HIGHER ENGINEERING SCIENCE

Pneumatic Engineering

Name ______________________________

Class ______________________________

Teacher ____________________________

Ellon Academy
Technical Faculty

Learning Intentions

- To know what Pneumatic Systems are and how they are used
- To know how to be safe when using pneumatics
- To know what cylinders are and how they are used
- To know what a valve is and how it is used
- To know how to create pneumatic circuits to complete every day tasks

Success Criteria

1 **Investigate a range of complex mechanisms and structures by:**

- Describing and producing diagrams of a range of complex pneumatic mechanisms

2 **Develop mechanical solutions to solve complex problems by:**

- Identifying key aspects of the problem
- Applying knowledge and understanding of mechanisms
- Designing mechanisms
- Simulating or building mechanisms
- Testing and evaluating solutions

To access video clips that will help on this course go to **www.youtube.com/MacBeathsTech**

Pneumatic Systems

Pneumatics is something that you probably know very little about yet come across everyday without ever realising it. Some examples are shown below.

Pneumatics are used a lot in industry and you would expect to see pneumatics systems in factories, production lines and processing plants. It can be used to do lots of different jobs such as moving, holding or shaping objects.

Every one of these pneumatic systems makes use of compressed air.

In the classroom you are supplied with compressed air through a ***manifold.*** The manifold lets you connect lots of components to the compressed air.

Safety Rules

Safety rules help keep us safe. The highlight dangers and this helps to prevent accidents.

When we are using pneumatics we must follow these rules.

1. Never blow compressed air at anyone, not even yourself
2. Never let compressed air come into contact with your skin, as this can be very dangerous.
3. Always wear safety goggles when you are connecting and operating circuits.
4. Check that all airlines are connected before turning on the main air supply.
5. Always turn off the main air supply before changing circuit.
6. Keep you hands away from moving parts.
7. Avoid having airlines trailing across the floor or where someone could trip or become entangled.

Advantages of Pneumatic Systems

- **Clean**
  Pneumatic systems contain air, so a leak doesn't cause mess. Hydraulic systems contain oil, so leaks are messy, making them unsuitable for clean environments such as food factories.

- **Safe**
  Pneumatic systems don't produce sparks so there is no fire or explosion hazard. Compressed air, unlike oil or high voltage electricity, does not create any major environmental or accident hazard. Compared with electrical systems, pneumatic systems have an extremely high safety record. However they must still be treated responsibly. See the Safety section for more information.

- **Dependable**
  Pneumatic components are relatively simple and contain few moving parts. This means that they tend to last a long time and are generally easy to maintain. A pneumatic cylinder provides the simplest source of linear movement and force. It will operate continuously in a fast-cycling machine that is required to run 24 hours a day, seven days a week.

- **Available**
  The basic raw material is air which is available everywhere. Compressors can easily be made portable. Compressed air can be transported through piping over considerable distances, whereas each piece of hydraulic equipment in a factory generally needs its own power pack.

Disadvantages of Pneumatic Systems

- Small Forces

  Pneumatic components produce relatively small forces. Whenever large forces are required, hydraulic systems are used.
  Hydraulic systems contain liquid which, unlike air, cannot be compressed. This means they can create large forces, and that the force and speed of movement are more controllable.

- Not Energy Efficient

  Compared with an electrical system, a pneumatic system is not very energy-efficient.
  A lot of energy is converted in the production of compressed air at the input end of the system, compared with the amount of energy finally converted into movement at the output end of the system.

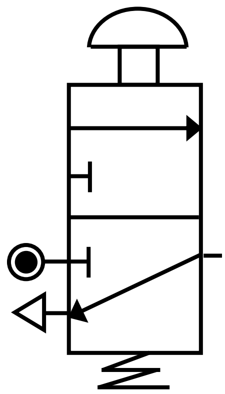
Components

The equipment you will use in this area of engineering can be split up into two basic categories - cylinders and valves.

Cylinders are the 'muscles' of pneumatic systems as they are used to move, hold or lift objects, or even used to operate other pneumatic components. Cylinders are operated by compressed air and they covert the stored energy in the compressed air into linear motion.

Valves are used to control the flow of compressed air to a cylinder. They can be used to either turn the air on or off, change the direction in which the air is flowing, or even slow down the airflow.

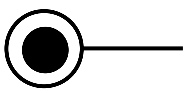
3/2 Valves



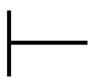
This component is known as a 3/2 valve – or to be specific a 'Push Button actuated, Spring Return, 3/2 Valve'. It gets its name because it has 3 ports (3 connections),and 2 states (on or off).

A port is where we can connect a pipe. In this example, our 3 ports are:

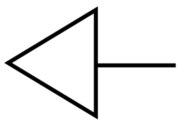
Port 1 – Mains Air



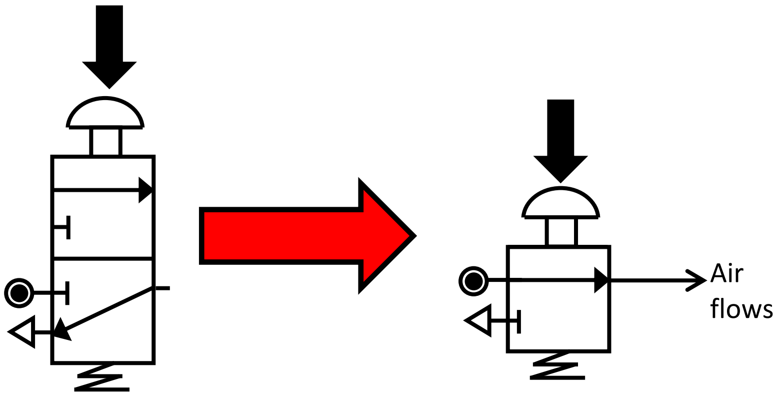
Port 2 – Output Connections



Port 3 – Exhaust Air

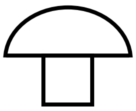


For this 3/2 valve to work the push button actuator is pressed. When this is pressed, imagine that the top square gets pushed down. This will then replace the bottom section and connect the mains air to the output, allowing air to flow. When the button is released, the spring return actuator will push it back up, reconnecting the output to the exhaust, stopping air from flowing.

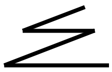


Actuators

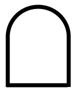
Actuators are what will switch the valve on or off. A number of different ways we can operate a 3/2 valve.



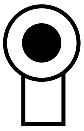
Push Button



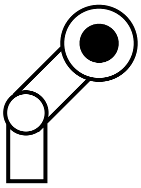
Spring



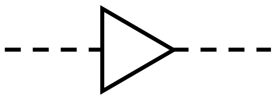
Plunger



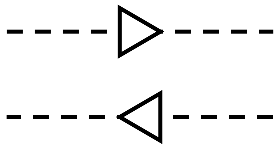
Roller



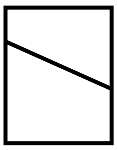
Roller Trip



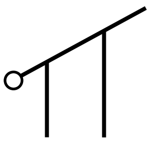
Pilot Air



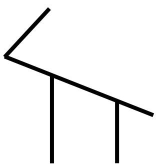
Diaphragm



Solenoid



Lever

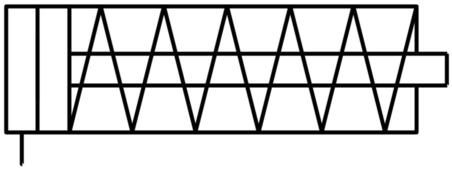


Foot Pedal

When naming a component you have to state its FULL name – that means stating what actuators are used. For example a 'Roller Trip Actuated, Spring Return 3/2 Valve'. Look at the top and bottom of the valve to see what actuators are used.

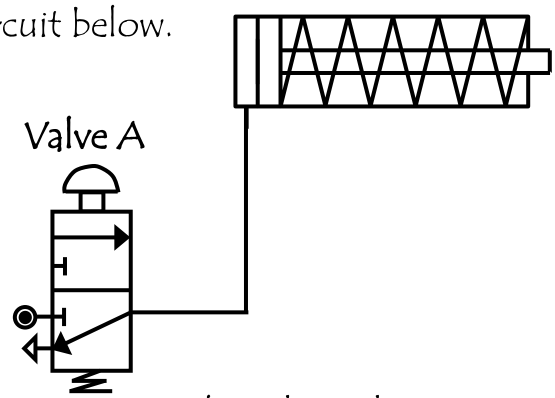
Single Acting Cylinder

A Single-acting cylinder requires only one air supply for it to work. When air is put into the cylinder, it will 'outstroke'. If the air stops, it will 'instroke'. It will do this automatically, due to the spring being in place forcing it back.



This can then be connected to other components to create movement.

Task 1
Build and test the circuit below.



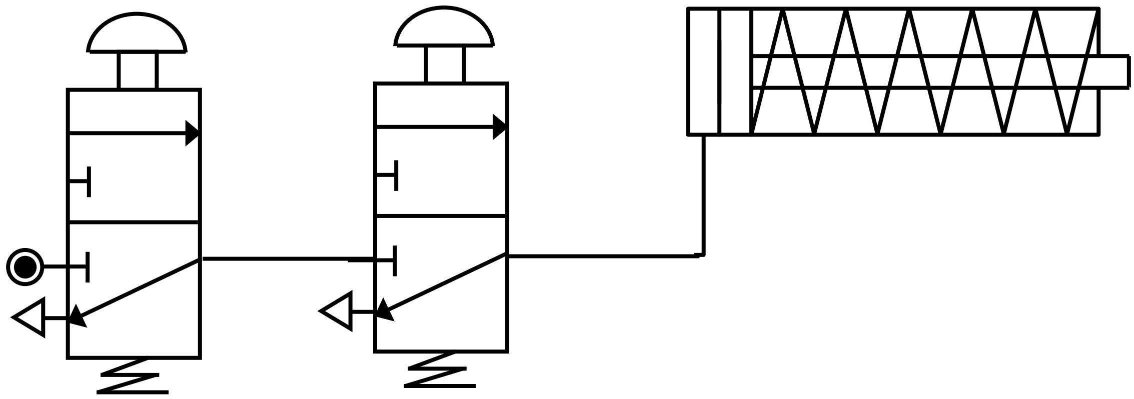
Explain using the correct terminology how this circuit works.

Task 2
Build this circuit using the Airways software. Open unit 2 and select task 2.1.

Logic Control with Pneumatics

AND Control

A simple circuit like the one previous can also be expanded to create a pneumatic version of an AND gate. By adding another push button 3/2 Valve, the first AND second valves needs to be pressed for the single acting cylinder to outstroke.



Task 3

a) Using the Pneumatic components available, build and test an AND circuit.

