of a disconnect switch, thus cutting power off and preventing serious shock:



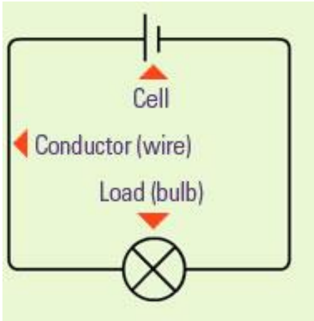
Such devices are called Ground Fault Current Interruptors, or GFCIs for short. Outside North America, the GFCI is variously known as a safety switch, a residual current device (RCD), an RCBO or RCD/MCB if combined with a miniature circuit breaker, or earth leakage circuit breaker (ELCB). They are compact enough to be built into a power receptacle. These receptacles are easily identified by their distinctive “Test” and “Reset” buttons. The big advantage with using this approach to ensure safety is that it works regardless of the appliance’s design. Of course, using a double-insulated or grounded appliance in addition to a GFCI receptacle would be better yet, but its comforting to know that something can be done to improve safety above and beyond the design and condition of the appliance.

The Arc Fault Circuit Interrupter (AFCI), a circuit breaker designed to prevent fires, is designed to open on intermittent resistive short circuits. For example, a normal 15 A breaker is designed to open circuit quickly if loaded well beyond the 15 A rating, more slowly a little beyond the rating. While this protects against direct shorts and several seconds of overload, respectively, it does not protect against arcs– similar to arc-welding. An arc is a highly variable load, repetitively peaking at over 70 A, open circuiting with alternating current zero-crossings. Though, the average current is not enough to trip a standard breaker, it is enough to start a fire. This arc could be created by a metalic short circuit which burns the metal open, leaving a resistive sputtering plasma of ionized gases.

The AFCI contains electronic circuitry to sense this intermittent resistive short circuit. It protects against both hot to neutral and hot to ground arcs. The AFCI does not protect against personal shock hazards like a GFCI does. Thus, GFCIs still need to be installed in kitchen, bath, and outdoors circuits. Since the AFCI often trips upon starting large motors, and more generally on brushed motors, its installation is limited to bedroom circuits by the U.S. National Electrical code. Use of the AFCI should reduce the number of electrical fires. However, nuisance-trips when running appliances with motors on AFCI circuits is a problem.

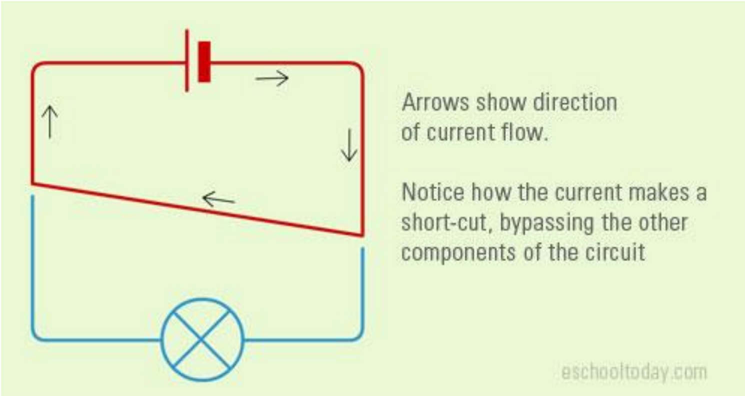
As a review Power systems often have one side of the voltage supply connected to earth ground to ensure safety at that point. The “grounded” conductor in a power system is called the neutral conductor, while the ungrounded conductor is called the hot. Grounding in power systems exists for the sake of personnel safety, not the operation of the load (s). Electrical safety of an appliance or other load can be improved by good engineering: polarized plugs, double insulation, and three-prong “grounding” plugs are all ways that safety can be maximized on the load side. Ground Fault Current Interruptors (GFCIs) work by sensing a difference in current between the two conductors supplying power to the load. There should be no difference in current at all. Any difference means that current must be entering or exiting the load by some means other than the two main conductors, which is not good. A significant current difference will automatically open a disconnecting switch mechanism, cutting power off completely.

Short Circuit.



A simple, well-designed circuit, has a cell providing current along a path (wire), to a load (resistor) and back to the other end of the cell as shown in the diagram. As the voltage gets to the resistor (load), there is a power drop, because the resistor uses some of the electricity up to produce heat and light. This means that the voltage that ends up at the other side of the cell is reduced.

In a short circuit, there is no load. For many reasons, the wires in a circuit can find a short-cut, bypassing the load (and other components). This causes the same voltage from the cell to flow to the other end of the cell. When this happens the high voltage causes the wires to heat up and catch fire.



The reasons why there could be a short circuit are wires may loose their insulation and touch each other in the circuit, there could be a fault (improper wiring) in a device, or intentionally connecting both ends of a cell / battery with wires. This causes amassive drain of electricity and the battery looses its power in a very short time. A short circuit can cause heating, melting of wires, harmful smoke and smell, and blinding light (like what you see during welding).

2.7. Tasks

Answer these following questions based on reading text given

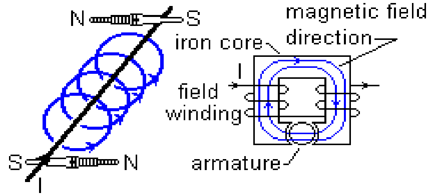
1. What makes series and parallel circuit are completely different?
2. What are practical steps that can be taken in improving safety and healthy at work?
3. Describe how solar panel works!
4. Conclude how to design a safety electrical circuit?
5. Give detail explanation on how short circuit occured and how fixed it?

CHAPTER III
TELLING PROCESS
(HOW ELECTRICAL MACHINES WORK/HOW POWER PLANT WORKS)

3.1. Electrical Machinery

Electrical energy and mechanical energy are transformed into each other by rotating machines. In rotating electrical machines, generators and motors are devices that transform mechanical power into electrical power, and vice-versa. Electrical power from a central power station can be transmitted and subdivided very efficiently and conveniently. The operation of electrical machines is explained by four general principles, that will be briefly presented below. These principles are not difficult to understand, and illuminate most of the reasons for the stages in the historical development of electrical power, and especially of electric railways. This unit discusses motors in general, but the specific application to electric locomotives is emphasized. Electricity is the medium that carries power from the prime mover, whether at a central power station or on the locomotive, to its point of application at the rail, and allows it to be controlled conveniently.

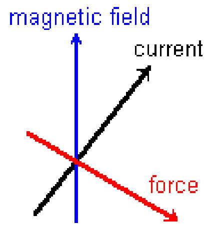
Power is rate of doing work. One horsepower means lifting 550 pounds by one foot in one second. Mechanical power is force times speed. One watt is a current of one ampere (A) flowing in a potential difference or voltage of one volt (V). Electrical power is current (in amperes, A) times voltage (in volts, V). 746W is equivalent to 1 hp. A medium-sized electric locomotive might have a rating of 2000kW, or 2680 hp. At 85% efficiency, and a voltage of 15kV, 157A is drawn from the overhead contact wire. Torque is the rotational equivalent of force, often useful in speaking of motors. It is force times perpendicular distance, and power is torque times rotational speed in radians per second.



Principle 1: a current creates a magnetic field surrounding it that is strengthened by passing through an iron core.

The first principle is that an electrical current causes a magnetic field which surrounds it like a whirlpool, and that this field, which is not material but rather a region of influence on other currents and magnets, is guided and greatly strengthened (by more than a thousand times) by passing through iron. When the current reverses in direction, so does the magnetic field. Currents deep in the earth cause its magnetic field, and the energy to drive them comes from either the rotation of the earth or the flow of heat within the earth. The field acts on the compass needle, which is a magnet. This principle can be called "electromagnet action."

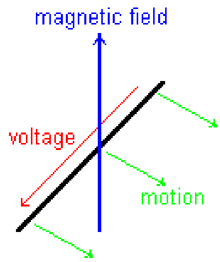
The second is that an electrical current in a magnetic field (produced by some other currents) experiences a force perpendicular to both the direction of the current and the direction of the magnetic field, and reverses if either of these reverses in direction. The force is proportional to the current and to the strength of the magnetic



Principle 2: a force is exerted on a current in a magnetic field perpendicular to the plane of the magnetic field and the current.

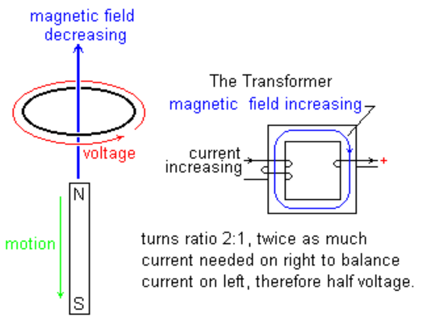
field. This principle can be called "motor action."

The third is that an electrical conductor, such as a copper wire, moving in a magnetic field has an electrical current induced in it. This is expressed by the creation of an electromotive force or voltage, which causes current to flow just as the voltage of a battery does. The effect is maximum when the wire, the motion, and the magnetic field are all mutually perpendicular. This principle can be called "generator action."



Principle 3: a voltage is induced in a conductor moved in a magnetic field. Note that the voltage is opposite to the current causing a force in the direction of motion by Principle 2.

The fourth principle is that a changing magnetic field causes a voltage in any circuit through which it passes. The change can be caused by changing the current producing the magnetic field, or by moving the sources of the magnetic field. This principle can be called "transformer action."



Principle 4: a changing magnetic field induces a voltage however the change is produced. Only a change induces, not a constant magnetic field.

A rotating electrical machine consists of a field and an armature that rotate with respect to each other. The armature is the part of the machine in which the energy conversion takes place. The field provides the magnetic field to aid this process. In DC machines, the field is stationary (the stator) and the armature rotates within it (the rotor), because the rotation is necessary to switch the armature connections by means of the commutator, but it is only the relative motion that counts. In an alternator, the armature is stationary and the field rotates. The field consists of an iron core to carry the magnetic field, and a winding to excite the magnetic field by the current passing through it (first principle). The magnetic field is a passive but essential component in the operation of the machine. Like the field, the armature also consists of iron to complete the magnetic circuit, and is separated by a short air gap from the iron of the field. It is important that the air gap be as small as possible and remain uniform as the armature rotates.

The armature also has windings. In a generator, these conductors are moved in the magnetic field producing a voltage (generator action). If a circuit is completed and current flows in these windings, a force is produced resisting the rotation of the armature (motor action) so that the driving machinery experiences a mechanical resistance and does work, which is being transformed into electrical energy. In a motor, these conductors are supplied with an electrical current, so that a force acts on them in the magnetic field (second principle), and this force can do external work. When the armature rotates while exerting the force, work is done, but a voltage is also produced opposing the applied voltage, resisting the flow of current in the armature (third principle), implying a change of electrical work into mechanical work.

This opposing voltage generated when the armature of a motor turns is called counter-electromotive force. It might seem that it resists current flow through the motor, and of course it does, but it is really the essential factor in turning electrical into mechanical energy. Only the current that is driven into a counter-emf appears as mechanical work at the motor shaft; all else is wasted, the energy going into heat instead of mechanical work. Early inventors of electric motors did not realize this, and tried simply to get as much current into the motor as possible, which only burned the motor up without producing any mechanical effect.

Current is supplied to the armature through sliding contacts formed by graphite blocks (called brushes because originally brushes of phosphor bronze wire were used instead) pressing against copper rings. It is usually necessary to change the connections of the armature windings as they rotate with respect to the magnetic field, and this can conveniently be done by making the copper rings in segments. The result is the rotary switch called the commutator. These days, semiconductor switches can be used for this purpose in small motors, eliminating the commutator, but the principle is the same. The commutator and brushes are the only parts of a machine that normally require maintenance, except for the bearings and other mechanical elements. If it is not necessary to switch the current, as in AC machines, the moving contacts are called *slip rings*.

Contemplate now the complete chain of energy flow from the prime mover, a steam or internal combustion engine, to the point where the mechanical power is finally applied. The transformation at each end must take place with a smooth mutual reaction, based on the second and third principles. This was not properly understood until the 1880's, so that practical electric transmission of power was delayed until that time. Power that is not delivered to the load is lost as heat in electrical resistance, which is equivalent to mechanical friction. Heat is produced in the generator, transmission lines, and motor, and limits the amount of power that can be handled.

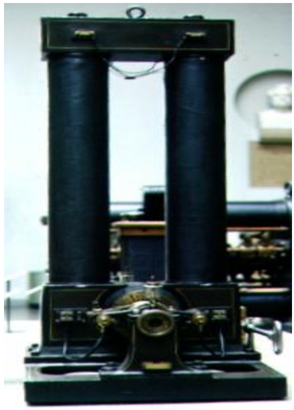
Electrical motors were invented early, in the 1830's, as soon as the magnetic effects of electrical currents and the magnetic properties of iron became known. The motors of Christie and Pixii are typical of these, which used the repulsion and attraction between electromagnetic poles switched by a commutator. Small motors of this kind are still made for classroom demonstration. Attempts in the 1840's to make these motors more powerful and larger failed completely, because the magnetic forces do not scale proportionally to distance, and the significance of counter-emf was not known. The motors of Davenport and of Long in the United States are examples of these unsuccessful attempts to scale up classroom demonstrations to practical size.

More success was encountered in making generators, usually by moving permanent magnets (thereby creating a moving magnetic field) with respect to coils of wire wound around iron cores, to generate alternating currents for supplying arc lights and direct currents for electrolysis tanks (transformer action). These generators all ran quite hot because of their lack of efficiency, but supplied the greater currents required for these applications more cheaply than chemical batteries. This industry evolved into the electrical power industries of later years.

Siemens and Gramme solved the problem of efficiency in the late 1870's by introducing magnetic circuits that did not change as the armature rotated, so that the electrical reactions were smooth and constant. Siemens' first machine (a generator) of 1866 is shown at the right, and a Gramme dynamo, which could also serve as a motor if the brushes were repositioned, is shown at the left. These machines had smooth armatures with conductors on their surfaces. It was still thought that the conductors actually had to be immersed in the magnetic field to produce forces. Soon it was discovered that if the conductors were put into *slots* in the armature surface, the same result was obtained. This was far superior mechanically, and also made a smaller air gap possible.

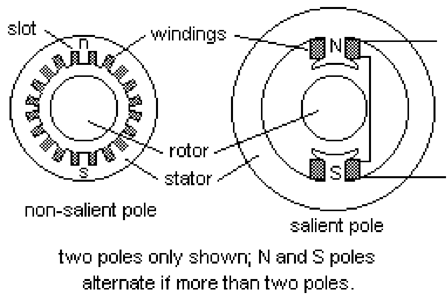
The first long-distance transmission of electrical power took place in 1886 over the 8 km between Kriegstetten and Solothurn in Switzerland. Two Gramme machines in series were used as generators, and two similar machines in series at the other end were used as motors. The line voltage was 2000V, and the wire 6mm in diameter (1/4"). The shaft-to-shaft efficiency was 75%, and the installation remained in service until 1908.

Edison's famous Z-type dynamos (as direct-current generators are often called) appeared in 1879 to supply his carbon-filament incandescent lamps. These had long fields on the mistaken assumption that this gave a more powerful magnet (like a longer lever), showing how little magnetic circuits were understood at the time. This arrangement allowed a great deal of magnetic leakage between the long arms, and made the flux distribution in the armature nonuniform. Hopkinson, an engineer with Edison's British company, rationalized the field geometry, making a very good generator of the modern type a few years later. The field was symmetrical with respect to the armature, and short. A closely related type, the Manchester dynamo, is shown below. Compare its compact and short magnetic circuit with that of the Edison Z. Note the brush holder and the brass commutator on the armature. This is a two-pole machine, because the field has one N pole and one S pole.



One thing that may worry you if you examine an electrical machine closely also worried early designers. They put the wires on the surface of the armature where they would actually be in the magnetic field and experience motor or generator action, in the way we have explained it here by our principles. However, wires are now always placed in slots cut in the armature iron, allowing the air gap to be made smaller and the magnetic circuit much more efficient. The overall result is the same as if the wires were actually in the magnetic field, but the mechanism is slightly different. Now the armature current in the motor magnetizes the

armature iron, and the interaction of this magnet with the field poles provides the force. In a generator, the field magnetizes the armature iron, and this field moves past the conductors as the armature rotates, with an effect like a transformer. Siemens, I believe, was the one who first saw this and the great improvement it could make in electrical machines.



Arrangement of Windings

The ways that windings of wire are arranged in modern machines are shown at the right. The windings are either around the pole pieces, or placed in slots on the surface. The part that rotates is called the rotor, and the part that remains at rest is called the stator. Both are of a magnetic core iron alloy, and are laminated if they are subject to alternating magnetic fields, to reduce eddy-current losses. DC machines typically have a salient-pole field on the stator, with the field windings on the pole pieces, and a non-salient pole winding on the armature, forming the rotor. The magnetic field of the stator is constant, while the field in the armature alternates. Therefore, the armature is laminated. The actions of salient and non-salient pole windings are equivalent. A non-salient pole winding can be arranged to give any desired spatial distribution of magnetic field. The typical salient-pole winding of a DC machine provides field-free regions between the poles that aids commutation, since switching can be done while the armature conductors are in this region and not generating any emf. In both salient and non-salient pole machines, the windings are firmly held mechanically.

The windings of motors and generators can be connected in one of two basic fashions. If the field windings and the armature windings are in series, they are called series-connected. In this case, the field windings are of heavy-gauge wire to carry the main motor current. The field becomes stronger as the armature current increases, leading to a very great force at low speeds. If the field and armature are in parallel, they are called shunt-connected. The field winding consists of rather fine wire. If the voltage applied to the motor is constant, then the field strength is also constant. If a generator is rotated at constant speed, then the output voltage is independent of the load. There are intermediate cases where the field has both series and shunt windings, and such machines are called compound.

Most direct-current power-station generators are mainly shunt-connected, and most traction motors mainly series-connected, as you might expect from the requirements of the two services: constant voltage in the first case, high starting torque in the second. Rotating machines can be made for voltages up to about 2000V, the restrictions being insulation and flashover at the commutator.

It is not easy to change DC voltages. One way to do this was to use a *dynamotor*, which had a normal field winding, but dual armature windings and two commutators. One winding was supplied at the input voltage and drove the dynamotor by motor action. The other winding supplied the output voltage. This can really be considered a kind of AC transformer. The input commutator creates AC from DC, and the output commutator changes the new AC voltage to DC. In World War II, when radios required a plate supply of, say 300 V, dynamotors were used to obtain this voltage from 6 V battery supply.

The speed of a direct-current motor is determined by both the field strength and the load. If there is no load, the speed is such that the voltage produced in accordance with the third principle exactly balances the applied voltage, and the armature current is zero. As the load is increased, the speed decreases to allow current to be drawn so the necessary electrical power can be converted. When the motor stalls, it is exerting its maximum force. Therefore, the speed of a shunt motor, or one in which the field is produced by a permanent magnet, is determined by the applied voltage, and can be adjusted finely.

If voltage is applied to a series motor without a load, the motor speeds up. As it does so, the field current decreases so the motor must speed up some more to generate the same back voltage. This keeps up until the motor flies apart. The loss of load on a series motor is a serious thing, and must be guarded against. When a loaded series motor is rotating with the maximum voltage applied to it, the current just produces the required amount of force with the existing field strength. If the field is weakened by reducing the current in it (by putting a resistance in series with it, for example) the motor must speed up to compensate. This is one method of speed control for direct-current motors.

A large direct-current motor must not be started by applying the full voltage across it while it is at rest, especially a series motor. The heavy current and field will create a great jolt that may damage the motor and its mechanical connections. A starting resistance is used to limit the initial current to only the amount necessary to put the motor into rotation. As it speeds up, the starting resistance can be removed in steps. In normal operation, the starting resistance should be removed, since it represents a significant loss of power. For further speed control when more than one motor is used, as on a streetcar or locomotive, the motors can be connected in series to start, and in parallel to run . In each case, the field can be weakened to give a higher speed. With four motors, series, series-parallel, and parallel connections, with field weakening, gives six speed levels that can be designed for service requirements. This could give, for example, speeds of 10, 15, 20, 30, 40, and 60 mph with starting resistance switched out.

