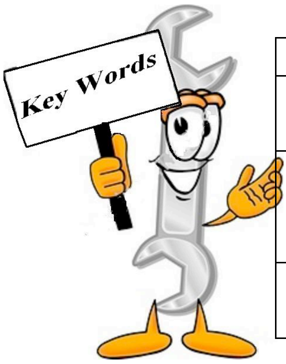



| Term | Definition | Example |
|---|---|---|
| **Dimension** | Size, distance | The dimensions of the plate were given in metres. |
| **Capacity** | Volume - the amount an object can hold | The capacity of an ice-cream container is 2 litres. |
| **Mass** | Weight | The project had a mass of 2.5 kg when it was finished. |

You, the fabricator, will be constantly surrounded by numbers.
You will need to cost out jobs, which may mean working out dimensions, capacities and masses along with calculating the consumables (welding materials, gasses etc) that you will require.
Accuracy is obviously the key to these costings. With dimensions ranging from millimeters to kilometers, there is potential to either:

- cost yourself out of a job by calculating over the actual cost
- cost your workplace because you have underestimated the cost

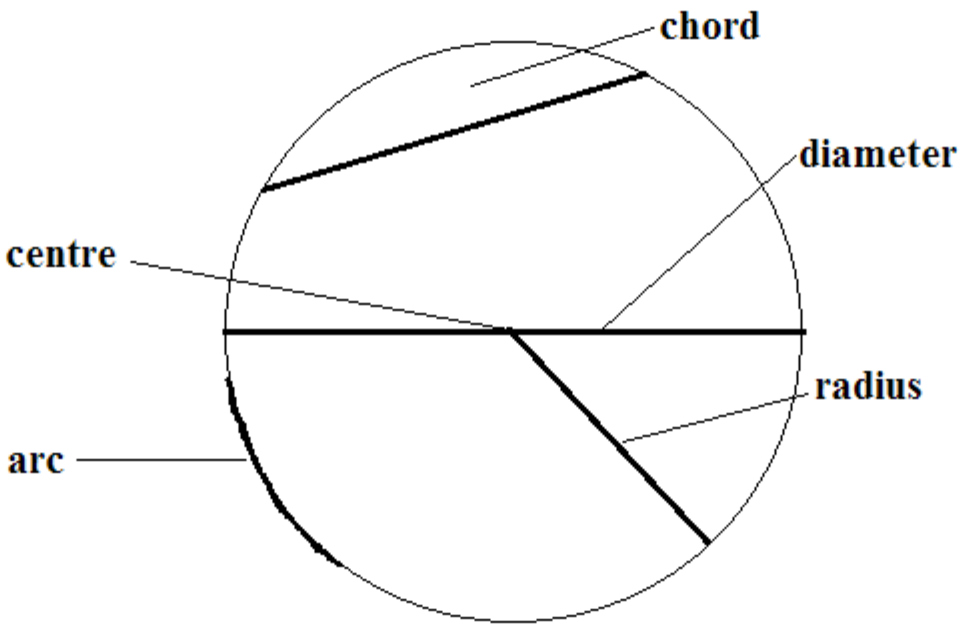
Calculating mass is also important when components you make need to be transported, so transport companies require accurate calculations for them to be able to assign vehicles to the transportation task.

In this unit we need to look at the different formulae we need and which formula is used in which calculation. You probably don't need to remember each formula but you do need to be able to select the correct formula for the correct calculation.

Also it is really important to be able to convert different values (numbers)
for example how many metres in a kilometer, how many millimeters in a centimeter.

http://www.mathsisfun.com/definitions/index.html is a really cool website you can use for all sorts of maths. If you go to this site, then go to the 'c' in the dictionary and click on circle. You will see all sorts of information on circles.

 Let’s start by looking at various shapes and their dimensions.
Start with the basic circle:





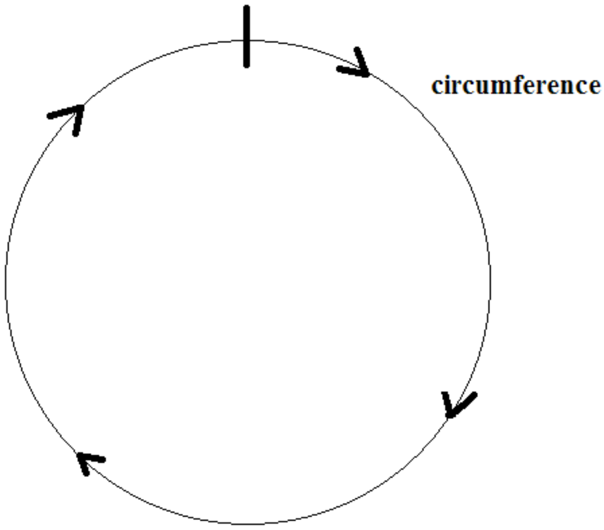
Complete these sentences

A diameter is ..

A radius is ….

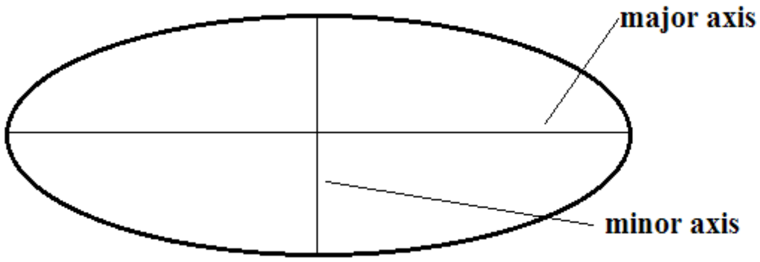
A chord is …..

An arc is….




The distance around the outside of the circle is the circumference. This dimension is really common in welding and engineering, so you will come across it a lot.

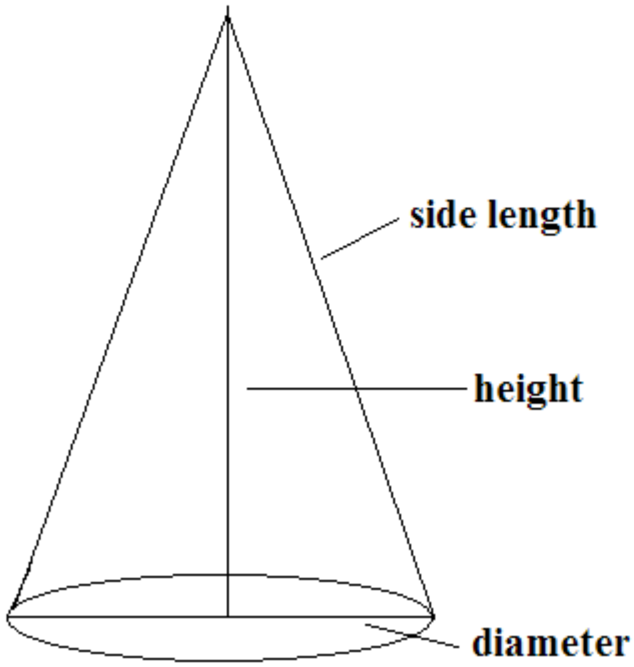
The shape below is an **ELLIPSE**. It looks like a circle that has been squashed.




Because the diameter and radius don't work for an ellipse, we say it has a major axis (the distance across the widest part lengthways) and a minor axis (distance across the widest part crossways)

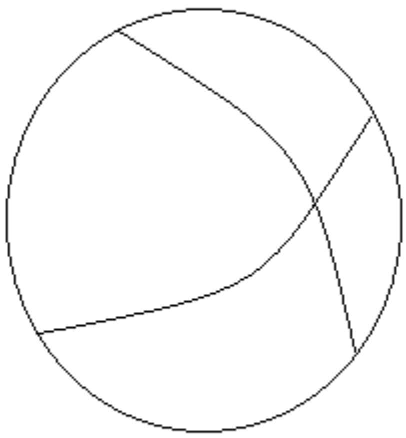
Again, check out the 'maths is fun' site and look at an ellipse.
You will also see how to make one.

A **cone** is another shape we need to look at.




