An Informal Guide to Sketching

By Christopher CHARE and Farhan QURESHI

Prepared for Design and Manufacture (MMAN 2130)
July 2009

This is a simple guide or refresher on sketching and is by no means exhaustive. For more detailed explanations and examples, we recommend reading;

1. Folkestad, J., Madsen, D.A. & Schertz, K., 2001, *Engineering Drawing and Design*, 3rd Ed., Cengage Learning.
2. Boundy, A.W., 2001, *Engineering Drawing*, 6th ed., McGraw-Hill, Sydney.
3. Rubeck, S., 1988, *Freehand perspective drawing for all who want to communicate through sketching*, Cole Publications, Melbourne. (Highly recommended)

However any other technical drawing book will also suffice. *NOTE: Learning sketching is not an outcome of this course; it is assumed that students have a basic level of knowledge from ENGG1000.*

What is 'Sketch'?

The term 'sketch' is generally used to describe a rudimentary form of visual communication and can portray an object or several objects together. In engineering terms, a 'sketch' refers to the depiction of an idea or concept during the initial design phase of the design process.

Historically, the method of developing sketches was based on the use of pen and paper. However since the development of computers there now exists a continual trend towards the use of computer aided methods.

Although such computer based methods are increasingly superseding most of the manual drafting aspects, as an engineer, good drawing skill is still needed to convey basic information in a visual format.

Straight Lines

Let’s start off with the basics. Straight lines can be considered the most common line type to be drawn by an engineer in representing an idea. Importantly, straight lines can also be used as construction lines or guide lines to build the framework for more complex shapes and objects.

There are many methods of drawing straight lines by using appropriate apparatus such as a ruler or inappropriately with the side of your student ID. A second alternative is by freehand.

Drawing lines by freehand is actually quite easy:

1. Draw two dots representing the start and end of the line.
2. Then draw shorter line segments along the axis intersecting the two dots (The segments have been emphasized here however visibly it should be one dark line).

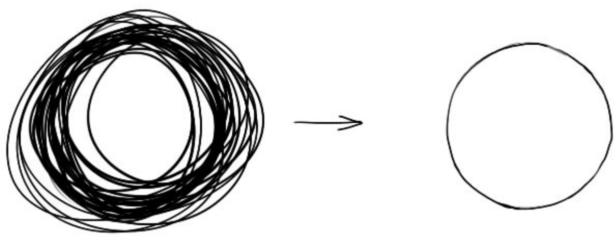
Unless you are very experienced, it isn’t good to draw the line in one go. Long lines tend to curve.

Curves , Ellipses and Circles

Sketching ellipses is just as fundamental to representing round or cylindrical objects as lines are to representing flat or planar objects. You can draw ellipses using a compass (or trammel) in the case of circles (a type of ellipse) or you can draw ellipses freehand. Drawing freehand ellipses takes a substantial amount of practice however we recommend the following tricks:

1. Practice by looping.

All the loops should start converging into a clear circle. This is purely for developing the ability to draw circles or ellipses in one go. The trick to this is realizing that the whole arm should be moving, rather than just the wrist and fingers. Remember to lift your wrist off the page.



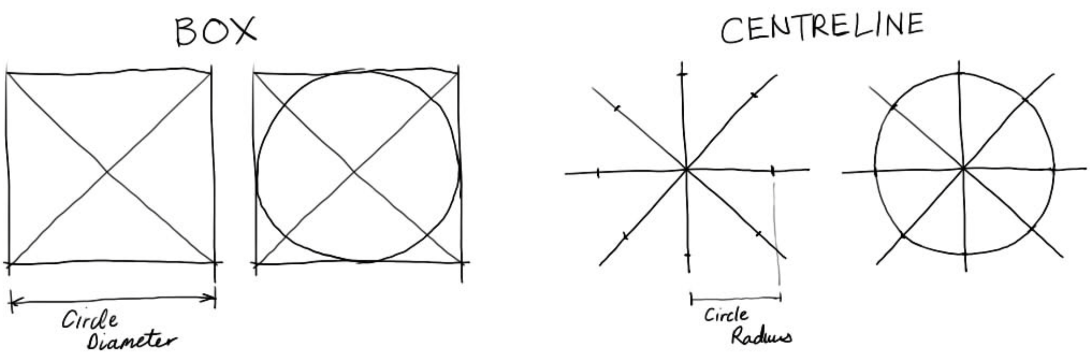
2. Using construction lines.

Instead of developing a good hand for circles or ellipses, we can just use construction lines (This comes in handy when drawing in other axonometric views such as isometric).

- Box method.
- Centreline method.
  (Adapted from *Engineering Drawing and Design 3rd ed.*)

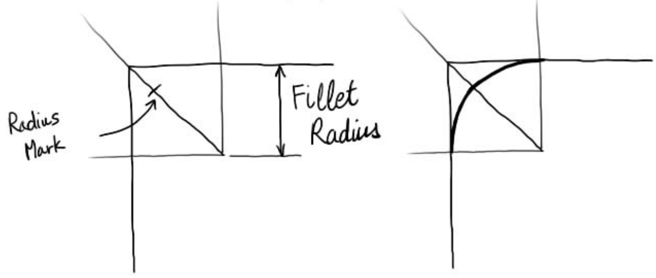
In both methods, the construction lines rely on the radius or diameter of the circle.

For example, the centreline method uses several lines angled apart equally. By doing this, the centre (or origin) of the circle is defined. Finally, you can simply mark the radius of the circle along each line, and then connect them to form a circle.

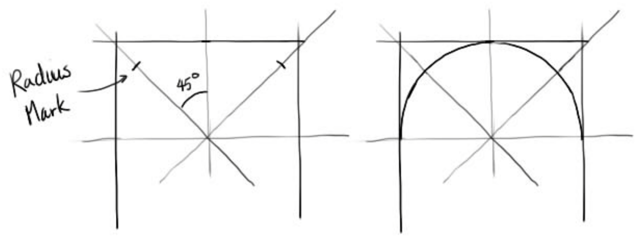


The same method applies to features like edge fillets (a curved edge) and arcs.

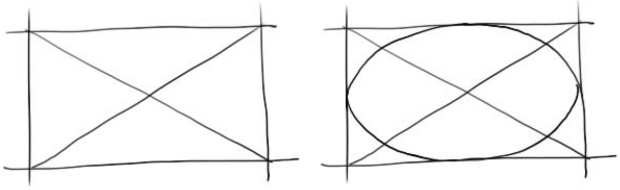
FILLET



ARC



ELLIPSE

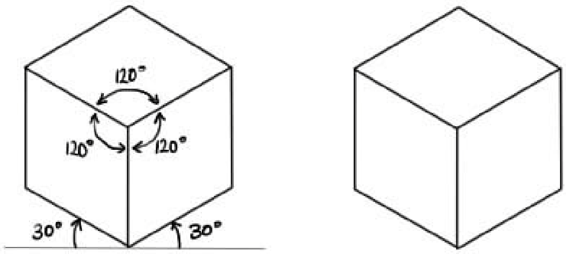


Drawing Views

A Drawing View refers to the technical style used to represent a 3D object on a 2D plane such as a piece of printer paper. Understanding this style requires in-depth knowledge about descriptive geometry and is therefore outside the scope of this document. Instead this guide presents you with a 'crash' course about two examples of drawing views including only isometric and orthogonally projected views.

