Practical Electronics

Contents

In the next few pages there will be tables with knowledge that **must** be learned before the National 5 Electronics exam. In the 1st box put a ✓ or ✗ to show your understanding. You can use the 2nd box to check your understanding at a later date.

Using this sheet **will** help you become more prepared for your final exam.

Use the extra space sections to include any additional information that you find when doing past paper questions/reading your notes etc…

Section 1 – Circuit Theory

In any calculation you will need to use the correct values. Sometimes a quantity is given with a **prefix**, for example a current of 20 mA. The prefix here is the symbol m. This means that the current is not 20 A but instead 20 x 10^{-3} A. If you do not change the prefix into a ‘x 10’ then you will **not** be awarded full marks in each question you do this in.

The prefixes are;

Prefix (symbol)	power of 10 (x 10 to)
Mega (M)	x 10^{6}
Kilo (K)	x 10^{3}
milli (m)	x 10^{-3}
micro (µ)	x 10-^{6}
nano (n)	x 10^{-9}
pico (p)	x 10^{-12}

Current is defined as the number of coulombs of charge per second.

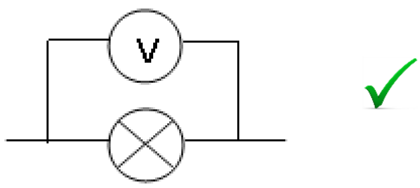
Voltage is defined as the energy given to each coulomb of charge.

Resistance is a measure of the opposition to current in a circuit. If the resistance increases in a circuit the current will decrease. If the resistance decreases the current will increase.

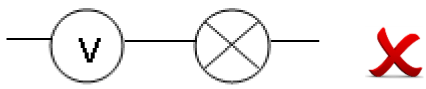
Ohm’s law is simply the equation; **V = I R** where V = voltage (V), I = current (A) and R = resistance (ohms, Ω).

Voltage is measured using a voltmeter. The circuit symbol for a voltmeter is 

A voltmeter must be connected **across** a component as shown.

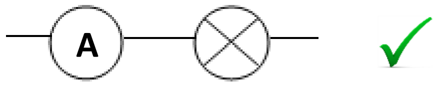


The voltage is always **across** a component and **never** flows through a component.



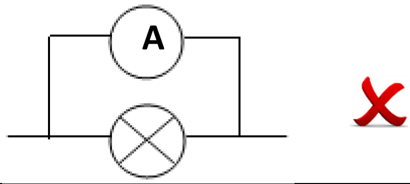
Current is measured using an ammeter. The circuit symbol for an ammeter is 

It must be connected **in series** with a component as shown.

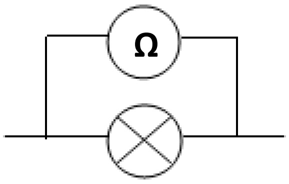


The current always **flows through** a component

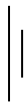
and **never** across a component.

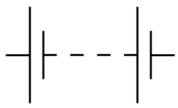


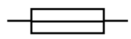
Resistance is measured using an ohmmeter. The circuit symbol for an ohmmeter is  The resistance is measured by connecting an ohmmeter as shown.

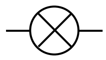


The following symbols represent components that are used in electrical circuits:

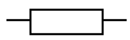
Cell – 

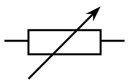
Battery – 

Fuse – 

Lamp – 

Switch – 

Resistor – 

Variable resistor – 

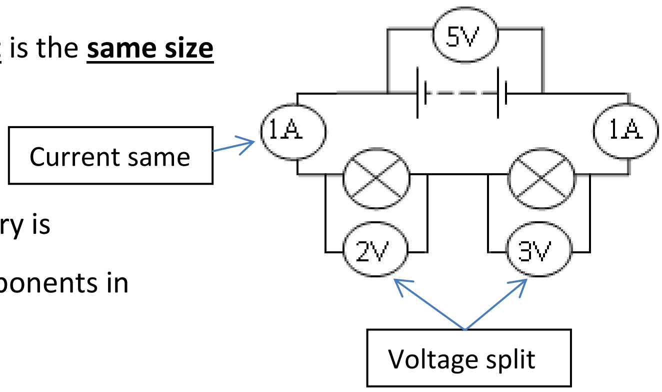
a.c. supply – 

There are two types of circuit called **series** and **parallel**. There are rules which must be used for each type of circuit.