A **cone** has a shape like an ice-cream cone. It has a diameter across the open end, a height from the centre of the diameter up through the tip of the cone, and a side length which is from the outer edge to the tip.

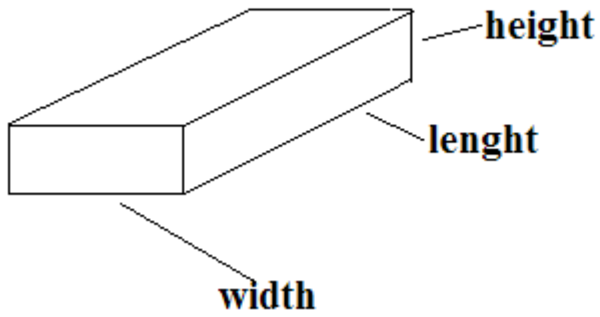
A **sphere** is a common shape to make tanks and vats to, so you will probably come across it in fabrication. It is a ball shape, so will have a diameter and a radius.



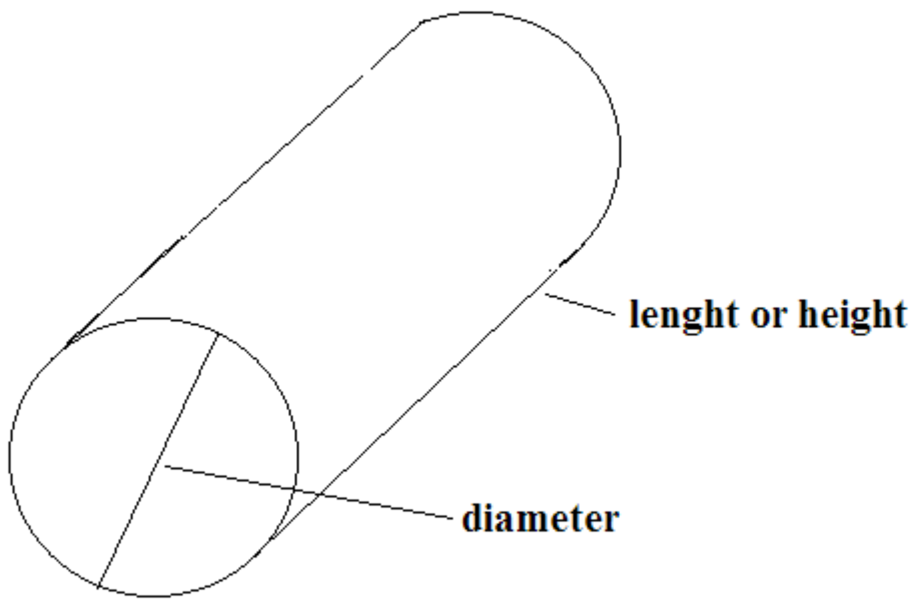
**Capacities**.

Capacities or volumes are the amount an object can hold. Think about the ice-cream cone - it has a volume of ice-cream it can hold.

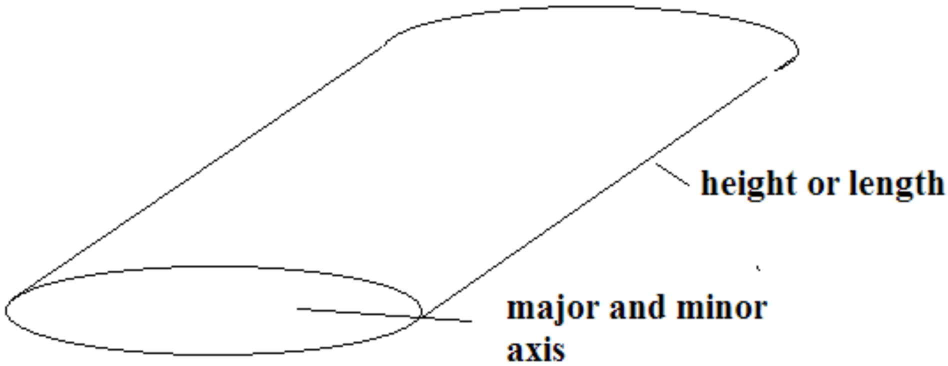
So we could have **rectangular** vessels,



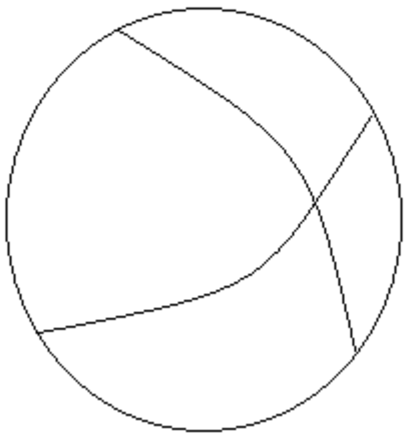

A **cylindrical** (a cylinder) vessel,



An **elliptical** vessel (think about the shape of the milk tanker tanks)




A **hollow sphere** shaped vessel. Imagine an orange peel without the fruit inside.



It will have a wall thickness (like the orange).

Your calculations are mostly around these shapes.

The circumference is the distance around the outside of a circle or ellipse. If the shape is a square or a rectangle it is said to have a perimeter. Sort of crazy to have different names but that's the way it is. These distances are in one plane only.
**(single dimension)**

When we talk about area we are in 2 dimensions (**2D**)

When we talk about volume we are in 3 dimensions (**3D**)

Try to remember this. Use

C = 1

A = 2

V = 3

So the circumference or perimeter is just a single number.

The area is a **squared** number ( $x^2$)

The volume is a **cubic** number ( $x^3$)

What is Pi? You may recognize the number, 3.14
But what does this mean?


- Go into the workshop and get a wheel/tyre or rim.
- Get yourself a piece of chalk and put a mark on the bottom of the tyre, where it meets the floor, and also mark the workshop floor at the same place.
- Roll the tyre one complete revolution along the floor in a straight line
- Mark the floor at the point where the tyre mark returns to the floor
- Get a tape measure and find the distance between the two marks (i.e. start and finish) on the floor
- Now measure the outside diameter of the tyre
- Finally, using a calculator, divide the measurement from the floor by the measurement of the diameter of the tyre.

What is your answer?

Does this number look familiar?

Now finish the following sentence:

**Pi is a measurement of the number of times the diameter of a circle …………….**

**…………………………………………………………………………………………….**


**It is really important you know about Pi (or π).**
**All through your engineering life you will need to be able to calculate distances around 'stuff' like gears, wheels, tanks etc.**

Find two other round items (maybe a CD or small gear) and do the same calculations as you did with the tyre.