A direct-current motor can be reversed by reversing the direction of the current in either the field or the armature. There is more to the story, however. The small demonstration locomotive of Werner Siemens of 1879 reversed by means of gears, and some authors have implied that it was not yet known how to reverse a DC motor, which is absurd. The problem lay in the brushes and commutator. The brushes must be placed so that their switching action takes place at the moment when the current in the windings being switched is zero. As the load on the motor increases, the armature current increases, and the magnetic field it produces causes the total magnetic field to change so that the brushes must be shifted to a new point of zero current. If this is not done, there is sparking at the commutator, which is rather destructive. The brushes on Siemens' locomotive were set at an average position for the load, so that if the motor were reversed, the brushes would have been at an improper position, and sparking would result. Therefore, he used reversing gears and the motor continued to rotate in the same direction.

A better way out of this difficulty was soon found. Small poles, called commutating poles, were placed between the main field poles. These windings are in series with the armature, and proportioned so that they cancel the varying field of the armature. The optimum brush position then becomes independent of motor load or direction of rotation.

Semiconductors have made possible a continuous control of voltage to the traction motors. This is called chopper control, and gives direct-current locomotives the same fine speed control as alternating-current locomotives. Using semiconductors, direct-current electrification is possible without any rotating machines, and all the advantages of both alternating and direct currents can be exploited.

If a commutator is not used on a generator, merely slip rings to connect with its windings without any switching, its output voltage alternates smoothly from positive to negative, which can be made to be a pretty good sine curve by using non-salient-pole windings. It is easier to generate such an alternating current by rotating the field inside a stationary armature, so that the main current does not have to flow through the sliding contacts. The sliding contacts, which are called slip rings, need handle only the lower voltage and current of the field windings. High voltages can be generated because it is much easier to insulate the stator, and because these voltages do not have to be handled by the slip rings. This is such an advantage that practically all electricity is generated as alternating current, and the generators are called alternators. These advantages were even reflected in automobiles, which previously used 6V dynamos, but now all use 12V alternators. Typically, the stators are non-salient-pole, while the rotating fields have salient poles.

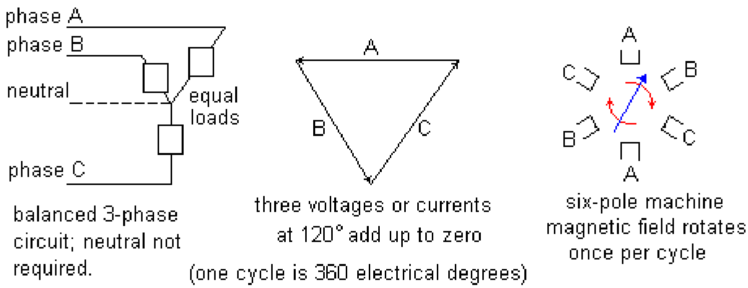
Alternating current has the compelling advantage that its voltage can be changed easily and efficiently by a transformer, which is a closed iron core surrounded by two windings (first and fourth principles). The ratio of the voltages in the two windings is the same as the ratio of the number of turns, and the ratio of the currents inversely, so that the power remains the same. Since there are no mechanical parts, the efficiency of transformers is very high, and maintenance very low. Alternating current is transformed to higher voltage and smaller current for transmission, and back to lower voltages for use. Transformers with taps can be used to obtain a series of voltages if desired. In fact, an almost continuous voltage variation without loss is possible.

If direct current is required for motors, alternating current can be converted to direct current in four ways. First, a motor-generator set can be used, running at constant speed. A better solution is the rotary converter, essentially a DC generator rotated by AC supplied to it. These were the only practical ways at first for large power requirements, especially for electric railways. Later, rectifiers based on electrical discharges, notably the mercury-arc rectifier, made conversion possible without rotating machines, and with currents appropriate for locomotives. Both of these methods have now been completely superseded by solid-state (silicon) rectifiers, which are trouble-free and easily controlled. Single-phase 50/60 Hz alternating current can be supplied at high voltage, reduced in voltage by a transformer, rectified by solid state rectifiers, and applied to direct-current traction motors, making a very serviceable and economical locomotive that is today's standard.

The Ward-Leonard system of speed control for a direct current motor used a generator driven by a motor supplied from any kind of current, alternating, three-phase, or direct. By control of the generator and motor fields, control of the motor over a wide range of speeds was possible. This system was used in a few locomotives to permit the use of direct-current traction motors with single-phase alternating current supply. The problem was that three machines of equal capacity were required in place of one, a very costly alternative. Semiconductor rectifiers or chopper control have completely replaced the Ward-Leonard system.

At first sight, it would seem easy to make alternating current motors. If the polarity of the supply to a DC motor is reversed, the motor continues to turn in the same direction. If AC is supplied, the torque might be pulsating, but at least it would always be in the correct direction. Unfortunately, this is not true (except at unrealistically low frequencies) because of the existence of reactance that causes phase differences and inductive kicks. The magnetic fields and the currents get out of register, torques are small, and there are sparks everywhere. However, with the series motor there is some hope, because the same current that creates the field also passes through the armature, so they must stay in phase. In fact, series motors can be designed for AC, and they have been brought to a high state of excellence, although best at 16 2/3 or 25 Hz.

Most AC motors, however, depend on a rotating field produced in the stator, or stationary part of the motor. This is a magnetic field produced by windings through which alternating currents are passed that seems to rotate around the stator with time. The number of poles P is the number of north and south poles around the circumference, and is determined by how the windings are placed on the stator. The rate of rotation of the field is given by N = 120 f/P rpm, where f is the frequency of the alternating current. A four-pole field rotates at 1800 rpm, for example, with 60 Hz current. This is called the *synchronous speed*. The easiest way to produce such a field is to use an AC supply that consists of several voltages with a constant phase difference between them, called a *polyphase* supply. One could use two voltages at 90° phase difference, and let each voltage supply alternate coils in a four-pole machine. Better, however, to use three voltages at 120°, called *three-phase,* for then the power flows as evenly as with DC. These voltages are generated by separate windings on the alternator, and are supplied over three wires. These stators have no salient poles, but have a smooth surface with the windings embedded in slots. Three-phase current is normally used for transmission and distribution of electrical power, since it is the most efficient means in terms of the copper required and transmission losses.



Three-Phase Alternating Current

Suppose that we have such a stator with a rotating magnetic field. For the armature, we use a drum armature as for a DC motor, but simply short-circuit the windings. Then, when the motor is not rotating, we have what is very much like a transformer with a shorted secondary winding. It is excited at the frequency of the stator currents. Unlike a transformer secondary, this secondary can rotate in response to the forces exerted on it (its windings are in a magnetic field). When it does so, it tends to follow the rotating field more and more closely. When it is rotating at exactly the same speed as the rotating field, the apparent frequency to the rotor is zero, and no currents are induced at all. If it rotates slightly slower, or *slips*, the frequency increases, and more currents are generated. The slip is the difference in rotating speed divided by the synchronous speed, expressed as a percentage. The forces on these currents provide the torque exerted by the motor. The torque increases about proportionately to the slip. At some point, however, the reactance of the armature windings come into play not only to limit the currents, but to move them out of phase with the magnetic field. So the torque levels off, and passes a maximum value called the *breakdown torque*. The motor now slows down more and more rapidly, the torque more and more out of phase. When the rotor comes to rest, the starting torque is produced, and the motor will not move until the required torque is less than this amount.

This kind of motor is called an *induction motor*, which has no DC analog. It rotates a bit more slowly than the speed of the rotating stator field, which is called the *synchronous* speed. Large polyphase motors may have a slip of only 1% or so at normal load, so the induction motor is essentially a constant-speed motor. Its speed can only be greatly changed by changing the frequency of the supply. The starting torque is considerable, but at the cost of rather high currents out of phase with the voltage. The lagging power factor of an induction motor can be a problem. Nevertheless, the lack of a commutator and brushes, and that it has a reasonable starting torque, make the induction motor the most commonly used AC motor. A typical motor has a rotor composed of parallel thick copper or aluminum conductors connected to a ring of the same material at the ends. This is called a "squirrel cage" rotor.

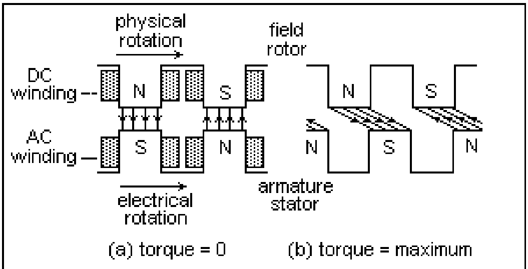
Squirrel-cage rotors, because of their low impedance, run with small slip and give high torque at speed. However, their starting torque is poor. If your sink garbage disposal is on the same circuit with some lights, note the lights dim briefly when you switch it on. This is the result of the high reactive current drawn by the static induction motor, which can be 4 times the normal load current. Fuses must be slow-blow to let this pass before deciding that there is some problem. There is usually a circuit breaker on the disposal that opens if the motor is stalled. You might also note the limited starting torque when the motor fails to start if it gets something in its teeth. By adding resistance to the rotor, better starting torque can be obtained, at the cost of poorer running at speed. Ways have been devised to cut out the resistance after starting, but these involve a wound rotor with brushes, or complicated double windings, and have not been worth the bother.

Small single-phase induction motors can be made that create the extra phase that is necessary for starting the motor internally. Examples are the split-phase, capacitor start and shaded-pole motors used on motors of a few hp and less. Split-phase motors use a separate winding of higher inductance to produce a phase shift; capacitor motors use a capacitor for the same effect, and the capacitor can be switched out after the motor has started and has come up to speed. A shaded-pole motor has a copper ring around one side of the poles to retard the flux there, so the field appears to rotate. These single-phase motors can operate on 50/60 Hz, but are not suitable for traction motors because of their poor starting characteristics, and their low efficiency.

An unusual type of single-phase AC motor has non-salient-pole stator and rotor. The stator is supplied by the single-phase AC current, while the rotor is very similar to a DC armature, with commutator and brushes. The brushes are short-circuited, and the armature current is created by induction from the stator. If the brushes connect turns that are in field-free regions, any armature current would be in phase to produce a torque. However, with this brush position, there is no current, since the emf's cancel. If the brushes connect turns that are under the poles, the induced armature currents are a maximum, but the forces exerted on them cancel. At some intermediate brush position, there is both current and a net force. The motor can be reversed by moving the brushes past a pole to an equivalent position. Such a machine is called a *repulsion motor*, and it acts somewhat like a series motor. Although it gives good torque, commutation at the brushes can be difficult, with sparking. The theory of the repulsion motor is rather difficult.

A non-salient-pole stator with a rotating field can be used with a salient-pole rotor to make an AC motor. This is, in fact, exactly like an alternator except that the mechanical power is output, not input. The rotor is fed DC by slip rings to magnetize it. As the stator field rotates (electrically), it will carry the rotor poles around with it at the synchronous speed (mechanically). For this reason, this type of motor is called a *synchronous* motor. A synchronous motor is essentially an alternator run backwards. Rotor current must be supplied, because there is no relative motion to induce it as in an induction motor. The magnetic field in the rotor is constant, and corresponds to the constant flux in a transformer. However, its alternating variation as seen by the stator windings is now produced by its motion.

A few poles of a synchronous motor are shown in the diagram on the left. Stator poles are shown as salient for clarity, though the stator is usually non-salient-pole. The rotor and stator poles remain in fixed relative positions. The rotor poles are carried along by the rotation, while the stator poles move as they are excited by the polyphase supply. When there is no torque exerted by the rotor, conditions are as in (a). When the motor supplies a torque, the rotor lags a bit behind, as shown in (b). The lines of force suggest the pull on the rotor, since there is a tension along the magnetic field. There is now a phase difference between rotor and stator, inducing a voltage that reduces the back emf presented to the supply, and the current to the motor stator, in phase with the voltage, must increase to bring the back emf up to the supply voltage, exactly as in a transformer. It is rather difficult to see this except by a detailed analysis involving phasor diagrams, but the force and energy relations can be verified as for a DC motor. Energy supplied against a back emf is transformed to an equal amount of mechanical enerby.



Synchronous Motor

The motor torque depends on the angle the rotor lags behind the rotating stator field. If the torque required is too high, the motor may drop out of synchronization, and then come to rest. Such motors can supply considerable power, but run at a fixed speed determined by the current frequency, and cannot start against a load. They may be started by an auxilary motor, by acting as an induction motor, or by other means, before load is applied. They are, therefore, unsuitable as traction motors, but can be the motor in a motor-generator set. They can drive a three-phase alternator in this arrangement, which can feed three-phase traction motors, or, of course, can drive a direct-current generator, as in a Ward-Leonard control. The synchronous motor requires DC excitation, and has slip rings to maintain, so it is not as commonly used as the induction motor. If the DC field excitation is changed, the synchronous motor can be made to draw reactive, wattless quadrature current and act as a capacitor or an inductor. Only for a certain level of excitation is the current in phase with the applied voltage. Synchronous motors without a mechanical load can be used to correct power factor in a transmission system.

One type of small synchronous motor is used to drive clocks. Tesla chose 60 Hz as the power frequency looking toward this application. More useful for this purpose are subsynchronous motors, that run at a fraction of the synchronous speed, making the gearing easier. These motors can have a toothed rotor, or a rotor consisting of copper rods, and will lock in at a subsynchronous speed, though they are fundamentally two-pole motors operating at 3600 rpm. Such motors cannot supply much torque.

A synchronous converter can convert AC to DC with high efficiency. This is a machine much like a DC generator, but with a polyphase non-salient-pole field. Polyphase, usually six-phase, power is supplied to the stator, while the rotor rotates at the synchronous speed. DC can now be taken from the commutator and brushes. The armature current is the difference of the AC and DC currents, so it is rather small and this helps the efficiency of the machine. The DC side of the machine can be used to bring it up to synchronous speed quite conveniently, if DC is available from batteries or some other source. Synchronous converters were much used before solid-state rectifiers became available.

Quite recently, semiconductors have made possible the creation of three-phase power of variable frequency, so that it becomes applicable to traction motors. Electrical power generated by an alternator, or supplied by a contact wire, is first converted to direct current, then to variable-frequency three-phase for supplying induction traction motors in a locomotive. In this way, commutators and other troublesome sliding contacts are completely eliminated, reducing maintenance costs. This has occurred even though DC has distinct advantages for traction.

Improvements in motors since the turn of the century, making them smaller, lighter, and more efficient for the same output, have been due to three main factors. The first was rational design of the magnetic circuit, to make the best use of the iron. Next was improved magnetic material, especially silicon iron with low losses, that meant less iron could be used and motors could be more compact. Finally came better insulating materials that required less room and could stand higher temperatures. These benefits extended to all other electrical machinery as well, including generating apparatus and transformers.

A supply in the range 600-700V DC was common for street railways, rapid transit, and interurban electric railways, in spite of the heavy currents required. Remember that power is voltage times current, so doubling the voltage halves the current for the same power, and the losses are proportional to the square of the current, so a decrease in current is very desirable. A voltage much above this cannot safely be used for third rails and where work must be done around energized equipment. With normal precautions, such voltages are not fatal and require actual contact for danger. 1500V was initially popular for main line electrification with an overhead contact wire. Somewhat higher voltages, up to 3000V, were later used to reduce the traction currents as far as possible, although 3000V generally requires traction motors to be permanently in series. 11, 15, and 20kV are used for alternating-current electric railways using an elevated contact wire. These are the highest voltages that can be safely used taking normal clearances into account. Personnel must be kept well out of the way of such voltages, which, unlike the lower voltages just mentioned, can reach out and be fatal at considerable distances. Transmission may be at 100kV and over, where the conductors are specially insulated on high towers.

Although we have seen a bewildering variety of rotating electrical machines, there is really only one fundamental principle at work. These machines are transformers between electrical and mechanical energy, just as the usual AC transformer transforms between electrical energy at different voltages. In fact, the ordinary transformer was also called a *static* transformer. These machines are *dynamic* transformers. On the mechanical side, the energy is transmitted by rotation. Torque times angle is work, torque times angular velocity is power. Every machine has a magnetic circuit, in which certain fluxes are established that are analogous to the flux in a static transformer. This magnetic field assists in the energy transfer, but does not receive or give energy itself. The magnetic flux links conductors, and can exert forces on them if they carry currents, and can induce emf's in them if the flux changes. The forces determine the mechanical power, while the emf's determine the electrical power. There are other energy effects, such as I^2R loss in the conductors and the eddy currents, iron losses due to hysteresis, mechanical friction and windage, and the alternating flows of reactive volt-amperes. However, the induced emf's and the forces are always such as to represent an ideal conversion between electrical (emf times current) and mechanical (force times distance) energy, accompanied by these losses, which can be minimized, but are unavoidable.

When the conductors are on the surface of the rotor, actually in the magnetic field of the air gap, it is easy to see how the emf is induced, and how, if current flows, the force times distance equals the emf times current, as we pointed out at the beginning of this paper. It is not so easy to see this if the windings are on the stator, while the force is on the rotor, and if the conductors are buried in the iron, or wrapped around the poles. Nevertheless, a careful analysis would show in every case exactly the same relations that are so evident with conductors in the air gap.

To generate electrical energy, we move conductors (armature) in a magnetic field (field) at rest, or else move a magnetic field (rotor) relative to conductors at rest (stator). In either case we get a periodically reversing emf that can be made sinusoidal by careful design. If generated in the rotor, the motion can be used to switch the connections so that the output current is unidirectional, and more or less constant. Mechanical energy always enters by the rotor, but electrical energy can be taken either from the rotor or the stator. Whenever any current is drawn, the mechanical side feels the effect as an increased drag. The energy received from the mechanical side is always greater than the electrical energy delivered.

To generate mechanical energy, we can place movable conductors (armature) in a steady magnetic field (field). Torque is produced when we drive a current through the conductors, and when the armature moves, we feel an electrical opposition to supplying the current. Or, we can wind the stator to produce a rotating magnetic field, and have this field drag along conductors on a rotor. Current is driven through the rotor conductors either by induction, or by an external source. In either case, when mechanical energy is drawn, there is an electrical effect amounting to an increase of the current driven into a back emf. The energy delivered to the mechanical side is always less than the electrical energy supplied.

The only general and satisfactory way to understand the forces on the rotor of an electrical machine is by considering the magnetic field over an imaginary surface surrounding the rotor. Electric fields play no role in the forces in electrical machinery. From the magnetic field, the Maxwell stress tensor can be found, and from it the forces on the rotor, by integrating the shearing stresses over the surface. In the usual DC motor, if no armature current exists, the magnetic field passes symmetrically through the armature, and there is no net torque on it. When armature current flows, it creates a transverse component of the magnetic field, so the total field is "twisted." This field has a tangential component in the air gap that is responsible for the torque on the armature. The picture of current-carrying wires in a magnetic field is of little help in understanding an actual motor.

Rotary motion is ideal for most applications. On the mechanical side, it allows the use of an excellent and efficient mechanical transformer, gearing. Bearings provide a convenient support for rotating shafts. Turbines provide rotary power for generators, and they are efficient prime movers when used at constant speed and constant power. Just as there are reciprocating engines, one can conceive of reciprocating electrical machines.

However, one notices that reciprocating motion usually has to be transformed to rotary motion for applications, aside from such things as driving a reciprocating pump. Even here, the centrifugal pump, with rotary motion, is used where possible. Reciprocating electrical machines have been tried, but were very unsatisfactory, and there is no reason to resurrect them. Motors with a linear stator would also seem quite impractical mechanically, if not electrically. The only application would be to traction, but here they are a solution without a problem. Professor E. Laithwaite of Imperial College promoted linear motors vigorously, and there are still efforts in this direction, usually with magnetic levitation as well. The best use of this idea would be if the power were supplied to the stator, with a passive "cursor," but this would be hopelessly uneconomic for practical transport, though feasible for very short distances. There is no essential difference in operation between these linear motors and the rotary ones.