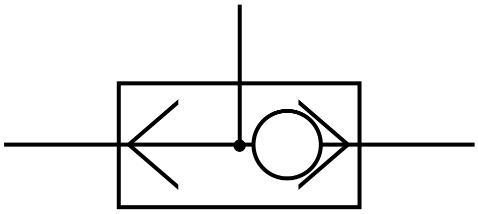
Attach a photo of the circuit below

b) Complete a truth table for this circuit and describe, using the appropriate terminology, how the circuit works.

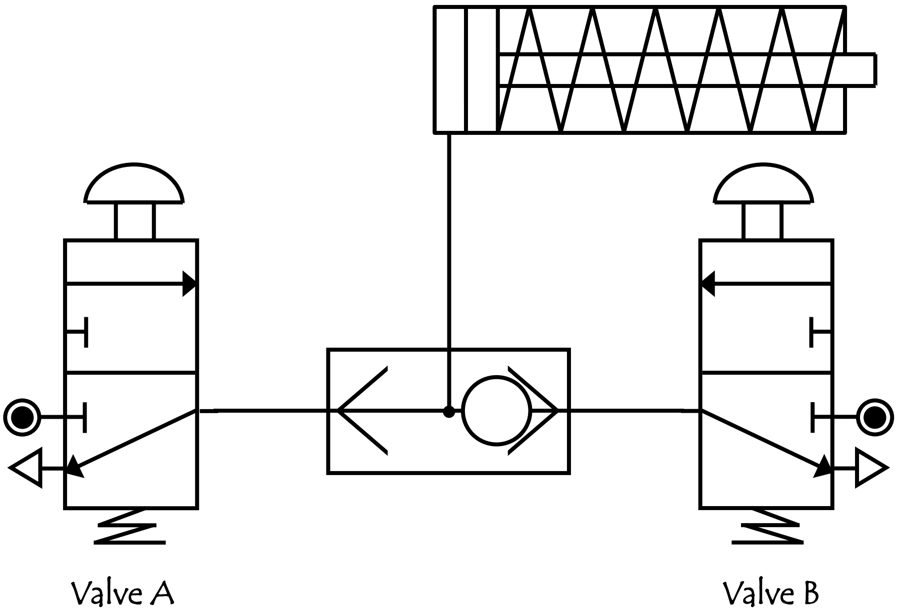
A	B	Z
0	0	0
0	1	1
1	0	1
1	1	1

OR Control

OR Gate control is also possible with 3/2 valves and a single acting cylinder. This is useful as sometimes we need to control a pneumatic circuit from more than one position. To do this we need to use another component called a shuttle valve.



A shuttle valve is used to change the direction of air in a circuit. A small ball inside the component gets blown from side to side allowing air to pass through to the cylinder.



If Valve A <u>OR</u> Valve B is pressed it will cause the Single Acting Cylinder to outstroke. Once the buttons are released, it will instroke.

Task 4

a) Using the Pneumatic components available, build and test an OR circuit below

Attach a photo of the circuit below

b) Complete a truth table for this circuit and describe, using the appropriate terminology, how the circuit works.

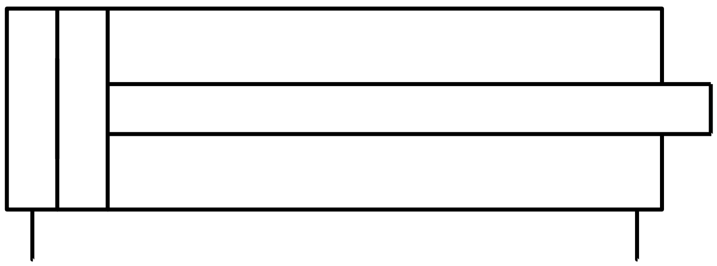
A	B	Z
0	0	0
0	1	0
1	0	0
1	1	1

Task 5

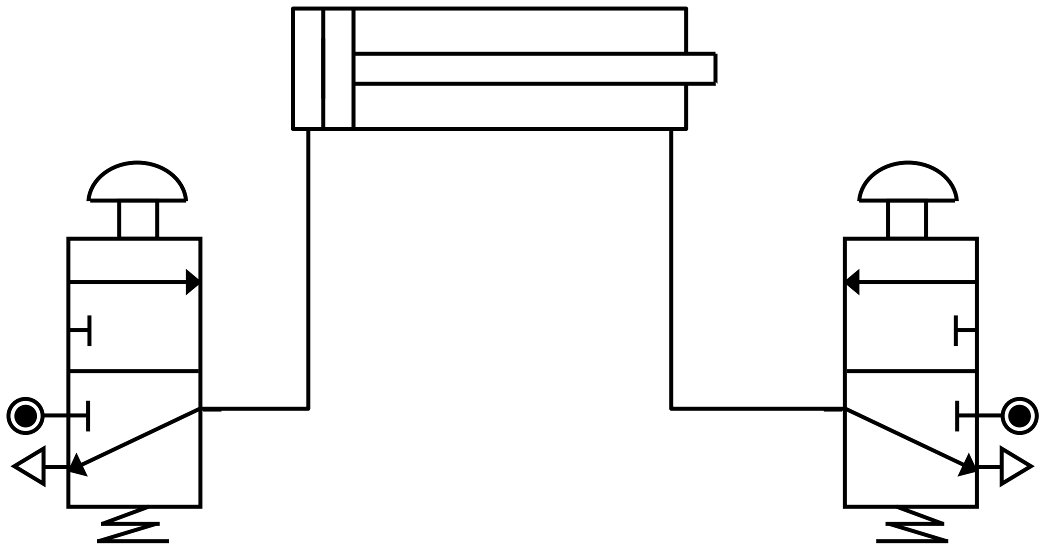
Using the Airways software open unit 4 and complete task 4.3

Double Acting Cylinder

Unlike a Single Acting Cylinder, It does not have a spring inside to return it to its original position. Instead it has 2 air supplies – one that will Cause it to outstroke, and another that will cause it to instroke.



