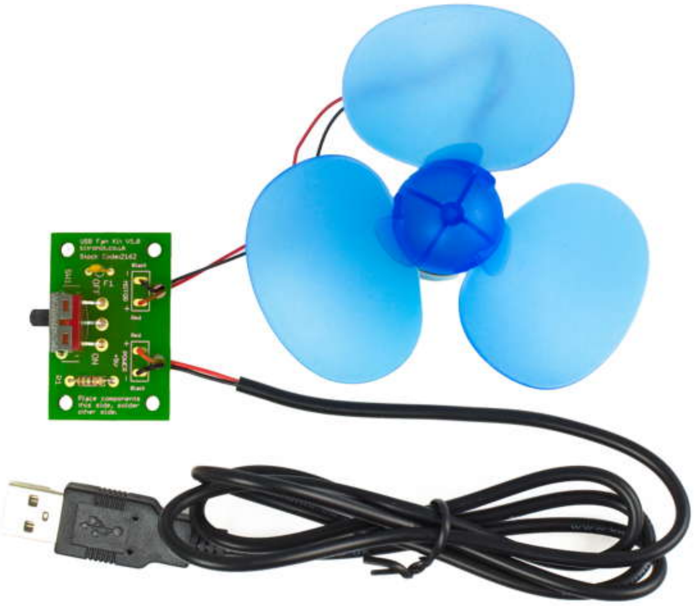
Kitronik

TEACHING RESOURCES

SCHEMES OF WORK
DEVELOPING A SPECIFICATION
COMPONENT FACTSHEETS
HOW TO SOLDER GUIDE

KEEP YOURSELF COOL WITH THIS

USB FAN KIT



Version 1.0

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Introduction

About the project kit

Both the project kit and the supporting material have been carefully designed for use in KS3 Design and Technology lessons. The project kit has been designed so that even teachers with a limited knowledge of electronics should have no trouble using it as a basis from which they can form a scheme of work.

The project kits can be used in two ways:

1. As part of a larger project involving all aspects of a product design, such as designing an enclosure for the electronics to fit into.
2. On their own as a way of introducing electronics and electronic construction to students over a number of lessons.

This booklet contains a wealth of material to aid the teacher in either case.

Caution: Shorting of the red and black wire on the USB cable could result in damage to the PC to which it is connected. All kits should be checked carefully once built so that this does not occur.

Using the booklet

The first few pages of this booklet contains information to aid the teacher in planning their lessons and also covers worksheet answers. The rest of the booklet is designed to be printed out as classroom handouts. In most cases all of the sheets will not be needed, hence there being no page numbers, teachers can pick and choose as they see fit.

Please feel free to print any pages of this booklet to use as student handouts in conjunction with Kitronik project kits.

Support and resources

You can also find additional resources at www.kitronik.co.uk. There are component fact sheets, information on calculating resistor and capacitor values, puzzles and much more.

Kitronik provide a next day response technical assistance service via e-mail. If you have any questions regarding this kit or even suggestions for improvements, please e-mail us at:

support@kitronik.co.uk

Alternatively, phone us on 0845 8380781.

Schemes of Work

Two schemes of work are included in this pack; the first is a complete project including the design & manufacture of an enclosure for the kit (below). The second is a much shorter focused practical task covering just the assembly of the kit (next page). Equally, feel free to use the material as you see fit to develop your own schemes.

Before starting we would advise that you to build a kit yourself. This will allow you to become familiar with the project and will provide a unit to demonstrate.

Complete product design project including electronics and enclosure

Hour 1	Introduce the task using 'The Design Brief' sheet. Demonstrate a built unit. Take students through the design process using 'The Design Process' sheet. Homework: Collect examples of fan products including some desk fans, free standing fans. List the common features of these products on the 'Investigation / Research' sheet.
Hour 2	Develop a specification for the project using the 'Developing a Specification' sheet. Resource: Sample of fan products. Homework: Using the internet or other search method, find out what is meant by 'design for manufacture'. List five reasons why design for manufacture should be considered on any design project.
Hour 3	Read 'Designing the Enclosure' sheet. Develop a product design using the 'Design' sheet. Homework: Complete design.
Hour 4	Using cardboard, get the students to model their enclosure design. Allow them to make alterations to their design if the model shows any areas that need changing.
Hour 5	Split the students into groups and get them to perform a group design review using the 'Design Review' sheet.
Hour 6	Using the 'Soldering in Ten Steps' sheet, demonstrate and get students to practice soldering. Start the 'Resistor Value' worksheet. Homework: Complete any of the remaining resistor tasks.
Hour 7	Build the electronic kit using the 'Build Instructions'.
Hour 8	Complete the build of the electronic kit. Check the completed PCB and fault find if required using the 'Checking Your USB Fan PCB' section. Homework: Read 'How the USB Fan Works' sheet in conjunction with the Motor sheet
Hour 9	Build the enclosure.
Hour 10	Build the enclosure.
Hour 11	Build the enclosure.
Hour 12	Using the 'Evaluation' and 'Improvement' sheet, get the students to evaluate their final product and state where improvements can be made.