3.2. Tools and Equipment

Electrical tools are used by professional contractors, electricians, and homeowners who wish to install or fix wires and electrical fixtures. Having the right tool for the job allows the electrician to work safely and efficiently. Basic tools are a good investment as tools especially for electricians are designed to protect against electric shock and make electrical connections that are safe and long lasting. The basic tool kit includes safety tools, diagnostic tools, and functional tools. Safety tools include lighting, ladders, and protective gear. Diagnostic tools identify voltages and measure for studs. Functional tools are hand or power tools, like pliers, wire strippers, and screwdrivers.

Safety is very important when working with electricity, so there are several safety tools available for the electrician. The tools are designed to make the environment safe and also protect the electrician.

Tool 1: Lights

Often, when working with electricity, the electrician must turn off all or most of the power at the circuit breaker. For situations with no light or dim light, the electrician can use a simple flashlight. These are available in different sizes, from the pocket size to a large flashlight. Electricians may also want to invest in head-mounted flashlights to peer into dark spaces while retaining the use of the hands. For more light, floodlights are useful as well as a generator to provide power to the floodlight.

Tool 2: Ladder

Ladders are important to reach both indoor and outdoor wires and fixtures. For electricians, a ladder made of a non-conductive material is best, like fiberglass or wood. Ladders made from aluminum or other metal are electrical conductors and should not be used.

Tool 3: Personal Protective Gear

Personal protection gear for the electrician is important, easily procured, and should be part of every electrician's basic set of tools. Gloves allow the fingers and wrists to be flexible, yet guard against cuts and scrapes. For added protection, use rubber insulating gloves and wear leather gloves on top. Work shoes rated for electricians have thick rubber soles that are resistant to electric shock. To protect the head, wear a hardhat, and to protect the eyes, wear safety glasses with a side shield.


Lineman's Safety Equipment
SAFETY GLASSES
Nylon, one-piece frame. Worn to block hazardous sun glare, particularly when working on energized lines.
HARD HAT
Made from hard plastic with inner web suspension system; has universal slots to attach accessories such as ear protection. Extended brim protects face from falling debris. Factory-tested for dielectric strength.
EAR PROTECTION
Mounts into hardhat slots and has replaceable foam cushions. Different types have different noise reduction ratings. (not pictured)
RUBBER SLEEVES
Dielectric-tested, seamless, vulcanized molded rubber that protects wearer's arms from unintentional contact with energized power source.
SAFETY HARNESS
Full body harness for working in elevated bucket. Harness attaches to truck boom with lanyard and locking snap hook.
SHIRT
55% Modacrylic/45% cotton flame resistant fabric and stitching with nonmetallic buttons.
RUBBER GLOVES
Dielectric-tested, rubber insulated gloves for electrical protection. Glove thickness dictates the level of voltage line personnel may work.
LANYARD
Nylon strap with locking snap hooks connects to lineman's safety harness (in back) to truck boom to prevent falling. (not pictured)
RUBBER GLOVE PROTECTORS
Leather gloves with Velcro tightening strap and attached orange vinyl cuff. Worn over insulated rubber gloves to reduce chance of puncturing or tearing from sharp objects.
HOT STICK
Insulated, dielectric-tested fiberglass tool for moving or adjusting live electrical equipment.
JEANS
88% Fire Resistant Cotton/ 12% Nylon with flame resistant stitching.
WORK BOOTS
Lace-to-toe, steel or ceramic-toe leather boots with extra arch support for climbing

Electrician's Diagnostic Tools

The most important part of electrical safety is diagnosing the electrical conditions before beginning work. Additionally, other tools are useful to find wires and complete the electrical project.

Tool 4: Wire Testers

Wire testers are diagnostic devices that tell the electrician whether the power is on or off and they measure the strength of the electricity. Depending on the application, electricians can use several different kinds of wire testers, such as a test probe. Some wire testers are basic devices while others offer digital readouts. The voltage detector is one of the first diagnostic tools to use, as it indicates whether a wire is live or not. The continuity tester checks for malfunctioning circuits, switches, and fuses. Electricians often use it to see if a light socket is working properly. The tester indicates an open or closed circuit status but is not capable of measuring normal and short loads. For maximum versatility, electricians can purchase a multimeter that checks for both voltage and continuity. A wire may be in an open area, behind a wall, or inside a pipe. Therefore, an electrician may also need an underground wire cable detector or a wire tracer to locate and test certain wires.

Tool 5: Measuring Tools

A stud finder is a useful tool for locating the beams in the walls and ceiling. Having this information helps indicate where wires are more likely to be located. A tape measure is often found in an electrician's basic set of tools to measure wall height and depth, wire lengths, and other tasks. To complete some tasks, like installing lighting, a level is used to indicate straightness of an object in relation to the floor.

Electrician's Functional Tools

Electricians use a variety of hand tools that are often available as power tools. Power tools have electric cords, so electricians should consider cordless hand tools. For additional power, an air compressor adds power and torque to power tools. When possible, electricians should buy rubber-gripped tools, as they can help protect themselves from shock. Because functional tools are used often, consumers should find tools with ergonomic designs.

Tool 6: Cutting Tools

Working with wire and cutting through walls requires cutting tools. To hack through walls, people use large power saws or small hacksaws. For some jobs, a simple box cutter can suffice. Since wires are made of different gauges and often have a protective housing, consumers can find several types of wire cutters. Wire cutters cut completely while wire strippers have a notch in the center to cut away the insulated casing without damaging the wire.

Tool 7: Pliers and Wrenches

For many electrical jobs, tools to manipulate wires, nuts and bolts, and other electrical and mechanical objects are necessary. To loosen nuts and bolts, electricians can use wrenches. Some are adjustable with jaws that open in various positions while others have interchangeable bits. A vise grip wrench is necessary at times. Pliers have different types of grip heads, shapes, and lengths. Linesman's pliers have a gripping edge and a cutting surface. Side-cutting pliers have a blade on only one side. Needle-nose pliers are long and pointed at the end for more detailed work. Lock pliers may also be used, if the user wants the pliers to hold their shape while the electrical work is being performed.

Tool 8: Screwdrivers

Screwdrivers are used to drive in screws in electric fixtures, electrical boxes, or the outside plates to the wall or ceiling. People can find both manual screwdrivers and power screwdrivers. A small cordless screwdriver is a valuable addition to the electrician's toolbox. The most common types of screwdrivers are the Phillips head and the flat head. An adjustable screwdriver is more versatile but it may not be as long or as short as needed for some jobs. People should consider a wire-bending screwdriver as it bends the wire when installing the screw.

Tool 9: Hammer

While cutting tools, pliers, wrenches, and screwdrivers are most often used by electricians, a hammer is useful in some situations. A basic hammer with a flat head and a claw can suffice, but other varieties are available. Consumers can purchase very small hammers, large hammers, and power hammers.

Electrical Tool Accessories

In addition to the basic tools, electricians can use other items and accessories. A tool belt is a pouch that is worn around the waist or strapped over the shoulder. A toolbox helps carry and organize a number of tools along with supplies, like screws. Extension cords enable the electrician's tools to reach further and heavy-duty cords are more appropriate for power tools. Some tools, like diagnostic tools, are better stored in pouches or in a tool kit. Electrical tape, especially colored tape, is always handy. For some jobs, electricians may need a soldering iron or staple gun. Extra battery packs for power tools are available. To patch holes, spackle and a putty knife are often needed.

Professional electricians, contractors, and homeowners all may need a basic set of tools to complete a certain job effectively. Safety is paramount in working with electricity, so the first concern about a tool should always be about its safety features. Examples of safety tools are wood ladders and rubber-handled screwdrivers. Diagnosing electrical circuits and measuring walls to look for electrical lines is simple with diagnostic tools, like continuity testers and stud finders. For creating holes in the wall, cutting wires, and screwing in plates, people can find hand tools or power tools. It is important to make sure that all of the tools gathered are meant specifically for electrical work.

The right tool for a particular job is important, so manufacturers make basic tools with varied designs and features.

3.3. Component/Instrument

There are many components or instruments used in electrical and electronics daily job. Some of them are:

Passive Linear Components

A resistor is an electronic component, which is used to resist the flow of current and cause a reduction in potential. It consists of a low conductive component joined by conducting wires at both its ends. When current flows through the resistor, the electrical energy is absorbed by the resistor and dissipated in form of heat. The resistor thus offers a resistance or opposition to the flow of current.

The resistance is given as

R = V/I, where V is the voltage drop across the resistance and I is the current flowing through the resistor. The power dissipated is given by:

P = VI.

Laws of Resistance:

The Resistance ‘R’ offered by a material depends on various factors

1. Varies directly on its length, l
2. Varies inversely on its cross section area, A
3. Depends on the nature of the material specified by its Resistivity or Specific Resistance, ρ
4. Also depends on the temperature
5. Assuming that the temperature is constant, the Resistance (R) can be expressed as $R = \rho l / A$, Where R is resistance in ohms (Ω), l is length in meters, A is area in square meters and ρ is Specific Resistance in Ω-mts

A resistor’s value is calculated in terms of its resistance. Resistance is the opposition to the flow of current.

Two methods to measure resistance values:

1. Using color code: Each resistor consists of a 4 or 5 color band on its surface. The first three (two) colors represents the resistor value, whereas the 4^{th} (third) color represents the multiplier value and the last one represents the tolerance.
2. Using Multimeter: A simple way to measure resistance is by using a Multimeter to measure the resistance value in ohms.

Types of Resistors:

Fixed Resistors: Resistors whose resistance value is fixed and are used to provide a opposition to the flow of current.

They can be carbon composition resistors which are made up of mixture of carbon and ceramic.

They can be carbon film resistors which consists of carbon film deposited on an insulated substrate.

They can be metal film resistor which consists of small ceramic rod coated with metal or metal oxide, with the resistance value being controlled by the thickness of the coating.

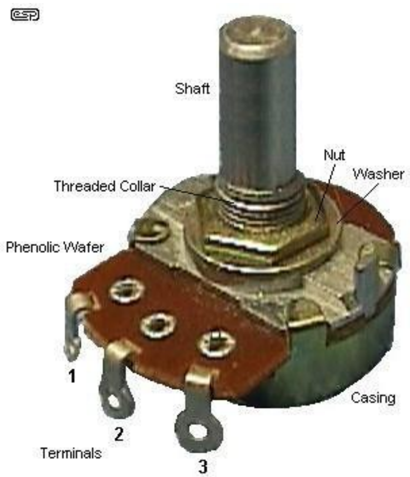
Metal Resistors

They can be wire wound resistor which consists of an alloy wrapped around a ceramic rod and insulated.

They can be surface mount resistor which consists of resistive material like tin oxide deposited on a ceramic chip.

Variable Resistors: They provide a variation in their resistance value. They are generally used in voltage division. They can be potentiometers or presets. The resistance can be varied by controlling the wiper movement. The variable resistor or variable resistance, which is consist three connections. Generally used as an adjustable voltage divider. It is a resistor with a movable element positioned by a manual knob or lever. The movable element is also called as wiper; it creates a contact with a resistive strip at any point which is selected by the manual control.

The potentiometer divides the voltage in to different proportions depending on its movable positions. It is used in different circuits where we require less voltage than the source voltage.



Potentiometer

A capacitor is a linear passive component which is used to store electrical charge. A capacitor generally provides reactance to the flow of current. Basically a capacitor consists of a pair of electrodes between which there is an insulated dielectric material.

The stored charge is given by

Q = CV where C is the capacitive reactance and V is the applied voltage. Since current is rate of flow of charge. Therefore, the current through a capacitor is:

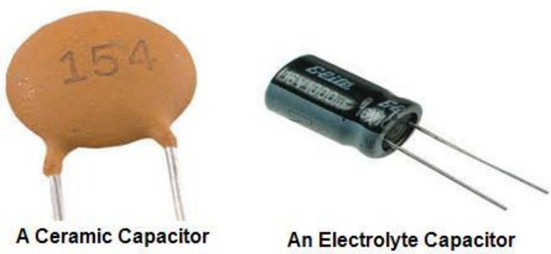
I = C dV/dt.

When a capacitor is connected in a DC circuit, or when a constant current flows through it, which is constant with time (zero frequency), the capacitor simply stores the whole charge and opposes the flow of current. Thus a capacitor blocks DC.

When a capacitor is connected in an AC circuit, or a time varying signal flows through it (with non zero frequency), the capacitor initially stores the charge and later offers a resistance to the flow of charge. It can thus be used as a voltage limiter in AC circuit. The resistance offered is proportional to the frequency of the signal.

Types of Capacitors

Fixed Capacitors: They offer a fixed reactance to the flow of current. They can be Mica capacitor which consists of mica as the insulating material. They can be non polarized ceramic capacitors which consist of ceramic plates coated with silver. They can be electrolyte capacitors which are polarized and used where high value of capacitance is required.



Fixed Capacitors

Variable Capacitors: They offer capacitance which can be varied by varying the distance between the plates. They can be air gap capacitors or vacuum capacitors.

Capacitance value can be either read directly on the capacitor or can be decoded using the given code. For ceramic capacitors, the 1st two letters denote the capacitance value. The third letter denotes the number of zeros and the unit is in Pico Farad and the letter denotes the tolerance value.

Inductors: An inductor is a passive electronic component which stores energy in form of a magnetic field. It generally consists of a conductor coil, which offers a resistance to the applied voltage. It works on the basic principle of Faraday's law of inductance, according to which a magnetic field is created when current flows through the wire and the electromotive force developed opposes the applied voltage. The stored energy is given by:

E = LI^2. Where L is the inductance measured in Henries and I is the current flowing through it.

Inductor Coils

It can be used as a choke to offer resistance to the applied voltage and store the energy or used in combination with a capacitor to form a tuned circuit, used for oscillations. In AC circuits, the voltage leads the current as imposed voltage takes some time to build up the current iPassive Non Linear Components:

Diodes: A diode is a device which restricts current flow in only one direction. A diode is generally a combination of two differently doped regions forming a junction at the intersection such that the junction controls the flow of charge through the device.

Types of Diodes:

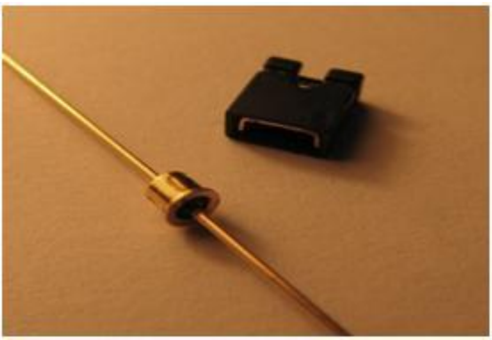
PN Junction Diode: A simple PN junction diode consists of a p-type semiconductor mounted on an n-type semiconductor such that a junction is formed between the p and n types. It can be used a rectifier which allows current flowing in one direction through proper connection.

A PN Junction Diode

Zener Diode: It is a diode made up of heavily doped p region compared to the n-region, such that it not only allows current flow in one direction, but also allows current flow in the opposite direction, on application of sufficient voltage. It is generally used as voltage regulator.

A Zener diode

Tunnel Diode: It is a heavily doped pn junction diode where the current decreases with increasing forward voltage. The junction width is reduced with increasing impurity concentration. It is made from germanium or Gallium Arsenide.

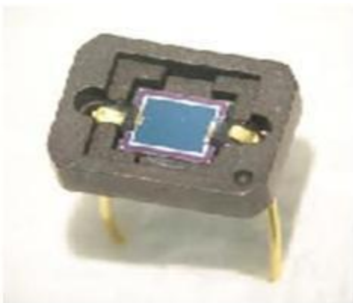


A Tunnel Diode

Light Emitting Diode: It is a special type of PN junction diode made from semiconductors like Gallium Arsenide, which emits light when a suitable voltage is applied. The light emitted by the LED is monochromatic, i.e. of single color, corresponding to a particular frequency in the visible band of the electromagnetic spectrum.

A LED

Photo Diode: It is a special type of PN junction diode whose resistance decreases when light falls on it. It consists of a pn junction diode placed inside a plastic.



A Photodiode

Switches: Switches are devices which allow the flow of current to the active devices. They are binary devices, which when completely on, allows flow of current and when completely off, block the flow of current. It can be a simple toggle switch which can be a 2-contact or a 3 contact switch or a push button switch.

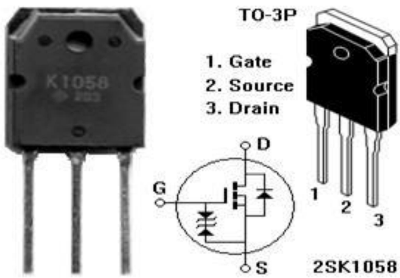
Transistors: Transistors are devices which generally transform resistance from one part of the circuit to another. They can be voltage controlled or current controlled. A transistor can work as an amplifier or as a switch.

Types of Transistor:

BJT or Bipolar Junction Transistor: A BJT is a current controlled device which consists of a layer of n-type semiconductor material sandwiched between two layers of p type semiconductor material. It consists of three terminals – The emitter, base and collector. The collector base junction is less doped compared to the emitter base junction. The emitter base junction is forward biased whereas the collector base junction is reverse biased in normal transistor operation.

A Bipolar Junction Transistor

FET (Field Effect Transistor) is a voltage controlled device. The ohmic contacts are taken from the two sides of the n type bar. It consists of three terminals – Gate, Drain and Source. The voltage applied across the Gate-Source and the Drain-Source terminal controls the flow of current through the device. It is generally a high resistance device. It can be JFET (Junction Field Effect Transistor) which consists of an n type substrate, on the side of which a bar of the opposite type is deposited or a MOSFET (Metal Oxide Semiconductor FET) which consists of an insulated layer of silicon oxide between the metallic Gate contact and the substrate.



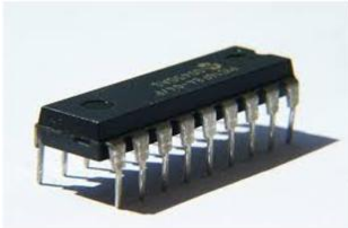
MOSFET

TRIACS or SCR: An SCR or Silicon Controlled Rectifier is a three terminal device which is generally used as a switch in power electronics. It is a combination of two back to back diodes having 3 junctions. The current through the SCR flows because of the voltage applied across anode and cathode and is controlled by the voltage applied across the Gate terminal. It is also used as a rectifier in AC circuits.

An SCR

So these are some of the important components in any electronic circuit. Apart from these active and passive components, there is one more component, which is of vital use in the circuit. That is the Integrated Circuit. An Integrated Circuit is a chip or a microchip on which thousands of transistors, capacitors, resistors are fabricated. It can be an Amplifier IC, a timer IC, a waveform generator IC, a memory IC or a Microcontroller IC. It can be an analog IC with a continuous variable output or a Digital IC operating at a few defined layers. The fundamental building blocks of Digital ICs are the logic gates.

It can be available in different packages like Dual in Line Package (DIP) or Small Outline Package (SOP) etc.



A Practical application of resistors – Potential Dividers

Potential dividers are frequently used in electronic circuits. Therefore it is desired that a thorough understanding of the same would greatly help in designing electronic circuits. Instead of deriving the voltages mathematically by applying Ohm's law, the following example by assessing in ratio way, one would be able to quickly get the approximate voltage while attending to R&D nature of work.

When two resistors of equal value (e.g. 6K both for R1 & R2) are connected across a supply, same current will flow through them. If a meter is placed across the supply shown in the diagram it will register 12v with respect to ground. If the meter is then placed between the ground (0v) and the middle of the two resistors it will read 6v. The battery voltage is then divided in half. Thus voltage across R2 with respect to ground =6v

Similarly

2. If the resistor values are changed to 4K (R1) and 8K (R2) the voltage at center will be 8v with respect to ground.
3. If the resistor values are changed to 8K (R1) and 4K (R2) the voltage at the center will be 4v with respect to ground.

