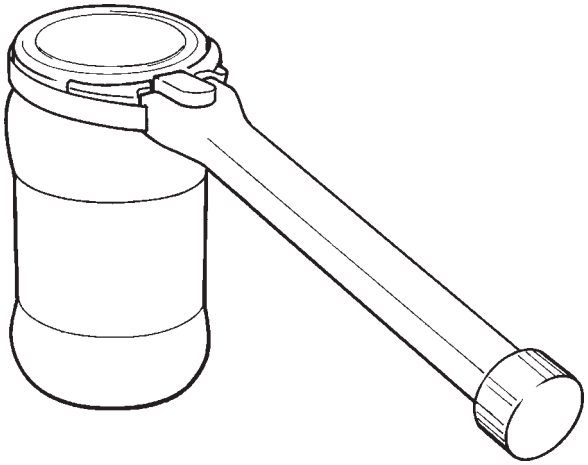
"EASY OPEN" JAR CLAMP

Many chemists sell a device like this to grip the lid of a jar.
Old or infirm people can use it to unscrew a lid if their hands are not strong enough.



MATHS/SCIENCE OPPORTUNITY

Working out mechanical advantage

But there is a problem...

Dear Sir/Madam

Just yesterday I bought one of your jar openers. You see, I have arthritis and find it very painful to grip things. At the moment I ask a neighbour to loosen all the lids when I buy anything in jars. I hoped that your jar opener would help to make me independent.

I have had to return it to you and I was hoping that you would give me back my money (the shop would not take it back as it was not defective). You see, the problem is that I need both hands to grip the lid and so have no way of holding the jar.

Your sincerely,

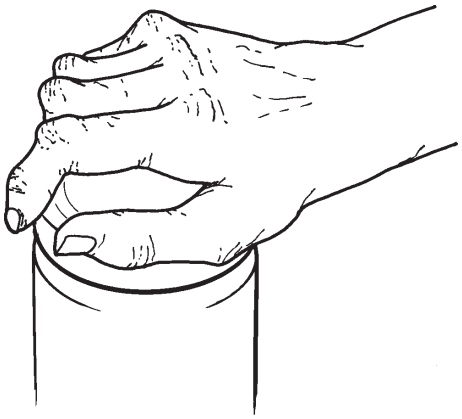
Mrs.G.Rashan.

The Managing Director of 'Easy Open' household tools has received the above letter. She has decided to commission a number of research teams to see if the company can manufacture a cheap clamping device to hold a jar firmly whilst it is being opened.

YOUR TASK

DESIGN BRIEF

Design an automatic clamp. It has to hold jam jars in place on a table top or kitchen work surface. You are supplied with an example jar opener and do not need to design this.



DESCRIBING YOUR TASK

DESIGN SPECIFICATION

First you need to draw up a specification for your clamp. A specification is a more detailed description of what a product will be like, what it will do and who will use it. Here are some questions to help you produce the clamp specification:

- Who will use the clamp?
- What size jars will it hold?
- How is it attached to the table?
- What should it cost?
- Are there any special safety precautions to take?

WHAT YOU HAVE TO WORK WITH

DESIGN CONSTRAINTS

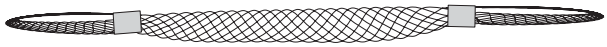
(a) **As your power source you will be using new air muscle technology** (see below). This has been chosen for low cost and safety.

(b) You may use any materials commonly found in the workshop, but bear in mind that the final product will have to be produced cheaply.

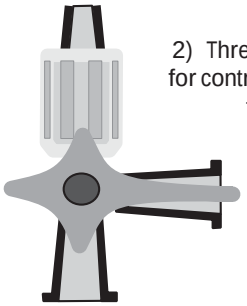
Later you will have to decide which parts will have to be made of metal and which of plastic when it is mass produced. It is no good making a large and intricate section of wood if this cannot be made of anything else for mass production.