Additional Work

Package design for those who complete ahead of others.

Electronics only

Hour 1	Introduction to the kit demonstrating a built unit. Using the 'Soldering in Ten Steps' sheet, practice soldering.
Hour 2	Build the kit using the 'Build Instructions'.
Hour 3	Check the completed PCB and fault find if required using 'Checking Your USB Fan PCB'.

Answers

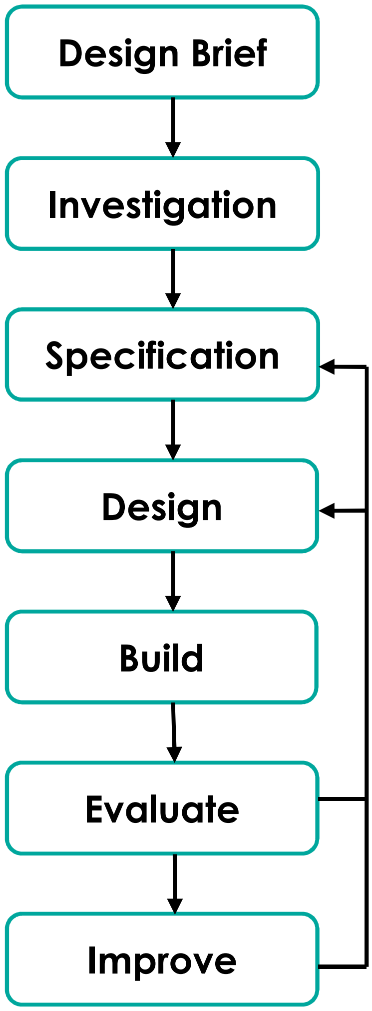
Resistor questions

1st Band	2nd Band	Multiplier x	Value
Brown	Black	Yellow	*100,000 Ω*
Green	Blue	Brown	*560 Ω*
Brown	Grey	Yellow	*180,000Ω*
Orange	White	Black	*39Ω*

Value	1st Band	2nd Band	Multiplier x
180 Ω	Brown	Grey	*Brown*
3,900 Ω	Orange	White	*Red*
47,000 (47K) Ω	Yellow	Violet	*Orange*
1,000,000 (1M) Ω	Brown	Black	*Green*

The Design Process

The design process can be short or long, but will always consist of a number of steps that are the same on every project. By splitting a project into these clearly defined steps, it becomes more structured and manageable. The steps allow clear focus on a specific task before moving to the next phase of the project. A typical design process is shown on the right.



Design brief

What is the purpose or aim of the project? Why is it required and who is it for?

Investigation

Research the background of the project. What might the requirements be? Are there competitors and what are they doing? The more information found out about the problem at this stage, the better, as it may make a big difference later in the project.

Specification

This is a complete list of all the requirements that the project must fulfil - no matter how small. This will allow you to focus on specifics at the design stage and to evaluate your design. Missing a key point from a specification can result in a product that does not fulfil its required task.

Design

Develop your ideas and produce a design that meets the requirements listed in the specification. At this stage it is often normal to prototype some of your ideas to see which work and which do not.

Build

Build your design based upon the design that you have developed.

Evaluate

Does the product meet all points listed in the specification? If not, return to the design stage and make the required changes. Does it then meet all of the requirements of the design brief? If not, return to the specification stage and make improvements to the specification that will allow the product to meet these requirements and repeat from this point. It is normal to have such iterations in design projects, though you normally aim to keep these to a minimum.

Improve

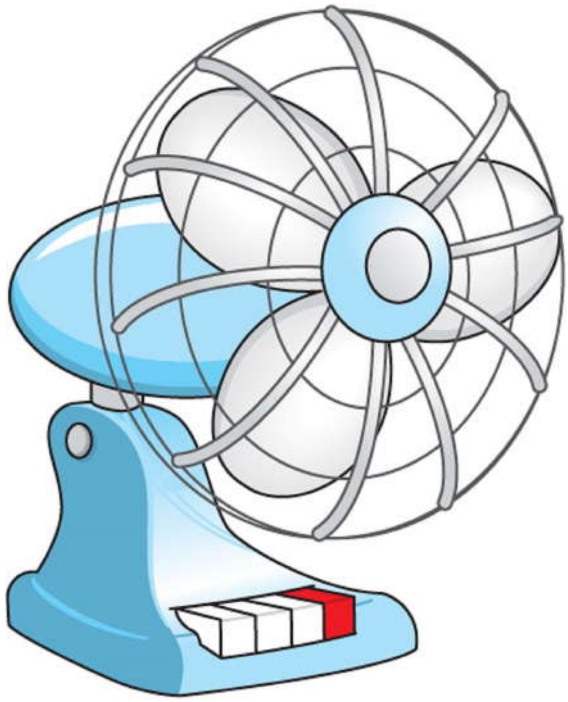
Do you feel the product could be improved in any way? These improvements can be added to the design.