The voltage at the center is better determined by the ratio of the two resistor values , though one can go by Ohms law to calculate to arrive at the same value. Case-1 the ratio was 6K:6K

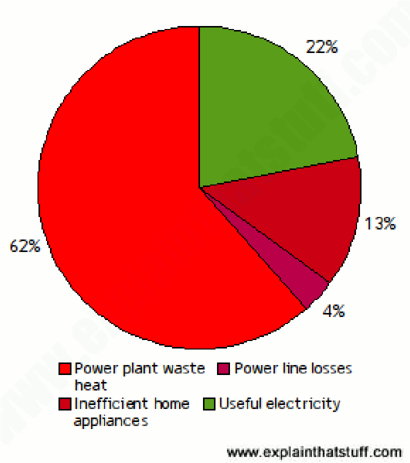
= 1:1=6v:6v , Case-2 ratio 4k:8k= 1:2 =4v:8v and Case-3 ratio 8k:4k= 2:1=8v:4v

Conclusion:-In a potential divider, if the upper resistor value is lowered then the voltage at the center goes up (with respect to ground). If the lower resistor value is lowered then the voltage at the center falls.

Mathematically but the voltage at the center can always be determined by the ratio of the two resistor values which is time consuming and is given by the famous Ohms law formula V=IR

3.4. The Process of How Power Plant Works

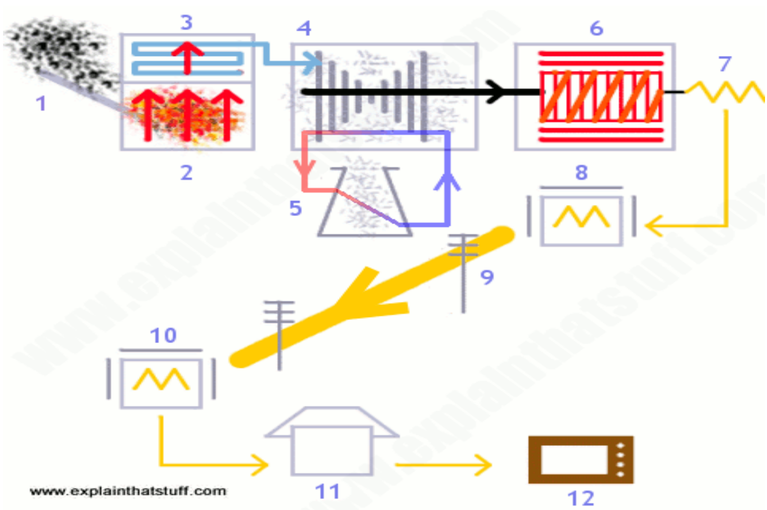
Power plants (also called power stations) pull off a similar trick, converting lumps of coal and drops of oil into zaps of electric current that can be used for charging phone and any electrical devices. In fact, most of the things that done every day and much of the stuff used by human owes a hidden debt of gratitude to these gigantic energy factories, which turn fossil fuels (coal, natural gas, and oil) into electric power. This energy-alchemy is a pretty amazing trick—and quite a recent one too, since the very first practical power station was built in only 1882 by Thomas Alfa Edison. Yet amazement is often the last thing felt when discussed about generating electricity at the start of the 21st century. In an age when caring for the environment is more important than ever, it is fashionable to sneer at power plants, dirty places pumping pollution into our air, land, and water. One day, we might be able to make all our electricity in a completely clean and green way. Until then, power plants are vital for keeping our schools, hospitals, homes, and offices light, warm,



and buzzing with life; modern life would be impossible without them.

A single large power plant can generate enough electricity (about 2 gigawatts, 2,000 megawatts, or 2,000,000,000 watts) to supply a couple of hundred thousand homes, and that is the same amount of power you could make with about 1000 large wind turbines. But the splendid science behind this amazing trick has less to do with the power plant than with the fuel it burns. Power plants turn fuel into electricity: it is even small amounts of fossil fuels contain large amounts of energy. A kilogram of coal or a liter of oil contains about 30MJ of energy a massive amount, equivalent to a good few thousand 1.5-volt batteries. A power plant's job is to release this chemical energy as heat, use the heat to drive a spinning machine called a turbine, and then use the turbine to power a generator as electricity making machine. Power plants can make so much energy because they burn huge amounts of fueland every single bit of that fuel is packed full of power. Unfortunately, most power plants are not very efficient: in a typical old plant running on coal, only about a third of the energy locked inside the fuel is converted to electricity and the rest is wasted. Newer designs, such as combined cycle power stations may be up to 50 percent efficient. As the chart here shows, even more electricity is squandered on the journey from the power plant to home. Adding all the losses together, only about a fifth of the energy in the fuel is available as useful energy in home. Based on the chart: Large, centralized fossil-fueled power plants are very inefficient, wasting about two thirds of the energy in the fuel. The typical scenario is about 62 percent is lost in the plant itself as waste heat. A further 4 percent disappears in the power lines and transformers that carry electricity from a power plant to home. Once the electricity has arrived, home appliances waste a further 13 percent. All told, only 22 percent of the original energy in the fuel (green slice) turns into energy that can actually use.

A power plant's is a bit like an energy production line. Fuel feeds in at one end, and electricity zaps out at the other. A whole series of different steps, roughly along these lines:



1. Fuel: The energy that finds its way into your TV, computer, or toaster starts off as fuel loaded into a power plant. Some power plants run on coal, while others use

oil, natural gas, or methane gas from decomposing rubbish.

2. Furnace: The fuel is burned in a giant furnace to release heat energy.
3. Boiler: In the boiler, heat from the furnace flows around pipes full of cold water. The heat boils the water and turns it into steam.
4. Turbine: The steam flows at high-pressure around a wheel that is a bit like a windmill made of tightly packed metal blades. The blades start turning as the steam flows past. Known as a steam turbine, this device is designed to convert the steam's energy into kinetic energy (the energy to make something moving). For the turbine to work efficiently, heat must enter it at a really high temperature and pressure and leave at as low a temperature and pressure as possible.
5. Cooling tower: The giant, jug-shaped cooling towers that can be seen at old power plants make the turbine more efficient. Boiling hot water from the steam turbine is cooled in a heat exchanger called a condenser. Then it is sprayed into the giant cooling towers and pumped back for reuse. Most of the water condenses on the walls of the towers and drips back down again. Only a small amount of the water used escapes as steam from the towers themselves, but huge amounts of heat and energy are lost.
6. Generator: The turbine is linked by an axle to a generator, so the generator spins around with the turbine blades. As it spins, the generator uses the kinetic energy from the turbine to make electricity.

7. Electricity cables: The electricity travels out of the generator to a transformer nearby.
8. Step-up transformer: Electricity loses some of its energy as it travels down wire cables, but high-voltage electricity loses less energy than low-voltage electricity. Therefore, the electricity generated in the plant is stepped-up or boosted to a very high voltage as it leaves the power plant.
9. Pylons: Hugh metal towers carry electricity at extremely high voltages, along overhead cables, to wherever it is needed.
10. Step-down transformer: Once the electricity reaches its destination, another transformer converts the electricity back to a lower voltage safe for homes to use.
11. Homes: Electricity flows into homes through underground cables.
12. Appliances: Electricity flows all round your home to outlets on the wall. When you plug in a television or other appliance, it could be making a very indirect connection to a piece of coal hundreds of miles away

Types of power plants

With a surge in demand for electricity to power industries and households across the world, many new sources of power generation have emerged in the past few decades. While coal still continues to be a major source of electric generation, solar, wind and other renewable energy sources have emerged as major alternatives to produce power in recent years. With growing energy needs, environmental concerns and depleting fossil fuel based energy sources, scientists are looking for alternative sources of energy. The list of different types of power plants are:

1. Nuclear Power Plant. Using a nuclear fission reaction and uranium as fuel, nuclear power plants generate high amount of electricity. As nuclear power plants emit low greenhouse gas emissions, the energy is considered as environmentally friendly. When compared to renewable sources of energy such as solar and wind, the power generation from nuclear power plants is considered to be more reliable. Though the investments required to set up nuclear power plants are huge, the costs involved in operating them are low. Besides, nuclear energy sources have higher density than fossil fuels and release massive amounts of energy. Due to this, nuclear power plants require low quantities of fuel but produce enormous amounts of power.

Image: The Bruce Nuclear Generating Station, the largest nuclear power facility in the world. Photo courtesy of Chuck Szmurlo/Wikipedia.

2. Hydroelectric Power Plant. Hydroelectricity is produced by harnessing the gravitational force of flowing water. Compared to fossil fuel-powered energy plants, hydroelectric power plants emit lesser amounts of greenhouse gases. However, construction of hydroelectric power plants and dams need huge investments. According to the International Hydropower Association's 2017 Hydropower Status Report, an estimated 31.5 GW of hydropower capacity was put into operation, including pumped storage, bringing the world's cumulative installed capacity to 1,246 GW in 2016. China alone accounted for almost one-third of global hydropower capacity and added around 11.74 GW of new capacity in 2016.

Image: The 22,500MW Three Gorges hydroelectric power plant in Yichang, Hubei province, China. Photo courtesy of http://www.power-technology.com.

3. Coal-Fired Power Plant. In this type of power plants, coal is used as a source to generate electricity. According to World Coal Association, coal-fired power plants currently account for 41% of global electricity. Coal-fired power plants use steam coal as source to generate electricity. However, these power plants emit a significant amount of harmful gases into the atmosphere. In a bid to reduce greenhouse gas emissions, some developed nations have already announced plans to phase out coal-fired power plants. In November 2016, the Canadian government had announced plans to phase out its coal-fired power plants by 2030. In the same month, the UK government had outlined plans to phase out coal-fired power plants by 2025.

Image: Coal-fired power plants use steam coal as source to generate electricity. Photo courtesy of John Kasawa/FreeDigitalPhotos.net.

4. Diesel-Fired Power Plant. With diesel as fuel, this type of power plants is used for small scale production of electric power. They are also installed in places where there is no easy availability of alternative power sources. Diesel power plants are mainly used as a backup for uninterrupted power supply whenever there are outages. These plants require a small area to install and offer higher thermal efficiency compared to coal-fired power plants. Due to high maintenance costs and diesel prices, the power plants have not gained popularity like other types of power generation plants such as steam and hydro.

Image: Diesel-fired power plants in Bitung, North Sulawesi, Indonesia . Photo courtesy of putramjl.blogspot.co.id.

5. Geothermal Power Plant. Geothermal energy is used by this kind of power plants to generate electricity. The three main types of geothermal plants include dry steam power stations, flash steam power stations and binary

cycle power stations. Geothermal power plants use steam turbines to produce electricity. As of May 2015, worldwide geothermal power capacity stood at 12.8GW spread across 24 countries, according to a report by Geothermal Energy Association. Geothermal power plants are considered as environmentally friendly as they emit lower levels of harmful gases compared to coal-fired power plants.

Image: The Domo de San Pedro geothermal power plant in Mexico. Photo: courtesy of Grupo Dragon/ Mitsubishi Hitachi Power Systems, Ltd.

6. Combined-Cycle Power Plant: Using both gas and steam turbines, combined-cycle power plants produce higher amounts of electricity from a single fuel source compared to a traditional power plant. The plants capture heat from the gas turbine to increase power production. They are also found to release low amounts of harmful gases into the atmosphere. The output heat of

the gas turbine flue gas is utilized to generate steam by passing it through a heat recovery steam generator (HRSG), so it can be used as input heat to the steam turbine power plant. This combination of two power generation cycles enhances the efficiency of the plant. While the electrical efficiency of a simple cycle plant power plant without waste heat utilization typically ranges between 25% and 40%, a CCPP can achieve electrical efficiencies of 60% and more. Supplementary firing further enhances the overall efficiency.

Image: Combined-cycle power plant in Finland. Photo: courtesy of wartsila.com

7. Solar Power Plant: These plants convert energy from the sun into thermal or electrical energy. It is one of the cleanest and most abundant renewable energy sources. Solar energy plants generally do not require high maintenance and last for about 20-25 years. The International Energy Agency (IEA) projected in 2014

that by 2050 solar PV and solar thermal would contribute about 16 and 11%, respectively, of the worldwide electricity consumption and solar would be the world's largest source of electricity. However, initial costs involved in setting up solar power plants are high. Installation of solar power systems requires a lot of space.

8. Solar-Thermal Power Plant. Solar thermal is a system of giant mirrors. They are arranged in such a way to concentrate the sun's rays on a very small area to create significant amount of heat. It is used to create steam to power a turbine that creates electricity.

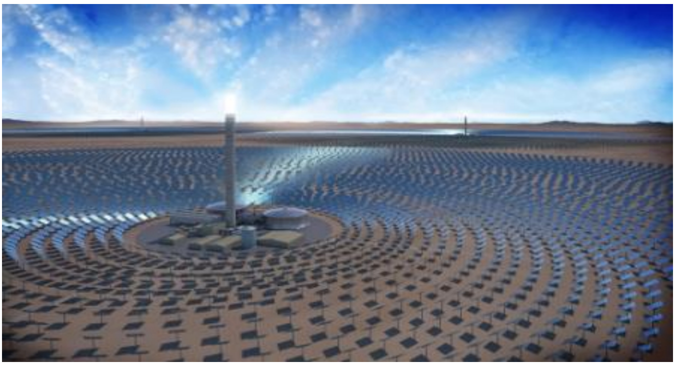


Image: Rendering of SolarReserve's 390 MW Concentrating Solar Power (CSP) Likana Solar Project with 5.1 GW-hours of energy storage. Photo: courtesy of SolarReserve, LLC.

9. Wind Power Plant. Wind energy is one of the major renewable energy sources with a huge potential. In recent years, there has been a rapid growth in the number of wind farms across the world, underpinned by

technological advancements. As wind is naturally occurring source of energy, there are no limitations to harness power from wind. Operational costs involved in maintaining wind power plants are low after the erection of wind turbines and they are considered to be cost effective. Wind farms can also be built on agricultural lands, without causing any interruption to cultivation activities. However, maintenance of wind turbines may vary, as some need frequent checks. Wind power projects also need huge capital expenditure.

Image: Wind power plant in United Kingdom, Photo: courtesy of tileenergy.uk.

10. Tidal Power Plant. Tidal energy is generated from converting energy from the force tides into power. Tidal energy production is considered to be more predictable compared to wind energy and solar power. Despite this,

tidal power is still not exploited widely even as the world's first large-scale tidal power plant became operational in 1966. However, increased focus on generating power from renewable sources is expected to accelerate the development of new methods to exploit the tidal energy. Though the development of the tidal power is at the nascent stage, it is estimated to have a vast potential globally.

Image: Tidal power plant in Brittany, France. Photo: courtesy of .nationalgeographic.org.

3.5. Tasks

Answer these following questions based on reading text given

1. State 4 electrical machinery and the function!
2. What are tools and equipments, which frequently used at laboratory and workshop?
3. Point out components or instruments used in electrical and electronics daily job and their usages!
4. What are the function of turbine and generator in power plant?
5. Mention 3 types of power plant and explain the process of those power plant works!

CHAPTER IV
SAFETY AT WORK

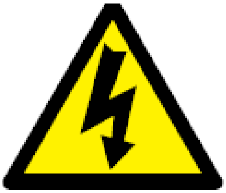
4.1. Warning Labels (Safety Sign)

Warning labels or safety signs are the regulations that cover a variety of methods of communicating about health and safety information. The terms used in the Regulations mean the following:

(a) Safety and/or health sign – a sign providing information or instruction about safety or health at work by means of a signboard, a colour, an illuminated sign or acoustic signal, a verbal communication or hand signal;

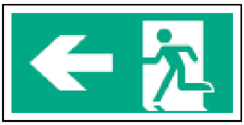
(b) Signboard – a sign which provides information or instructions by a combination of shape, colour and a symbol or pictogram which is rendered visible by lighting of sufficient intensity. In practice, many signboards may be accompanied by supplementary text, eg 'Fire exit', alongside the symbol of a moving person. Signboards can be of the following types:

(i) **prohibition sign** – a sign prohibiting behaviour likely to increase or cause danger (eg 'no access for unauthorised persons');



(ii) **warning sign** – a sign giving warning of a hazard or danger (eg 'danger: electricity');

(iii) **mandatory sign** – a sign prescribing specific behaviour (eg 'eye protection must be worn');



(iv) **emergency escape or first-aid sign** – a sign giving information on emergency exits, first aid, or rescue facilities (eg 'emergency exit/escape route';

(c) Safety colour – a colour to which a specific meaning is assigned (eg yellow means 'be careful' or 'take precautions');

(d) Symbol or pictogram – these appear in Schedule 1, although some variation in detail is acceptable provided the meaning is the same (examples of variations are included in BS EN ISO 7010). They are for use on a signboard or illuminated sign (eg the trefoil ionising radiation warning sign);

(e) Illuminated sign – a sign made of transparent or translucent materials which is illuminated from the inside or the rear to give the appearance of a luminous surface (e.g. emergency exit signs);

(f) Acoustic signal – a sound signal which is transmitted without the use of a human or artificial voice (eg a fire alarm);

(g) Verbal communication – a predetermined spoken message communicated by a human or artificial voice;

(h) Hand signal – a movement or position of the arms or hands giving a recognised signal and guiding people who are carrying out manoeuvres which are a hazard or danger to people;

(i) Fire safety sign – sign related to the prevention in case of fire safety.

The Regulations are designed for:

Employers/employees

1. The Regulations place duties on employers in respect of risks to their employees with the principal duty being to ensure that safety signs are in place.
2. In some industries, for example offshore, many employees are employed by contractors who are not in control of the places in which their employees work. In practice, safety signs will normally be provided by the employer or person in charge of the workplace, usually the owner or operator of the installation. This requires

the ‘host’ employer (or self-employed person) to give information on risks and the associated precautions arising from that employer’s activities to the employer of persons at work there. In these cases, the employer or contractor will usually be able to meet their obligations by relying on the arrangements made by the host (ie the owner or operator).

3. Contractors who are also employers will want to check that their employees are familiar with the meaning of safety signs likely to be encountered during the course of their work. They may also wish to make checks – where there is a ‘host’ employer – that appropriate signs are in place.

Application offshore

The Regulations apply to work activities carried out in waters territorial and in designated areas of continent. This includes offshore installations, wells, pipeline works and activities connected with installations and wells such as construction, loading and unloading of supply vessels, and diving operations offshore. Note that for offshore installations the emergency warning arrangements, including the tones of acoustic signals and colours of illuminated signs, are covered in the Offshore Installations (Prevention of Fire and Explosion, and Emergency Response) Regulation.

Fire safety

The way these Regulations apply with respect to fire safety signs (e.g. fire exit signs and fire alarms). Provisions for specific fire safety signs are required by other provisions such as Building Regulations and the Regulatory Reform (Fire Safety).

Circumstances where these Regulations do not apply:
Non-employees

These Regulations do not place any duty on employers to provide signs to warn other people (e.g. visitors, neighbours) of risks to their health and safety. They do not apply to the self-employed regarding the health and safety of non-employees, and may find the safety signs described here helpful in meeting their general duties to ensure, so far as is reasonably practicable, the health and safety of others not in their employ but who may be affected by their work activity.

Supply of articles and dangerous substances

The Regulations have no requirements regarding the supply of either articles or dangerous substances. Most machinery will be subject to the Supply of Machinery (Safety) Regulations which also contain marking requirements (supporting by countries standards provide ways of meeting these requirements).

Internal works traffic

The signs of the regulations are not intended for use in directing traffic on public roads, waterways etc. However, the Regulations require the use of road traffic signs, as prescribed in the Road Traffic Regulation (examples of which are shown in the Department for Transport publications) to regulate road traffic within workplaces where necessary.