	Current	Voltage
Series circuit	same everywhere	split across components
Parallel circuit	split through branches	same in each branch

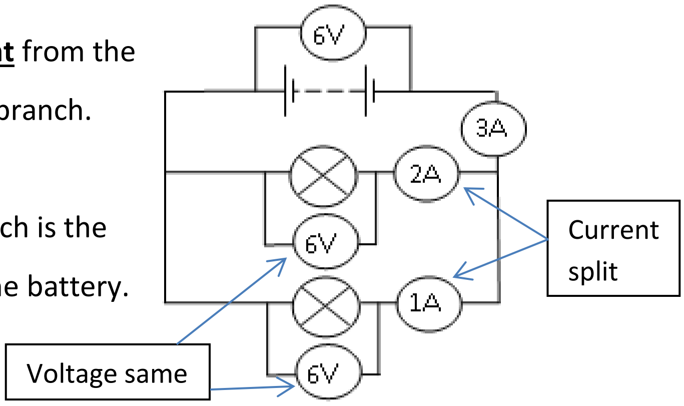
In a series circuit the **current** is the **same size** at any point in the circuit.

The **voltage** across the battery is **split across** each of the components in the circuit.



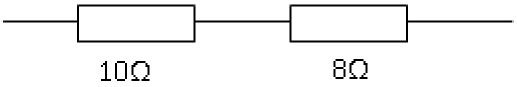
In a parallel circuit the **current** from the battery is **split** through each branch.

The **voltage** across each branch is the **same** as the voltage across the battery.



To calculate the resistance in a **series** circuit the equation $\mathbf{R_T = R_1 + R_2 + \ldots}$ is used.

For example;

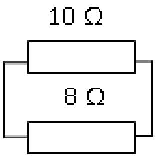


RT = 10 + 8 = 18 Ω

To calculate resistance in a parallel circuit the equation $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots$ is used.

An alternative method is to use M.A.D (Multiply. Add. Divide.)

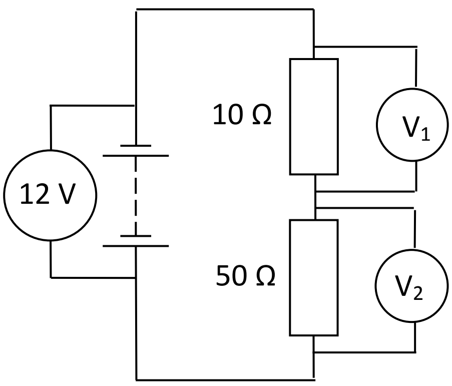
For example;



M.A.D. $\frac{10 \times 8}{10+8} = \frac{80}{18} = \underline{4.4\Omega}$

If both resistors are the same value the total resistance is half. i.e. 10 Ω and 10 Ω in parallel = 5 Ω. The M.A.D. method only works if there are two resistors in parallel. If there are **three** resistors in parallel M.A.D. must be done **twice** or the equation $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots$ used.

These types of circuits are called voltage dividers. The supply voltage is shared (divided) between the two resistors. There are two ways these questions are solved depending on different conditions.

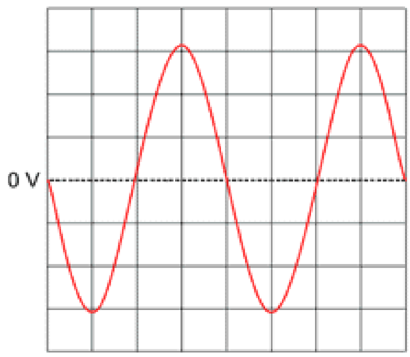


1 – The supply voltage **IS NOT** known but V_1 or V_2 is known. Use the equation:

$$\frac{V_1}{V_2} = \frac{R_1}{R_2}$$

2 – The supply voltage **IS** known.