As a push button, spring return 3/2 valve (Valve A) is pressed the double acting cylinder outstrokes. Once the other the other push button, spring return 3/2 valve (Valve B) is pressed, the cylinder will instroke.



Valve A

Valve B

Task 6

a) Using the Pneumatic components available, build and test a double acting cylinder circuit

Attach a photo of the circuit below

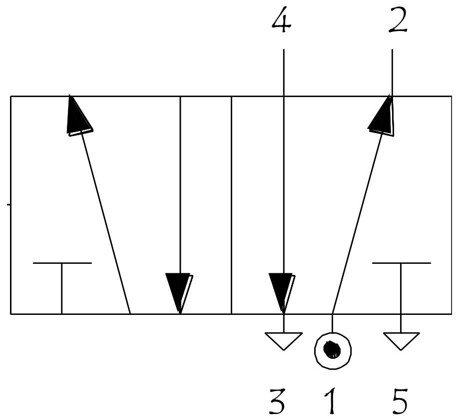
b) Explain using the correct terminology how this circuit works.

Task 7

Using the Airways software open unit 3 and read through task 3.1

5/2 valve

There are many problems when controlling a double acting cylinder with 2 3/2 valves, with the main one being that after you have actuated the 3/2 valve, it returns to the off state and therefore the air is no longer being supplied to the cylinder. This means the pressure will have dropped and it can be moved easily by hand.

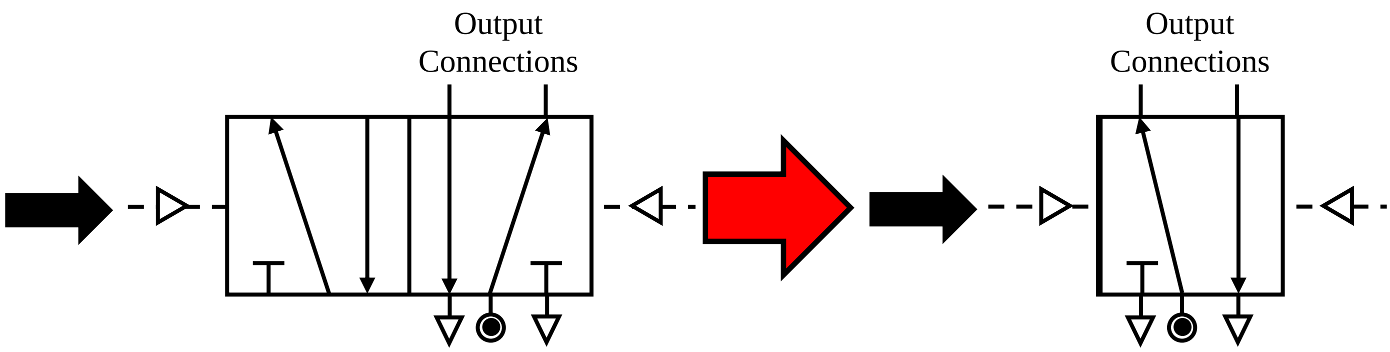


Another disadvantage is that the 3/2 valve needs to be actuated until the cylinder is fully out/in stroked. Releasing the valve will mean the piston will stop short of its final position.

We have greater control over a double-acting cylinder if we control its out/in stroke with a 5/2 valve.
The ports are numbered in the same way as a 3/2 valve except there are 2 exhaust ports and 2 output connections.

A 5/2 Valve is usually actuated by Pilot air, as shown by a dashed line. Pilot air is a short burst of air that will activate the valve.

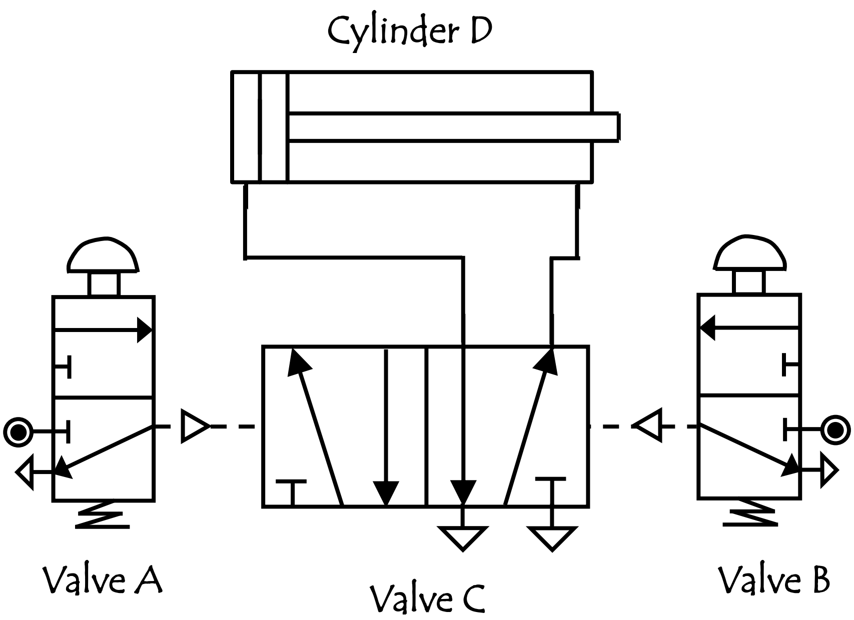
If air is supplied from this side it will connect using that sides connections, sending output air to the right hand side output connection, and allowing air to come in from the other output, going straight through to the exhaust.