Example 1 -
Item –

Length measurement -

Diameter measurement -

$\frac{\text{Length}}{\text{Diameter}}$

Answer =

Example 2 -
Item –

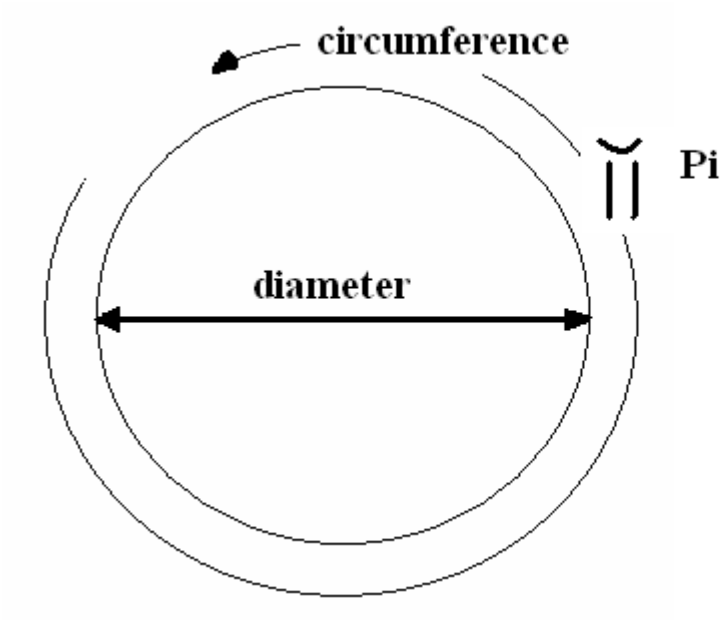
Length measurement -

Diameter measurement -

$\frac{\text{Length}}{\text{Diameter}}$

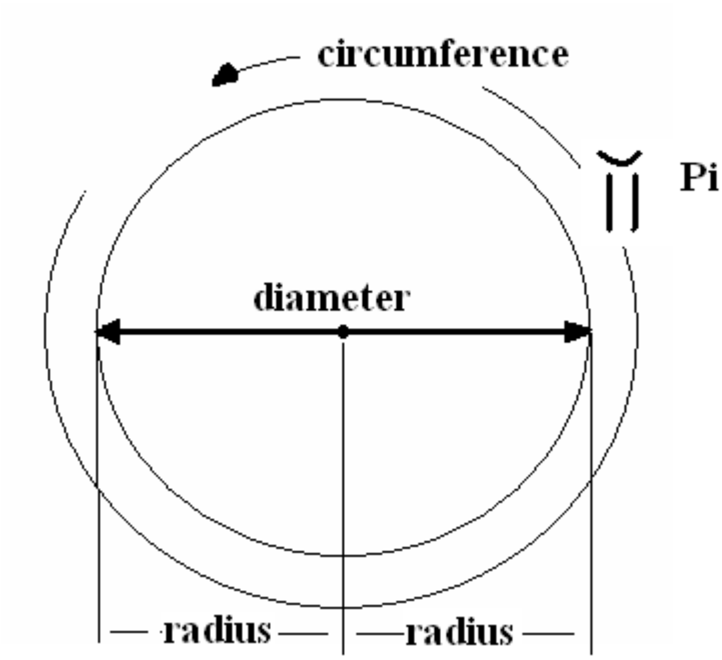
Answer =

Have you now got enough information to make a formula for the **circumference of a circle**?




**Circumference of a circle =**

**Circumference of a circle = Pi x diameter (so we write: C = $\pi \times D$)**




Now let's move on to the area of a circle. This is the first bit you will need when we work out the volume of a tank.

The formula for the area of a circle is $\frac{\textbf{Pi}}{\textbf{4}}$ **x diameter squared**

You may be more familiar with the formula for the area of a circle as

**Area of circle = $\pi$ x $r^2$**

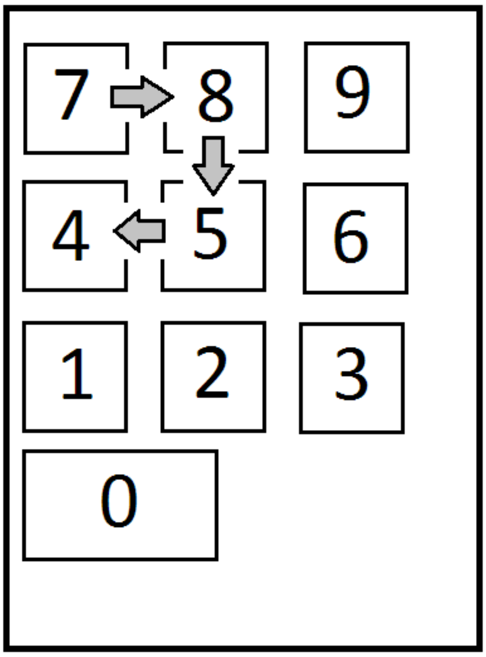
however in most of our automotive and engineering applications we are given a diameter or bore measurement so to make the formula easier we use:

$$\frac{\pi}{4} \times d^2$$

To make the equation even easier, if you **divide $\pi$ by 4** you get a value of **.7854**

Now the formula for the area of a circle is:

**.7854 x $d^2$**

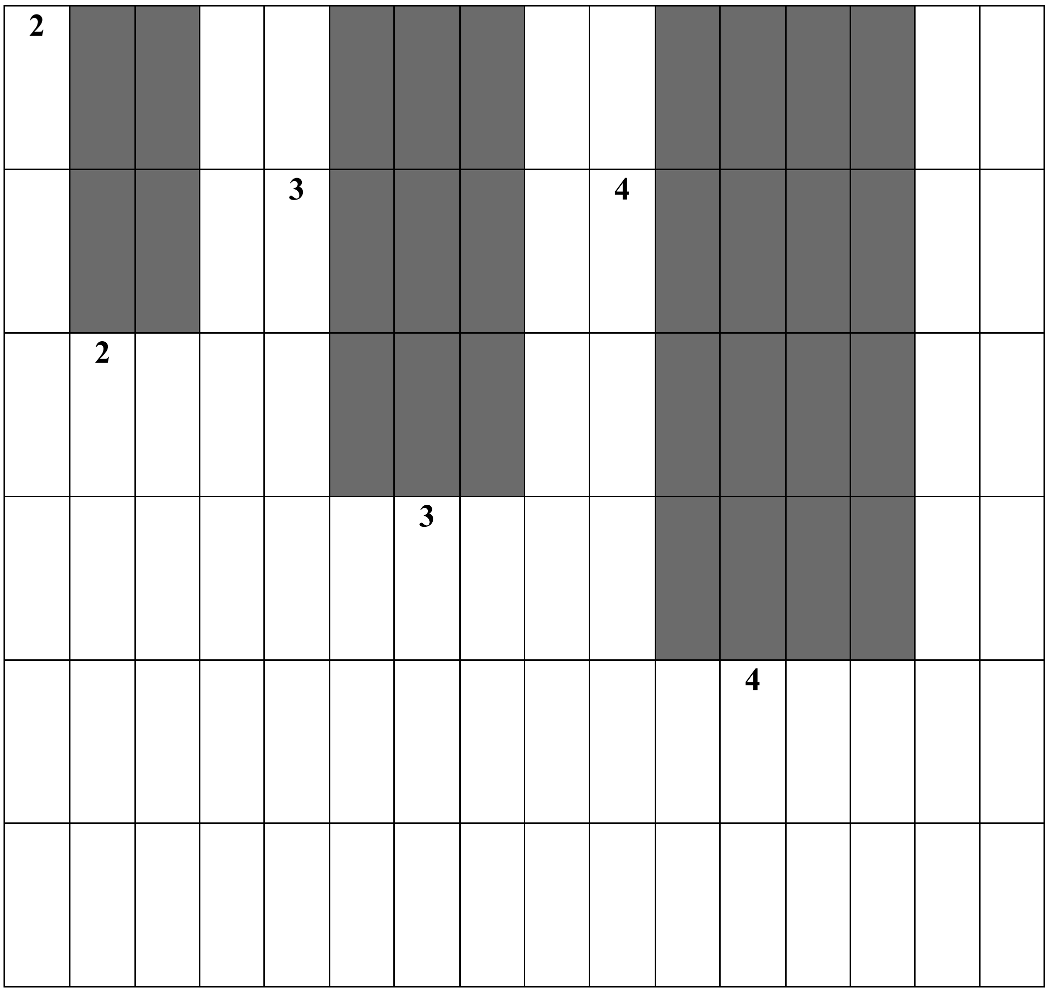



Look at the keypad of your calculator or computer, to help you remember the

**.7854**

**Squared** means **times itself**, check out the table below.
Look below and see how

2 squared is 2x2 which gives us 4 squares
3 squared is 3x3 which gives us 9 squares
4 squared is 4x4 which gives us 16 squares



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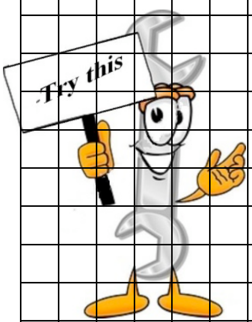



Complete these calculations by shading in the areas.

5 squared =

8 squared =

10 squared =


**When a number is squared it is shown with a small 2 following and placed above the number.**

$12^2$ is 12 squared

If a number being squared is part of a formula, **ALWAYS do the squared bit first.** This is shown by putting the squared number in brackets and can be written in 3 ways.