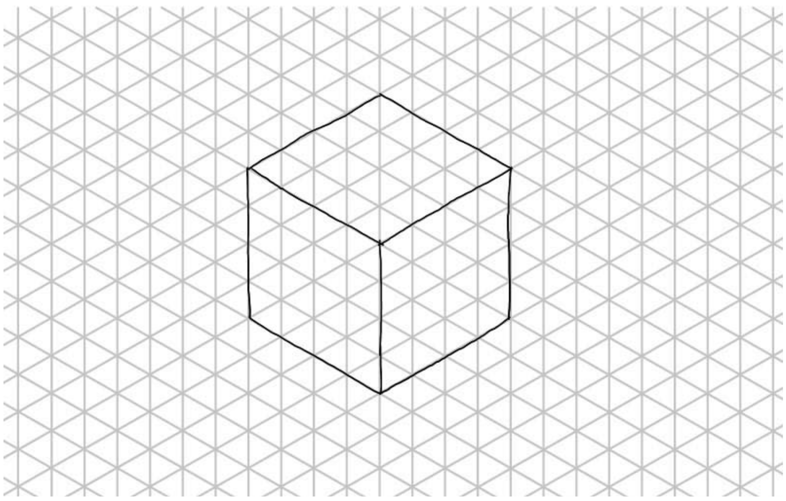
1. Isometric View

An isometric view is a '3D' view that has all its axes equal in length and angular separation.



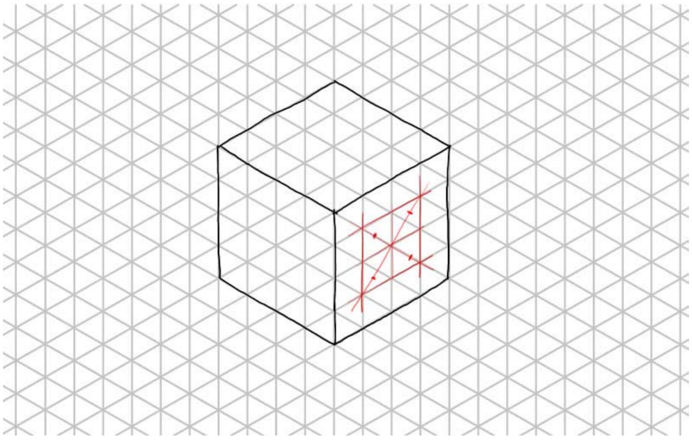
Above is a drawing of a cube in an isometric view. Note that the two axes are each angled 30 degrees above the horizontal.

Isometric grids can be used to aid drawing parts in an isometric view. The grid consists of vertical and 30 degree lines. Below is the same box drawn on an isometric grid.

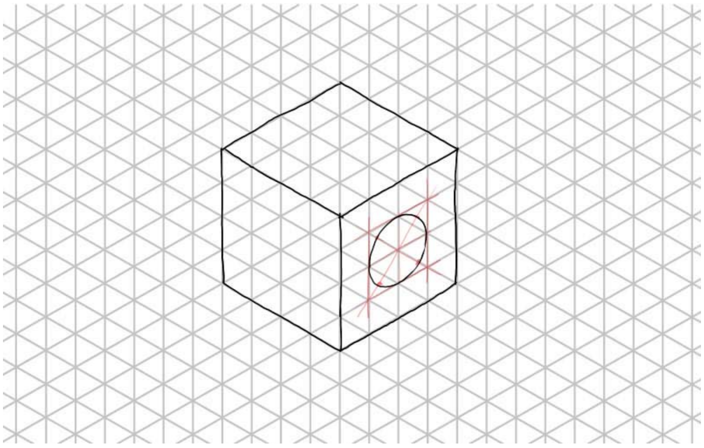


This is simple enough for straight lines; however features like curves and circles cannot simply trace the gridlines. Let's take the cube and pocket a circular hole on one of its faces.

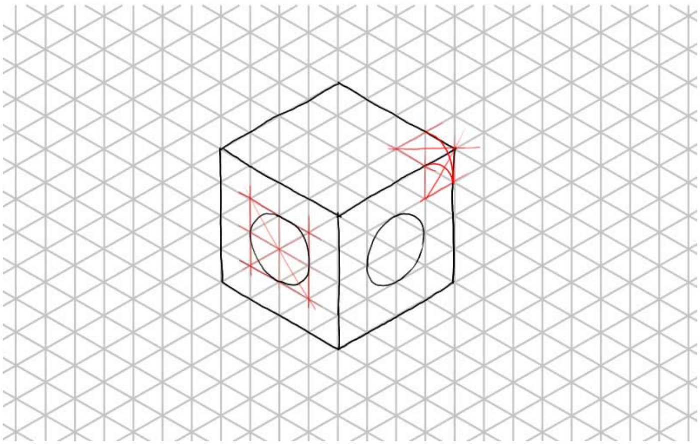
First we use the box method to draw the construction lines.



Then draw in the circle.

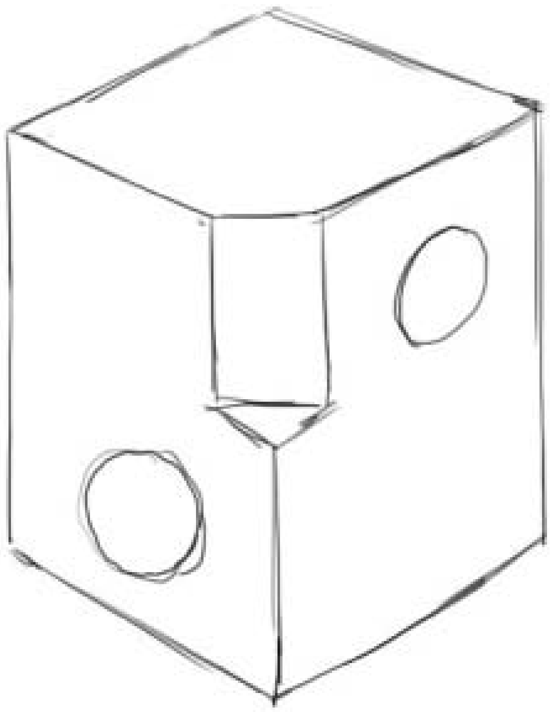


This concept can also be extended to other types of curves.