If the air is supplied from the other side, that side of the valve 'slides' over and creates new connections to the output, mains air and exhausts. This means that air will now be supplied to the left hand output connection, and air can come back into the valve through the right connection, and into the exhaust.

Task 8

a) Using the Pneumatic components available, build and test the circuit below



Task 8 Continued)

b) Take a photo of your model and glue to the space below

c) Explain using the correct terminology how this circuit works.

http://www.bbc.co.uk/schools/gcsebitesize/design/systemscontrol/pneumaticsrev1.shtml

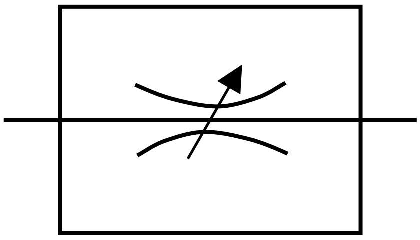
Task 9

Using the Airways software open unit 3 and complete task 3.2

Speed Control

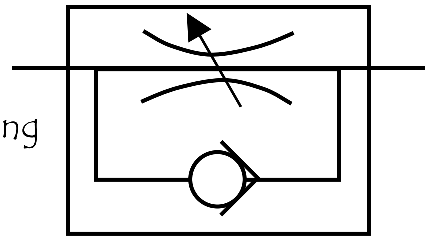
So far every circuit we have looked at cause the pistons to move very quickly. In a real world situation this could be very dangerous, or could even cause the circuit to stop working correctly. To solve this problem we can use certain components to control the flow of air through the valves.

One way of doing this is using a **restrictor**.

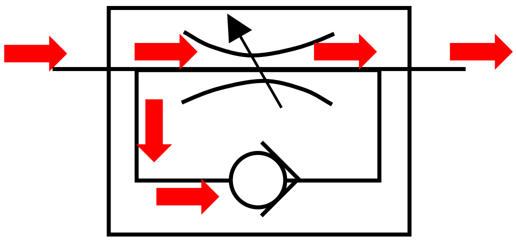


This will slow down the air in both directions, meaning it will slow the down instroke and the outstroke. This is essentially like a screw going into the wire. If the screw is tightened it gives a smaller area for the air to get through, hence slowing it down.

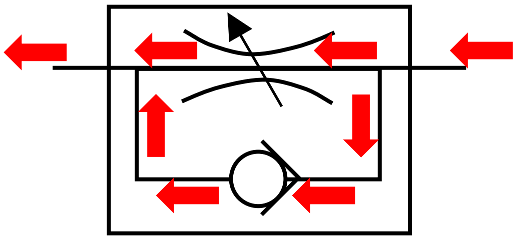
The other way of controlling speed is by using a **unidirectional restrictor**.



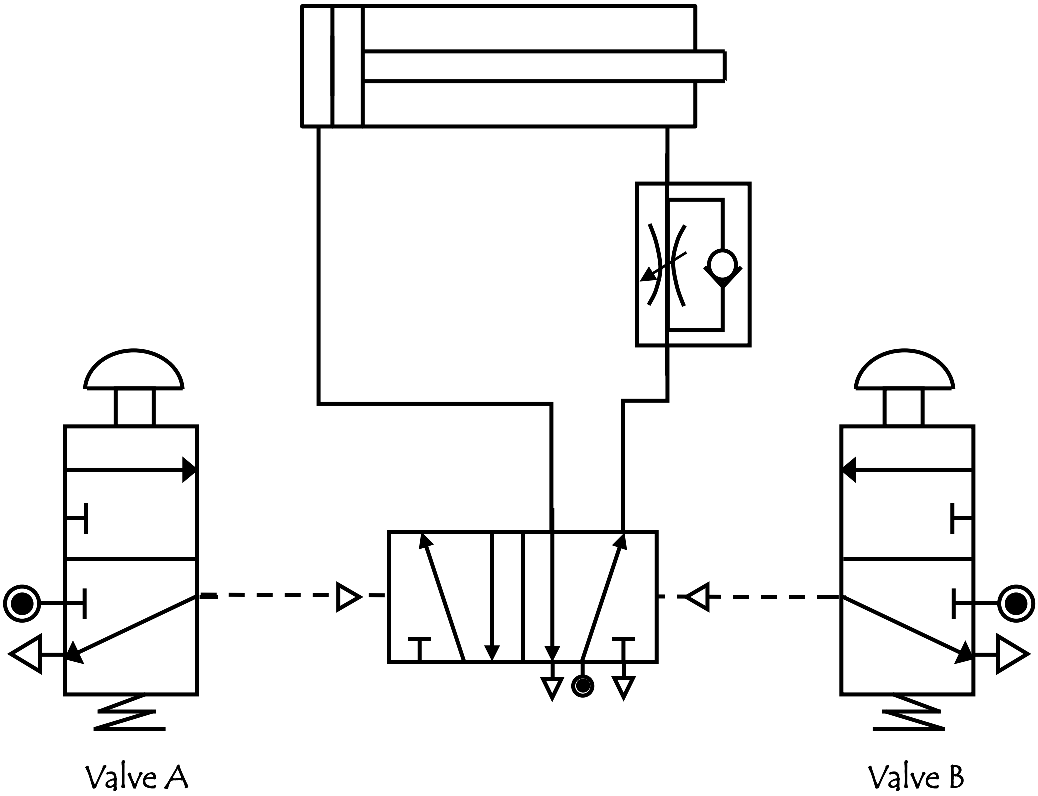
This will slow down the air in 1 direction only. This is dependent on the bottom section. As the air flows through the component it gets split between 2 paths. If the air flows from this direction, the ball is blown into the valve, blocking this path for the air to follow. This in turn will slow it down.