The Design Brief

A manufacturer has developed a simple circuit for producing a fan that is powered by plugging it into a USB port of a computer. The circuit has been developed to the point where they have a working Printed Circuit Board (PCB).

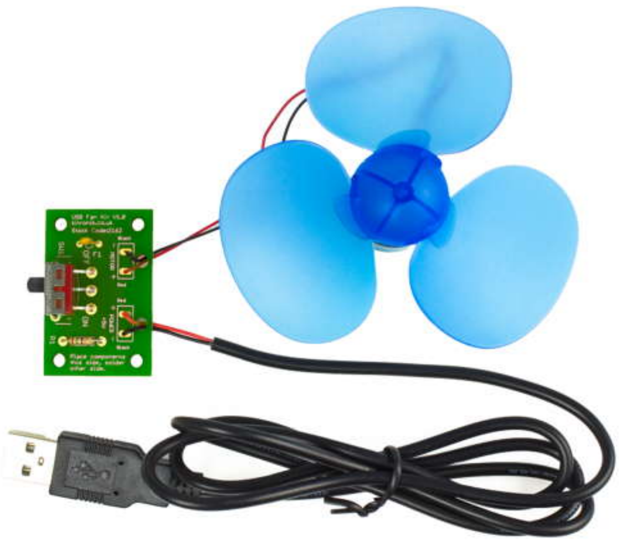
The manufacturer would like ideas for a product that can be created by designing an enclosure for this PCB. For example the fan could be used for a cool breeze on a hot day while working at PC.

The manufacturer has asked you to do this for them. It is important that you make sure the final design meets all the requirements that you identify for such a product.



Complete circuit

A fully built circuit is shown below.



Investigation / Research

Using a number of different search methods, find examples of similar products that are already on the market. Use additional pages if required.

Name……………………………………………… Class……………………………

Developing a Specification

Using your research into the target market for the product, identify the key requirements for the product and explain why each of these is important.

Name…………………………………………………………… Class………………………………….

Requirement	Reason
Example: The enclosure should allow access to the on / off switch.	Example: So that the fan can be turned on and off.

Design

Develop your ideas to produce a design that meets the requirements listed in the specification.

Name…………………………………………… Class……………………………

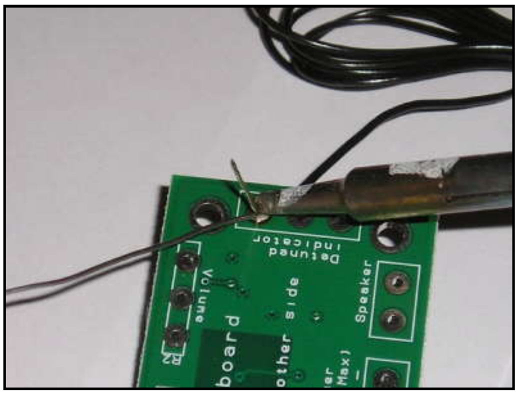
Design Review (group task)

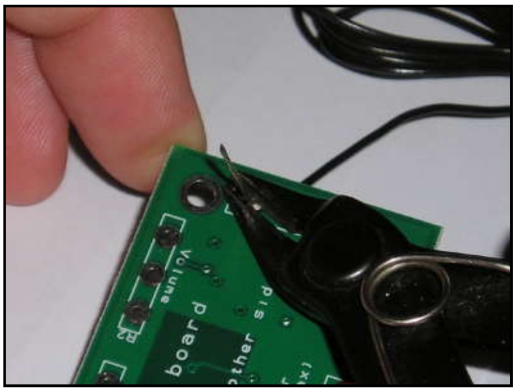
Split into groups of three or four. Take it in turns to review each person's design against the requirements of their specification. Also look to see if you can spot any additional aspects of each design that may cause problems with the final product. This will allow you to ensure that you have a good design and catch any faults early in the design process. Note each point that is made and the reason behind it. Decide if you are going to accept or reject the comment made. Use these points to make improvements to your initial design.

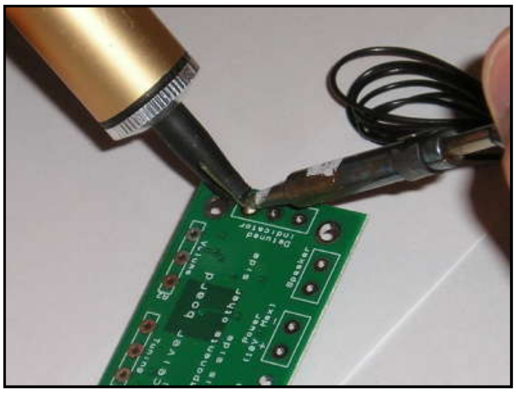
Comment	Reason for comment	Accept or Reject