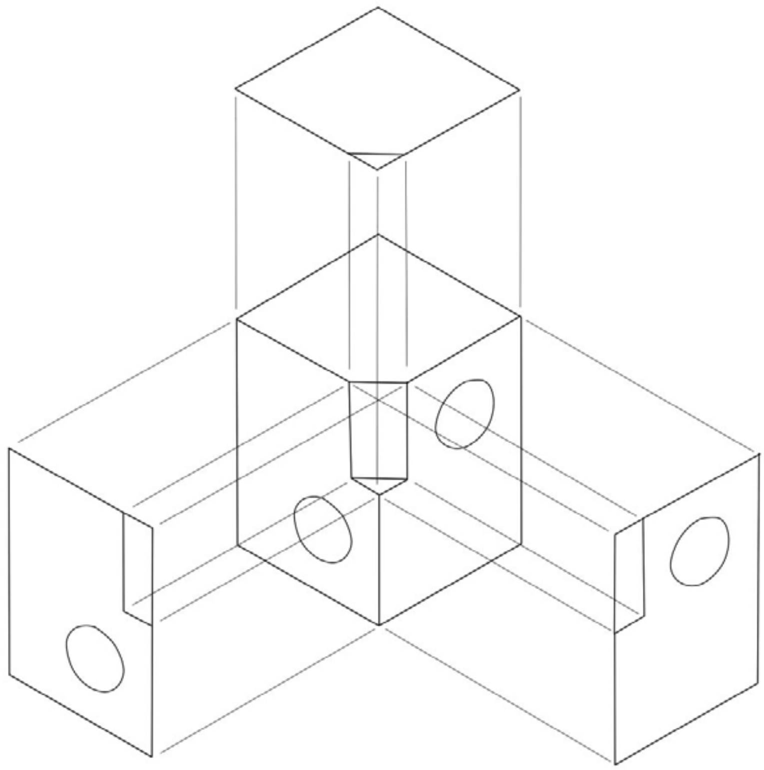
Once you have mastered isometric sketching with use of an isometric grid, you should begin practicing without a grid. A grid is simply a training tool and rarely used except for technical drawings that require more detail. Free-hand isometric sketching is more than adequate and efficient for concept sketches.

An example of a freehand isometric sketch is shown below.

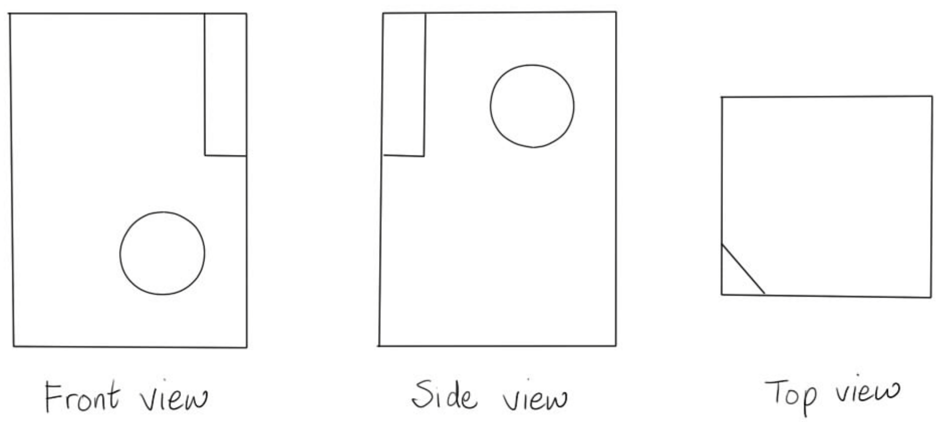


2. <u>Orthogonal Projection</u>

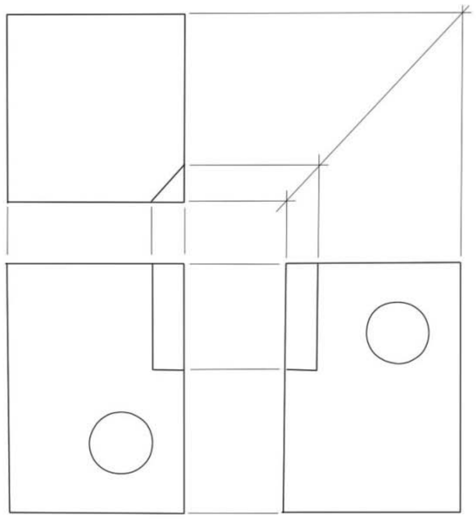
Orthogonal projection views are drawings that basically show what the part would look like from each perpendicular plane (similar to the Cartesian x, y, z planes). Let's take that isometric part from earlier. The projections are basically views of the part from different (orthogonal) angles. Note: This is in third-angle projection.

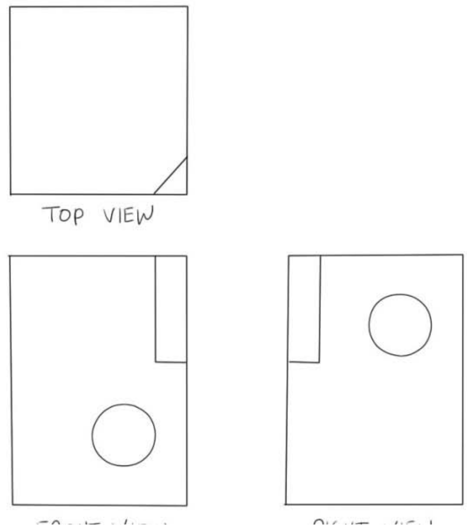


In this case, the views would be;



However, the correct placement of views would be;



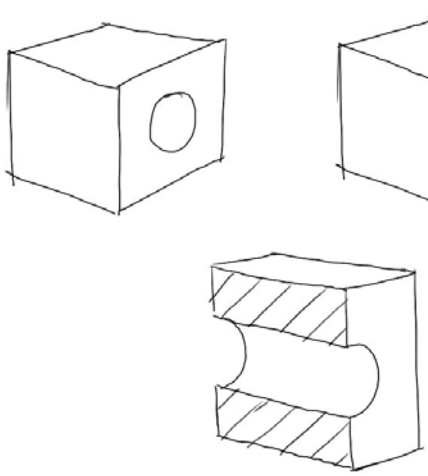


The sketch on the left represents how views are aligned, and on the right is shown how the final sketch should look.

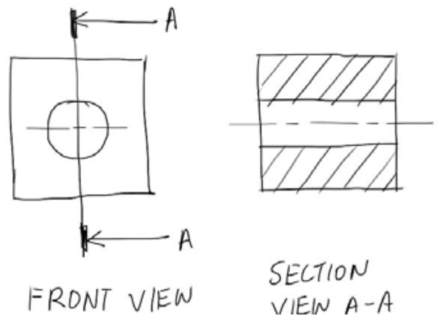
Although there are three regular views in orthogonal projection, many more irregular view planes can also exist. Considering the surfaces of the object, they can be included by placing them in appropriate positions relative to the front view.

3. <u>Section Views</u>

Most often than not, there are parts of a drawing that cannot be seen. In this case, you can 'section' the part. A section view basically cuts the part across the plane you want to see.