**Pi x (radius squared)**

**Pi x ( radius x radius)**

**Pi x ( $r^2$ )**

Use the formula for finding the area of a circle and work out these areas.
Example: Calculate the area of a circle that has a diameter of 14cm.
Formula:
Area of circle = .7854 x $\text{diameter}^2$
= .7854 x (14 x 14)
= .7854 x 196

= 153.9 $cm^2$

Your turn:

Calculate the area of a circle that has a diameter of **8cm**

Calculate the area of a circle that has a diameter of **13cm**

Calculate the area of a circle that has a diameter of **12.5cm**

Calculate the area of a circle that has a diameter of **14cm**

Calculate the area of a circle that has a diameter of **24cm**

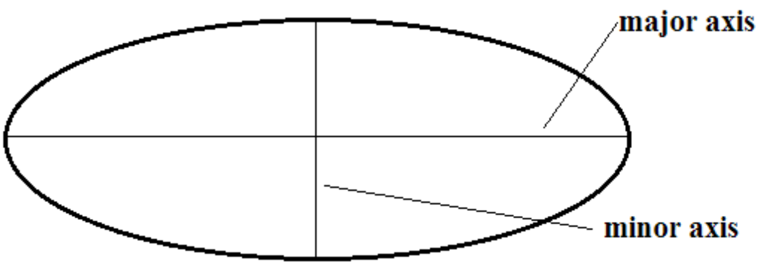
Calculate the area of a circle that has a diameter of **29cm**

That should be the circumference and area of a circle sorted (all these formulae will be in the back of these notes).

The other circumference we need to be okay with is the circumference of an **ellipse.**

Remember the ellipse doesn't have a radius but has the two axes (major and minor). You will see the two axes are added together in the formula.

Circumference of ellipse = $\frac{\pi \times (D + d)}{2}$




One axis is called D.
The other is called d.


Calculate the circumferences of these ellipses.

1/ D = 800 mm d = 400 mm

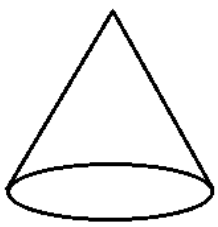
2/ D = 1.2 m d = 760 mm


| Term | Definition | Example |
|---|---|---|
| **Surface area** | Amount of space of an object that is exposed. | The surface area of a balloon increases as it is blown up |

On to **surface areas.**

The three basic shapes that are referred to in this unit are: **Cone**
**Ellipse**
**Sphere**

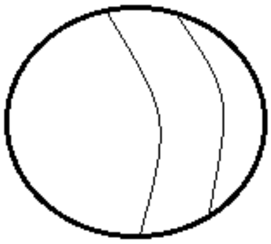
We need to be able to calculate the surface areas of these shapes. This type of calculation is important in the trade as you will need to work out surface areas for coatings (paint etc.). The formulae are shown below and repeated at the back of this material



Cone – **π x R x S**

R = radius
S = slant height

Ellipse – $\mathbf{\frac{\pi}{4} \times D \times d}$ D = major axis
d = minor axis



Sphere – $\mathbf{4 \times \pi \times r^2}$ r = radius


Calculate the surface area of these bits:

1/ Cone with a radius of 45 mm and a slant angle of 140 mm

2/ An ellipse with a major axis of 550mm and a minor axis 270 mm

3/ A sphere with a radius of 350 mm

If you are having trouble with any of these, please talk to your tutor. Let's get it sorted now.

It will be useful at this stage to have a look at place values.
The place value of a number is where it sits relative to the decimal point.

A number like 222 the 2's have a different place value.

The first 2 is hundreds
The second 2 is tens
The third 2 is ones.

See how although we are using the same number it has three different place values?

The place value of numbers becomes really important when we are working with numbers that need to be converted to their place values so we can do the calculation.

For example 56kg plus 3.5g

See how we need to get all the numbers either in kg or in grams so we can do the calculation?

We may need to convert $mm^2$ to $cm^2$

We may need to convert $mm^3$ to $m^3$

To do these conversions we need a good knowledge of place values.

There are a whole lot of resources that can help you understand this stuff.


ASK YOUR TUTOR TO GO THROUGH IT WITH YOU.


| Term | Definition | Example |
|---|---|---|
| **Volume Capacity** | Amount a shape can hold | The volume of an ice cream container is 2 litres |

Volumes become extremely important when we start looking at tanks and other vessels. You may even need to work backwards from getting a request from a customer to build a tank that will hold a certain amount of product and it has a certain floor space to fit. For this sort of problem you need to work out the size and shape of the most suitable container, how much material you need to make it and even how much the finished tank weighs.
Here are the formulae you will need to complete the calculations for this unit standard. They are also at the back of this material.

**Volumes:**

Rectangular vessels – **L x B x H**

L = length
B = breadth
H = height

Cylindrical vessels – $\underline{\pi}$ **x** $\mathbf{D^2}$ **x H**

D = diameter of vessel

**4** H = height or length

Elliptical vessel – $\frac{\pi}{4} \times D \times d \times H$

D = major axis
d = minor axis
H = height or length

Sphere – $\frac{4}{3} \times \pi \times r^3$

r = radius of sphere

Cone or pyramid – $\pi \times r^2 \times \frac{H}{3}$

H = height

Mass or weight of objects or fabrications is another calculation you will need to get sorted.

The formula is:

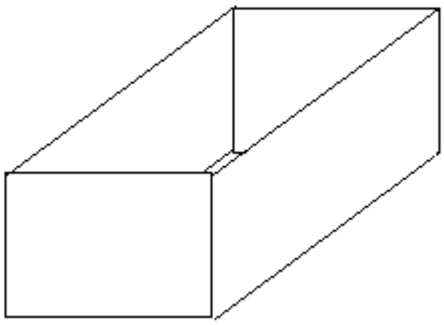
**Mass = density x volume of material in an object**

Here is a table of densities of common materials. It is repeated at the back of this material

| MATERIAL | DENSITY | |
|---|---|---|
| | $kg/m^3$ | $g/cm^3$ |
| Water | 1000 | 1.0 |
| Steel | 7750 | 7.75 |
| Aluminium | 2720 | 2.72 |
| Brass | 8580 | 8.58 |
| Cast Iron | 7200 | 7.2 |
| Oil/Petrol | 720 | 0.72 |

Note the density is given in $kg/m^3$ and $g/cm^3$ - so make sure you choose the correct column for the calculation you are doing.

When we are talking about mass or weight we are usually talking in 3D so we need to be aware things are in 'cubic' values.



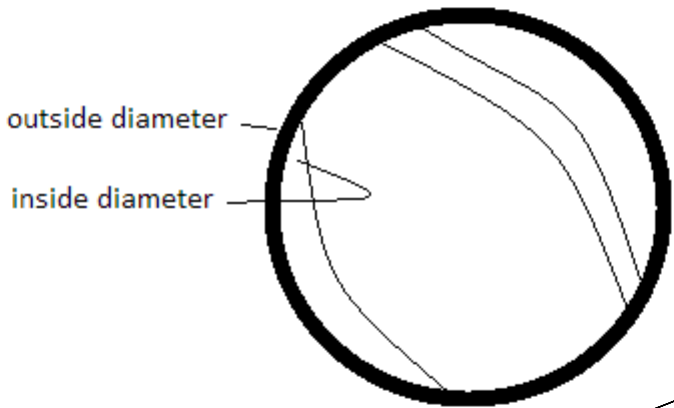
This container will have a mass and if we fill it with water for example, the water will have a mass as well.

The mass of the container would take into account its surface area and its wall thickness.

The hollow sphere seems to be a real pain to sort out. It is a great shape for a storage tank as it has no corners or sharp edges, so it's quite likely you will come across it. Have another look at the formula.

Hollow sphere – $\mathbf{D^2 \times \pi \times t}$

D = mean diameter
t = thickness




See it's got a mean diameter.

The mean diameter is half way between the outside and inside diameter, so if the outside diameter is 800mm and the material is 8mm thick there will be 8mm on the opposite side.
Remember we are talking about diameters and not the radius, so we need to be aware of the other (opposite) side.