Soldering In Ten Steps

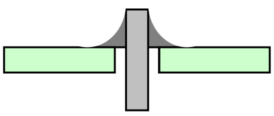
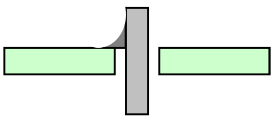
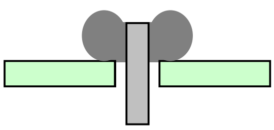
1. Start with the smallest components working up to the taller components, soldering any interconnecting wires last.
2. Place the component into the board, making sure that it goes in the right way around and the part sits flush against the board.
3. Bend the leads slightly to secure the part.
4. Make sure that the soldering iron has warmed up and if necessary, use the damp sponge to clean the tip.
5. Place the soldering iron on the pad.
6. Using your free hand, feed the end of the solder onto the pad (top picture).
7. Remove the solder, then the soldering iron.
8. Leave the joint to cool for a few seconds.
9. Using a pair of cutters, trim the excess component lead (middle picture).
10. If you make a mistake heat up the joint with the soldering iron, whilst the solder is molten, place the tip of your solder extractor by the solder and push the button (bottom picture).







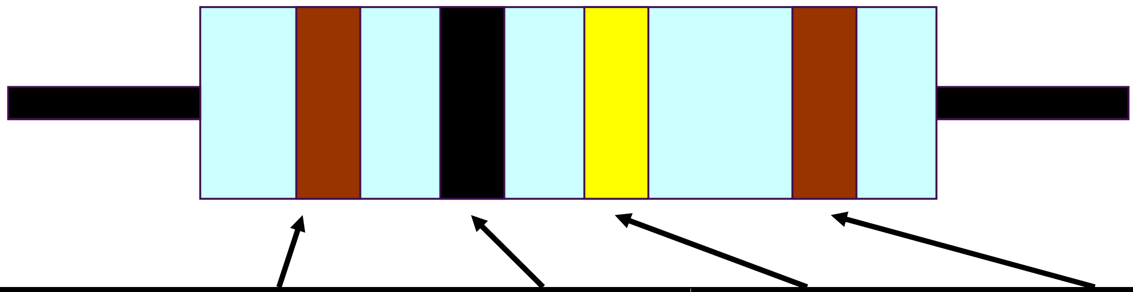
Solder joints

 Good solder joint	 Too little solder	 Too much solder

Resistor Values

A resistor is a device that opposes the flow of electrical current. The bigger the value of a resistor, the more it opposes the current flow. The value of a resistor is given in Ω (ohms) and is often referred to as its 'resistance'.

Identifying resistor values



Band Colour	1st Band	2nd Band	Multiplier x	Tolerance
Silver			÷ 100	10%
Gold			÷ 10	5%
Black	0	0	1	
Brown	1	1	10	1%
Red	2	2	100	2%
Orange	3	3	1000	
Yellow	4	4	10,000	
Green	5	5	100,000	
Blue	6	6	1,000,000	
Violet	7	7		
Grey	8	8		
White	9	9		

Example: Band 1 = Red, Band 2 = Violet, Band 3 = Orange, Band 4 = Gold

The value of this resistor would be:
2 (Red) **7** (Violet) x **1,000** (Orange) = 27 x 1,000
= **27,000** with a 5% tolerance (gold)
= **27KΩ**

Too many zeros?

Kilo ohms and mega ohms can be used:

1,000Ω = 1K

1,000K = 1M

Resistor identification task

Calculate the resistor values given by the bands shown below. The tolerance band has been ignored.

1st Band	2nd Band	Multiplier x	Value
Brown	Black	Yellow	
Green	Blue	Brown	
Brown	Grey	Yellow	
Orange	White	Black	

Calculating resistor markings

Calculate what the colour bands would be for the following resistor values.

Value	1st Band	2nd Band	Multiplier x
180 Ω			
3,900 Ω			
47,000 (47K) Ω			
1,000,000 (1M) Ω			

What does tolerance mean?

Resistors always have a tolerance but what does this mean? It refers to the accuracy to which it has been manufactured. For example if you were to measure the resistance of a gold tolerance resistor you can guarantee that the value measured will be within 5% of its stated value. Tolerances are important if the accuracy of a resistors value is critical to a design's performance.

Preferred values

There are a number of different ranges of values for resistors. Two of the most popular are the E12 and E24. They take into account the manufacturing tolerance and are chosen such that there is a minimum overlap between the upper possible value of the first value in the series and the lowest possible value of the next. Hence there are fewer values in the 10% tolerance range.

E-12 resistance tolerance (± 10%)											
10	12	15	18	22	27	33	39	47	56	68	82

E-24 resistance tolerance (± 5 %)											
10	11	12	13	15	16	18	20	22	24	27	30
33	36	39	43	47	51	56	62	68	75	82	91

How does a Motor Work?

Motors convert electrical energy into mechanical energy. A basic motor is made up of a magnet and a coil of wire. When current flows through a wire, it creates a magnetic field. Placing a magnet near to this field creates a force.