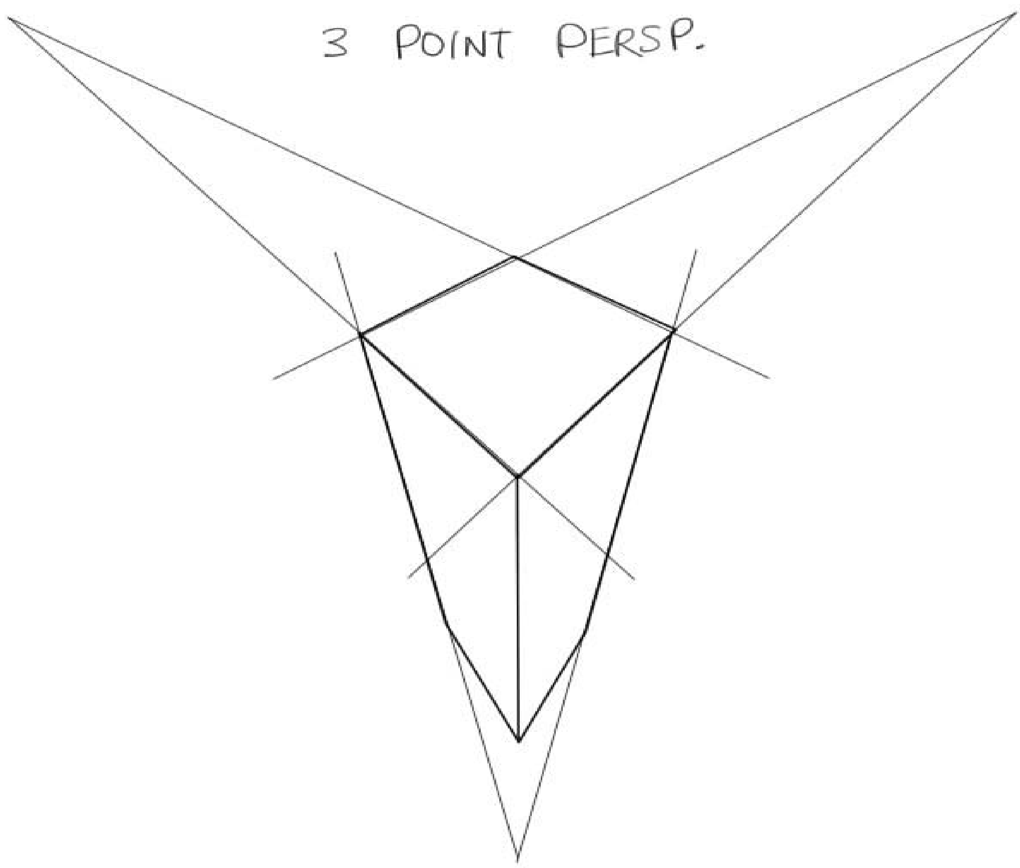


Usually a part that is sectioned can be cross hatched to indicate the region which has been sliced across. In orthogonal projection, a section view is represented as shown below.



4. Perspective Views

Perspective views have up to three vanishing points but should have been covered in ENGG1000. We will not go into the detail of perspective views in this guide.



Concept Sketching

A concept sketch is typically a sketch that represents a specific combination of ideas which together meet a set of expectations. These expectations could be self motivated or in most cases arise as a need to solve a problem provided to you by a client.

Now that we have the tools required to draw a concept sketch, we can go through an example of concept sketching.

Consider the following functional specification also referred to as customer's needs (Voland 2004, p.56):

CLINIMED DYNAMICS

CliniMed Dynamics requires a peristaltic pump for a new dialysis machine. Your company has been shortlisted as one of the bidders to become the successful pump manufacturer.

The pump must be able to connect onto the existing connections on the dialysis machine which comprises of an inlet and outlet pipe with an external M12 thread 10mm deep. The placement of the I/O pipes is arbitrary.

The displacement volume per second must be in excess of 60ml with a hydraulic pressure of less than 100Pa.

The pump must fit within a rectangular prism of size 150x150x70mm including the shaft which is connected to a brushless electric motor. The shaft must contain a grub screw and shaft socket to which the motor shaft will be connected. The motor shaft is 7mm in diameter.

At this stage you might be wondering one of the following questions:

1) Why does a sketching guide include an example functional specification?
2) How does sketching relate to a functional specification?
3) How much do I need to know about the functional specification to make a good sketch?

These are all valid questions and at some stage should have been answered in either ENGG1000, or as a part of another extracurricular project involving a similar functional specification.

However, you should make sure you answered these questions with the following responses:

1) A sketching guide needs to include a functional specification since a concept sketch is mainly used in order to represent ideas that solve a problem contained by a functional specification. This example shows the importance of sketching and justifies the use of

sketching during the initial design phase as a communication tool as opposed to an artistic pursuit or hobby.

2) Sketching is used in the initial design phase of the design process. However the design process can only begin once you have a set of functional specifications after which you begin problem formulation. After problem formulation you can begin the initial design phase which includes sketching.

3) The functional specification allows you to begin Problem Formulation and develop a set of design parameters which include design goals, constraints, considerations and other limitations. Once you have design parameters you can begin solving the overall problem and representing ideas with the use of sketches in initial design. If you have an incorrect set of design parameters, your solutions may not work and therefore your sketches may also contain mistakes.

Problem Formulation

This guide does not go into the details of problem formulation since you should have already mastered this process in ENGG1000. However we need to obtain a set of design parameters in order to begin our sketching:

The design constraints for the pump are as follows:

- The pump is peristaltic.
- The pump has a geometric constraint of 150x150x70mm.
- The pump is connected to a 7mm dia. motor shaft via a setscrew.
- Displacement volume > 60ml.
- Hydraulic pressure < 100Pa.
- Pipes connect to nozzles with an M12 thread on the outside that is 10mm long.

Remember that since we only care about the design of this pump other design parameters such as manufacturing limitations have not been included.

Initial Design

At the beginning we can ignore the numerical values such as functional specifications of displacement volume and pressure since they will not affect the overall shape of the pump. They only change the size of our design.

However before we develop some ideas do we know exactly what the design parameters mean?

What is a peristaltic pump? What is a set-screw? What is an M12 thread?

Part of the initial design process is doing ***<u>initial research</u>*** to fill gaps in your knowledge about the problem and in this case the design parameters. However this does not imply that a good designer will already have prior knowledge about every single design problem. The ability to gather information and understand a problem needs to be done for each functional specification and is an integral part of the design process and your ability to be a successful designer.

In this case you could have accessed a search engine such as Google search and typed - peristaltic pump.

During our initial research we can conclude that there are 5 parts to this pump.