- So for our hollow sphere the mean diameter will be 792mm. This figure comes from: the 800mm outside diameter sphere
- 8mm wall thickness on either side
- The mean diameter will be at 4mm of the wall thickness on each side =8mm
- So for our hollow sphere the mean diameter will be 800mm – 8mm = 792mm


What is the mean diameter of a sphere 1.2m in diameter and has a wall thickness of 40mm?

Have a go at these. Set out your answers by:

- first writing the formula
- then putting the values (numbers) you know into the formulas
- doing the calculation

Try to get used to this method as it should help you trace each step and your workings.

a) Calculate the mass of a block of steel measuring 0.6m wide, 0.5m high and 0.8m long.

*Formula*

*Values given*

*calculation*

b) Calculate the mass of a cast iron ingot measuring 0.65m wide, 0.45m high and 1.8m long.

c) Calculate the volume (in litres) and the mass of water required to fill a rectangular tank 1.2m wide, 0.5m high and 1.5 metres long.

d) Calculate the mass per square metre ($kg/m^2$) of 20mm thick steel plate.

e) Calculate the volume (in litres) and the total mass of a farm petrol storage tank when full. Dimensions of the tank are 0.8m diameter and 1.2m high. The empty storage tank has a mass of 150.0kg.

f) Petrol storage tank for a motorised yacht is to be made from 8mm aluminium plate. The inside dimensions of the tank are 0.6m wide, 0.5m high and 1.2m long.

Calculate:

1. The volume in litres of this tank

2. The mass of the empty storage tank using the inside measurements when calculating the sizes of the plates

3. The total mass of the tank when filled with petrol

g) You are required to manufacture a rubbish handling bin to fit on a heavy duty car trailer. The bin is required to hold 2 cubic metres of rubbish but must fit inside the trailer deck. The inside measurements of the trailer deck are 1.1 metres wide and 1.8 metres long. Calculate the height that you need to make the bin. You will need to allow an extra 300mm to stop the rubbish spilling on the road during transport.

h) You are required to manufacture a number of rectangular containers each to hold 4 litres. Calculate the width of container if the height is 90mm and the length is to be 300mm.

i) To static balance an object attached to a lathe faceplate requires a mass of 2.2kg to be added. Calculate the length of flat mild steel 20mm x 100mm required to make up this mass.

k) You are required to manufacture a cylindrical wastewater storage tank to hold 9000 litres from 10mm thick mild steel.
Calculate:

1. The height of the tank if the inside diameter is 2.4m

2. Calculate the mass of steel required to manufacture the tank (use the tank measurements for your calculations).

3. Calculate the total mass of the tank and water when full.

l) You have received an order to manufacture a cylindrical pressure vessel 2.2 metres diameter and 3.5 metres long from 20mm steel boiler plate. Note: pressure vessels normally have spherical shaped ends but for the purpose of this exercise use flat ends.

Calculate:

1. The mass of plate in the tank using the dimensions given as the mean sizes.

2. Boiler plate costs $2050.00 per tonne, calculate the cost of the plate. Do not allow for wastage

3. What is the capacity of this vessel in cubic metres? Use dimensions given.

4. Your company has a crane with a SWL of 5.0 tonnes can this crane be used to safely lift the empty vessel? Justify your answer.

m) Calculate the capacity in litres of an elliptical storage tank inside measurements, major axis 2.0 metres, minor axis 1.4 metres, and 2.4 metres long. If the storage container is to be manufactured from 10mm stainless steel with density of 7990 $kg/m^3$, using the inside measurements, calculate the mass of the empty tank. Ten millimetre stainless steel plate costs $310.00 per square metre, calculate the cost of stainless steel in the tank, disregard wastage, labour, fabricating and welding.

n) You are required to manufacture an elliptical storage vessel to hold 8 000 litres. Calculate the length of the tank if the major axis is to be 1.3 metres and the minor axis 0.8 metres.

o) Calculate the mass of a cast steel cannon ball 100mm diameter.

p) You are required to manufacture 50mm diameter steel balls to be mounted on top of RHS posts on a decorative fence. Calculate the cost to galvanise each ball if galvanising costs $1.45 per kilogram.

q) Calculate the capacity in litres of a conical tank 1.3 metres high and 0.9 metres diameter.

r) Calculate the mass of steel required to manufacture a cone diameter 2.2 metres and 3 metres vertical height from 12mm mild steel plate. Note no base in cone.

s)	Calculate the height and mass of a cone base diameter 1.8 metres and made from 6mm mild steel with a capacity of 5000 litres. The cone is to have a welded base.

 Okay, that's got to the end of that bit.

Element 2 of this unit is about costing jobs.
If you are required to do 'x' – what will it cost?

We don't need to look at the cost of the material you are working with, just the cost of the consumables, the welding electrodes, gas and wire, depending on the job. We also need to be able to calculate the time taken to complete the tasks.
Again if you get this bit wrong, your costing estimate could be too high or too low.

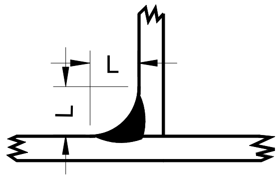
Let's look at a sample question and go from there.

*Estimate the number of 4mm satincraft electrodes and the estimated welding time to complete 12 metres of 6mm fillet weld on a structural steel member.*

The question looks simple but **there are 4 bits to working out the answer** and some tables we need to get some of the information.

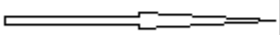
The first table is related to the type of weld. You will be given a full set of tables at the back of this unit.

**Fillet Welds**




| Size of Fillet Length (in mm) | Kilograms of weld metal required per linear metre of weld (approx.) |
|---|---|
| 3 | 0.04 |
| 5 | 0.10 |
| 6 | 0.14 |
| 8 | 0,25 |
| 10 | 0.39 |
| 12 | 0.57 |
| 16 | 1.01 |
| 20 | 1.57 |
| 25 | 2.46 |

The question refers to a 6mm Fillet weld



| Size of Fillet Length (in mm) | Kilograms of weld metal required per linear metre of weld (approx.) |
|---|---|
| 3 | 0.04 |
| 5 | 0.10 |
| 6 | 0.14 |
| 8 | 0,25 |
| 10 | 0.39 |
| 12 | 0.57 |
| 16 | 1.01 |
| 20 | 1.57 |
| 25 | 2.46 |

See from the chart we get the Kilograms of weld per linear meter.

The 6mm fillet weld has 0.14kg per linear meter.
From the question we know the weld is 12 metres so the total weld metal is:

0.14 x 12 = **1.68 kg** of weld metal

That's part 1 of the calculation; part 2 is to find out how much weld metal you will get from a single electrode.

We need another table to get the properties of the electrodes.

| Product | Size | Deposition rate kg/hr | Weld metal recovery | No of Rods per 5 kg packet | No of Grams deposited per electrode |
|---|---|---|---|---|---|
| Satincraft 13 | 3.2 | 0.92kg/hr | 56% | 140 | 20g |
| Satincraft 13 | 4.0 | 1.3kg/hr | 58% | **100** | 29g |
| Ferrocraft 22 | 3.2 | 2.0kg/hr | 59% | 90 | 33g |
| Ferrocraft 22 | 4.0 | 2.8kg/hr | 61% | 55 | 55g |
| Ferrocraft 61 | 3.2 | 1.3kg/hr | 57% | 120 | 24g |
| Ferrocraft 61 | 4.0 | 1.8kg/hr | 59% | 80 | 37g |

From the question we are given the electrodes we are to use so from the chart you will get the properties of the electrode.

*Estimate the number of* ***4mm satincraft electrodes*** *and the estimated welding time to complete 12 metres of 6mm fillet weld on a structural steel member.*


| Product | Size | Deposition rate kg/hr | Weld metal recovery | No of Rods per 5 kg packet | No of Grams deposited per electrode |
|---|---|---|---|---|---|
| Satincraft 13 | 3.2 | 0.92kg/hr | 56% | 140 | 20g |
| Satincraft 13 | 4.0 | 1.3kg/hr | 58% | **100** | 29g |
| Ferrocraft 22 | 3.2 | 2.0kg/hr | 59% | 90 | 33g |
| Ferrocraft 22 | 4.0 | 2.8kg/hr | 61% | 55 | 55g |
| Ferrocraft 61 | 3.2 | 1.3kg/hr | 57% | 120 | 24g |
| Ferrocraft 61 | 4.0 | 1.8kg/hr | 59% | 80 | 37g |


From this column you will see there are 100 electrodes per 5 kg packet.