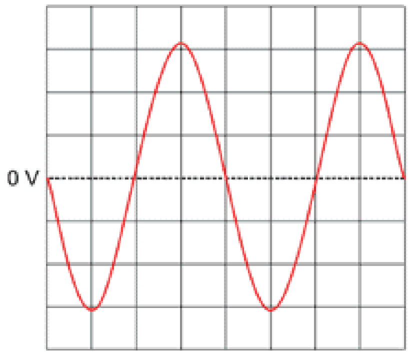
$$V_2 = \left(\frac{R_2}{R_1 + R_2}\right) V_s$$

Power is defined as the energy transferred per second.		
Power has the symbol P and the units Watts (W)		
There are three power equations involving current, voltage and resistance. The best advice here is to look at the information given in the question and select the equation that allows you to find the power. The equations are: $P = IV$ — If current and voltage $P = \frac{V^2}{R}$ — If voltage and resistance $P = I^2 R$ — If current and resistance		
 **Analogue signal** An analogue signal has a range of values from a maximum value to a minimum value  Digital Signal A digital signal only has two states or two values. These states are called **<u>on/off</u>** or **<u>high/low</u>** or **<u>1/0</u>**		
Using either an analogue or digital signal there are three things that can be determined. The peak voltage, the period of the wave and the frequency of the wave.		
The peak voltage is the voltage at the top of the wave. It is determined by counting the number of boxes from the centre of the wave and multiplying this by the **<u>y-gain</u>** setting. Remember y-gain is like y-axis (up and down). <u>Example:</u> Determine the peak voltage if the y-gain setting is 2 V/div.  <u>Solution:</u> 3 boxes from centre of wave to peak so, 3 x 2 = <u>6 Volts</u>		

The period of the signal is the time taken for one whole wave. It is determined by counting the number of boxes for one whole wave and multiplying by the **<u>timebase</u>** setting.

<u>Example:</u>

Determine the period of the wave if the timebase is 5 ms/div.



Solution:

4 boxes for one wave so,

4 x (5 x 10^{-3}) = 20 x 10^{-3} s

The frequency of the signal is the number of waves in one second. This is a calculation that is done using the equation;

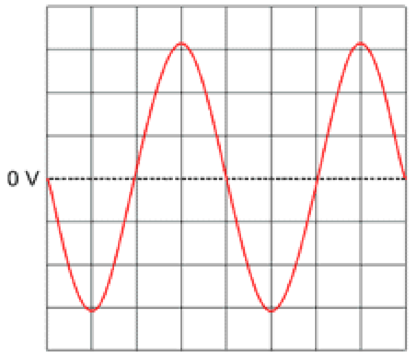
$$\mathbf{f = \frac{1}{T}}$$

where f = frequency measured in Hz

and T = period measured in s

<u>Example:</u>

The period of the wave is 20 ms. Calculate the frequency.



<u>Solution:</u>

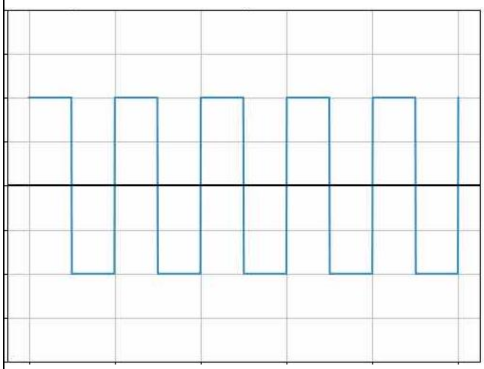
f = ?

T = 20 x 10^{-3}

$f = \frac{1}{T}$

$f = \frac{1}{20 \text{ x } 10^{-3}}$

<u>f = 50 Hz</u>



The peak voltage, period of a wave and the frequency of a wave can all be determined from a digital signal in exactly the same way as mentioned above. From this signal there would be two boxes from the centre of the wave to the peak. Also there would be two boxes for one complete wave.