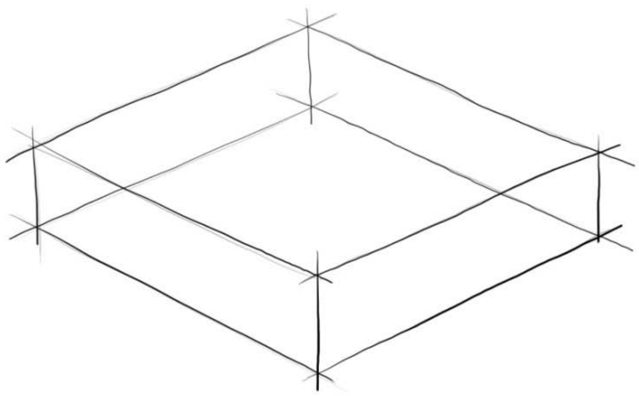
1. The shaft
2. The rollers
3. Base-plate
4. Tube
5. Casing

After fully understanding what each part does, we can finally proceed to create some concepts.

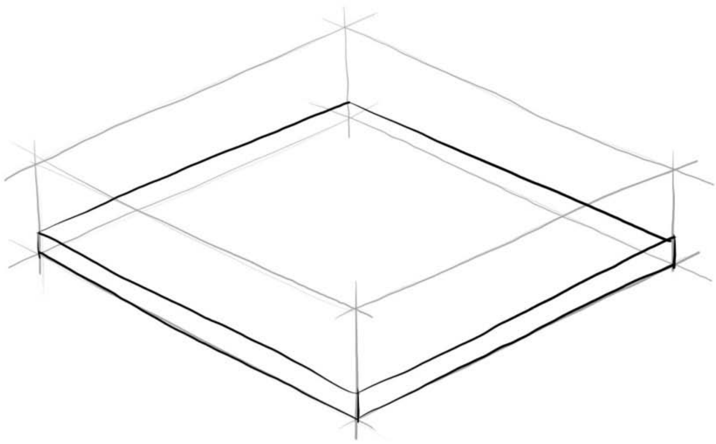
From here on, the process in which you create the concept is *<u>arbitrary</u>*. In other words, use your imagination and capture your ideas in any order.

Traditionally we can start our sketch by visualizing the whole pump in 3D. We can draw a rectangular box showing the envelope (geometric constraints) of the pump. We have done this in an isometric view.

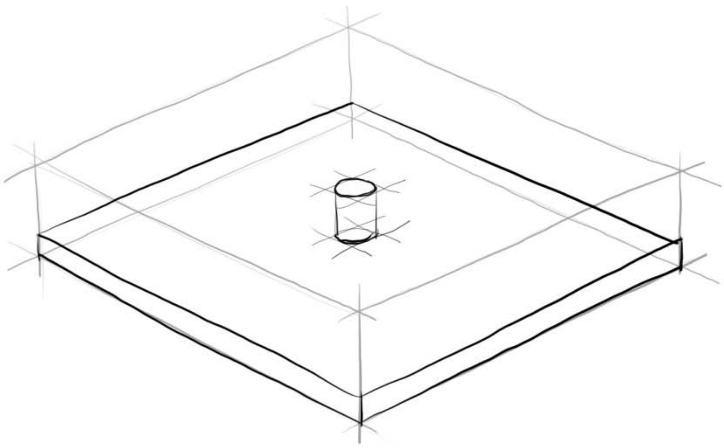
Remember sketching is not a precise art, so you don't need to worry about if the lines are 30 degrees or not.



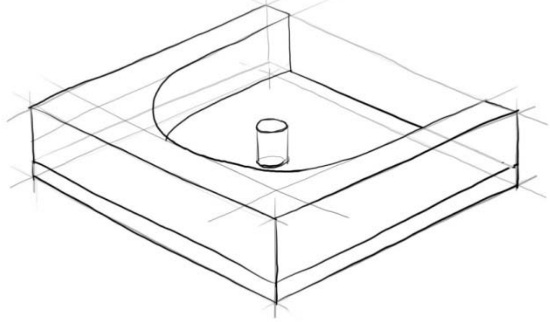
Let’s draw from bottom to top; based on our knowledge we can draw a base:



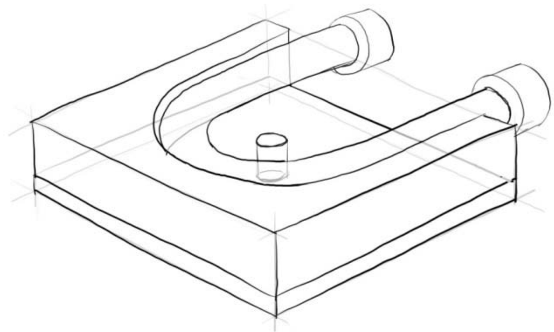
Next, we can draw the shaft since we can use it to centre all the remaining parts. Here we have used construction lines, but you don’t have to use them if you can achieve the same ellipse with a steady hand.



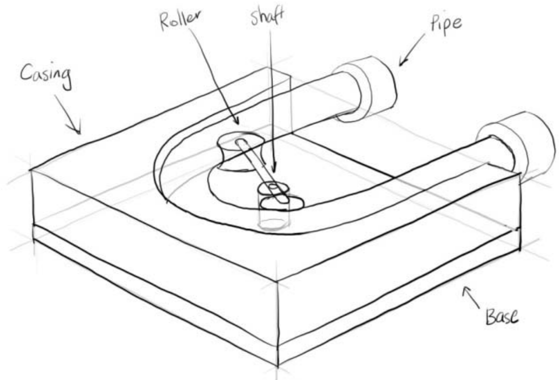
After the shaft position is determined, we can draw the casing around it, making sure the arc is concentric with the shaft (i.e. the centre of the arc’ circle is the shaft).



Now we can draw in where the tube is supposed to be.



We can finish off with the rollers and label the parts. Since this is a rough sketch, explaining how it works is un-necessary.



Wait. Have we forgotten something? How is the pump supposed to stop falling apart if it isn't held together?

Always remember that hardware such as adhesives, screws, bolts and nuts can usually be assumed to be necessary. However, we still need to show these components.

We can draw in some screws and nuts to hold the pump together but it is suggested you perform research on the different types of screws and nuts before deciding on the best option for your concept.