So each rod will have a mass of $\frac{5000g}{100} = 50$ grams.

The next bit can get a bit tricky. See on this column there is a percentage (%) recovery from each electrode. This figure takes into account the wastage of each electrode. So for the electrodes we are working with you will have a 58% recovery rate. This means 58% of each 50 gram electrode.
To calculate % use your calculator, but remember to check your answer. 58% is just over half so the answer should be just over half of 50, so somewhere around 28.

On your calculator key in 50 x 58 then hit the % key.

You should get 29 grams per rod.

This is part 2 of the answer.

Now we can calculate the number of electrodes:

From part 1 we need **1.68kg of weld**

From part 2 each electrode will deposit **29 grams**.

So if we divide 1.68 kg by 29 grams we will get the number of rods.

Go back to the place value we looked at:

**1.68 kg is 16800grams**

So the calculation is $\frac{16800}{29}$ = 579 or round up to 580 electrodes. That's part 3

Part 4 is the time - back to the electrode chart

| Product | Size | Deposition rate kg/hr | Weld metal recovery | No of Rods per 5 kg packet | No of Grams deposited per electrode |
|---|---|---|---|---|---|
| Satincraft 13 | 3.2 | 0.92kg/hr | 56% | 140 | 20g |
| Satincraft 13 | 4.0 | 1.3kg/hr | 58% | **100** | 29g |
| Ferrocraft 22 | 3.2 | 2.0kg/hr | 59% | 90 | 33g |
| Ferrocraft 22 | 4.0 | 2.8kg/hr | 61% | 55 | 55g |
| Ferrocraft 61 | 3.2 | 1.3kg/hr | 57% | 120 | 24g |
| Ferrocraft 61 | 4.0 | 1.8kg/hr | 59% | 80 | 37g |

See the deposit rate per hour column.

The type of rod we are using has a deposit rate of 1.3 kg/hour.

From part 1 again we have 1.68 kg of weld metal
Deposited at a rate of 1.3kg/hr, so if we divide 1.68 by 1.3 we will get the time required in hours.

$$\frac{1.68}{1.3} = 1.29 \text{ hours to complete the weld.}$$

JOB DONE!


Guess what?

Estimate the number of 3.2mm Satincraft 13 electrodes required to weld 60metres of square edge butt weld on both sides of 3mm plate with no root gap. The time required to complete the weld.

Estimate the number of 4.0mm Ferrocraft 22 electrodes required to weld 15 metres of single vee butt weld on 12mm plate. The time required to complete the weld.

Estimate the number of 3.2mm Ferrocraft 22 electrodes required to weld a 5mm horizontal fillet weld 100 metres long on both sides. The time required to complete the weld.

Estimate the number of 4.0mm Ferrocraft 61 electrodes required complete 4 circumferential welds around a 3.5 metre diameter tank on 16mm plate using a double vee preparation. The time required to complete the weld.

The rectangular storage container drawn is to be welded using 4.0mm Ferrocraft 22 electrodes. Estimate the number of electrodes required and the time to complete the welding.

| Welding process | Average efficiency |
|---|---|
| Oxy-Acetylene Welding (OAW) | 100% |
| Gas Tungsten Arc Welding (GTAW) | 100% |
| Manual Metal Arc Welding (MMAW) | 60% |
| Gas Metal Arc Welding (GMAW) | 95% |
| Flux Cored Arc Welding (FCAW) | 88% |

| Material thickness | Type of gas | Wire diameter | Wire feed rate m/min | Gas flow rate l/min | Mass of weld deposited gr/min |
|---|---|---|---|---|---|
| 1.0 | Argoshield Light | 0.8 | 3.5 – 4.0 | 12 | 15 |
| 3.0 | Argoshield Universal | 1.0 | 4.0 – 5.2 | 15 | 28 |
| 6.0 | Argoshield Universal | 1.2 | 6.6 – 7.3 | 16 | 58 |
| 10.0 | Argoshield Universal | 1.2 | 7.0 - 7.8 | 16 | 62 |
| >10.0 | Argoshield Heavy | 1.2 | **7.5 – 8.5** | 15 | 67 |

*Estimate the mass of welding wire, volume of gas required, and the time to GMAW 20 metres of square edge butt joint with a 1.5mm root gap, welded both sides on 6mm plate.*

Square edge butt joint with a 1.5mm root gap, welded both sides
Weld process – GMAW
Length - 20 meters
Material thickness = 6 mm
Wire diameter = 1.2mm

For the weld above calculate

Time to complete weld ____________________________

Volume of gas ___________________________________

Mass of welding wire ___________________________

| Material thickness | Type of gas | Wire diameter | Wire feed rate m/min | Gas flow rate l/min | Mass of weld deposited gr/min |
|---|---|---|---|---|---|
| 1.0 | Argoshield Light | 0.8 | 3.5 – 4.0 | 12 | 15 |
| 3.0 | Argoshield Universal | 1.0 | 4.0 – 5.2 | 15 | 28 |
| 6.0 | Argoshield Universal | 1.2 | 6.6 – 7.3 | 16 | 58 |
| 10.0 | Argoshield Universal | 1.2 | 7.0 - 7.8 | 16 | 62 |
| >10.0 | Argoshield Heavy | 1.2 | **7.5 – 8.5** | 15 | 67 |

| Welding process | Average efficiency |
|---|---|
| Oxy-Acetylene Welding (OAW) | 100% |
| Gas Tungsten Arc Welding (GTAW) | 100% |
| Manual Metal Arc Welding (MMAW) | 60% |
| Gas Metal Arc Welding (GMAW) | 95% |
| Flux Cored Arc Welding (FCAW) | 88% |

Material thickness = 6 mm

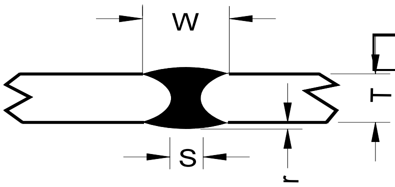
Wire diameter = 1.2mm

Length - 20 meters x 2

Weld process – GMAW

Square Edge Butt Joint

| *Joint Dimensions in mm* | | | Kilograms of weld metal required per linear metre of weld (approx.) |
|---|---|---|---|
| T | W | S | |
| 3 | 6.5 | 0 | 0.14 |
| 3 | 6.5 | 1.0 | 0.16 |
| 5 | 9 | 1.0 | 0.23 |
| 5 | 9 | 1.5 | 0.25 |
| 6 | 10.5 | 1.5 | 0.29 |
| 6 | 10.5 | 2.5 | 0.34 |




## GAS CONSUMPTION

### Welded two sides

Back to **part 1:**
Kg of weld per metre = .29 x metres to be welded 40
= 11.6 kg of weld material.

**Part 2:**
**Time to weld** = gm of weld metal required / gm of metal deposited per minute(from charts)

= 11.6 kg or 11600grams / 58

= 200 minutes or 3.3 hours

**Part 3:**
Mass of wire required = 11.6 kg x efficiency rate from chart 95%

Or 11.9 kg plus 5% added on for wastage.

= 11.6 kg x 5% = .58 waste

= 11.6 + .58

= 12.18 kg of wire.

**Part 4:**
Quantity of gas required = litres per minute x time

= 16 (from chart) x 200 (from part 2)

= 3200 litres.

See we are still doing the calculation in stages, but need slightly different information from the tables.