A capacitor is used to store charge. If the **capacitance** of the capacitor is greater then the capacitor will store more charge. A capacitor with greater capacitance will decrease the flash rate of an LED. The flash rate can be increased by decreasing the capacitance of the capacitor.		
Another way to change the flash rate is to change the resistance in the circuit. A resistor of greater resistance will decrease the flash rate and a resistor of smaller resistance will increase the flash rate.		
When a current flows in a conductor (a wire) then a magnetic field is produced around the wire. The greater the current the greater the strength of the magnetic field.		
The magnetic field can be made even stronger by coiling (wrapping around) the wire around a conductor.		
A device which uses and electrical current to produce a magnetic field is called an electromechanical device.		
Extra space for additional information		

Section 2 – Circuit Simulation and Design

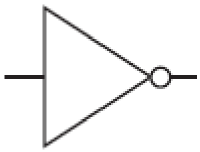
Simulations are used in circuit design for many reasons such as;

- To see if the circuit works
- To improve the circuit design
- Can be changed easily to try different combinations of components
- Can test smaller sub-systems (parts)

Every electronic system has three main parts: Input, process and output.

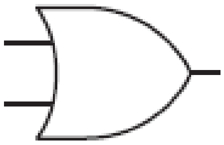
Logic gates are used to allow an input device to affect an output device. They are digital process devices (only have two states)

<u>NOT gate</u> – The output is **<u>NOT</u>** the same as the input.



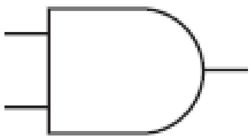
Input	Output
0	1
1	0

<u>OR gate</u> – The output is a 1 if input A **<u>OR</u>** input B are a 1.



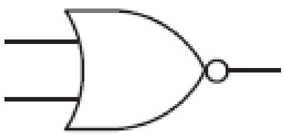
Input A	Input B	Output
0	0	0
0	1	1
1	0	1
1	1	1

<u>AND gate</u> – The output is a 1 only if Input A **<u>AND</u>** input B are a 1.



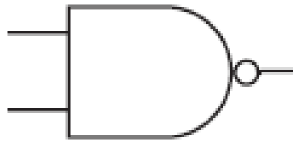
Input A	Input B	Output
0	0	0
0	1	0
1	0	0
1	1	1

<u>NOR gate</u> – This gate works in the **<u>opposite</u>** way from an OR gate



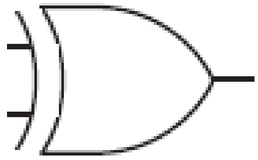
Input A	Input B	Output
0	0	1
0	1	0
1	0	0
1	1	0

NAND gate – This gate works in the **opposite** way from an AND gate.



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

XOR gate – This gate will give an output of 1 **ONLY** if input A or input B are a 1 and not if both inputs are a 1. It is an exclusive OR gate.



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

There may be faults with a circuit which you must identify. The three most common faults are;

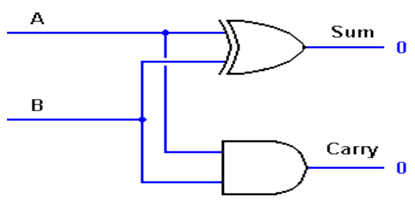
- A supply voltage which is too high or too low.
- Incorrect resistor values which again are too high or too low.
- Having components connected the wrong way (a diode or LED which is not facing the negative terminal). This is called **component orientation** and the word **orientation** must be used.

Before constructing a circuit you should compile a **pre-power up checklist** to make sure the circuit will work properly. This will include;

- checking the components are connected the correct way (correct **orientation**)
- Checking the supply voltage is appropriate.
- Checking the resistor values are appropriate.

Half-adder circuit

This circuit is used to add up numbers using logic gates. The XOR gate and AND gate are used.

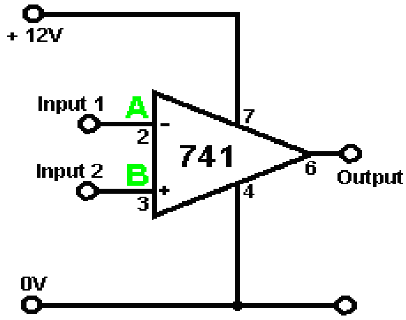


Input		Output	
A	B	Sum	Carry
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

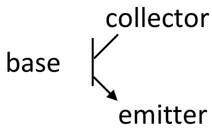
The inputs A and B can only be a 1 or 0. This means there are 4 possible outputs as shown in the truth table.

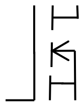
741 comparator

This component is an op-amp which is used to compare the voltage of two signals. When it measures the voltage of each signal it can then be used to show which signal has the greatest voltage.