Application to merchant shipping

Seagoing ships are subject to separate merchant shipping legislation. Regulations disapplies them from ships in respect of the normal shipboard activities of a ship's crew under the direction of the master. It does not, however, disapply them in respect of other work activities. For example, where a shore-based contractor goes on board to carry out work on the ship, that person's activities will be subject to the Regulations within territorial waters. In these cases, the contractor should make checks to ensure, for example, that appropriate signs are in place. This partial exemption applies to seagoing ships only. The Regulations apply in full to ships operating on inland waters.

4.2. Using Safety Signs Effectively

This part describes and provides information to help employers comply with their duties to select, make effective use of, and maintain safety signs. The technical requirements of the Regulations relating to the various types of safety signs are explained.

General rules on use

The signs shown in Regulations are to be used when it is necessary to convey the relevant message or information specified in the Regulations. If the hearing or sight of any employee is impaired, for example by wearing personal protective equipment, additional measures should be taken to ensure that employees can see or hear the warning sign or signal, for example by increasing the brilliance or volume. In some cases, more than one type of safety sign may be necessary, for example an illuminated warning sign indicating a specific risk combined with an acoustic alarm meaning 'general danger' to alert people, or hand signals combined with verbal instructions.

Maintenance

All safety signs must be properly maintained so that they are capable of performing the function for which they are intended. This can range from the routine cleaning of signboards to regular checks of illuminated signs and testing of acoustic signals to see that they work properly. All safety signs should maintain their intrinsic features under power failure – either from emergency lighting or phosphorescent material – unless the hazard is itself eliminated by the power failure.

Safety colours

In these Regulations signs incorporating certain colours have specific meanings. Table 1 identifies the colours for safety signs in general.

Table 1 Safety sign colours (excluding fire safety signs)

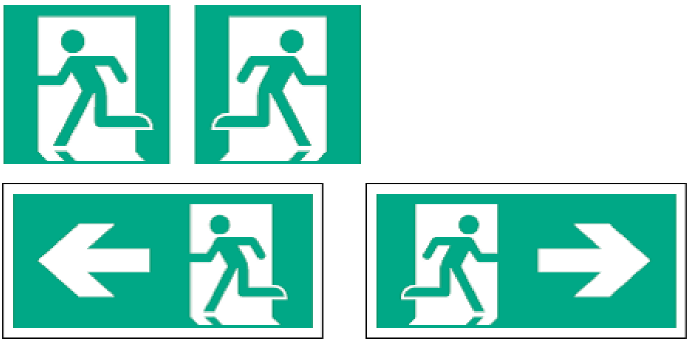
Colour	Meaning or purpose	Instruction and information
Red	Prohibition sign Danger alarm	Dangerous behaviour; stop; shutdown; emergency cut-out devices; evacuate
Yellow Amber	Warning sign	Be careful; take precautions; examine
Blue	Mandatory sign	Specific behaviour or action, eg wear protective equipment
Green	Emergency escape First-aid sign No danger	Doors; exits; escape routes; equipment and facilities Return to normal

Using signboards

Signboards are used in a workplace to ensure that they are sufficiently large and clear to be easily seen and understood. For example, when describing available equipment the safety sign should show clearly where that equipment is. All safety signs require adequate illumination and size should be appropriate for intended viewing distance. Signboards should also be durable, securely fastened and properly maintained (e.g. washed or resurfaced) to ensure they remain visible. Permanent signboards are necessary, except in cases where the workplace or hazard is temporary. Even in these cases safety signs must still be consistent with the requirements of the Regulations. For example, use of a portable warning sign by cleaners may be necessary if a hazard such as a slippery floor exists for a short period. Avoid using too many signboards in close proximity. Signboards are only effective if they can be seen and understood. If too many signs are placed together there is a danger of confusion or of important information being overlooked. If circumstances change, making a particular signboard unnecessary (i.e. if the hazard no longer exists), it is important to ensure its removal so that misleading information is not displayed.

Pictograms

Small differences from the pictograms or symbols shown in Regulations are acceptable, providing they do not affect or confuse the message that the sign conveys and as long as the resultant sign still meets the relevant identified 'intrinsic features'. If the Regulations does not contain a suitable signboard then it is acceptable to design your own, providing it conforms to the general principles described in the Regulations. However, where the warning sign is to be used on a room storing material or containers used at work for chemical substances or mixtures (classified as hazardous according to the criteria for any physical or health hazard class) subject to the Regulation, you must use one of the signs, if there is no equivalent warning sign, the relevant hazard pictogram, must be used. If a pictogram needs to be designed it should be as simple as possible, containing only necessary detail. Guidance can be found where design principles that can be followed are described. The principles will ensure the pictogram is understood for the application and will meet the geometric shape and colour required by the Regulations. Pictograms used in signs should be as simple as possible and contain only necessary detail. As an example, the following emergency escape route pictograms are from BS EN ISO 7010.



It may sometimes be useful to supplement a safety sign with text to aid understanding. This may be important, for example when introducing a new or unfamiliar sign, or using a general danger or warning sign. In these cases, the meaning is reinforced if the background colour of the supplementary sign is the same as the colour used on the safety sign it is supplementing. Any supplementary sign or text used with a particular safety sign must be chosen to reflect the same safety sign category. So, for example, if a mandatory sign is used, ensure that accompanying text (if any) describes the mandatory nature (using the word ‘must’ rather than ‘should’ or ‘may’) of the action to be taken, such as ‘Face protection must be worn’.

Signboards

The intrinsic features of the four types of signboards referred to in Table 1, and also fire safety signs, are described. Examples of each type of sign are also included. The variations of these signs as long as they retain the ‘intrinsic features’ can be used as it is described in each section, which has been developed and provides more variations, particularly of the fire exit/ escape signs.

Prohibitory signs

Intrinsic features:

(a) Round shape;
(b) Black pictogram on white background, red edging and diagonal line (the red part to take up at least 35% of the area of the sign).


No access for unauthorised persons


Smoking and naked flames forbidden


No smoking


No access for pedestrians


Not drinkable


Do not extinguish with water


No access for industrial vehicles


Do not touch

Warning signs – General

Where the warning sign does not relate to the Regulation, new designs of pictograms may be developed as long as they are clear and meet these intrinsic features.

Intrinsic features:

(a) triangular shape;

(b) black pictogram on a yellow background with black edging (the yellow part to take up at least 50% of the area of the sign).

Flammable material or high temperature*

Explosive material

Toxic material

Corrosive material

Radioactive material

Overhead load

Industrial vehicles

Danger: electricity

General danger

Laser beam

Oxidant material

Non-ionising radiation

Strong magnetic field

Obstacles

Drop

Biological risk†

Low temperature

This sign has been deleted from the list by the UK CLP Regulations and should not be used

Harmful or irritant material

Mandatory signs

Intrinsic features:

(a) round shape;

(b) white pictogram on a blue background (the blue part to take up at least 50% of the area of the sign).

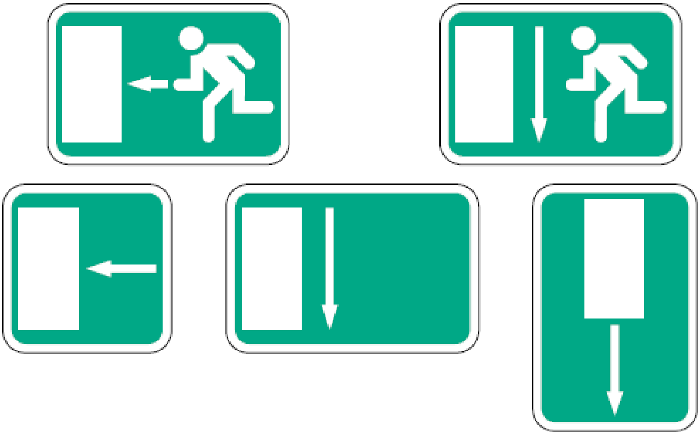
Emergency escape or first-aid signs

Intrinsic features:

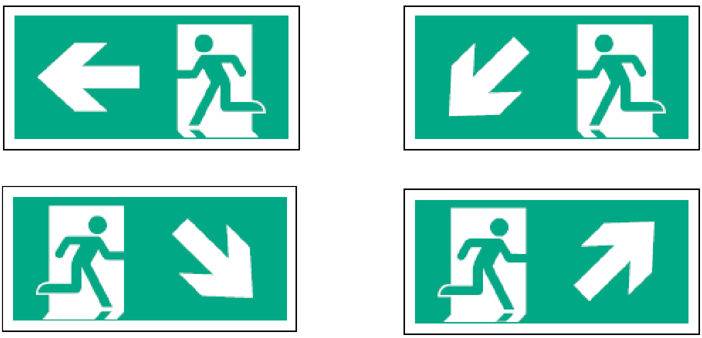
(a) rectangular or square shape;

(b) white pictogram on a green background (the green part to take up at least 50% of the area of the sign).

Emergency exit/escape route signs

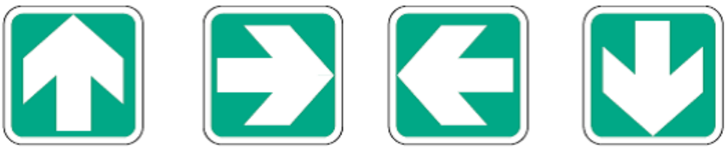


Examples from BS EN ISO 7010



Supplementary 'This way' signs for emergency exits/escape routes

For emergency exit signs for safe exit routes should be taken that 'This way' arrows for emergency equipment location (red background direction arrows) are not in contradiction with escape direction.



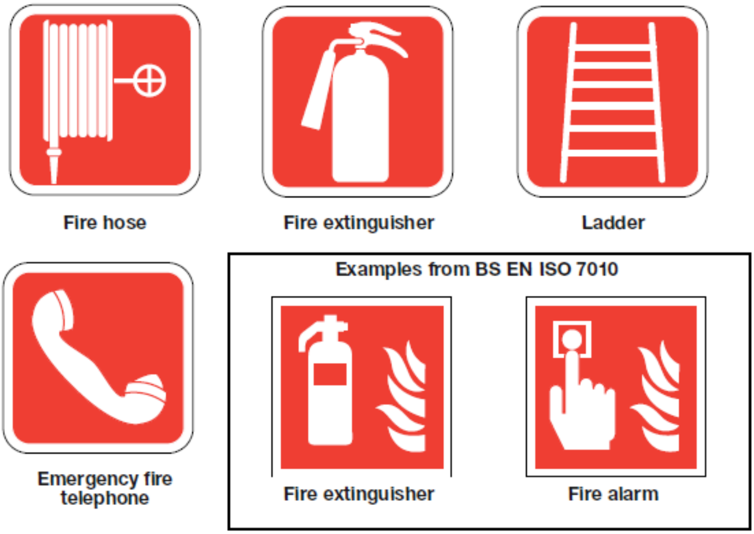
First-aid signs

Firefighting signs

Intrinsic features:

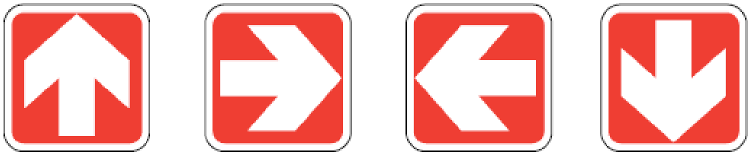
(a) rectangular or square shape;

(b) white pictogram on a red background (the red part to take up at least 50% of the area of the sign).



Supplementary 'This way' signs for firefighting equipment

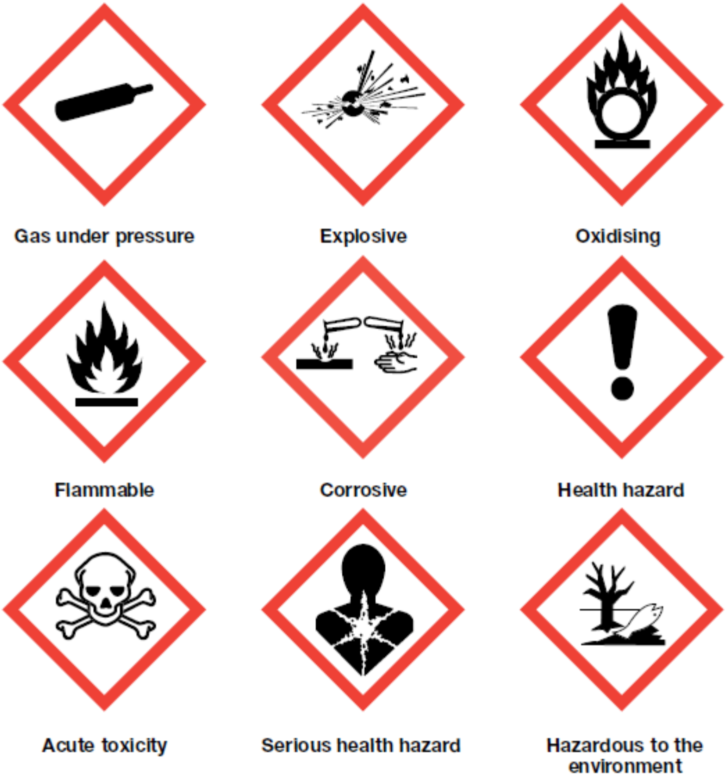
Care should be taken that the use of arrows to indicate the direction to emergency equipment cannot be confused with direction of escape and should not be in contradiction. If there is a risk that confusion may arise which could result in those evacuating a building being misdirected, you should consider whether these signs should be used.



Warning signs – Chemical labelling and packaging

These labels do not appear in the Regulations. There are no intrinsic features laid down for the labels under the Regulation. You must use the most appropriate sign of those available and cannot create variations. These labels do not form part of the Regulations but have an impact on signage used with hazardous substances and mixtures which have resulted in changes to those Regulations.

GHS hazard pictograms



Using signs on containers and pipes

Containers, tanks and vessels used in the workplace for hazardous chemical substances or mixtures, and the visible pipes in the workplace containing or transporting hazardous substances and mixtures, should generally be labelled with the relevant pictograms in accordance with the Regulation.

There are, however, a number of exceptions:

(a) it may not be necessary to affix signs to pipes where the pipe is short and connected to a container which is clearly signed, such as a welding set;
(b) containers need not be labelled where the contents may change regularly (for example chemical process vessels and pipework which are not dedicated to one substance). In these cases, employers must have other arrangements for ensuring that employees know the hazardous properties of the contents of the container; for example, employers could provide suitable process instruction sheets or training for employees.

The (Amendment) Regulations amend the provisions relating to containers and pipes. Where these containers or pipes are not excepted and are used for, contain or are involved in the transporting of hazardous chemical substances and mixtures, they must be labelled in accordance with the Regulation, using the relevant hazard pictogram.

However, the (Amendment) Regulations also permit use of the hazard warning symbols specified in other systems so labels can be:

(a) replaced by warning signs of the Regulations, provided they contain the same pictograms or symbols. If there is no equivalent, the relevant hazard pictogram from Regulation must be used;
(b) supplemented by additional information, e.g. about the risk or the hazardous chemical;
(c) in the case of containers transported at the place of work, supplemented or replaced by applicable standard international signs.

Confusion is unlikely to arise since similar pictograms are used in the different types of signs. What may differ are the shape and the colour of the signs. Where signs or labels are used they may be supplemented by additional information, such as the name of the hazardous substance or mixture and details of the hazard. The signs or labels must be mounted on the sides that are visible and to be durable. Labels can be in self-adhesive or painted form. When deciding where signs or labels should be placed on pipework containing hazardous substances it is important to avoid causing confusion, so do not use too many signs. Signs or labels will be most useful at points where employees are likely to be exposed to the contents of the pipework, for example sampling or filling points, drain valves, and flanged joints which are likely to need periodic breaking. Where there are long pipe runs on which points of potential exposure are infrequent, labels or signs may also be displayed at intermediate points guidance on the use of different colours and safety signs to identify the contents of pipework and the associated risk.

Using signs to mark areas, rooms and enclosures

It is important to mark those areas, rooms or enclosures used for the storage of significant quantities of hazardous substances or mixtures by a suitable warning sign, unless the warning labels on individual containers are clearly visible from outside or nearby. Where stores are being used for hazardous chemicals or mixtures they should be indicated by the relevant warning sign taken from the Regulations (the yellow triangle black pictogram warning signs). If there is no equivalent warning sign in these provisions then the relevant hazard pictogram Regulation must be used. Stores containing a number of different substances may be indicated by the 'general danger' warning sign.

The signs or labels referred to above must be positioned, as appropriate, near storage areas or on doors leading into storage rooms.

Dangerous Substances (Notification and Marking of Sites) Regulations

The provisions in the Regulations for marking stores containing dangerous substances overlap with the requirements of the Regulations. Site entrances to most stores containing 25 tonnes or more of dangerous substances must be marked under the Regulations. The purpose of the marking is to provide information to the fire and emergency services attending an incident at the site. However, the primary function of the Regulations is to provide information to employees. The signs to be used under both sets of Regulations are very similar and signs complying with the Regulations, on sites where they apply, will in general also satisfy the marking requirements of the Regulations. The Regulations do not apply offshore.

Using signs to mark obstacles, dangerous locations and traffic routes

The Work at Height Regulations are concerned with preventing injuries caused by falls from heights or from being struck by falling objects. Regulation of the Workplace (Health, Safety and Welfare) includes requirements to prevent injuries caused by falling into, for example, a tank or a pit. In many cases, fall protection measures such as secure barriers are required to prevent falls. However, where the risk is low or where it is impracticable to safeguard by other means, marking the dangerous location in accordance will be necessary – for example, highlighting the edge of a raised platform or area where objects may fall using markings consisting of yellow and black (or red and white) stripes, as shown overleaf:

Signs for marking obstacles and dangerous locations
The stripes are at an angle of 450 and more or less of equal size.

Regulation of the Workplace includes requirements for indicating traffic routes within workplaces where necessary for reasons of health and safety. The Regulations requires the markings to take the form of continuous lines, preferably yellow or white, taking into account the colour of the ground. Traffic routes in built-up areas outdoors do not have to be marked if suitable pavements or barriers are already provided. The Regulations do not require outdoor traffic routes to be marked in areas that are not built-up. This is because risks to the health and safety of employees are likely to be low. However, there may be cases requiring either use of clearly defined traffic routes or safe systems of work (possibly including the use of banksmen to direct traffic) to help meet general duties e.g. when vehicles are operating (particularly during reversing) close to employees working on foot. In some cases it may not be possible to mark traffic routes clearly by means of painted lines, for example in underground coal mines. In these cases other measures may be necessary to ensure that pedestrians are not put at risk by vehicles.

Using acoustic signals and illuminated signs

Requirements for work equipment to incorporate any warning or warning devices necessary for reasons of health and safety. This could include the use of acoustic signals and illuminated signs instead of conventional signboards. The signals or signs used must meet the minimum requirements described in the relevant part The signals also must be suitable for the working environment. For example, in an explosive atmosphere ensure they do not pose a risk of ignition. When acoustic signals or illuminated signs have to be activated (either automatically or in line with other safety arrangements) it is important they remain so for as long as the danger exists or until receipt of any planned acknowledgement. Acoustic signals and illuminated signs must be checked at regular intervals to ensure that they are functioning correctly. The more hostile the environment, the more frequently they should be checked.

Illuminated signs

The sign has to be bright enough to be seen, without causing glare. Care should be taken to ensure that a number of illuminated signs are not used together if this could give rise to confusion. Confusion could also arise if an illuminated sign is placed close to any other similar light source. The luminous area of the sign may be of a single safety colour or contain a pictogram on a specified background consistent with the requirements. If an illuminated sign can be either ‘on’ continuously or operate intermittently (i.e. flash on and off), use the flashing sign to indicate a higher level of danger or a more urgent need for intervention or action. The duration and frequency of flashes for an intermittent illuminated sign should be such as to ensure the message is properly understood, and avoid any confusion with other illuminated signs, including continuous illuminated signs.