If it flows from the other direction, the ball instead is blown away from the entrance, allowing air to flow unrestricted.



The unidirectional restrictor is placed so that it will slow down the exhaust air coming from the cylinder. When valve A is pressed, the 5/2 valve will change state and start to supply the double acting cylinder with air, causing it outstroke. Air trapped on the other side of the cylinder will escape slowly because of the unidirectional restrictor. This in turn makes the piston outstroke slowly and smoothly, without effecting the force exerted.



Task 10

a) Using the Pneumatic components available, build and test this circuit.
Attach a photo of the circuit below

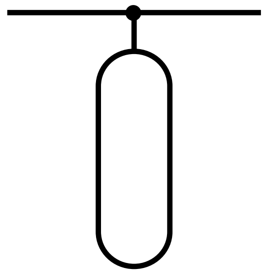
b) Explain using the correct terminology how this circuit works.

c) Move the unidirectional restrictor onto the other input for the Double acting Cylinder. What happens?

http://www.youtube.com/watch?v=LcZcSKUwzjo

Time Delay

Sometimes it is desired for there to be a time delay between when the valve is actuated, and the cylinder to respond. This pause can be created by a component known as a reservoir.

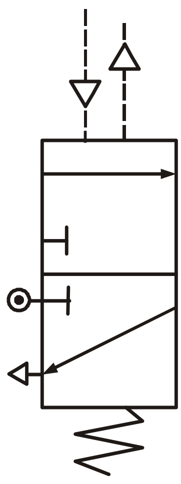


This is simply a container for the compressed air. By connecting this to a pipe, it increases the space that has to be pressurised before the next component is operated. This will create a time delay.

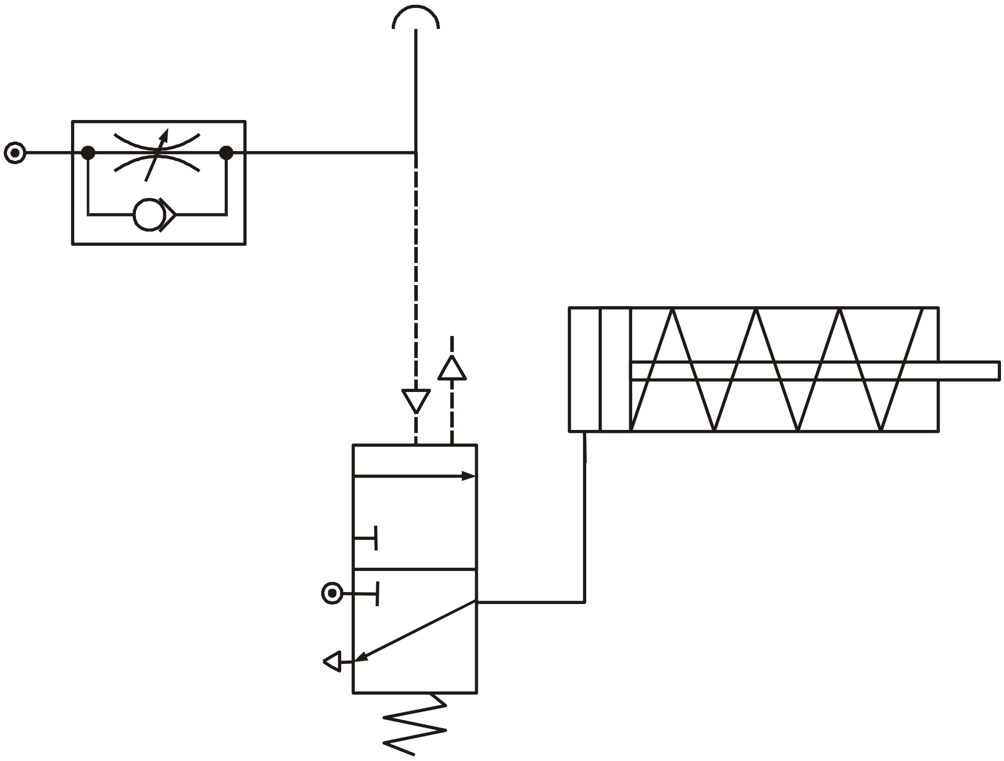
Air Bleeds

Sometimes with the pneumatics we find that the actuators on valves can get in the way of the circuit. Also some actuators need large forces to make them operate which is not always possible. An air bleed is simply an open pipe that allows the air in the circuit to escape. This air must be at a low pressure, otherwise the pipe would 'wave' about and be dangerous.