A transistor is used as an electronic switch to conduct electrical current if the voltage across the transistor is high enough. There are two types;





bipolar transistor – **switches on at 0.7 V**

MOSFET transistor – **switches on at 2 V**

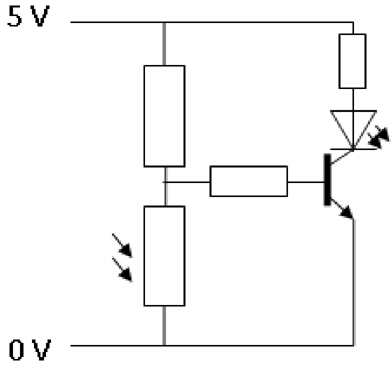
The base is always connected to the **input device**.

The collector is always connected to the **output device**.

The emitter is always connected to the **zero volt rail**.

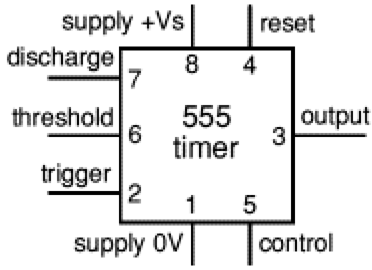
You may be asked to describe how a circuit like this works. Split your answer into 4 parts:

- Say what happens to the resistance of the LDR if light level decreases – LURD.
- If the resistance increases the voltage across the LDR will increase and vice versa.
- If the voltage is large enough the transistor will switch on.
- Current will pass through the LED and it will light.



You can get different versions of the circuit above. The best advice is to mention what is happening at each stage by starting with the LDR or thermistor, the voltage across the base and emitter and then what happens to the output device.

A 555 timer is used to send a regular signal to an output device. It could be used to make an LED light flash on and off. The symbol shows the location of each pin.



1. Connected to 0 V rail.
2. Connected to the capacitor.
3. Is connected to the output device (LED).
4. Connected to the positive voltage rail.
5. Not connected to anything.
6. Connected to the capacitor.
7. Connected back into the input part (usually a resistor).
8. Connected to the positive voltage rail.

Extra space for additional information

Section 3 – Circuit Construction

Resistors have different values which can range from a few ohms (Ω) to Millions of ohms (Ω). Prefixes kilo (K) and Mega (M) are often used with resistors.

BS notation or R notation is used to identify the resistance of a resistor.

<u>If the resistance is less than 1 thousand ohms it is written as;</u>

270 Ω would be 270R.   560 Ω would be 560R.

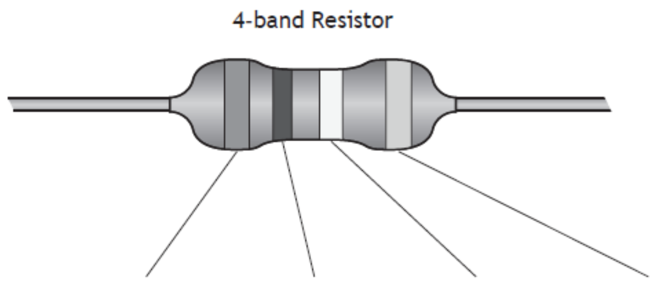
<u>If the resistance is between 1 thousand and 1 million ohms it is written as;</u>

2700 Ω would be 2k7.   56000 Ω would be 56k.

<u>If the resistance greater than 1 million ohms it is written as;</u>

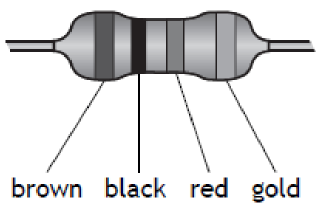
3000000 Ω would be 3M.   5600000 Ω would be 5M6

The resistance of a resistor is found using a colour code (although the image will be in black and white!). Looking at the colours starting from the left the first and second colour are the first and second value of the resistance and the third colour is a multiplier. The fourth colour is the tolerance of the resistance.



You will be given this table in any exam.