If a flashing sign is used instead of, or together with, an acoustic signal, it is important to synchronise the two. This means that the duration and frequency of flashes should be in line with both the pulse length and interval for an acoustic signal. The choice of equipment and the way it operates, of course, must take account of other risks. For example, with fast flicker rates epilepsy could be triggered in some people or, in other cases, some types of electronic pulse could be a danger in respect of stores containing certain explosives. Where flashing signs are used to warn of imminent danger, it is particularly important to ensure that measures are in place to either detect failure of the sign quickly or to prevent its failure (e.g. by fitting duplicate bulbs etc).

Acoustic signals

So that they can be heard, acoustic signals should be set at a level which is considerably higher in terms of frequency than the ambient noise, for example 10 dB above the level of ambient noise at that frequency. However, make sure the level is neither excessive nor painful. It is also important for signals to be easily recognisable, particularly in terms of pulse length and the interval between pulses or groups of pulses. Ensure that acoustic signals are not used more than one at a time. If a device can emit an acoustic signal at variable frequencies (this includes an intermittent signal operating on a discrete frequency) or constant frequencies, use the variable frequency set at 10 dB above the ambient level at the appropriate frequency to indicate a higher level of danger or a more urgent need for intervention or action.

Using hand signals to direct hazardous operations

Hand signals can be used to direct hazardous operations such as crane or vehicle manoeuvres. Ensure that the signals are precise, simple and easy to make and to understand. Check also that the signaller is competent to make hand signals and is trained in their correct use.

Specific rules governing use

The signaller must be able to see all the manoeuvres being made by the people receiving the signals without being endangered by them. During manoeuvres, make sure that the duties of the signaller are confined to directing manoeuvres and to other specific measures aimed at the safety of nearby workers (e.g. keeping people back a safe distance). In some cases, the precautions described may have to be supplemented, for example with further signallers to help co-ordinate the action. In such cases, make sure that the person receiving the signals takes them from one signaller only unless specific arrangements have been made. When an operator is unable to continue the manoeuvre safely, the operation must be discontinued until further instructions are received from the signaller. Where weather conditions may obscure viewing or result in poor light, the use of high-visibility clothing may be required to ensure the safety of the signaller under the Personal Protective Equipment at Work Regulations such clothing provides an additional benefit as it may also help the operator see the signaller. The use of other items such as signalling bats and reflective arm bands may also help the operator see and understand the signals.

Codes of hand signals

Where hand signals are used, ensure they are consistent with the code of signals shown in the Regulations. There may be situations where these codes of hand signals are insufficient to meet communication needs. In these cases, additional signals can be used based on existing signalling practice. Irrespective of the code of hand signals chosen, it is important that they are used consistently throughout a firm or workplace. If employees are unfamiliar with the code in use then appropriate training is necessary. Particular care is needed with new employees who have previously used different codes of hand signals. They may not fully understand the signals in use and may therefore require retraining.

Using verbal signals to direct hazardous operations

Verbal signals can also be used to direct hazardous operations. Such signals can be spoken messages given either by human or artificial voice, and either given directly or recorded. Spoken messages must be clear, concise and understood by the listener. The verbal signals described here also represent a suitable means to help comply with relevant Act and Regulations of the Management Regulations (i.e. those parts which require employees to be provided with adequate information, instruction and training to ensure their health and safety when directing hazardous operations).

Specific rules governing use

The people involved should have a good knowledge of the language used so that they are able to pronounce and understand the spoken message correctly and react accordingly. If verbal communication is used instead of hand signals, use the code words in Table 2 and ensure that if the two are used together they are co-ordinated.

Table 2 Code words for verbal communication

Code word	**Meaning**
Start	Start an operation
Stop	Interrupt or end an operation
End	Stop an operation
Raise	Raise a load
Lower	Lower a load
Forwards	Move forwards
Backwards	Move backwards
Right	Move to signaller's right
Left	Move to signaller's left
Danger	Emergency stop
Quickly	Speed up a movement

Whatever system of code words is being used it is important that it can be properly understood. Where English is not the first language of most staff the codes do not necessarily have to be in English. However, there must be safeguards to ensure others affected by the operation can be easily made aware of any danger.

Fire Safety Sign

A fire safety sign is defined in regulation as a sign (including an illuminated sign or an acoustic signal) which:

(a) provides information on escape routes and emergency exits in case of fire;

(b) provides information on the identification or location of firefighting equipment;

(c) gives warning in case of fire.

Fire Safety Signs Requirements

Duties on employers to provide these signs will mostly arise, the Fire Act and other fire legislation. The effect here of the Regulations will, in most cases, be to describe the types of sign you may use. Often the enforcing authority for fire safety will determine where to locate the signs. In other cases, you should provide signs depending on the outcome of your assessment of risks to health and safety. If changes to existing signs are proposed, check first with your enforcing authority.

Safety colours

Information on colours for safety signs, but for fire safety signs in particular, is given in Table 3.

Table 3 Colours for fire safety signs

Colour	Meaning or purpose	Instruction and information
Red	Firefighting equipment	Identification and location
Green	Emergency escape	Doors, exits, escape routes

The signs

The signs for emergency escape routes and firefighting equipment are contained in the Regulations. As for safety signs generally, the symbols used may be slightly different from those shown provided the meaning is clear. These may be supplemented by directional arrows which are used with the pictogram to form the sign.

Maintenance

All signs should be properly maintained. It is also important that signs are fixed securely and are sufficiently large to be clearly seen.

Using signs in buildings and structures

People usually leave premises by the same way that they enter or by routes which are familiar to them. Alternative exits (ie all emergency exits and any exits not in normal use) should be clearly indicated so that people know there are additional ways to leave. In addition, the provision of well-signposted exits in full view will give a feeling of security in an emergency. Make sure the fire exit sign is displayed immediately above the exit opening or, if this is not possible, choose a position where the sign can be clearly seen and is least likely to be obstructed or obscured by smoke. Where an exit cannot be seen or where a person escaping may be in doubt about the location of an exit (eg in warehouses where goods for transit and other obstructions may prevent a clear view of the exit doors), fire exit signs, including a directional arrow, are appropriate at suitable points along the escape route.

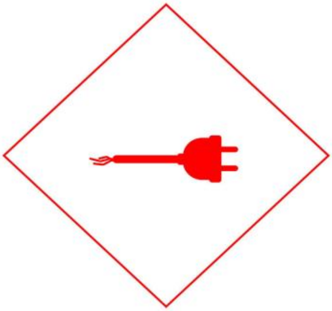
In buildings with multiple occupants a common approach to the provision of fire safety signs is sensible so that people are not confused about the exit routes from the building. In such cases, it is normally the owner of the building who has responsibility for displaying signs in common areas (e.g. stairways) and if there is any doubt check this with your enforcing authority for fire safety. Individual occupiers are normally responsible for the signs necessary within their part of the building. In addition to the fire safety signs referred to in these Regulations, require provision of certain supplementary signs to aid the effective and efficient use of the escape routes provided. For instance, where there is a danger that a door which is a fire exit may become obstructed (because its importance is not appreciated) such as a final exit door opening into a car park or storage yard, or a seldom used intercommunicating or bypass door between rooms, a conspicuous 'Fire Escape – Keep Clear' sign should be shown on the appropriate faces of the door. Check with your enforcing authority if you have any doubts. If the level of natural light is poor, then adequate illumination (which includes emergency lighting) will be required. Signs incorporating photoluminescent materials may also have a role in poor light conditions.

4.3. Safety from Electrical Hazard

With our modern reliance on electricity, there are potential electrical safety hazards in any home, office, or factory. Fortunately, these hazards can be eliminated or reduced by staying aware and taking steps to eliminate their dangers, ideally with the assistance of an electrician. These are eight of the most dangerous electrical hazards that could arise in any home.

1. Poor Wiring and Defective Electric Wires

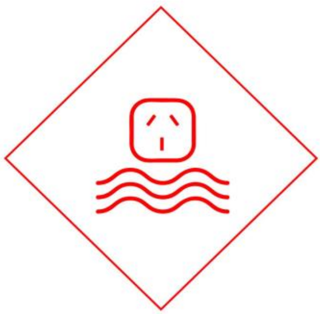
Good quality wiring that conforms to safety standards is vital for safety. Poor wiring can increase chance of fire, power surges, arc faults, and other serious consequences. For this reason, it is always best to avoid do-it-yourself electrical work and get professional electricians to perform electrical wiring around the house.



Damaged, worn, cracked or corroded electrical wires can increase the chance of electrical accidents. Have a qualified electrician in checking the wiring on a regular basis to ensure wiring is safe. If you need to, upgrade and replace old and faulty wires.

Some hazards include Loose or improper connections, such as electrical outlets or switches, Frayed appliance or extension cords, Pinched or pierced wire insulation, which could occur from, for example, a chair leg sitting on an extension cord, Cracked wire insulation caused by heat, age, corrosion or bending, Overheated wires or cords, Damaged electrical appliances, and Electrical wire that has been chewed by rodents

2. Outlets Close to Water



Outlets in bathrooms, kitchens, and other living areas with water should be installed a fair distance away from the water source. As water conducts electricity, keeping outlets away from water reduces the chance of electric shock. Never use a radio, hair dryer, phone, or other device in the bath, near the pool, or anywhere with a wet floor.

3. Wet Hands

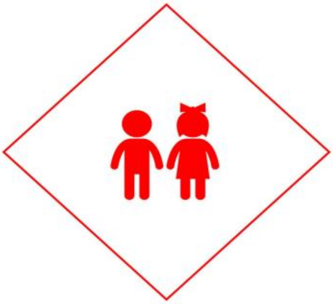
Similarly, electrical appliances should never be handled with wet hands as this heightens the chance of getting an electric shock. Yet too many of us tend to reach for the hair dryer with wet hands out of the shower. Keep appliances far away from sinks, bathtubs, showers, and taps.

4. Pouring Water on Electrical Fires

A common error is pouring water on electrical fires. If an electrical fire does occur, avoid pouring water on the flames as water will further fuel the fire and could cause electrocution. Keep a fire extinguisher on site if worried about electrical fires and use it properly instead of water in times of emergency. If there is no fire extinguisher, have one nearby, turn off electrical power, evacuate people at home and directly call the fire brigade.

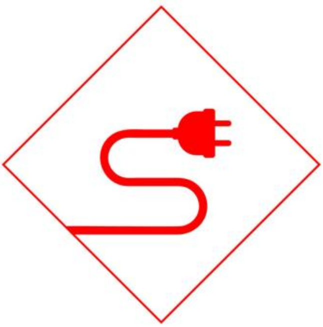
5. Inquisitive Young Children

Young babies and toddlers tend to be extremely inquisitive and keen to explore their world. While it is always best to supervise children of this age all the time, parents and adults expecting children at their house can take extra measures to protect young children.



Any electrical outlet at their height and within their reach can be replaced with Extra-Safe powerpoints. These can be interchanged with normal powerpoint and prevent sharp objects and fingers from going into the socket. Unprotected sockets can lead to serious injury.

6. Extension Cords

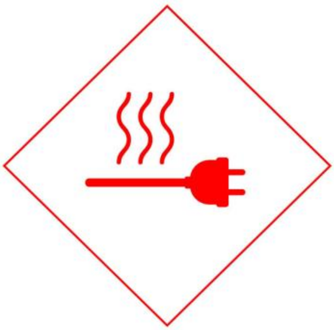


Extension cords should be carefully fixed in place where possible to reduce the chance of tripping or accident. Use plastic socket closures on unused sockets. Extension cords should not use as a permanent substitute for additional power sockets, and avoid using them for too many appliances at once.

7. Lightbulbs

Lightbulbs as being electrical hazards, but the potential for an electrical fire arises when lightbulbs are kept near flammable materials. These can include beds, drapes, plastics, or other items such as upholstery. Lights, like all sources of electricity, can also cause electric shock, so ensure always turn the light switch off before replacing a light bulb, and never replace a light bulb or touch a light switch with wet hands. Always ensure use a light bulb with the correct wattage to prevent overheating.

8. Covered Electrical Cords and Wires



Heavy covering of wires can cause the cords to overheat, which could lead to an electrical fire. Keep cords and wires away from other items and keep them uncovered.

Similarly, make sure that items like computers and televisions have enough space around them for ventilation, to prevent them from overheating. Never try to repair electrical appliances by yourself, always contact a licensed electrician. Check your appliances regularly for faulty switches, plugs and frayed cords. Avoid overloading power boards with too many appliances at once e.g. if a heater plugged into the power board, unplug it before using the hair dryer. Never poke anything into an appliance while it is plug in or in use. Always use outdoor grade extension cords outside of the home. Make sure hands are dry before touching switches or electrical appliances. Before cleaning areas like the kitchen, bathroom or laundry, make sure all appliances are switch off.

One of the best ways to reduce risk of death from electric shock at home is to install a safety switch, also called a Residual Current Device (RCD). However, never try to do any electrical work on your own. If you think, there are hazards present at home, contact a licensed electrician to help resolve them.

4.4. Tasks

Answer these following questions based on reading text given

1. Why do warning labels/safety signs are very useful?
2. What makes warning labels/safety signs must be properly maintenance?
3. What are the meaning or purpose and instruction or information in different types of warning labels/safety signs color red, yellow, blue, and green!
4. Why does pictogram very useful in warning labels/safety sign?
5. Point out every warning labels/safety signs that exist in your laboratory/workshop and their purposes!

CHAPTER V
APPLYING FOR A JOB

5.1. Resume, Curriculum Vitae, and Cover Letter

A resume is a brief, informative summary of your abilities, education, and experience. It should highlight the strongest assets and skills, and differentiate yourself as a candidate from other candidates seeking similar positions. Although it alone will not get you a job or internship, a good resume is an important element toward obtaining an interview. Tailor your resume to the type of position you are seeking. This does not mean that all of your work history must relate directly, but your resume should reflect the kind of skills the employer would value.

RESUME TIPS

RESUME LANGUAGE SHOULD BE:

- Specific rather than general
- Active rather than passive
- Written to express not impress
- Articulate rather than "flowery"
- Fact-based (quantify and qualify)
- Written for people who scan quickly

TOP 5 RESUME MISTAKES:

1. Spelling and grammar errors
2. Missing email and phone information
3. Using passive language instead of "action" words
4. Not well organized, concise, or easy to skim
5. Too long

DON'T:

- Use personal pronouns (such as I)
- Abbreviate
- Use a narrative style
- Number or letter categories
- Use slang or colloquialisms
- Include a picture
- Include age or sex
- List references
- Start each line with a date

DO:

- Be consistent in format and content
- Make it easy to read and follow, balancing white space
- Use consistent spacing, underlining, italics, bold, and capitalization for emphasis
- List headings (such as Experience) in order of importance
- Within headings, list information in reverse chronological order (most recent first)
- Avoid information gaps such as a missing summer
- Be sure that your formatting translated properly if converted to a .pdf

Action Verbs for your Resume

LEADERSHIP

Accomplished	Achieved	Administered	Analyzed	Assigned	Attained	Chaired	Consolidated
Contracted	Coordinated	Delegated	Developed	Directed	Earned	Evaluated	Executed
Handled	Headed	Impacted	Improved	Increased	Led	Mastered	Orchestrated
Organized	Oversaw	Planned	Predicted	Prioritized	Produced	Proved	Recommended
Regulated	Reorganized	Reviewed	Scheduled	Spearheaded	Strengthened	Supervised	Surpassed

COMMUNICATION

Addressed	Arbitrated	Arranged	Authored	Collaborated	Convinced	Corresponded	Delivered
Developed	Directed	Documented	Drafted	Edited	Energized	Enlisted	Formulated
Influenced	Interpreted	Lectured	Liaised	Mediated	Moderated	Negotiated	Persuaded
Presented	Promoted	Publicized	Reconciled	Recruited	Reported	Rewrote	Spoke
Suggested	Synthesized	Translated	Verbalized	Wrote			

RESEARCH

Clarified	Collected	Concluded	Conducted	Constructed	Critiqued	Derived	Determined
Diagnosed	Discovered	Evaluated	Examined	Extracted	Formed	Identified	Inspected
Interpreted	Interviewed	Investigated	Modeled	Organized	Resolved	Reviewed	Summarized
Surveyed	Systematized	Tested					

TECHNICAL

Assembled	Built	Calculated	Computed	Designed	Devised	Engineered	Fabricated
Installed	Maintained	Operated	Optimized	Overhauled	Programmed	Remodeled	Repaired
Solved	Standardized	Streamlined	Upgraded				

TEACHING

Adapted	Advised	Clarified	Coached	Communicated	Coordinated	Demystified	Developed
Enabled	Encouraged	Evaluated	Explained	Facilitated	Guided	Informed	Instructed
Persuaded	Set Goals	Stimulated	Studied	Taught	Trained		

QUANTITATIVE

Administered	Allocated	Analyzed	Appraised	Audited	Balanced	Budgeted	Calculated
Computed	Developed	Forecasted	Managed	Marketed	Maximized	Minimized	Planned
Projected	Researched						

CREATIVE

Acted	Composed	Conceived	Conceptualized	Created	Customized	Designed	Developed
Directed	Established	Fashioned	Founded	Illustrated	Initiated	Instituted	Integrated
Introduced	Invented	Originated	Performed	Planned	Published	Redesigned	Revised
Revitalized	Shaped	Visualized					

HELPING

Assessed	Assisted	Clarified	Coached	Counseled	Demonstrated	Diagnosed	Educated
Enhanced	Expedited	Facilitated	Familiarized	Guided	Motivated	Participated	Proposed
Provided	Referred	Rehabilitated	Represented	Served	Supported		

ORGANIZATIONAL

Approved	Accelerated	Added	Arranged	Broadened	Cataloged	Centralized	Changed
Classified	Collected	Compiled	Completed	Controlled	Defined	Dispatched	Executed
Expanded	Gained	Gathered	Generated	Implemented	Inspected	Launched	Monitored
Operated	Organized	Prepared	Processed	Purchased	Recorded	Reduced	Reinforced
Retrieved	Screened	Selected	Simplified	Sold	Specified	Steered	Structured
Systematized	Tabulated	Unified	Updated	Utilized	Validated	Verified	

Sample Resume

Jin Wang
wang@gmail.com • (213) 555-6666

Education

Harvard University, Extension School
Master of Liberal Arts, Information Management Systems May 2016
GPA 4.0

- Class Marshall Award
- Dean's List Academic Achievement Award
- Data Science Project: Financial Market Analysis Using Machine Learning
- Capstone Project: Enterprise Data Lake

University of Malaya
Bachelor of Computer Science June 2008

Technical Skills

• Machine Learning	• Python/Scikit-learn	• Spark	• Data Visualization
• Quantitative Analysis	• Cloud Computing	• Hadoop	• Java/C#
• Unix Scripting	• Oracle/SQL Server	• PLSQL/T-SQL	• Data Warehouse/ETL
• RDBMS Tuning	• Network Protocals	• Agile & DevOps	• Web Development

Professional Experience

Rande Corporate & Investment Banking Detroit, MI
Associate – Information Technology September 2013 – Present

- Lead a team of 6 people to manage, operate, and support low latency post-trade brokerage platform
- Improved the performance of straight-through processing by tuning database applications
- Reduced number of major incidents by 23% through problem management
- Automated manual back-office processing through scripting and automation engine
- Actively participated and contributed to the internal data science project initiatives

Olson Financial Singapore
Associate – Information Technology February 2011-September 2013

- Built a new application support team of 5 people focusing on post-trading straight-through processing and data warehouse extract-transform-load processing
- Designed and implemented global application monitoring platform.
- Eliminated 80% of manual checks for trading support, and decreased SLA breaches for client reporting by 15%

Sample Resume (page 2)

PS Engineering Information Ltd. Singapore
Software Developer – Technology Office July 2010 – January 2011

- Built Command & Control System for Singapore Civil Defence Force using C# .NET WCF Services
- Integrated proprietary software components with commercial off-the-shell software product

Well Beijing, China
Software Developer June 2009 – June 2010

- Built supply chain management system using Java Spring/Hibernate Framework and Service Oriented Architecture
- Improved the performance of real-time business activity monitoring report and reduce the report response time by more than 50%

Silver Technologies Ltd. Singapore
Software Developer May 2008 – May 2009

- Developed web-based Point of Sale (POS) application using C# .NET for a multinational fashion retailor
- Researched and implemented RFID authentication software module

Certifications

- 4-course graduate-level certificate in Data Science, Harvard University — January 2016
- ITIL Foundation V3 — January 2015
- Project Management Professional (PMP)® — March 2013
- Certified Salesforce Developer — October 2012

Sample Resume

Sarah Lopes Jones

23 South St. • Concord, MA 01742 • 978-333-9898 • sljones@post.harvard.edu

Summary

- Accomplished Certified Project Management Professional with extensive experience managing project teams in all phases of the Software Development Life Cycle, as well as in infrastructure implementations.
- Proven track record of initiating and delivering successful projects to improve systems and performance in large complex development and production environments.