THE SHADOW AIR MUSCLE KIT

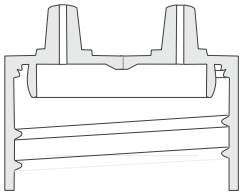
You are supplied with the following equipment for powering the clamp...



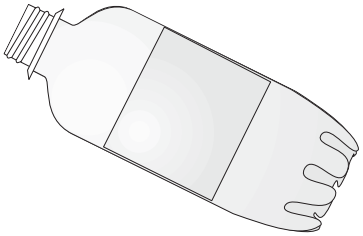
1) Air muscle which can be attached directly by hooking the loops over a bolt or peg, or indirectly with cable ties for adjustment.



2) Three way valve for controlling the air flow.

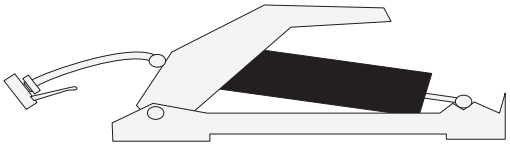


3) Bottle cap adapter for attaching an air reservoir.



4) Fizzy drinks bottle to be used as the air reservoir.

5) Footpump adapter for connecting the footpump to the 3 mm air line.

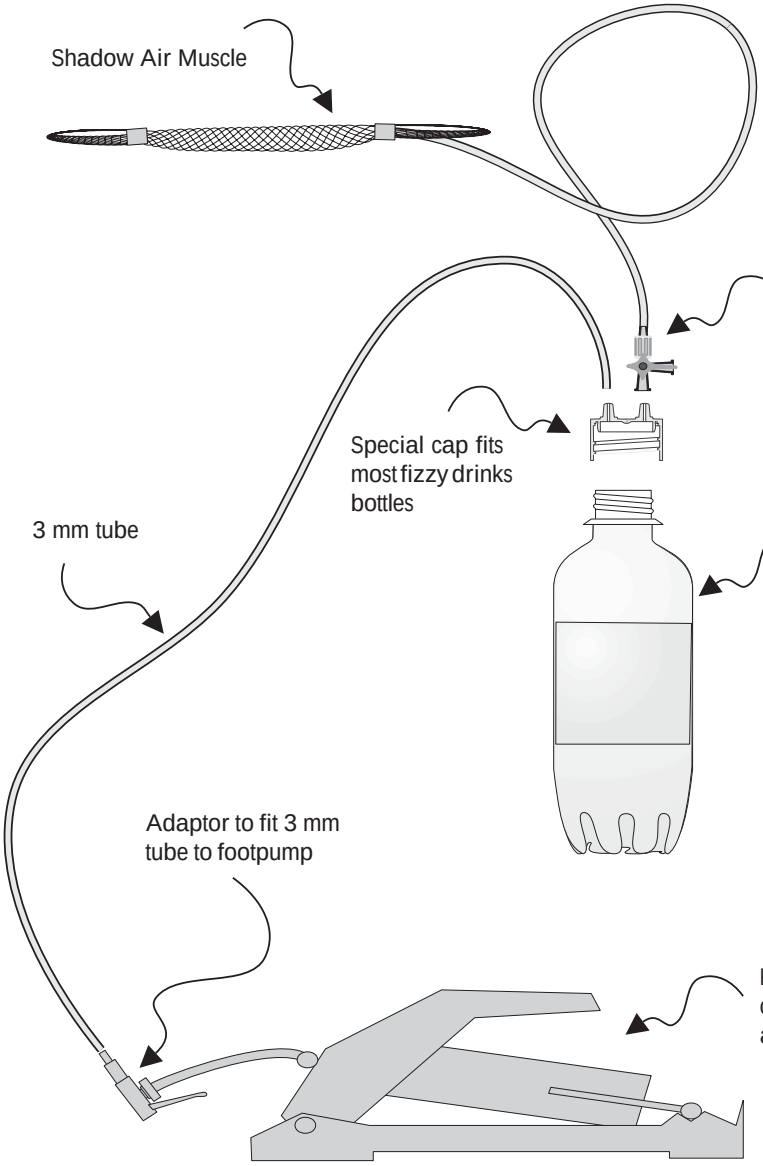


6) Foot- pump for charging the reservoir.