The size of the force depends on three factors
- The amount of current flowing in the wire
- The length of the wire
- The strength of the magnetic field

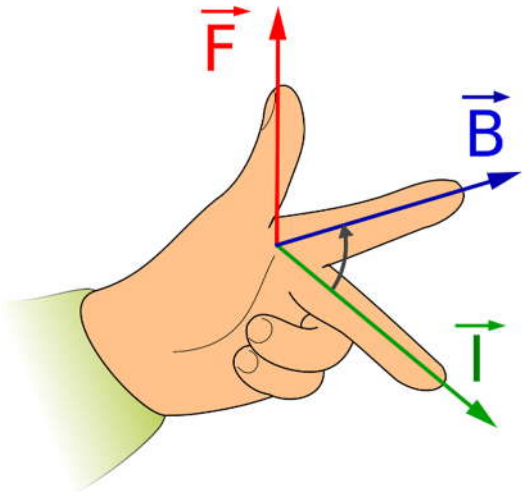
The force can be calculated by the following equation.

Force α (current) x (wire length) x (magnetic field)

Increasing any of these factors will increase the force and therefore increase the speed of the motor.

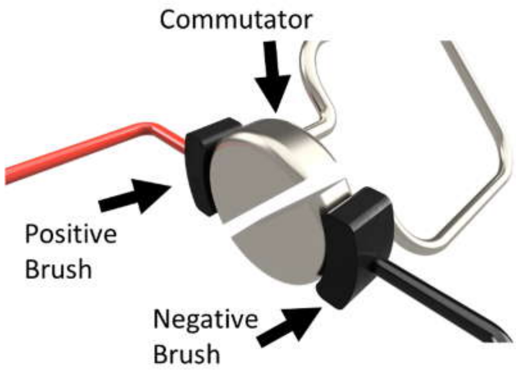
The direction of the current, the magnetic field, and the resulting force are related. John Ambrose Fleming devised the Left hand rule to show the direction of force on a current carrying wire in a magnetic field.
Fleming's Left Hand Rule shows:
- Direction of the current flow in the wire (middle finger).
- Direction of the magnetic field (Index finger).
- Direction of the force created (thumb).

The direction of the force shows the direction that the motor coil will move, and hence the direction of rotation.



In order to allow current to flow through a moving wire, a brush is used. This slides over the connection surface. In a motor this rotating surface is called a commutator.
In the following example the commutator is split into two, to allow connection to each end of the single coil of wire. Typical motors have commutators with many segments. Each end of the coil is connected to part of the commutator and will rotate with the motors shaft.

As the commutator rotates, it connects with two contacts, known as brushes (a positive and a negative brush). Because the commutator is split this causes the current to continue to flow in the same direction as the motor turns, even though the ends of the coil have changed.



USB Fan Kit Teaching Resources

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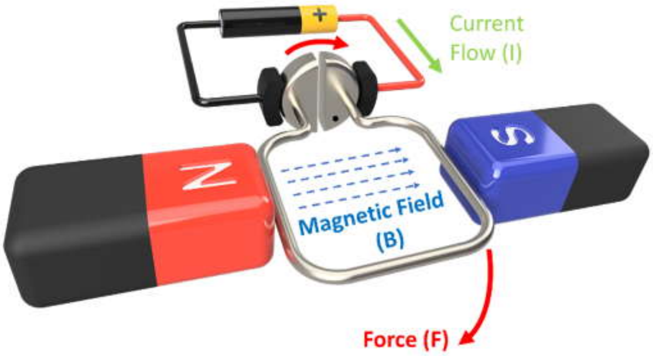
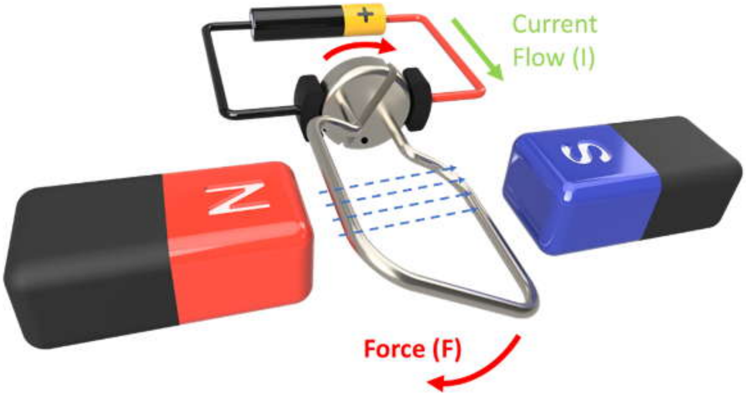
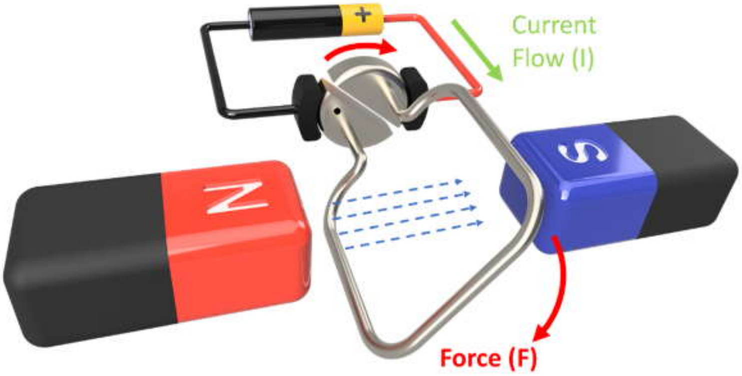


When a voltage is applied (via the commutator) current flows around the coil. A force is created from magnetic field, and the coil moves away in accordance with Flemings Left Hand Rule.