Finally there is a similar calculation for gas usage. One more table.

| Thickness of steel (mm) | **Tip No.** | GAS PRESSURES **kPa** | | **GAS CONSUMPTION** | | CUTTING SPEED |
|---|---|---|---|---|---|---|
| | | Oxygen | **Acetylene** | **Oxygen Litres/Min** | **Acetylene Litres/Min** | mm/Min |
| 6 | 8 | 180 | 70 | 15 | 3 | 380 |
| 12 | 12 | 200 | 70 | 32 | 4 | 330 |
| 20 | 12 | 235 | 70 | 37 | 4 | 305 |
| 25 | 15 | 180 | 70 | 54 | 4 | 250 |
| 40 | 15 | **300** | 70 | 71 | 5 | 230 |
| 50 | 15 | 350 | 70 | 86 | 6 | 180 |
| 75 | 15 | 400 | 70 | 99 | 7 | 150 |
| 100 | 20 | 350 | 100 | 141 | 8 | 150 |

Estimate the time and quantities of oxygen and acetylene required to gas cut 12 column base plates 500 x 400 from 20mm mild steel plate.

Distance to cut = perimeter of one plate x 12

= (500 + 400) x 2 x 12

= 21600mm

From chart 20mm plate cuts at 305mm per minute

Time to cut plates = $\frac{21600}{305}$

= <u>70.8 minutes</u>

From chart gas cutting 20mm plate requires 37 litres of oxygen and 4 litres of acetylene per minute.

Total oxygen = 37 x 70.8
= 2619.6 litres

Total acetylene = 4 x 70.8
= 283.2 litres

THATS IT!


Invent yourself some jobs as examples and sort out your calculations.

Remember:

- Refer to your formulas
- Write down your formula
- Insert the values you know
- Do your calculation
- Be aware of place values
- Try to keep to step by step
- Try making sentences around your numbers to show what you are doing

**Basic formulae**

**Circumference:**

Circle – $\pi \times D$ — D = diameter, R = radius

Ellipse – $\frac{\pi \times (D + d)}{2}$ — D = major axis, d = minor axis

**Surface area**:

Cone – $\pi \times R \times S$ — R = radius, S = slant height

Ellipse – $\frac{\pi}{4} \times D \times d$ — D = major axis, d = minor axis

Sphere – $4 \times \pi \times r^2$ — r = radius

**Volumes:**

Rectangular vessels – $L \times B \times H$ — L = length, B = breadth, H = height

Cylindrical vessels – $\frac{\pi}{4} \times D^2 \times H$ — D = diameter of vessel, H = height or length

Elliptical vessel – $\frac{\pi}{4} \times D \times d \times H$ — D = major axis, d = minor axis, H = height or length

Sphere – $\frac{4}{} \times \pi \times r^3$ — r = radius of sphere

Cone or pyramid – $\pi \times r^2 \times \frac{H}{3}$ — H = height

**Mass:** Hollow sphere – $D^2 \times \pi \times t$ — D = mean diameter, t = thickness

**Mass = density x volume of material in the object.**
**Mass of electrodes required = kg's of electrodes per metre x length of weld.**
**To calculate the number of electrodes = <u>Mass of electrode required</u>**

Mass of 1 electrode (remember % waste)

**Use this table to find the density of various materials.**

| MATERIAL | DENSITY | |
|---|---|---|
| | kg/m$^3$ | g/cm$^3$ |
| Water | 1000 | 1.0 |
| Steel | 7750 | 7.75 |
| Aluminium | 2720 | 2.72 |
| Brass | 8580 | 8.58 |
| Cast Iron | 7200 | 7.2 |
| Oil/Petrol | 720 | 0.72 |

**Use this table for electrode information**

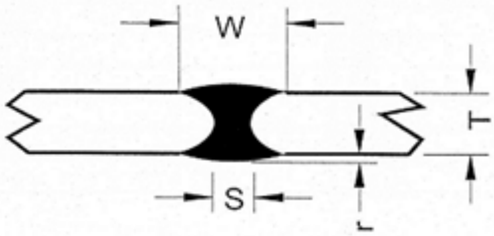
Weld metal recovery rates give an estimate as to the number of electrodes and time to complete the welding task.

| Product | Size | Deposition rate kg/hr | Weld metal recovery | No of Rods per 5 kg packet |
|---|---|---|---|---|
| Satincraft 13 | 3.2 | 0.92kg/hr | 56% | 140 |
| Satincraft 13 | 4.0 | 1.3kg/hr | 58% | 100 |
| Ferrocraft 22 | 3.2 | 2.0kg/hr | 59% | 90 |
| Ferrocraft 22 | 4.0 | 2.8kg/hr | 61% | 55 |
| Ferrocraft 61 | 3.2 | 1.3kg/hr | 57% | 120 |
| Ferrocraft 61 | 4.0 | 1.8kg/hr | 59% | 80 |

The following tables give a guide and the amount of weld metal required per metre of weld

Square Edge Butt Joint

**Welded two sides**



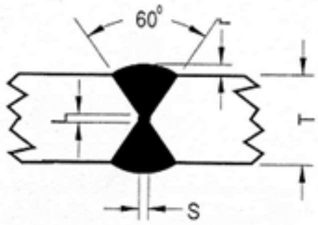

r = 2mm

| **Joint Dimensions in mm** | | | Kilograms of electrodes required per linear metre of weld (approx.) |
|---|---|---|---|
| T | W | S | |
| 3 | 6.5 | 0 | 0.23 |
| 3 | 6.5 | 1.0 | 0.26 |
| 5 | 9 | 1.0 | 0.38 |
| 5 | 9 | 1.5 | 0.41 |
| 6 | 10.5 | 1.5 | 0.48 |
| 6 | 10.5 | 2.5 | 0.56 |

Weld metal recovery rates give an estimate as to the number of electrodes and time to complete the welding task.

| **Product** | **Size** | **Deposition rate kg/hr** | **Weld metal recovery** | **No of Rods per 5 kg packet** |
|---|---|---|---|---|
| Satincraft 13 | 3.2 | 0.92kg/hr | 56% | 140 |
| Satincraft 13 | 4.0 | 1.3kg/hr | 58% | 100 |
| Ferrocraft 22 | 3.2 | 2.0kg/hr | 59% | 90 |
| Ferrocraft 22 | 4.0 | 2.8kg/hr | 61% | 55 |
| Ferrocraft 61 | 3.2 | 1.3kg/hr | 57% | 120 |
| Ferrocraft 61 | 4.0 | 1.8kg/hr | 59% | 80 |

Double Vee Butt Joints
**Welded two sides**

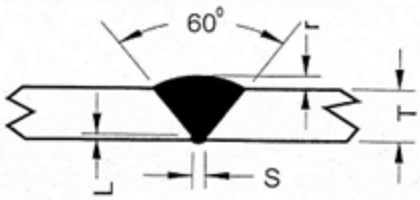



| Joint Dimensions in mm | | | Kilograms of electrodes required per linear metre of weld (approx.) |
|---|---|---|---|
| T | L | S | |
| 12 | 1.5 | 1.5 | 0.92 |
| 16 | 1.5 | 1.5 | 1.46 |
| 20 | 1.5 | 1.5 | 2.12 |
| 25 | 3.0 | 3.0 | 3.33 |

Weld metal recovery rates give an estimate as to the number of electrodes and time to complete the welding task.

| Product | Size | Deposition rate kg/hr | Weld metal recovery | No of Rods per 5 kg packet |
|---|---|---|---|---|
| Satincraft 13 | 3.2 | 0.92kg/hr | 56% | 140 |
| Satincraft 13 | 4.0 | 1.3kg/hr | 58% | 100 |
| Ferrocraft 22 | 3.2 | 2.0kg/hr | 59% | 90 |
| Ferrocraft 22 | 4.0 | 2.8kg/hr | 61% | 55 |
| Ferrocraft 61 | 3.2 | 1.3kg/hr | 57% | 120 |
| Ferrocraft 61 | 4.0 | 1.8kg/hr | 59% | 80 |