7) Tee piece, in case you want to connect one footpump to more than one system.

8) A length of 3 mm air line which can be cut and push fitted into the other components.

This is how they all fit together...



NOTE

The air muscle system is available either as a complete pack or as component parts.

MATHS/SCIENCE OPPORTUNITY

Why does the reservoir heat up during pumping?

NOTE

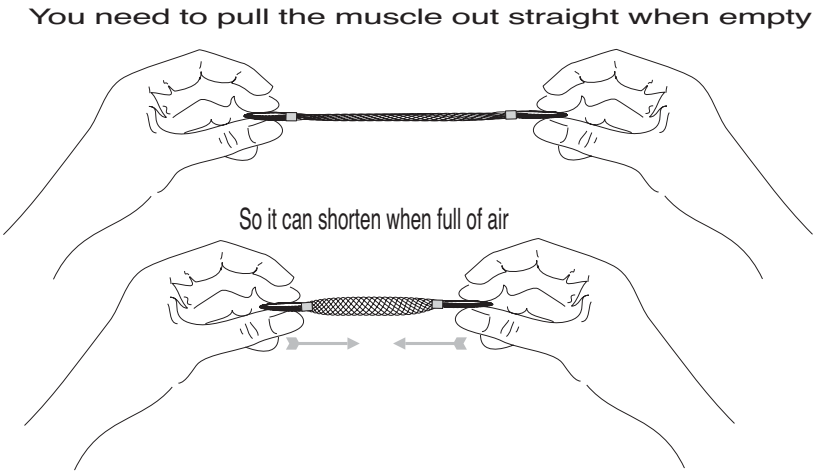
How is pressure measured? What is the relationship between pump piston diameter, force applied and air pressure? See Study File 10 (Crank Slider).

IMPORTANT - AIR MUSCLE SAFETY

- Wear goggles during prototype work.
- Never connect a fizzy drinks bottle to an air compressor or air line.
- Do not pressurise glass bottles.
- Never use a bottle larger than 400 ml.
- Do not put your finger over the end of a tube or nozzle to stop air coming out.
- Never unscrew the bottle top or pull off a valve or fitting when there is compressed air in the system.

ASSEMBLY

You can cut the 3 mm air line with scissors. It is then simply pushed onto the special cap and onto the foot pump adapter. Obviously , you will need to have the air line long enough to reach down to the foot pump on the floor.



THE STRENGTH OF AN AIR MUSCLE

Test the strength of your friends...

1) Make sure that the muscle is empty.
2) Pump up the reservoir until the bottle starts to become rigid.
3) Get your friend to try to stretch the muscle.
4) Now open the valve to the muscle.
5) The muscle will contract whether your friend likes it or not!