Some screw types are as listed below:

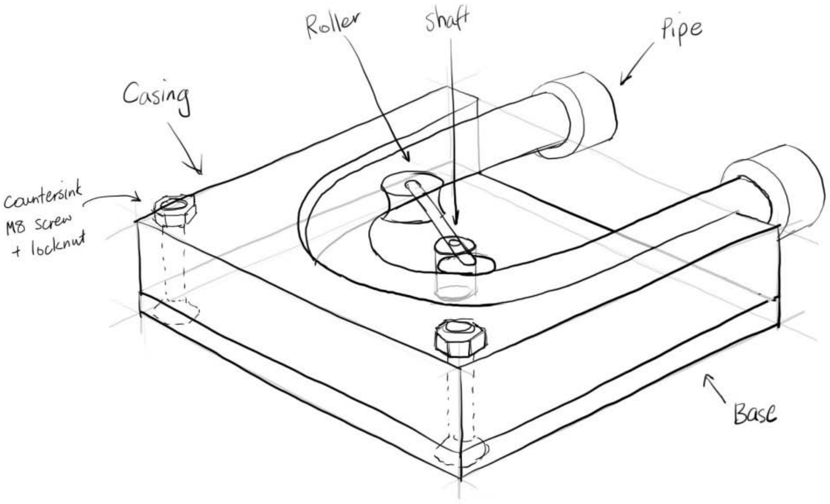
- *Socket screws*
- *Countersunk screws*
- *Button cap screws*

Also, different head types are as follows:

- *Hex (Allen)*
- *Flat head*
- *Phillips (cross head)*

In this example we have used a countersunk hex head screw, because the base had to sit flush with the dialysis machine.

Note that this sketch does not show where the shaft connects with the motor.



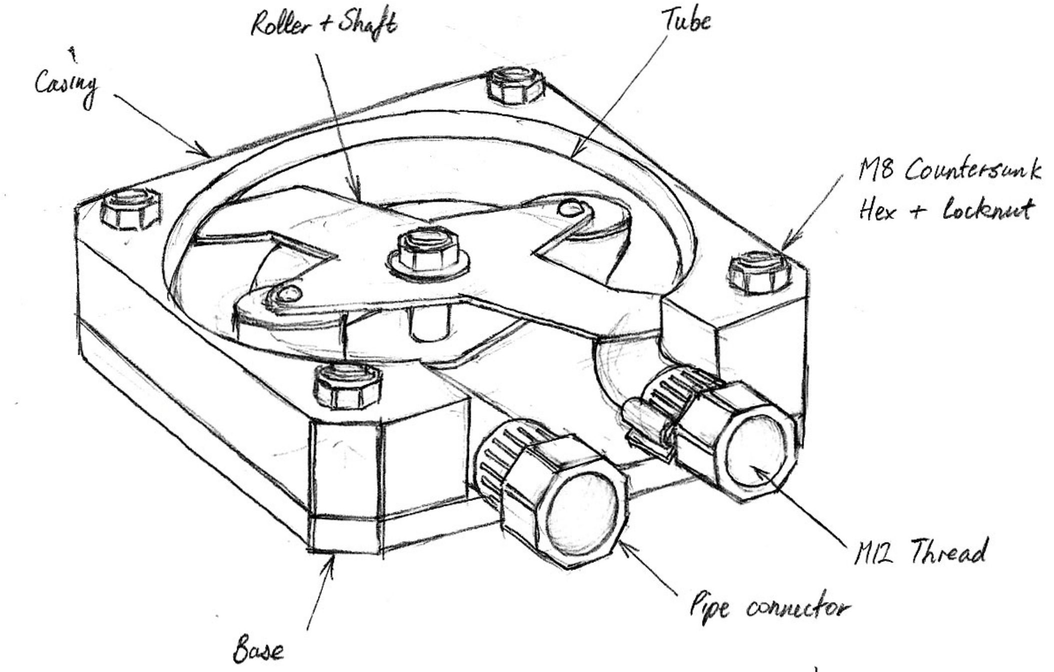
A drawing of this level should suffice as a concept sketch. It shows all the parts, and their relationships to each other.

This example showed an isometric sketch, but you can draw the concept orthogonally if you wish. As long as you show sufficient detail to represent your ideas or concept and how it solves the problem. Preferably you will use multiple drawing views to show your ideas and in most cases this is necessary to represent the whole concept.

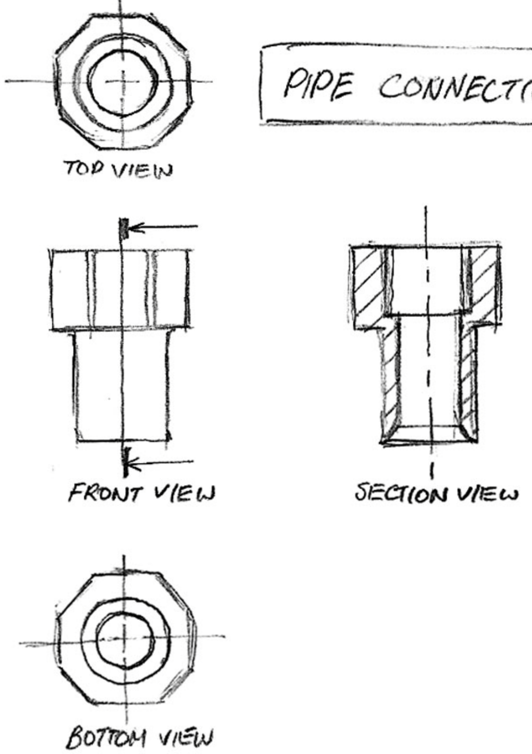
On the next page is an example of a completed concept sketch for these functional specifications.

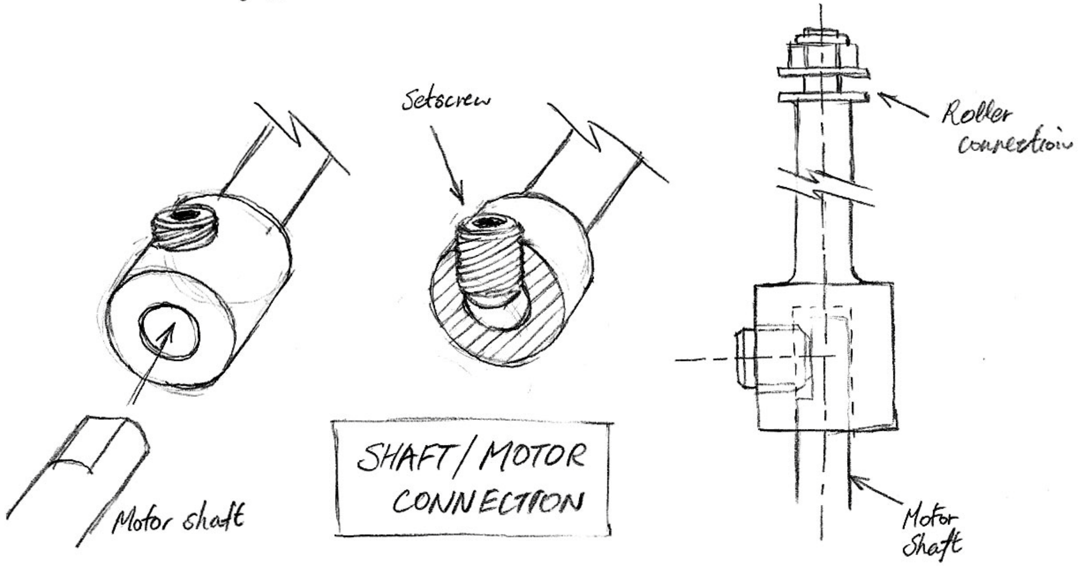
There is an orthogonal view for the pipe connection. This is purely because it is easier and clearer to draw it this way. As you progress through the subject, you will also realize that having both top and bottom views is redundant, but we currently assume that you have no knowledge about engineering drawing.