Colour	1st band value	2nd band value	Multiplier	Tolerances
Black	0	0	× 1	
Brown	1	1	× 10	±1%
Red	2	2	× 100	±2%
Orange	3	3	× 1000	±3%
Yellow	4	4	× 10000	±4%
Green	5	5	× 100000	±0·5%
Blue	6	6	× 1000000	±0·25%
Violet	7	7	× 10000000	±0·10%
Grey	8	8	× 100000000	±0·05%
White	9	9	× 1000000000	
Gold			× 0·1	±5%
Silver			× 0·01	±10%
No band				±20%



This resistance would be;

10 x 100 = 1000 Ω with a tolerance ± 5%

<u>R = 1000 Ω ± 5%</u>

The tolerance is a percentage and is used to calculate the maximum and minimum resistance value allowed for that resistor. The first step is to find out what the tolerance is using the equation: $\frac{\text{value}}{100}$ x tollerance

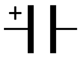
i.e. Calculate a tolerance of 10% of a 200 Ω resistor: $\frac{200}{100}$ x 10 = 20 Ω.

To calculate the maximum resistance of a resistor you would **ADD** the tolerance to the value. So: 200 + 20 = 220 Ω.

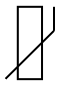
To calculate the minimum resistance of a resistor you would **SUBTRACT** the tolerance from the value. So: 200 - 20 = 180 Ω.

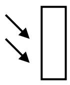
Input devices with their symbols which should be used when drawing them:

Non-Electrolytic Capacitor –  Have **NO** positive or negative side. Usually have a low capacitance value.

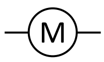
Electrolytic Capacitor – 

Have a positive and negative side. Usually have higher capacitance values.

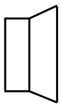
Thermistor – (Temperature sensor)  As temperature increases the resistance decreases.
Temperature Up Resistance Down - **TURD**

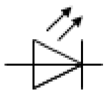
LDR – (Light dependent reisistor)  As light level increases the resistance decreases.
Light Up Resistance Down - **LURD**

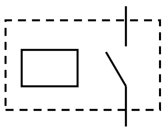
Output devices with their symbols which should be used when drawing them:

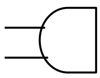
Motor – 

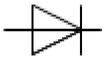
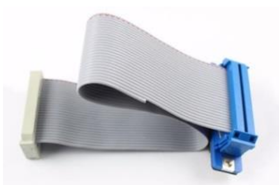
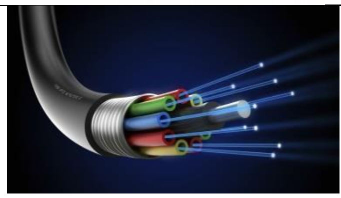
Electrical energy to kinetic energy. Energy wasted as heat and sound.

Loudspeaker –  Electrical energy to sound energy. An analogue device.

LED– (Light emitting diode)  Electrical energy to light energy. Very little energy wasted as heat so LEDs are much more efficient than lamps.

Relay –  Used to allow a circuit with low current (safe) to control a circuit with high current (unsafe). When a current passes through the coil a magnetic field is produced. This closes the relay switch allowing the second circuit.

Buzzer –  Electrical energy to sound energy. A digital device.

A diode –  It is used to allow electrical current to flow in one direction. It will only conduct electrical current if it faces/points toward the negative terminal of the battery.		
A continuity tester can be used to test for good connections. It is a lamp or LED connected to a power supply with two wires. To test for good connections the continuity tester would be; • connected to both ends of the wire or component that is being tested. • The LED would light.		
A logic probe would work in the same way to a continuity tester but is used to test if the logic state is a 1 or a 0.		
When soldering there are safety measures which must be taken; • wear eye protection • good ventilation • avoid breathing fumes		
When connecting two boards together **<u>spiral wrapping</u>** is used to protect the wires. This is plastic and spirals around the wires which are used.		
When connecting two boards together it is important to identify the correct wiring between the boards. This can be done by; • colour coding the wires • numbering the wires		
Multi-strand cables are used as they are flexible and are not easily broken. If a single strand cable was used it may be broken more easily. 		
Ribbon cables are used for connecting electronic components which have lots of wires. This means they can all be connected at once and do not need to be connected individually. 		
Co-axial cables are used to send radio frequency signals. These are used when connecting sky TV. 		
Fibre optic cables are used to send light signals. These are used for Virgin TV and usually use laser light to send a signal. 		

Extra space for additional information		