As the coil rotates towards the opposite side the force would change direction, and the motor would not spin.
To prevent this the commutator switches the current to flow in the opposite direction through the coil, which then continues to rotate.

This process is done every half turn and keeps on repeating while there is a supply to the commutator.
To change direction the motor turns, simply change the polarity of supply to commutator.



Typical DC motors have multiple coils to ensure that they run smoothly, and can start easily.

Evaluation

It is always important to evaluate your design once it is complete. This will ensure that it has met all of the requirements defined in the specification. In turn, this should ensure that the design fulfils the design brief.

Check that your design meets all of the points listed in your specification.

Show your product to another person (in real life this person should be the kind of person at which the product is aimed). Get them to identify aspects of the design, which parts they like and aspects that they feel could be improved.

Good aspects of the design	Areas that could be improved

Improvements

Every product on the market is constantly subject to redesign and improvement. What aspects of your design do you feel you could improve? List the aspects that could be improved and where possible, draw a sketch showing the changes that you would make.

Packaging Design

If your product was to be sold in a high street electrical retailer, what requirements would the packaging have? List these giving the reason for the requirement.

Requirement	Reason

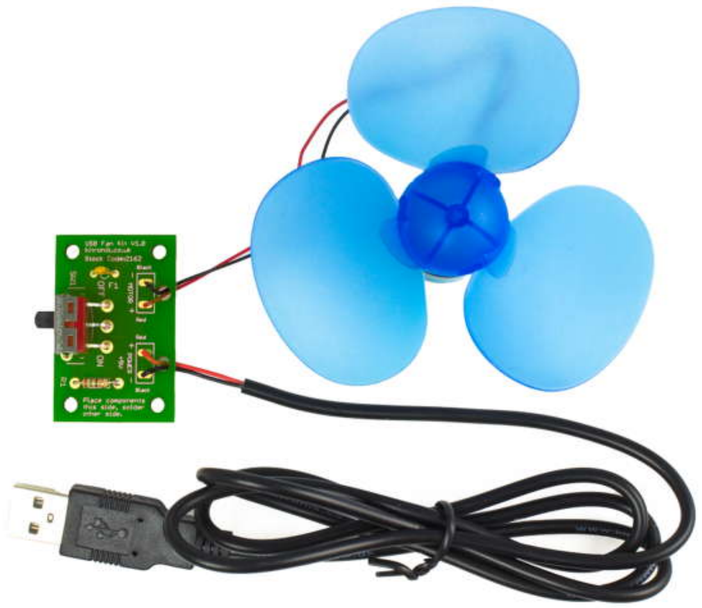
Develop a packaging design for your product that meets these requirements. Use additional pages if required.

ESSENTIAL INFORMATION

BUILD INSTRUCTIONS
CHECKING YOUR PCB & FAULT-FINDING
MECHANICAL DETAILS
HOW THE KIT WORKS

KEEP YOURSELF COOL WITH THIS

USB FAN KIT



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USB Fan Kit Essentials

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Build Instructions

Before you start, take a look at the Printed Circuit Board (PCB). The components go in the side with the writing on and the solder goes on the side with the tracks and silver pads.

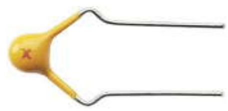
1 PLACE RESISTORS

Start with the resistor R1. The text on the PCB shows where R1 should go. It doesn't matter which way around the resistor goes into the board.

PCB Ref	Value	Colour Bands
R1	15Ω	Brown, green, black

2 PLACE THE FUSE

Place the fuse into F1. It doesn't matter which way around the fuse goes into the boards.



3 SOLDER THE SWITCH

Solder the PCB mounted right angled slide switch into SW1. The row of three pins that exit the back of the switch must be soldered but it will not matter too much if you can't solder the other two pins.

4 CONNECT THE POWER LEAD

The USB power lead needs to be connected. Feed the red and black wire of the lead through the strain relief hole.

The red wire of the USB power cable is soldered to the power pad labelled 'Red' and the black wire of the USB power cable is soldered to the power pad labelled 'Black'.

5 CONNECT THE MOTOR LEAD & FAN

Finally, the motor lead needs to be connected. Feed the red and black wire of the lead through the strain relief hole.

The red wire of the motor is soldered to the motor pad labelled 'Red' and the black wire of the motor is soldered to the motor pad labelled 'Black'.

Once soldered, push the plastic fan onto the motor shaft.

Checking Your USB Fan PCB

Check the following before you plug your fan into a USB port.