GUIDELINES FOR ATTACHING AIR MUSCLES

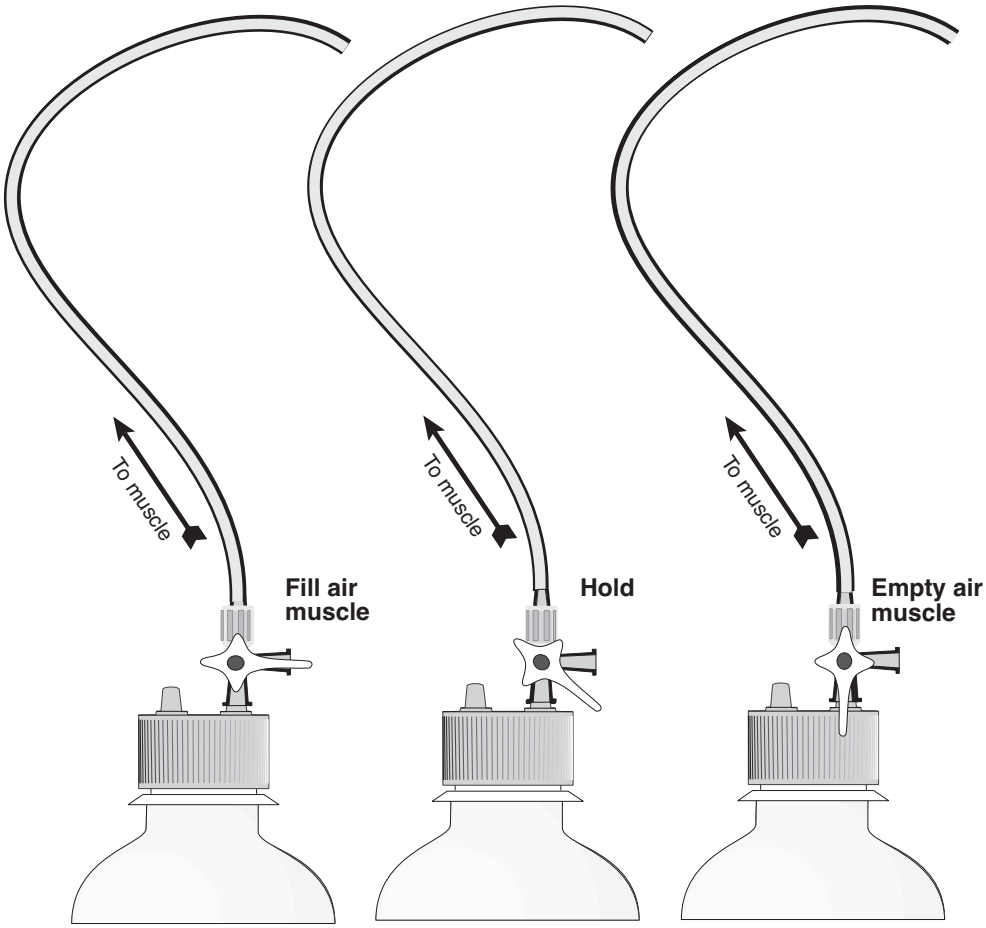
1) Make sure the muscle is pulled taut. If the muscle is slack, the rubber tube inside will expand without having any effect.

   It may be necessary to use a spring or elastic band to pull against the muscle. Do not worry about pulling too hard on the muscle; they are very strong (the larger sizes can pull over a quarter of a ton).

2) You should pump up the reservoir until it is quite rigid. It will feel hard.

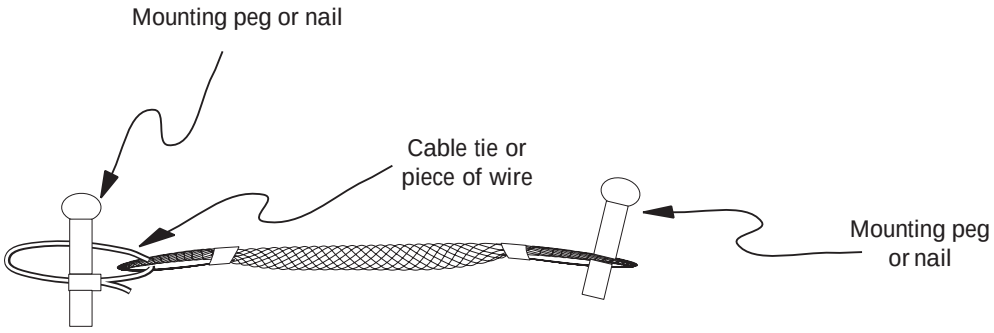
3) The three way valve can be used to fill the muscle from the reservoir and to empty it to the outside. (See below)

   Note: it is quite easy accidentally to vent the reservoir to the atmosphere, in which case you will have to pump it up again! This happens if you turn the white lever towards the muscle.