Experience

IBM, Cambridge, MA, 2004 - 2014
Senior Technical Services Professional, 2006 - 2014
IBM Software Group (SWG) HQ division, which manages services to 7 brands/divisions, including: Lotus, Rational, Tivoli, Cognos, and WebSphere, with a total client base of 35,000.

- Simultaneously led 3 cross-matrix teams of 5-15 members each, in projects to research, develop, and deliver yearly software development capital forecast plans. Total budget for all 7 divisions $100M.
- Saved an estimated $2M yearly by increasing productivity of 600 employees. Organized the development and implementation of a worldwide database application, including requirements gathering, development, UA testing, rollout, and training. Directed 4 major version upgrades. Considered "best in breed" application by IBM managers.
- Developed and managed a $30M yearly IT spending budget split between 35 groups/divisions located in 10 different European countries.
- Saved $8M/yearly by initiating and managing a project to transition all US datacenters to standardized servers. Prepared and maintained 25 cutting-edge configurations available by a single part number and delivered fully assembled.
- Managed relationships with Sun Microsystems and Hewlett Packard, to provide ongoing discounts on a variety of servers needed for SWG development.
- Insured compliance for Sarbanes Oxley audits by establishing and maintaining an out-of-cycle capital approval process. Authorized over $50M in requests yearly.
- Created the first standardized high-end ThinkPad to meet the needs of the Software Group developer community. Within 6 months this standard was adopted by all of IBM.
- Saved an estimate of $2M/yearly by reducing capital expenditure through cross-lab sharing and reuse. Member of *The Asset Reutilization Council*, and founder of *The Asset Sharing Database*.

Advanced Systems Management Integration Professional, 2004 - 2006

- Managed deployment projects specializing in security and systems management software throughout the Cambridge data center (200+ servers).
- Specified, ordered, loaded, and installed Windows data center servers as lead MS Certified Systems Engineer on internal project teams.
- Published white papers, processes, procedures, and work instructions for IBM on OS and software standards.

Sample Resume (page 2)

Sarah Lopes Jones ***page 2***

MJ Research (currently Bio-Rad Laboratories), Waltham, MA
Network Administrator and Help Desk Manager, 2001 - 2004

- Managed infrastructure projects, including: setup of multi-site DSL; DHCP and NAT conversion; SMS rollout; firewall installation; email migration; web server launch; database design; license server implementation; sales database rollout; VPN integration across WAN; Intranet design and installation in DMZ.
- Supervised helpdesk and staff. Prioritized help desk issues. Handled problem escalation.
- Directed selection, installation, administration, maintenance, upgrades, and backups for critical Windows servers on a cross-platform LAN/WAN with 200 nodes, and 50 remote users.
- Specified, ordered, installed, and distributed Macintosh systems to new hires. Trained employees on usage, company computer policy, and procedure.
- Held internal training classes in computer use, software applications, Internet, and project management.

Technical Skills

Hardware: IBM System x, BladeCenter, Intellistation, ThinkPad, PowerBook, AMD, Dell, Cisco, TotalStorage, NAS, tape backup.
Networking: switches/hubs, cabling, DSL/VPN, TCP/IP, remote access, DMZ/firewall.
Software: Windows Operating Systems, Mac OS X, VMware, security and virus protection, system mgmt software, middleware, BrioQuery, ACT!, Filemaker Pro, Eudora Pro, *Apple*: iLife, iWork. *Microsoft*: Office, FrontPage, Project, SMS, Outlook, Visio. *Lotus*: Notes, Symphony, Sametime, SmartSuite, *Adobe*: Photoshop, Illustrator, PageMaker, Acrobat.

Education

Harvard University Extension School, Cambridge, MA
Master of Liberal Arts, Management, May 2015
Emerson College, Boston MA
Bachelor of Science in Marketing Communications: Advertising and Public Relations, May 2001
PMI Institute: PMP Certified
IBM: Leadership Excellence Program: 148 class hours developing leadership skills
Microsoft: Windows 2000 Certified Systems Engineer

Cover letter is a writing sample and a part of the screening process. By putting best foot forward, it can increase the chances of being interviewed. A good way to create a response-producing cover letter is to highlight skills or experiences that are most applicable to the job or industry and to tailor the letter to the specific organization based on company that you are applying to.

	Your Street Address City, State, Zip Code
	Date of Letter
Use complete title and address.	Contact Name Contact Title Company Name Street Address City, State, Zip Code
Address to a particular person if possible and remember to use a colon.	**Dear _________:**
	Opening paragraph: Clearly state why you are writing, name the position or type of work you're exploring and, where applicable, how you heard about the person or organization.
Make the addressee want to read your resume. Be brief, but specific.	**Middle paragraph(s):** Explain why you are interested in this employer and your reasons for desiring this type of work. If you've had relevant school or work experience, be sure to point it out with one or two key examples; but do not reiterate your entire resume. Emphasize skills or abilities that relate to the job. Be sure to do this in a confident manner and remember that the reader will view your letter as an example of your writing skills.
Ask for a meeting and remember to follow up.	**Closing paragraph:** Reiterate your interest in the position, and your enthusiasm for using your skills to contribute to the work of the organization. Thank the reader for his/her consideration of your application, and end by stating that you look forward to the opportunity to further discuss the position.
Always sign letters.	Sincerely,
	Your name typed

General rules in making cover letter:

1. Address your letters to a specific person if you can.
2. Tailor your letters to specific situations or organizations by doing research before writing cover letters.
3. Keep letters concise and factual, no more than a single page.

4. Avoid flowery language.
5. Give examples that support your skills and qualifications.
6. Put yourself in the reader’s shoes. What can you write that will convince the reader that you are ready and able to do the job?
7. Don’t overuse the pronoun “I”.
8. Remember that this is a marketing tool. Use lots of actionwords.
9. Have an adviser proofread your letter.
10. If converting to a pdf, check that your formatting translated correctly.
11. Reference skills or experiences from the job description and draw connections to your credentials.
12. Make sure your resume and cover letter are prepared with the same font type and size.
13. Be honest, the resume should be compelling but never misleading or deceptive.

Sample Cover Letter

February 21, 2016

Ms. Liza Wideman
Recruiting Coordinator
Great Strategy Consulting Firm
200 Shell Fish Blvd, Suite 199
San Francisco, CA 94080

Dear Ms. Wideman:

I am writing to express my interest in securing an Associate position at Great Strategy Consulting Firm. I am a Master of Liberal Arts degree candidate at Harvard Extension School, specializing in Information Technology. I come from a solid technical background with a strong interest in business and a passion towards strategy. My area of focus and interest varies from quantitative analysis to project management. I have maintained a 3.95 GPA through a well-balanced program of study, which is not only very analytical and technical by nature but also helps to build leadership and team building qualities. I am extremely impressed with Great Strategy's approach to strategy consulting, especially within the Business Development and Innovation practice areas. I believe my academic background, business knowledge and industry experiences have provided me with the credentials needed to thrive as an Associate.

Prior to Harvard, I worked as a technology professional, primarily resolving strategic issues related to technology process improvement. I gained solid research, analytical and problem solving skills while working in Fortune 500 companies. My background in generating innovative ideas and strategies to improve processes has provided me with a deeper understanding of multifaceted problems that companies encounter in their daily operations. Moreover, because of my work experiences, I fully understand how important it is to have great team dynamics in today's multi-disciplinary business environment.

To date, my experience as an IT professional has been extremely rewarding and productive. However, it is through strategy consulting that I can use my analytical aptitude and creative problem solving skills to their fullest. I strongly believe that consulting is a discipline that will force me to view problems not only from the client's standpoint but also from a marketplace, best practices and "think out of the box" point of views.

I would appreciate the opportunity to interview with Great Strategy Consulting Firm for the Associate position. Please find enclosed my resume for your review. I can be reached via email at jacob.mclean@post.harvard.edu or by phone at (617) 555-3456. I enthusiastically look forward to hearing from you soon.

Thank you for your time and consideration.

Sincerely,

Jacob A. McLean

The best candidate can let themselves down and even lose a job at interview by being poorly presented. It is wrong to judge by appearances, but you also have to take human nature into account - people do. Before interviewing you, an interviewer will have made themselves look presentable, arranged a room, refreshments, read your resume or CV, and prepared questions to ask you. In return, it is perfectly natural for them to expect you to have made some effort yourself. These are the example of cover letter and CV.

6 Haymarket
Newcastle
NC1 4YU

15 December 19—

Ms Denise Dickens
Personnel Department
Administrative Block A
Castleton Airport
Castleton CS21 3SL

Dear Ms Dickens,

Re: Engineering Technicians

I would like to apply for the post of Engineering Technician as advertised in today's issue of the Tribune. I enclose my CV with the names of two referees.

You will note from my CV that I have a National Certificate in Electrical and Electronic Engineering and considerable experience. My work at S & T (UK) means that I am familiar with HVAC plant and systems including electronic system control. As an inspection technician, I have experience of a wide range of systems for product testing and component evaluation.

I enjoy my work at S & T but would like now to broaden my experience, especially in the area of maintenance. I feel that I can bring considerable skill to the post together with the ability to work well in a team. I am also interested in further improving my qualifications by studying for an HNC, part-time.

I look forward to hearing from you.
Yours sincerely

Fiona Weaver

Fiona Weaver

CURRICULUM VITAE

Personal details

Name:	Fiona Weaver
Date of birth:	7 April 1974
Address:	6 Haymarket, Newcastle, NC1 4YU
Marital status:	Single

Education and qualifications

1991-1995	Faraday College of Further Education, Newcastle - National Certificate in Electrical and Electronic Engineering (day release from S & T (UK) Ltd)
1985-1990	George Stephenson Secondary School, Newcastle

I hold a clean driving licence. I have been driving for three years.

Work experience

1995 to present	Inspection Technician Sturner & Thomson (UK) Ltd - Responsible for checking incoming components and completed products using a wide range of test equipment including computer-based record systems.
1991-1995	Apprentice electrical technician Sturner & Thomson (UK) Ltd
1990-1991	Office junior Brent & Wicker, Solicitors - Basic secretarial duties–filing, word-processing, telephone receptionist, in a busy lawyers' office

Interests and activities

Travel, modern dance, swimming

References	College:	Work:
	Mr Andrew Wood Head of Department Electrical Engineering Faraday College Cornwallis Road NEWCASTLE NC2 3PL	Mrs Joy Milne Personnel Officer S & T (UK) Ltd North Street NEWCASTLE NC14 7TL

The primary differences between resume and CV are length, what is included, and what each is used for. While both are used in job applications, resume and CV are not always interchangeable.

Curriculum Vitae.

CV provides a summary of one's experience and skills. Typically, CV are longer than resumes at least two or three pages for CV, while resume is only in one page. CV include information on one's academic background, including working experience and position, degrees, research, awards, publications, presentations, and other achievements. CV are thus much longer than resumes, and include more information, particularly related to academic background. CV is a one-to-two-page, condensed version of a full curriculum vitae. A CV summary is a way to quickly and concisely convey one's skills and qualifications. Sometimes large organizations will ask for a one-page CV summary when they expect a large pool of applicants.

Resume

Resume provides a summary of your education, work history, credentials, and other accomplishments and skills. There are also optional sections, including a resume objective and career summary statement. Resumes are the most common document requested of applicants in job applications. Resume should be as concise as possible. Typically, a resume is one page long, although sometimes it can be as long as two pages. Often resumes include bulleted lists to keep information concise. Resumes come in a few types, including chronological, functional, and combination formats. Select a format that best fits the type of job you are applying for.

CV and Resume Writing Tips

Whether writing a CV or a resume, there are a few helpful rules you should follow:

1. Match your resume or CV to the position. This is most important when writing a resume, but it applies to a CV too. Make sure that you highlight your education, work experience, and skills as they relate to the particular industry or job.In CV, for example, if you are applying for a job in education, you might want to put your teaching experience at the top of your CV. In a resume, you might include only the work experience that relates directly to the job you're applying for.You can also include keywords from the job description in your resume or CV. This will show the employer that you are an ideal fit for the position. Here's how to match your qualifications to a job.
2. Use a template. You may want to use a template to structure your resume or CV. This will give your application a clear organization, which will help the employer quickly see your qualifications and experience.
3. Edit, edit, edit. No matter whether you use a CV or resume, you need to thoroughly edit your document. Make sure there are no spelling or grammatical errors.
4. Also make sure your format is uniform – for example, if you use bullet points in one job description, use bullet points in all your job descriptions.

How to Write a Successful Resume are Choose the right format for your needs. Your industry, experience, and desired role will inform your choice of resume format – e.g. chronological, functional, or combination. See sample resumes organized by occupation and industry, here. Write for both robots and humans. Your resume needs to get past the Applicant Tracking System and grab the attention of the human being on the other end. These resume writing tips will help you craft a document that appeals to both software and Human Resources.

How to Write a Successful CV are Know what to include and how to format the information. These sample CVs form a helpful guide; this piece offers tips for writing your very first CV. Choose an appropriate format. Make sure you choose a curriculum vitae format that is appropriate for the position you are applying. If you are applying for a fellowship, for example, you will not need to include the personal information that may be included in an international CV.

5.2. Job Interview

The most important thing is that the interviewer's main objective is to determine whether or not you are the best candidate for the job. Your main objective is to communicate your skills and accomplishments, while determining if this is the right job and the right company for you. Your resume or CV provides your interviewer with some answers to questions about your educational background and work history, but of all the criteria the interviewer uses to judge your qualifications for the job, none will be more important than your accomplishments.

Many companies today, particularly large companies, strive to make the recruiting process more scientific than in the past. These companies have done research to see what factors (such as skills and traits) have made their employees successful. These factors are called behavioral measures of success or success factors. Every firm values different success factors; the only way to know the specific factors a particular company esteems is to speak with someone who works for this company.

The best interviewing strategy is to talk about the academic and work experiences that pertain to these generic success factors. As you tell the stories, the company success factors will stand out, showing the interviewer that you are a viable candidate for the job.

The most effective way to discuss your accomplishments is to recast them in the form of stories: Each one must successfully document and illuminate your successes. Depending on the job, your interviewer will be looking for certain kinds of success stories based on a number of factors, such as your ability to solve problems, think independently, take initiative, or communicate skillfully. The ten success factors that most employers expect from job candidates are listed in Exhibit 4–1. Your task is to weave these factors into your own success stories.

Exhibit 4-1.
Ten Success Factors Most Employers Look for in Job Candidates

1. Accomplishments/getting results
2. Taking initiative
3. Communication skills
4. Problem solving
5. Teamwork and team leadership
6. Project management
7. Decision making
8. Strategic thinking
9. Innovative thinking
10. Handling pressure

Make Your Own Opportunities to Describe Your Successes

Learning how to use success stories effectively cannot be overemphasized. There is simply no better way to showcase your achievements and prove your suitability for a job. It takes some skill to weave success stories into an interview, but this can be done with relative ease if you rehearse them many times *before* you go to the interview, and use all of your communication skills to *tell* your stories once you get there. You will have to take some initiative to find openings for your success stories. Even if your interviewer asks you a question that can be answered with a simple yes or no, resist the urge to give a one- or two-word answer, as in the following example.

Weak answer:
Interviewer: Do you think you work well on a team?
John: *Yes.*

Interviewer: Can you think of any times when you had difficulty working on a team?
John: *No.*

Instead, take the opportunity to present yourself in the best possible light. Use one of your strongest success stories. The following example shows how it can be done.

Great answer:

Interviewer: Do you think you work well on a team?

Jim: *Yes. I was cocaptain of the basketball team in college—it was a great experience and a great chance to work with my peers outside of the classroom. I would keep track of new strategies, organize extra practices, and arrange social events for the team. I always thought it was important for the team to spend time together off the court—we got to know each other better, and this helped us work together in games.*

Interviewer: Can you think of any times when you had difficulty working on a team?

Jim: *One incident comes to mind. A member of our team was a bit of a ball hog. If he got the ball in the game, he refused to pass it, and the other team members were getting upset. But I didn't want to single him out or scold him. Instead, I came up with practice drills that involved a lot of passing. I complimented him on his passing ability and told him it was just the sort of thing he could use in a game. And I spoke to the whole team about passing more in games. Well, he got the picture—and because I was supportive instead of confrontational, I didn't end up with a big argument on my hands.*

Who would you hire, John or Jim? Jim took advantage of his interviewer's questions by telling stories that demonstrated his positive traits. Although John might have been a stronger candidate than Jim in some ways, his interviewer had no way of knowing, because John didn't capitalize on the opportunity to illustrate his better qualities.

Making the Connection between Success Factors and Success Stories

No matter what kind of work you've done in the past, you can find a success story to match all ten factors listed in Exhibit 4–1. Keep your mind open—don't dismiss any work experience as insignificant until you've thoroughly examined it. Think about your academic and work experiences in terms of the problems presented, the actions you took to solve them, and the results. Let's look at each success factor in more detail, to give you ideas about how you can describe to interviewers your past success in the best possible way.

Success Factor #1: Accomplishments/Getting Results

One of the most common interview questions is: "What is your greatest accomplishment—the thing you are most proud of?" By asking this question, the interviewer is trying to determine if you get satisfaction from achieving results. The interviewer may also want to see if you are proud of your accomplishments; being proud of past results will translate into taking pride in your work with your prospective employer.

There are many types of accomplishments you could use to answer this question. For example, completing your education is an accomplishment. Focus on individual challenges or why you're proud of receiving your degree. Perhaps there's a story that illustrates your overcoming an obstacle, such as saving money under difficult circumstances, figuring out how to pass a challenging class, or getting your writing published. What were the results of your efforts?

Great answer:

Here is a sample story that illustrates how you could answer the question:

> *I was extremely happy when I got into my first-choice college, Elmherst—but the scholarship they offered didn't quite cover my needs. Although I had been admitted to several schools, I felt that, for me, Elmherst would provide the best possible education. So,*

instead of going straight to school, I deferred for a year and spent the time working at a local hardware store. After a few months, I took on a second job waiting tables. It was a very tough year—but I was proud that I stuck to it. By the time September rolled around, I had saved enough money to attend the school of my choice, and I had some solid work experience.

This story tells volumes about the speaker's abilities to *persevere*, *solve problems*, and *take charge* of his career. It also demonstrates that the speaker is *goal oriented*, an extremely important trait in the business world, where every action has a purpose and leads to a greater goal.

Good success stories, like this one, are rich composites of your experiences and skills, so you will have some flexibility in using them; one story should answer a number of different interview questions. For example, if the speaker in the previous example had been asked not about his accomplishments, but about a time when he took charge or used initiative, his story about saving money for school would also apply.

Success Factor #2: Initiative

In a fast-paced, competitive business environment, it is important to hire people who can take charge—even if the responsibility is not in their job description. Time is an important element in taking initiative: It's about *doing something when it needs to be done*, instead of waiting for someone else to do it first.