Air bleeds are often used to overcome this problem in conjunction with s diaphragm valve. This valve is capable of detecting small changes in air pressure. A diaphragm is a piece of rubber stretched inside the valve. When air flows into the top of the valve, the rubber expands much in the same way as when a balloon is blown up. When the diaphragm expands, it presses down inside the valve and changes its state.



The circuit below shows a circuit, which uses an air bleed to actuate a cylinder.
When the air bleed is blocked the air is diverted down to the diaphragm valve, which activates the 3/2 valve, and in turn the cylinder out strokes.

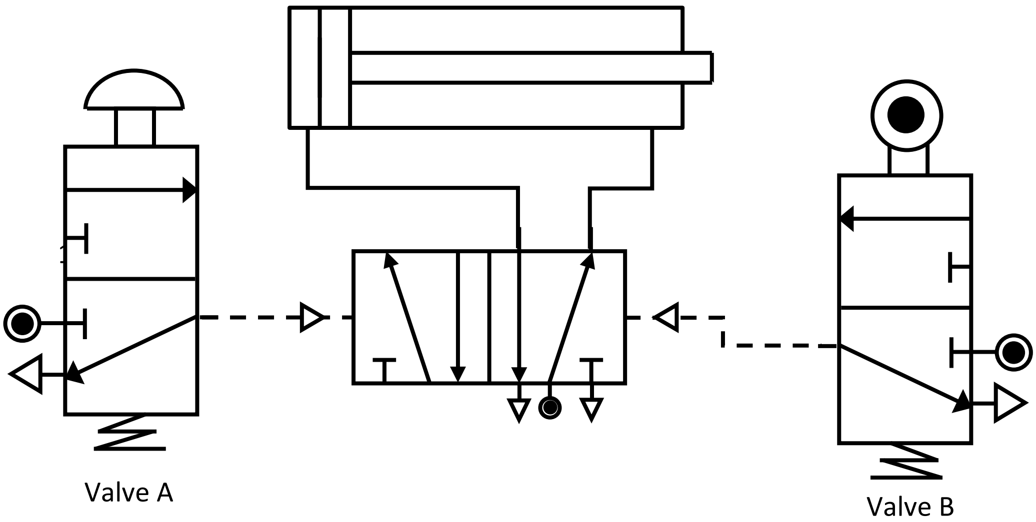


Automatic Circuits

Automatic circuits are how pneumatics are mostly used in industry. They not only help speed up production, but they allow for uniformity, making sure that goods are all made to the same standard. There are two types of automatic circuits that could be used:

Semi-Automatic Circuits

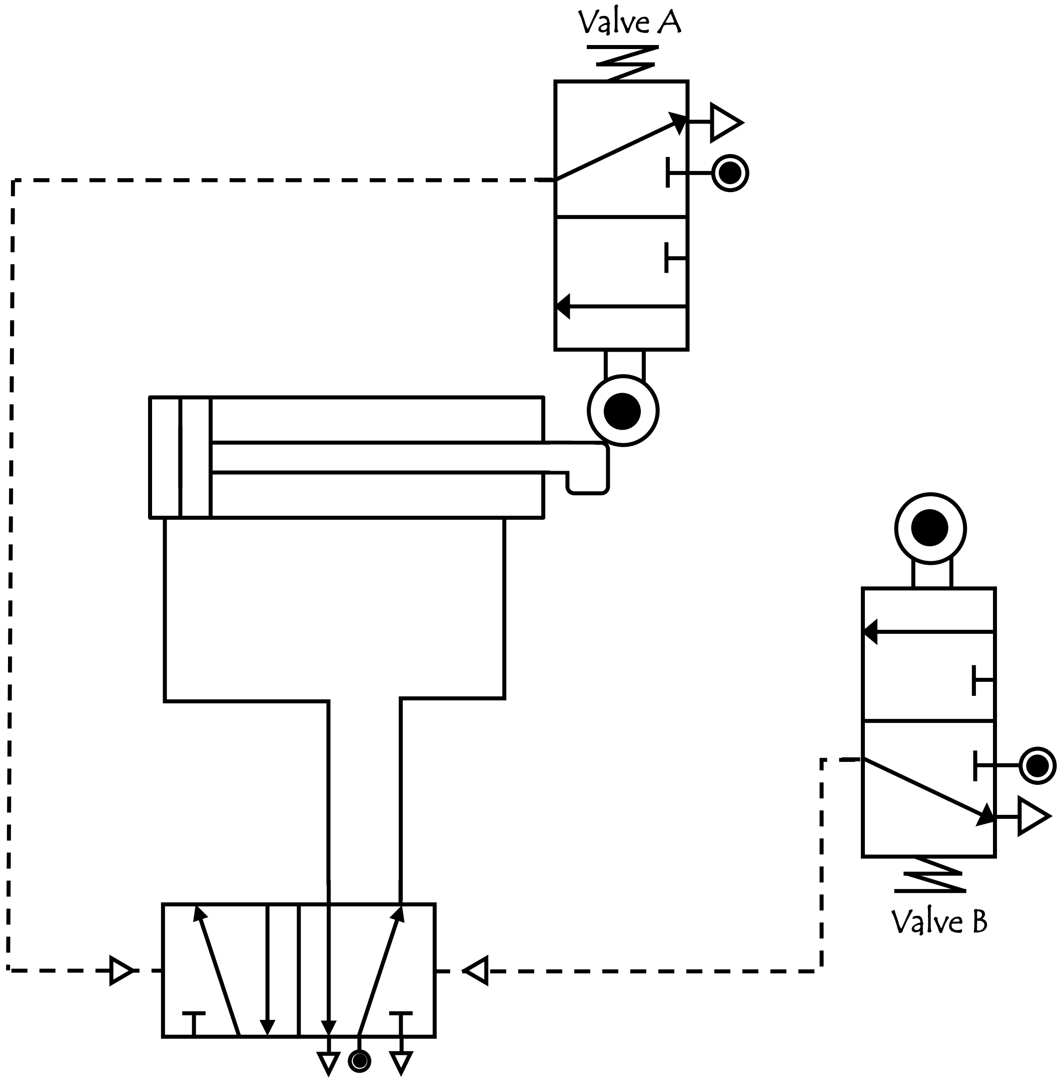
A semi-automatic circuit is one which will complete a set process once a human operator has started it.