WAYS TO CONNECT THE AIR MUSCLE

The air muscle can be connected to any kind of peg or spindle, but care must be taken to ensure that no moving parts are rubbing on anything. The peg could simply be a nail or bolt screwed into the surface. Instead of connecting the air muscle directly, it can be attached with a cable tie or length of wire. This allows fine adjustment if the muscle is too slack and is a good idea for the first model. The muscle will contract about 20% if it is at full stretch to start with.



OTHER EQUIPMENT YOU WILL NEED

Besides the air muscle kit and the workshop tools, you will need a jar as an example and a commercial jar opener. In addition, you will need a way of estimating the strength of an old person. One way is to get someone to pull on a forcemeter or spring balance. Alternatively, you could get them to press on different sizes of bulldog clip to see which ones they could press. Does anyone in your group know an older person who could help?

GUIDELINES ON DESIGNING AND MAKING A CLAMP

The two key points are how the jar is gripped and how gripper is held.

1) Holding the clamp

(a) The clamp could have a handle that is held in one hand. An arthritic person would need a lot of leverage, so perhaps a long handle may be necessary. You will have to experiment.

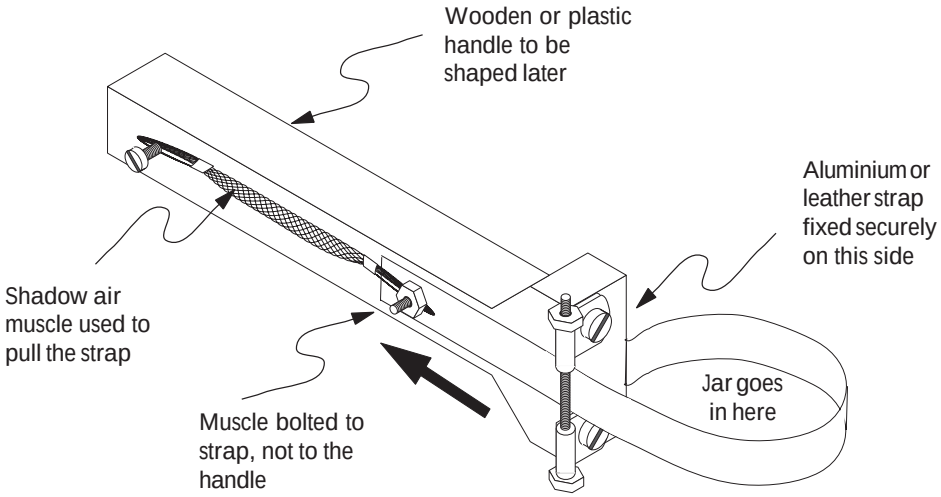
(b) A G-cramp arrangement or some kind of screw attachment. But if the user is too weak to grip the jar, he or she will probably be too weak to tighten up the G-cramp!

One idea is to have a large knob on the G-cramp -- in fact the same size as a jar... That way the jar opener can be used to fix the clamp to the table!

(c) A second digit muscle could operate a clamp at the same time that the jar holding muscle is filled. You will need either two muscle kits or a tee piece fitted to the air line so that you can fill both the muscles at once. The forces needed to grip a table are very large, so the muscle will need a great deal of leverage.

(d) The device could simply be screwed down to the table. This might require a neighbour or relative, but would be secure once fitted.