Make sure you include all the information that is necessary to understand your concept even if it is sometimes repeated. for example, the envelop dimension needs to be specified.



PIPE CONNECTION





SHAFT/MOTOR CONNECTION

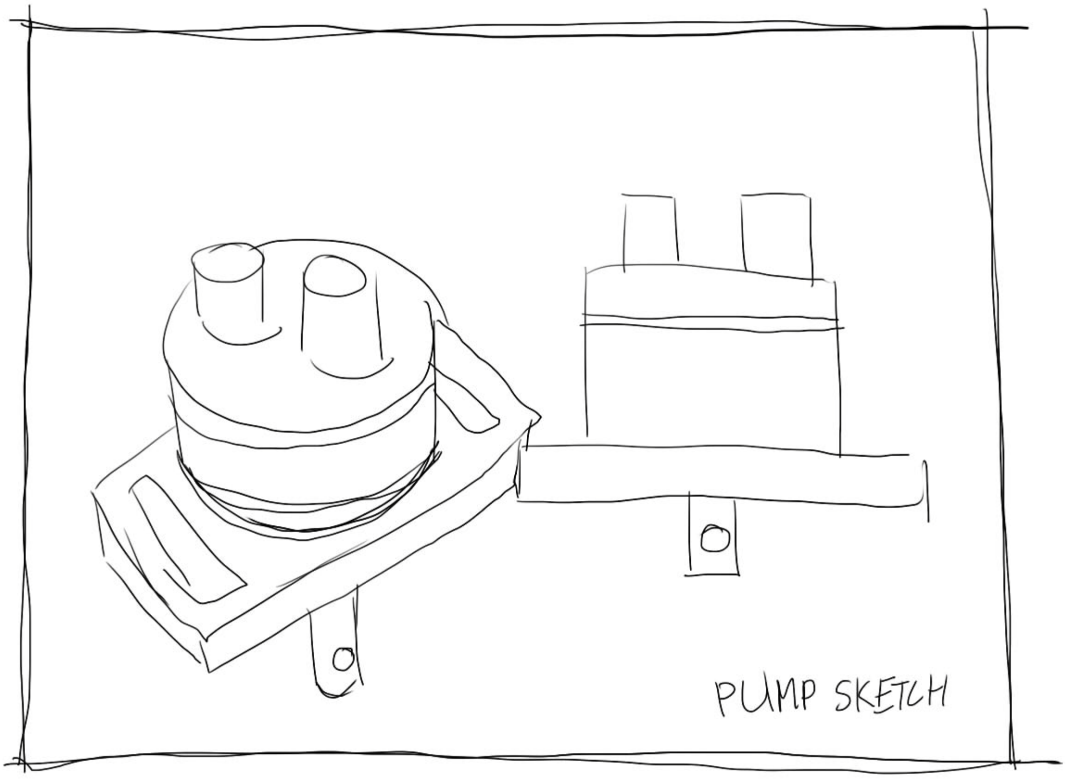
NAME: JOHN DOE (z1111111)	
GROUP: 13	
TITLE:	PERISTALTIC PUMP CONCEPT

Examples

The following sketch is an example of a **bad concept sketch**.

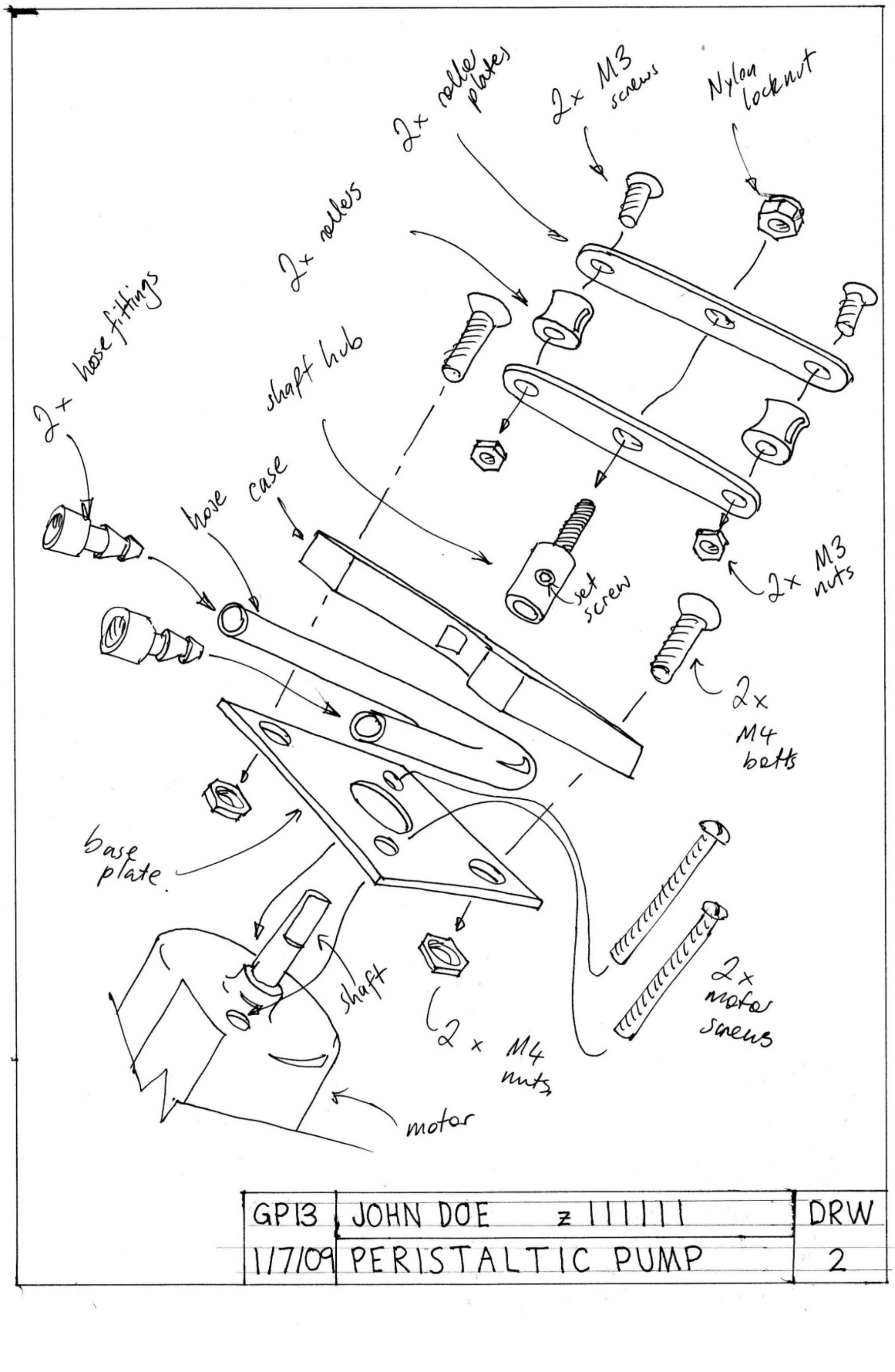
The proportions look wrong, nothing is labelled, and the author's name, student number and group number isn't written down.