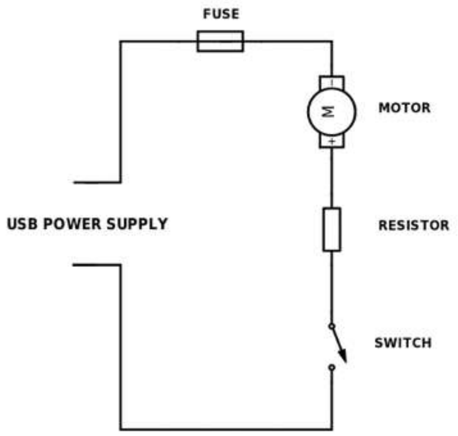
Check the bottom of the board to ensure that:

- All holes (except the four large mounting holes and two strain relief holes) are filled with the lead of a component.
- All these leads are soldered.
- Pins next to each other are not soldered together.

Check the top of the board to ensure that:

- The red wire on the USB power cable is connected to the power connector labelled 'Red' and the black wire on the USB power cable is connected to the power connector labelled 'Black'.
- The red wire on the Motor is connected to the motor connector labelled 'Red' and the black wire on the Motor is connected to the motor connector labelled 'Black'.

How the USB Fan Works



The circuit diagram for the USB Fan is shown above. It is a very simple circuit. The 5V that powers the circuit is supplied from the USB connector.

The low power motor in this fan has been selected to not draw too much current from a computer USB port. If it was powered directly from 5V it would take more current, and possibly damage a computer. The 15Ω resistor drops the voltage down, reducing the voltage to prevent this happening in normal operation.

If the Fan becomes jammed then the motor will stall, and start to take more current. The fuse will protect the USB port if this happens.

Finally, the on / off switch allows the circuit to be opened and closed: open the switch to turn the Fan off and close the switch to turn the Fan on.

USB Fan Kit Essentials

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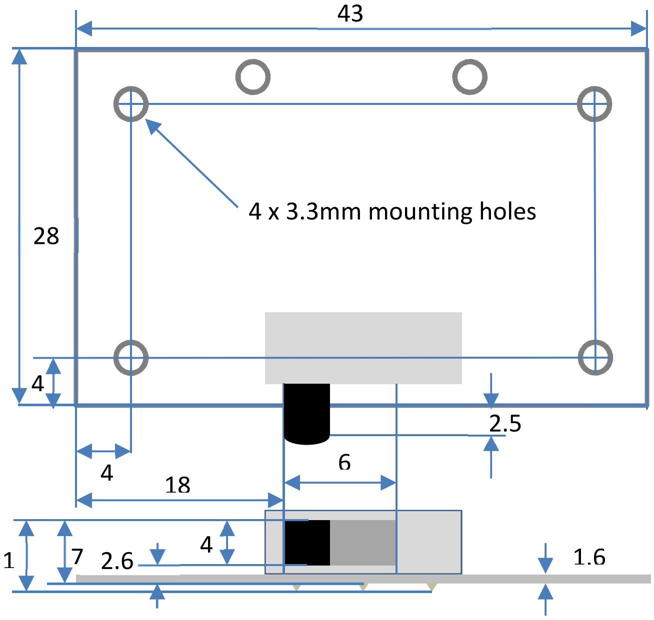
Designing the Enclosure

When you design the enclosure, you will need to consider:

- The size of the PCB.
- Where the on / off switch is mounted.
- There are four 3.3mm holes in the corners of the PCB to secure the PCB in the enclosure.

The following technical drawings of the built USB Fan PCB and motor should help you to design your enclosure.



Dimensions in mm

The four mounting holes are all 4mm from the board edge.

The assembled PCB is approximately 10 mm tall including solder points.

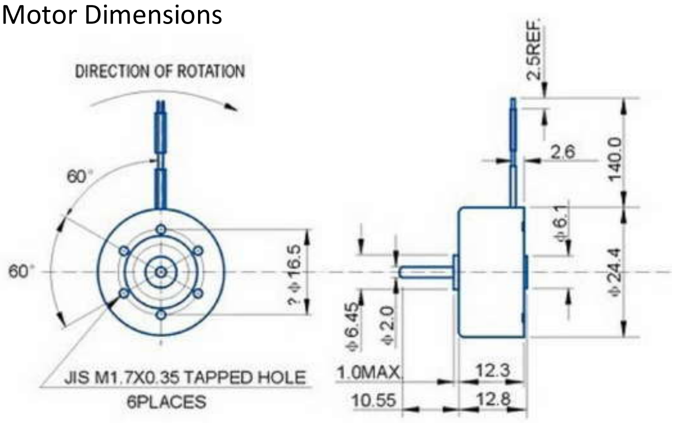
The Fan is 90mm in diameter, and approximately 18mm in depth.