**Single vee butt joint**



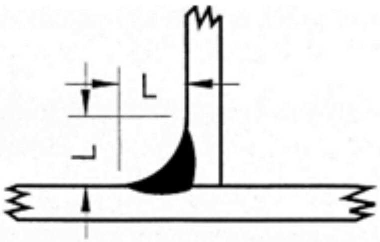

r = 2mm

| Joint Dimensions in mm | | | Kilograms of electrodes required per linear metre of weld (approx.) |
|---|---|---|---|
| T | L | S | |
| 6 | 1.5 | 1.5 | 0.39 |
| 8 | 1.5 | 1.5 | 0.63 |
| 10 | 1.5 | 1.5 | 0.87 |
| 12 | 3 | 3 | 1.33 |
| 16 | 3 | 3 | 2.22 |
| 20 | 3 | 3 | 3.37 |
| 25 | 3 | 3 | 5.14 |

Weld metal recovery rates give an estimate as to the number of electrodes and time to complete the welding task.

| Product | Size | Deposition rate kg/hr | Weld metal recovery | No of Rods per 5 kg packet |
|---|---|---|---|---|
| Satincraft 13 | 3.2 | 0.92kg/hr | 56% | 140 |
| Satincraft 13 | 4.0 | 1.3kg/hr | 58% | 100 |
| Ferrocraft 22 | 3.2 | 2.0kg/hr | 59% | 90 |
| Ferrocraft 22 | 4.0 | 2.8kg/hr | 61% | 55 |
| Ferrocraft 61 | 3.2 | 1.3kg/hr | 57% | 120 |
| Ferrocraft 61 | 4.0 | 1.8kg/hr | 59% | 80 |

**Fillet Welds**




| Size of Fillet Length (in mm) | Kilograms of electrodes required per linear metre of weld (approx.) |
|---|---|
| 3 | 0.06 |
| 5 | 0.16 |
| 6 | 0.24 |
| 8 | 0,42 |
| 10 | 0.65 |
| 12 | 0.95 |
| 16 | 1.68 |
| 20 | 2.62 |
| 25 | 4.10 |

| Welding process | Average efficiency |
|---|---|
| Oxy-Acetylene Welding (OAW) | 100% |
| Gas Tungsten Arc Welding (GTAW) | 100% |
| Manual Metal Arc Welding (MMAW) | 60% |
| Gas Metal Arc Welding (GMAW) | 95% |
| Flux Cored Arc Welding (FCAW) | 88% |

**Gas Cutting**

The quantity of gas consumed in cutting operations can be calculated (estimated) using tables. These tables give the recommend tip size, gas pressures, gas consumption and cutting speed for a given thickness of steel.

Gas Cutting Chart (using acetylene)

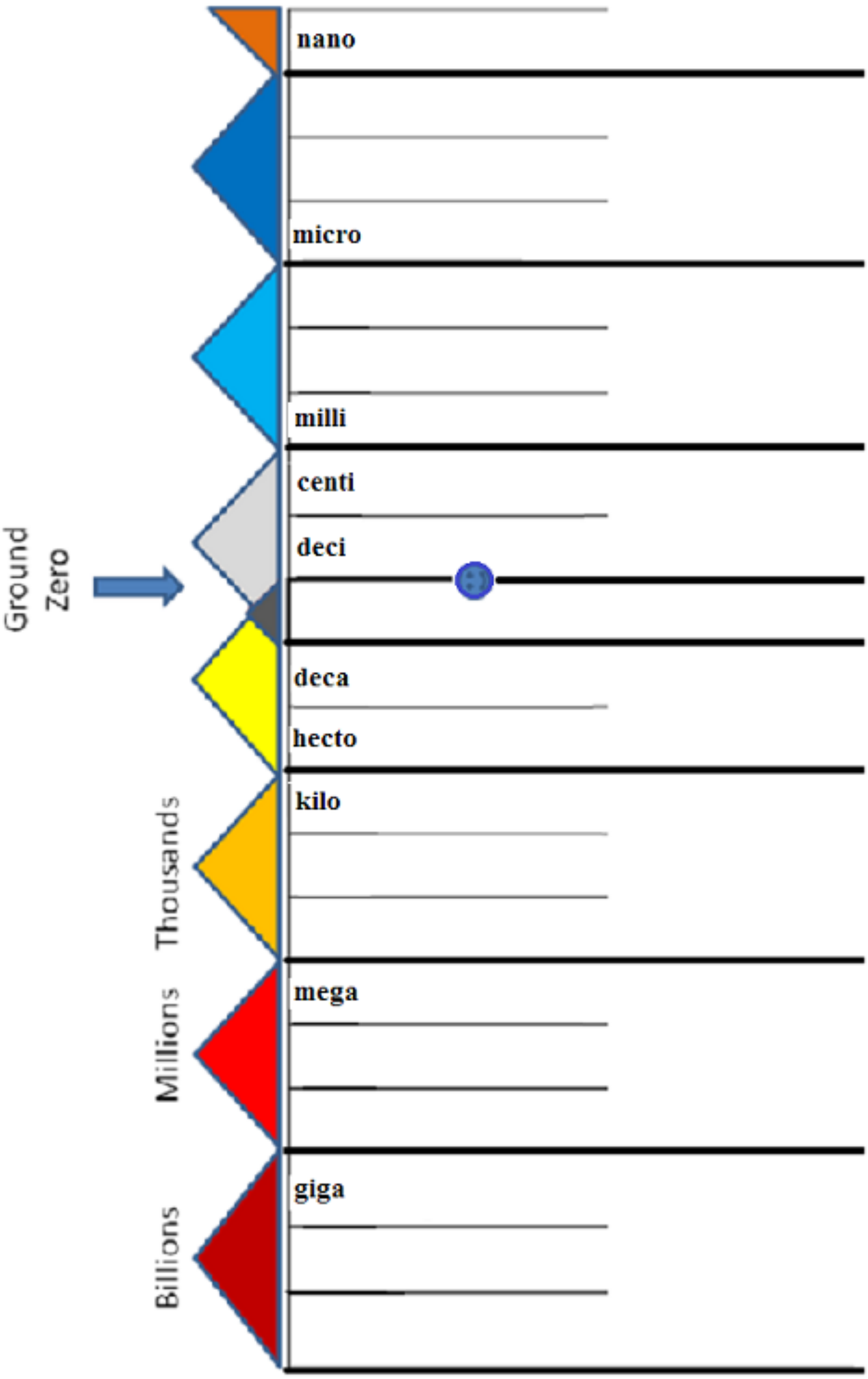
| Thickness of steel (mm) | Tip No. | GAS PRESSURES kPa | | GAS CONSUMPTION | | CUTTING SPEED |
|---|---|---|---|---|---|---|
| | | Oxygen | Acetylene | Oxygen Litres/Min | Acetylene Litres/Min | mm/Min |
| 6 | 8 | 180 | 70 | 15 | 3 | 380 |
| 12 | 12 | 200 | 70 | 32 | 4 | 330 |
| 20 | 12 | 235 | 70 | 37 | 4 | 305 |
| 25 | 15 | 180 | 70 | 54 | 4 | 250 |
| 40 | 15 | 300 | 70 | 71 | 5 | 230 |
| 50 | 15 | 350 | 70 | 86 | 6 | 180 |
| 75 | 15 | 400 | 70 | 99 | 7 | 150 |
| 100 | 20 | 350 | 100 | 141 | 8 | 150 |

**Gas metal arc welding (GMAW)**

The quantity of gas consumed, quantities of wire required and time involved can be calculated (estimated) using tables.

**Gas Metal Arc Welding Chart**
**Mild steel downhand position allowing for 95% efficiency**

| Material thickness | Type of gas | Wire diameter | Wire feed rate m/min | Gas flow rate l/min | Mass of weld deposited gr/min |
|---|---|---|---|---|---|
| 1.0 | Argoshield Light | 0.8 | 3.5 – 4.0 | 12 | 15 |
| 3.0 | Argoshield Universal | 1.0 | 4.0 – 5.2 | 15 | 28 |
| 6.0 | Argoshield Universal | 1.2 | 6.6 – 7.3 | 16 | 58 |
| 10.0 | Argoshield Universal | 1.2 | 7.0 - 7.8 | 16 | 62 |
| >10.0 | Argoshield Heavy | 1.2 | 7.5 – 8.5 | 15 | 67 |



nano
micro
milli
centi
deci
Ground Zero
deca
hecto
kilo
Thousands
mega
Millions
giga
Billions