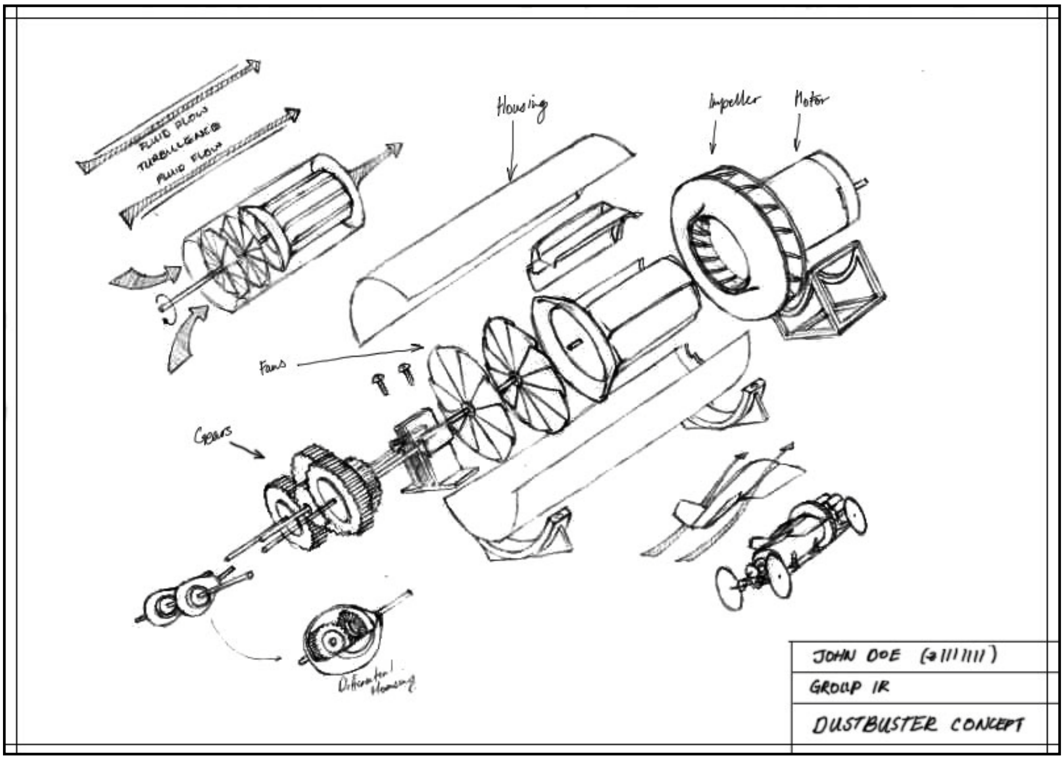
The main point here is that it *lacks detail*. *It is impossible to know how the pump works.*

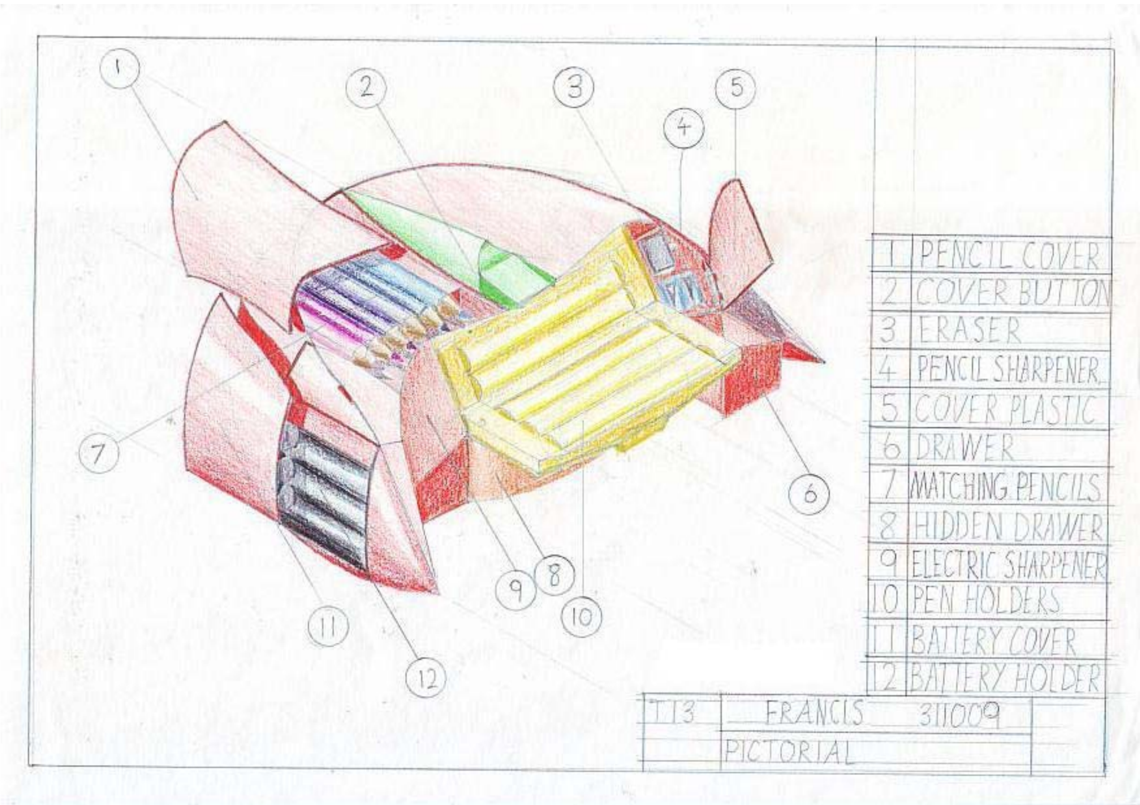


Here are some examples of sensible concept sketches.

Required information for individual designs need to be specified.




FLUID FLOW
TURBULENCE
FLUID FLOW
Housing
Impeller
Motor
Fans
Gears
Differential Housing
JOHN DOE (a1111111)
GROUP IR
DUSTBUSTER CONCEPT


1 PENCIL COVER
2 COVER BUTTON
3 ERASER
4 PENCIL SHARPENER
5 COVER PLASTIC
6 DRAWER
7 MATCHING PENCILS
8 HIDDEN DRAWER
9 ELECTRIC SHARPENER
10 PEN HOLDERS
11 BATTERY COVER
12 BATTERY HOLDER
T13 FRANCIS 311009
PICTORIAL