2) Holding the jar (1)

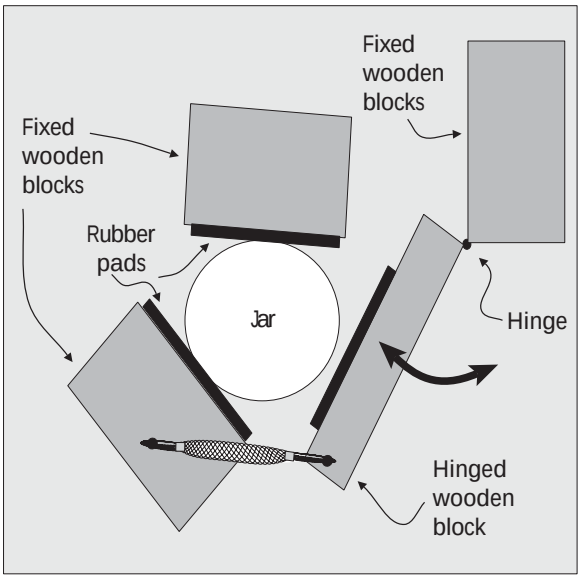


Note: If a metal strap is used, it should be lined with rubber or similar material for grip

This device is hand held and works by tightening a metal or leather belt around the jar. If this device is to work with different sizes of jar, some kind of adjustment will be needed. For example, several screws could be added for the rear attachment of the muscle. For a different size of jar, the muscle would be unhooked and attached to a different screw.

2) Holding the jar (2)

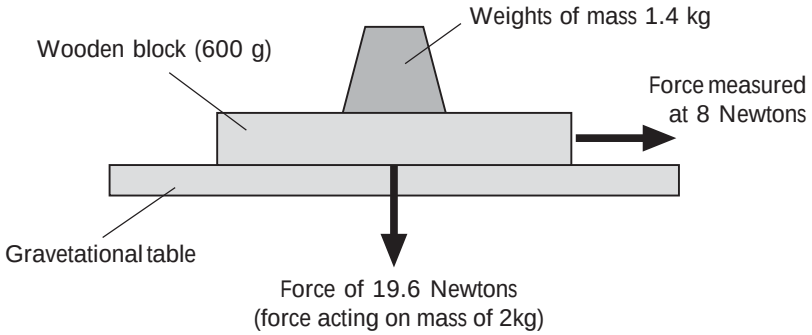
This device is a table mounted clamp that uses the muscle to force the jar into a wedge. The hinge is a simple door hinge and the rest of the pieces are wooden blocks. The blocks have had a rubber pads attached for a secure grip. The whole device is screwed down onto a solid baseboard.



NOTES ON FRICTION

No surface is completely flat. There are small bumps and ridges that will be worn away if two surfaces are rubbed together. As the surfaces pass over each other, these bumps will collide (and break off) and will be felt as a resistance called friction. That is why your shoes grip, but this is also how they manage to gradually wear down. The friction between two surfaces depends on the strength of the force pushing them together and the properties of the materials. Rubber, for example, is soft enough to squeeze into the crevices and gaps and can easily get stuck in another material and so grips strongly. Stone starts very rough, but will gradually smooth off with wear and so becomes more slippery. For example...

NOTE
See Study File 13 (Friction)



These two pieces of wood were held together by resting a weight on top. One was dragged along and the force was measured. Gravity pulls down a 2 kg mass with a force of 19.6 Newtons. When we drag the block, we need a force of about 8 Newtons. We say that for these two surfaces, the coefficient of friction is 0.4 . Designing your clamp will involve getting the greatest possible force gripping the jar with the highest coefficient of friction. This frictional force is (8/19.6 = about 0.4) of the force between the surfaces.

EVALUATING THE CLAMP

When your group has finished designing, making and testing your jar clamp, you have to assess it and submit a formal report. You should answer at least the following questions in your report...

(i) Did the device require any hand strength?

(ii) Was the device easy to set up?

(iii) Was the device secure and strong?

(iv) Would it be easy to manufacture? What redesign would be necessary?

(v) If your clamp did not work very well, what was the main problem ? Should the air muscle technology be pursued, or is it inappropriate here?

Your report should include a drawing of your device. If possible you should trial the clamp under realistic conditions e.g. a kitchen.