Great answer:

Consider the following story:

I worked on my college literary magazine. Producing the magazine was always an uphill battle. We received most of our revenues from ads, but the number of advertisers was constantly dwindling—and no one seemed to be doing anything about it. I organized a small committee, and we went door to door, speaking with local businesses about our magazine. Sometimes it took a lot of persuading, but once they saw the quality of the magazine and heard about our *diverse audience, most businesses were eager to advertise. We raised so much money that we were even able to print the magazine in color for the first time.*

This story brings out a number of the interviewee's good qualities, including *team leadership*, *determination*, and, above all, *initiative*. All of these qualities are highly valued in the business world. An employer wants to hire people who can recognize problems and take independent *action* to remedy them.

Success Factor #3: Communication Skills

Your interviewer will be aware of how long it takes you to answer questions: There is a delicate balance between saying enough to get your success stories across and saying too much. Ask your acquaintances what kind of speaker you are: Do you tend to go on and on or are your answers short and blunt? Better yet, have a friend or family member conduct a practice interview with you. Tell them to evaluate your speaking skills, and then try to improve your style.

Tell your story clearly to ensure that the interviewer gets your point. Be concise. Don't get sidetracked by focusing on endless details or irrelevant aspects of the story. If you're telling a story about working on your uncle's farm, for instance, don't bother telling the interviewer the names of all the horses for whom you cared. Also, it's important to avoid using slang words such as *like* and *y'know* and *filler* words, such as *um*, *eh*, and *uh*. A common interview mistake is beginning every answer with "Ummm . . . " Usually, a candidate uses this opening to stall for time to take a few seconds to collect his or her thoughts.

However, there are better ways to give yourself time to think. Don't be afraid to sit in silence for a moment while you prepare your answer. Your interviewer will not be surprised if you need to collect your thoughts. If this makes you uncomfortable, try paraphrasing the question as you begin your answer. For instance, if your interviewer asks, "How would a coworker describe you?" you should reply, "I think that a coworker would describe me as . . . " By repeating the question, you've given yourself time to compose your answer.

The *only* way to present your credentials well is to prepare prior to the interview—know what you want to say and how you want to say it. Have someone else listen to you and give you feedback. This will help you feel more confident and do your best.

Quick! Which sentence sounds more professional?

1. Uh . . . I think that I'd be an asset to your firm because I'm diligent, and, um, efficient and people tell me that I'm, y'know, a good communicator.
2. I think I'd be an asset to your firm because I'm diligent and efficient, and I have excellent communication skills.

Success Factor #4: Problem Solving: Thinking and Working Independently

It's just as important to take directions as it is to work independently. However, when you *do* work independently, it's not always smooth sailing. So, when you're thinking of a story to demonstrate independent thinking, focus on the *obstacles* you had to overcome to solve a particular problem. What steps did you take?

Great answer:

Here is an anecdote that shows a candidate's abilities to think independently *and* solve problems. In addition, it demonstrates analytical skills, reflective abilities, and an ability to learn from mistakes.

> *I worked at the registrar's office during college. My primary responsibility was filing, but the filing system was hopelessly confusing. I came up with a great way to reorganize the files and spoke to my supervisor about implementing my plan. I was thrilled when she approved*

I spoke with the owner of the shop and he was thrilled—he had also been trying to come up with new promotional ideas. Some of the club members were skeptical of my idea, but the refreshments and discounts worked like a charm—ticket sales improved 30%!

Success Factor #6: Leadership and Team Playing

So much work today is done in teams that employers often want to know if you can get along with others and get the work done. What have you done in the past that illustrates your ability to work successfully with others?

Remember Jim, the basketball team captain you met earlier in this chapter? His anecdotes about playing on and managing a sports team showed that he was comfortable as both a team leader and a team player. Stories about playing sports, working in small groups in classes, or participating in college clubs and organizations all demonstrate that you work well with others.

Success Factor #7: Project Management

Just finishing college exemplefies the ability to plan, organize, and set priorities, particularly if you were a student who successfully juggled schoolwork, part-time jobs, club activities, a healthy social life, and maybe even volunteer work. Try to think of specific examples that illustrate your abilities to manage many tasks at once.

Great answer:

The following is a story from a recent college graduate:

I was an editor of my college newspaper, which came out every Friday. On Thursday nights, all of the editors would gather in the newspaper office to make last-minute changes, finalize the layout, and so on. Usually, we were there until seven or eight in the morning. There was a lot of fallout from these all-nighters: Some people weren't prepared for their Friday classes. They fell behind in their reading and turned assignments in late.

After a couple of difficult weeks, I discovered that managing the all-nighters at the paper was simply a matter of budgeting my time.

I finished my reading the weekend before it was due and completed all of my assignments early in the week. If I had a project due on a Friday, I made sure to get it done well in advance.

Because I stuck to my schedule, late nights at the newspaper office didn't sabotage either my academic responsibilities or my social life. In fact, I was more efficient and also found that I had more free time to spend with friends.

This story demonstrates the speaker's ability to *set priorities*, *manage time*, and *successfully juggle* various facets of academic and personal life.

Success Factor #8: Decision Making

Decisive action taking is important to any business, whether your job involves working independently or in a group, but how you arrive at decisions will especially interest prospective employers. Decision making involves generating multiple solutions to a problem and using your discernment to select the best choice from those options. Being judicious—thoughtfully weighing the pros and cons of a situation before taking action—is just as important as knowing how to make decisions. It involves deciphering which path to take and following a logical thought process to the end.

If you've ever worked in student government or ran a college organization, then you should have plenty of stories to tell about active decision making. Or, you could discuss how you chose your major, why you decided to take a certain class, or why you decided to attend your college. We make decisions every day, and any number of them could be incorporated into an anecdote to tell your interviewer.

Great answer:

Try a college-related story like this one:

At my college, students typically live on campus for the first two years, and then they tend to find off-campus housing for the next two years. At the end of my sophomore year, I had to decide where to live in the fall and with whom I wanted to share housing. My current roommate got offered a position as Resident Advisor on campus. The *perks included a large room to share; the downside was that I'd have to remain on campus if I wanted to be her roommate. My other choices were to take a shared room in my sorority's house or take a private room in an apartment with three other friends, fellow education majors.*

The choices were tough: continuing to live with the tried and true roommate in a less-than-choice setting, giving up privacy for the potential fun that the sorority house offered, or taking the open room at the apartment, which was further from campus but offered some personal space not often found at college.

I opted for the apartment. I was scheduled for student-teaching the following spring semester, and I knew that I'd need to go to bed early and prepare my lessons. I decided that the atmosphere at the sorority house could get tiring—if I wanted that scene, I could visit any time, day or night. I realized that I needed to be more independent, so the dorm option was out for me, too.

I ended up making the right choice—I got my work done, had a successful experience in the classroom, and, with my own apartment, was able to invite my old roommate or sorority sisters over for an occasional escape from their surroundings.

Success Factor #9: Strategic Thinking

Thinking strategically is the ability to link long-range visions to daily work. The emphasis is on having a long-range goal where you needed to sustain effort over time despite setbacks and unpredictable events. In your academic experience, it could mean how you ensured that you graduated college in four years. In the workplace, it would translate to knowing company initiative was to cut expenses and taking action to cut expenses or save money for your department throughout the year.

Great answer:

Midway through my sophomore year in college, I decided that I wanted to spend a semester studying in Paris. I was a French major, so I knew this would be the best way to improve my skills and knowledge of French culture. Some of my friends strongly advised *against it, however—my college had a lot of course requirements, and many people who spent time abroad were unable to complete their degrees in four years or they spent senior year struggling under impossible course loads.*

After thinking about the situation, I realized that studying abroad was not impossible—I just had to plan ahead. I had planned on taking two electives per semester, but I decided to replace one with a required course and add an additional required course to my schedule. Taking six courses a semester was tough, but I made a strict study schedule for myself and stuck to it.

I studied in Paris during spring of my junior year, and it was the best educational experience I ever had. And, thanks to my good planning, I had no trouble completing my requirements. I was able to take all the electives I wanted senior year, and even had time to work as a research assistant for one of my French literature professors.

Success Factor #10: Staying Cool under Pressure

Part of the maturity equation is coping with pressure—knowing what to do first when you walk into your office and have 50 e-mails and a ringing phone to answer, not to mention five people who are waiting for appointments.

Think of a story about your own performance under pressure. Maybe you were on your college swim team and had a meet the day before a big test. Or maybe you came to work one day to discover that several employees were sick—and you were left to handle their work as well as your own. How did you control the situation? Was the result positive?

Great answer:

Here's how one candidate demonstrated the ability to handle pressure:

When dealing with pressure, I try to step back from situations and assess them logically, rather than getting carried away by my emotions. In college, I was the stage manager for the drama club's production of My Fair Lady. *When we got to the theater to prepare opening night, we discovered that all our props, makeup, and* *costumes were scattered and out of place. Apparently, a group of students had used the theater to practice some improvisational comedy, not knowing that a production was going up the next night.*

We didn't have much time to get ready, and the cast started panicking about their missing items. I asked everyone to find his or her costume. While they were busy, I quickly found some cardboard boxes and labeled each one with a character's or group's name: Eliza, Henry, street merchants, racetrack patrons, and so on. The stage crew collected props and other items, brought them to me, and I deposited them in the proper box. Everything got sorted quickly, and the curtain went up on time.

Rehearsing Your Success Stories

In order to weave your stories into an interview so that they sound effortless and natural, write them down and rehearse them, saying them several times. The goal is to be clear, concise, and to make your point; you don't want to sound like your answers are pat or over-rehearsed. Eventually, you may feel comfortable enough to tailor your stories to individual interviewers, but this takes a lot of practice.

Recording your stories is a great way to hear all the things that need to be smoothed out or tightened so that your delivery is perfectly natural. Also, ask your family and friends to critique your stories and edit them. The reason for rehearsing your stories aloud is that the way you *tell* a story is different from the way you write one.

While you're rehearsing, you may want to watch your facial expressions in a mirror. Are you smiling and enthusiastic, or do you look somber and serious? Observe how your facial expressions affect your tone. When you're smiling, your voice sounds friendly, pleasing, and warm; when your expression is somber, your delivery may sound flat. Vary the tone of your voice and the tempo at which you speak. This will help create interest in what you say, especially if your interviewer's attention seems to be momentarily drifting away.

5.3. Tasks

Answer these following questions based on reading text given

1. Find job vacancy advertisement and make cover letter based on the advertisement!
2. Type neatly your own Resume and Curriculum Vitae!
3. Do simulations on job interview in pair with your classmates in turn, provide feedback for your job interview simulation!

CHAPTER VI
PRESENTATION

6.1. How to Deliver Presentation in Proper English

Giving the perfect oral presentation in English requires practice. Remember that even great orators like Steve Jobs, Abraham Lincoln, Nelson Mandela and Martin Luther King became excellent public speakers through years of dedicated practice. Tips for Giving a Great Presentation

1. Think about the Details in Advance

Giving a presentation in front of an audience is always stressful. Thinking about such details as the location of the presentation, equipment, materials, timing, your appearance and outfit will help you avoid nervousness.

2. Do Your Homework

Effective preparation requires consideration of the following things:

- Ask yourself what the presentation is all about, its title and its goal
- Think about who your audience is
- Figure out what your main message is
- Think about the structure of the presentation: the opening, the main part and the summary
- Make it easier for the audience and yourself: use simple language
- Prepare yourself for questions. Think about what questions the audience might ask
- Usually an orator has a maximum of 15 minutes to present. Therefore, make the presentation simple, have

no more than 20 slides using a font that is legible from a distance

- Do not put large blocks of text in your presentation. No one will be interested in reading it; people prefer visual material. So think about images, graphs and videos that support your idea, but don't overwhelm the audience with too many visual aids

3. Introduce Yourself and Set the Theme

At the beginning of the presentation, it is important to introduce yourself, giving your full name, position and company you represent. Some people also include their contact information on the first slide. That is in the case you want someone from the audience to contact you after your presentation. After the introduction, always remember to state the topic of your presentation.

Useful phrases in English:

"Hello, ladies and gentlemen, thank you for coming..."

"The topic of today's meeting is..."

"Let's get the ball rolling"

"Shall we get started?"

4. Provide an Outline or Agenda of your Presentation

Providing an outline of the presentation is a must, as people want to know why they should listen to you. That is why the opening part is very important. It should be cheerful, interesting and catchy. You should know it by heart, so you do not lose track of your thoughts even if you are nervous.

Useful phrases in English:

"I'd like to give you a brief outline of my presentation..."

"Here is the agenda for the meeting..."

"My presentation consists of the following parts…"
"The presentation is divided into four main sections…"

5. Explain When the Listeners Can Ask Questions

A Question & Answer period (Q&A) usually takes place at the end of the presentation, so you have enough time to deliver the main message of your speech without being interrupted by multiple questions. If you want the audience to ask questions during or after the presentation, say so.

Useful phrases in English:
"There will be a Q&A session after the presentation"
"Please feel free to interrupt me if you have any questions"
"I will be happy to answer your questions at any time during the presentation"

6. Make a Clear Transition in between the Parts of the Presentation

Using transition words and phrases in English makes your presentation look smooth and easy to follow.

Useful phrases in English:
"I'd like to move on to another part of the presentation…"
"Now I'd like to look at…"
"For instance…"
"In addition…"
"Moreover…"
"This leads me to the next point…"

7. Amaze Your Audience

If you are not excited by your presentation, your audience will not be excited either. When presenting, you should plan to amaze your audience. Use adjectives and descriptive words as they will help to attract the audience's attention and make your speech more vivid and memorable.

Useful phrases in English:

"The product I present is extraordinary."

"It's a really cool device"

"This video is awesome"

"This is an outstanding example"

8. Make Your Data Meaningful

If you need to present numbers or some comparative analysis of algorithms for integration, use some visuals to present it. You can use charts, graphs or diagrams to make your data meaningful and visually attractive. Remember that pie charts are good for representing proportions, line charts to represent trends, column and bar charts for ranking.

Useful phrases in English:

"Here are some facts and figures"

"The pie chart is divided into several parts"

"The numbers here have increased or gone up"

"The numbers change and go down (decrease)"

"The numbers have remained stable"

9. Summarize

At the end of the presentation, briefly summarize the main points and ideas. Provide the audience with your opinion and give them a call to action, let them know what you want them to do with the information that shared. End of the presentation by thanking all the listeners and inviting them to the Q&A.

Useful phrases in English:

"Let's summarize briefly what we've looked at…"

"In conclusion…"
"I'd like to recap…""I'd like to sum up the main points…"

10. Practice

Try rehearsing your presentation using the above tips. Practice in front of a mirror or with your friends, parents or spouse. The more you practice, the better. While practicing, try not to use crutch words (examples: uhhhhh, ahhhh, so on, you know, like etc.)

6.2. Proper English Phrases to Deliver Presentation

There are English phrases that you can trust to help you transition smoothly from the beginning to the end of your presentation. They are:

Greeting Your Audience

You are now standing in front of your audience. Before you begin your presentation, start by greeting your audience, welcoming them to the event and introducing yourself.

1. Good morning/afternoon/evening, everyone.
2. Welcome to [name of event].
   Sample sentence: Welcome to our [name of event].
3. First, let me introduce myself. I am [name] from [company].

Beginning Your Presentation

After you have given an introduction, you are ready to begin speaking about your topic. Use these phrases to get started.

4. Let me start by giving you some background information.

Use this phrase to give your audience a brief overview of the topic you will be discussing. This is a good way to give them an idea of what is going on and to bring them up to date.

5. As you are aware, …

   If you're bringing up a topic that your audience already knows about or is aware of, then you can use this phrase to introduce this known topic.

   Sample sentence: As you are aware, the expert of the industry has often said that globalization is here to stay.

Transitioning to the Next Topic

Before you move on to your next point, be sure to make it clear to your audience that you're now starting a new topic. Let them know exactly what that new topic will be. The two phrases below are very similar in meaning, and they can both be used for transitions.

6. Let us move on to…

   Sample sentence: Let us move on to our second statement.

7. Turning our attention now to…

   Sample sentence: Turning our attention now to the results of our 2016 survey.

Providing More Details

Use these phrases to tell your audience that you will be giving them a more detailed explanation of the topic. Both the words 'expand' and 'elaborate' mean to explain more fully.

8. I would like to expand on…

   Sample sentence: Now I would like to expand on my point about increasing the chance of cooperation.

9. Let me elaborate further.

Linking to another Topic

When making reference to a point you made earlier, or to remind your audience about something you said before, use these phrases to that link.

10. As I said at the beginning, …

    This phrase lets you remind your audience about a point you made earlier. It can also be used to emphasize a point or theme.

    Sample sentence: As I said in the beginning, we will see an increase in the chance if we follow these five steps procedures.

11. This relates to what I was saying earlier…

    This phrase will help you make connections between ideas in your presentation. It shows that two different ideas are connected.

    Sample sentence: This relates to what I was saying earlier about increasing chance to cooperate with NGO to meet the year-end demand.

12. This ties in with…

    Sample sentence: This ties in with the way we have been doing research for the past four years.

Emphasizing a Point

Use these phrases to draw attention to an important point that you want your audience to note.

13. The significance of this is…

    The word significance is similar in meaning to importance.

    Sample sentence: The significance of this is, if we complete this reserach project on schedule, we will have more people available to work on the next project.

14. This is important because…

    Sample sentence: This is important because any effort we put in now will help to boost demand for our project in the long run.

15. We have to remember that …

    Sample sentence: We have to remember that people are our most important resource.

Making Reference to Information

Very often, you may need to support your discussion points by drawing attention and making reference to information and data from studies, reports and other sources.

16. Based on our findings, …

    Sample sentence: Based on our findings, 74% of our product based on research result is made up of teenagers who find our product line stylish and upbeat.

17. According to our study, …

    Sample sentence: According to our study, 63% of working people in this city go directly to the Mall after work.

18. Our data shows …

    Sample sentence: Our data shows that more than 23% of men in this town who used to drive to work now prefer to save money and the environment by cycling instead.

Explaining Visuals

To present a clearer picture of your point, you may show your data, information or examples in the form of visuals such as charts, tables and graphs.

19. I would like to illustrate this point by showing you…

    The word illustrate means show, usually with examples, data or visuals.

Sample sentence: I would like to illustrate this point by showing you a chart of the number of people in each age group who prefer to consume our product.

20. This chart shows a breakdown of …

    A breakdown refers to the detailed parts or figures that make up the total picture. A breakdown is often used in a presentation to show all the smaller parts behind something bigger.

    Sample sentence: This chart shows a breakdown of the ingredients we use in our gluten-free products.

Restating Your Point

Sometimes in order to emphasize your point, you have to state it in a way that's easier for your audience to understand and remember. This often involves rephrasing, simplifying or clarifying your point.

21. In other words, …

    Use this phrase to rephrase or reword your point in another way.

    Sample sentence: In other words, we need to change our current design to make it more attractive to older children.

22. To put it simply, …

    Use this phrase to simplify points that are complex or difficult to understand.

    Sample sentence: To put it simply, we will need you to work harder at making this launch a success.

23. What I mean to say is …

    Use this phrase to explain your point in a way that's easier for your audience to understand.

    Sample sentence: What I mean to say is that we need to change the way we market our products.

Concluding Your Presentation

This is the very end of the presentation. You have said everything you need to say, and now you need to finish it nicely. You may also have some time for questions. If there is time for questions, invite your audience to ask any questions they have.

24. In conclusion, let me sum up my main points.
    As part of your closing statement, sum up (summarize, state briefly) your speech by mentioning the main points of your speech.
25. Thank you for your attention. Now I am happy to answer any questions you might have.
    End your presentation by thanking your audience and offering to answer their questions.

6.3. Tasks

Answer these following questions based on reading text given

1. Prepare and arrange 10 slides of your project presentation in English from laboratory/workshop project!
2. Practice in using proper English phrases in presenting your project in front of the classroom!
3. Organize the presentation in turn and give feedback to your classmates' project presentation!

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