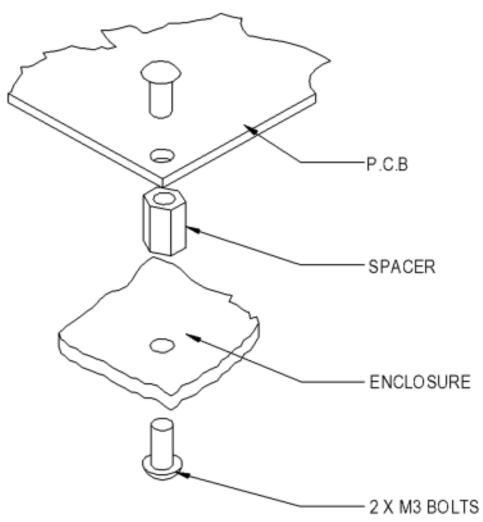
Mounting the PCB to the enclosure

The drawing below shows how a hex spacer can be used with two bolts to fix the PCB to the enclosure.

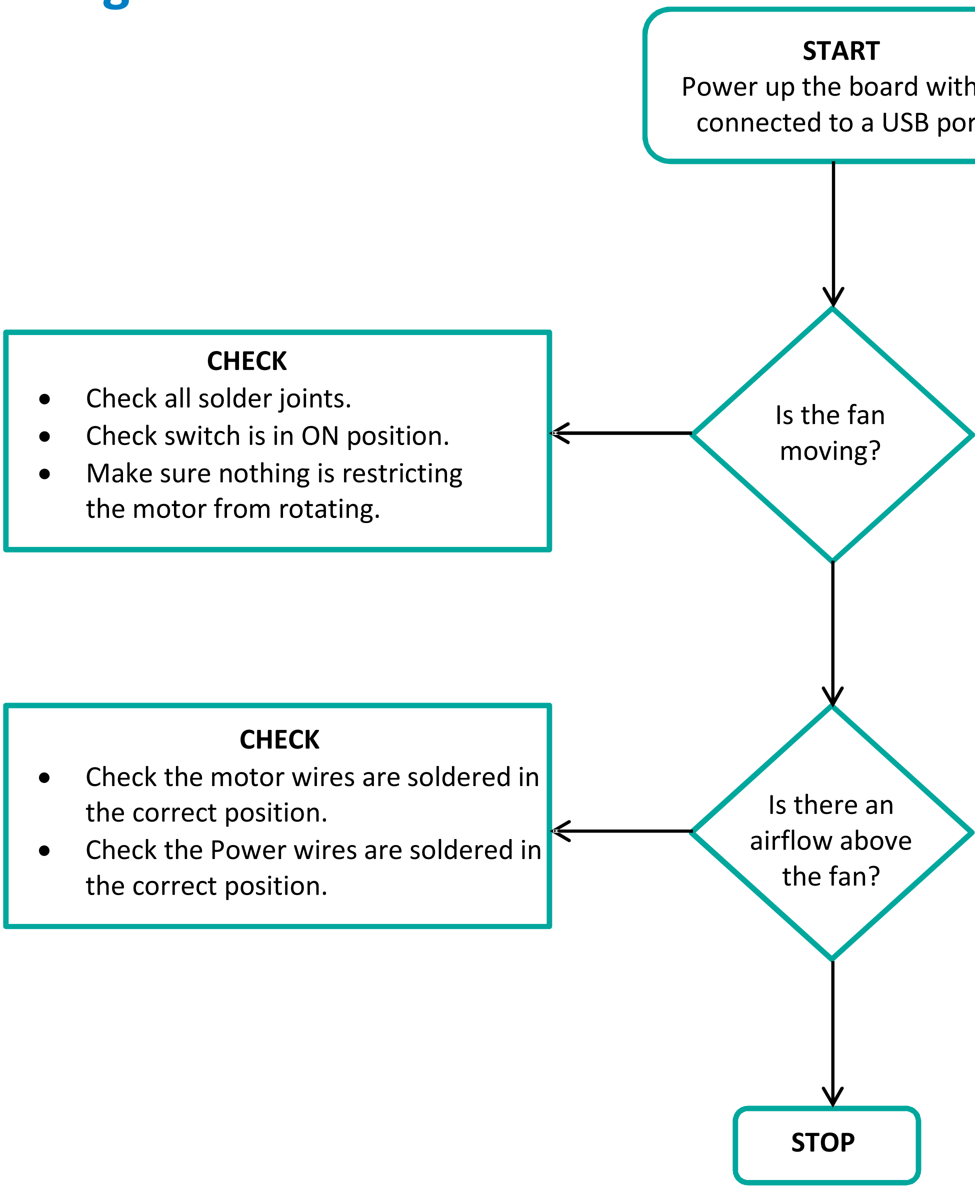
Your PCB has four mounting holes designed to take M3 bolts.

Motor Dimensions





Fault Finding Flowchart



Online Information

Two sets of information can be downloaded from the product page where the kit can also be reordered from. The 'Essential Information' contains all of the information that you need to get started with the kit and the 'Teaching Resources' contains more information on soldering, components used in the kit, educational schemes of work and so on and also includes the essentials. Download from:

www.kitronik.co.uk/2162

This kit is designed and manufactured in the UK by Kitronik

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