Within this circuit, it will start when the operator presses the push button on the 3/2 Valve (valve A). This will change the state of the 5/2 valve, causing the double acting cylinder to outstroke. The cylinder, when outstroked far enough, will activate the roller trip actuated 3/2 valve (Valve B). This will then change the state of the 5/2 valve, causing the cylinder to instroke. The process is then ready to begin again.

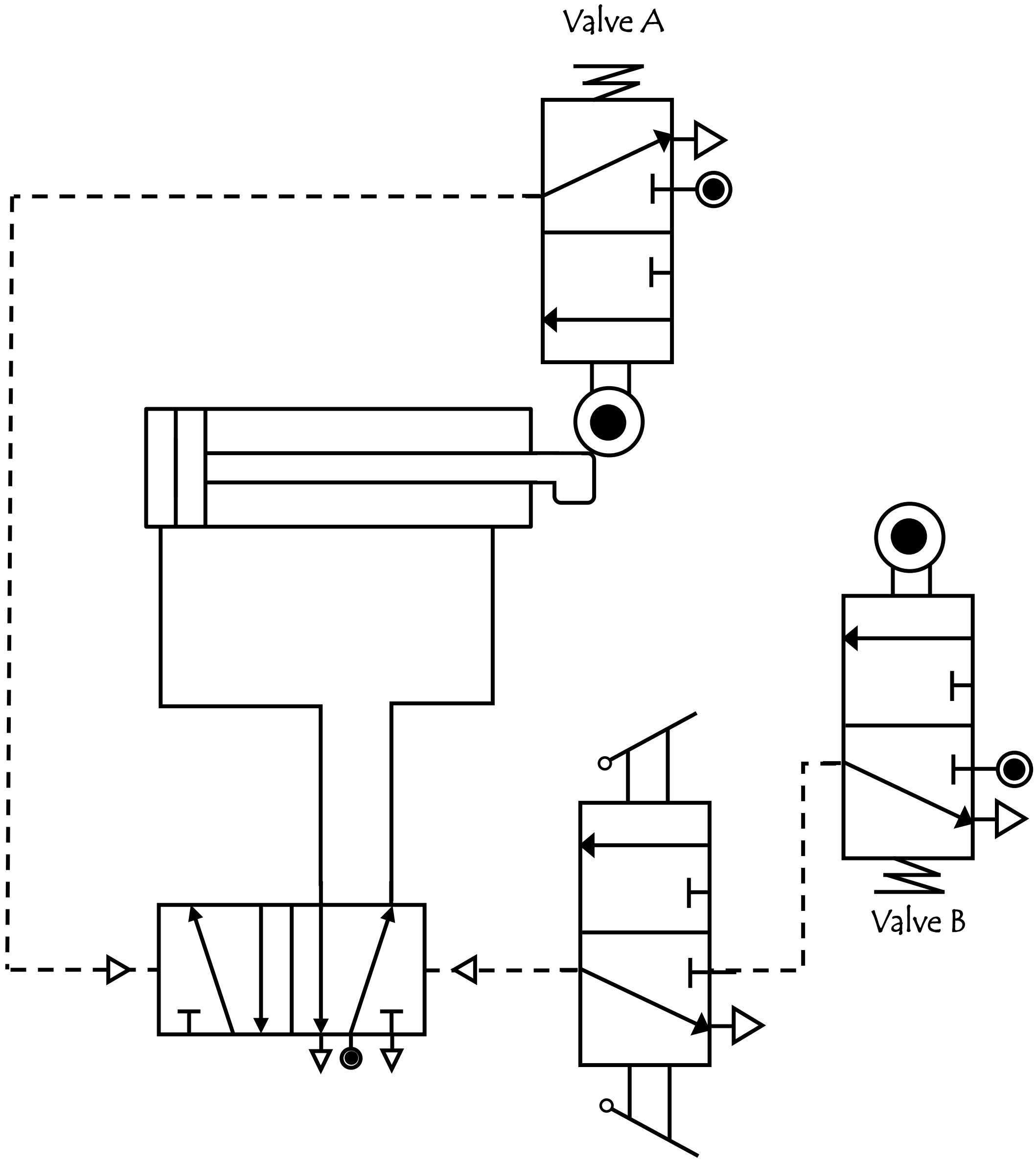
Fully Automatic Circuits

A fully automatic circuit is one that will continue to work, performing the task over and over again, without manual intervention. When mains air is supplied, it will start and continue to work.



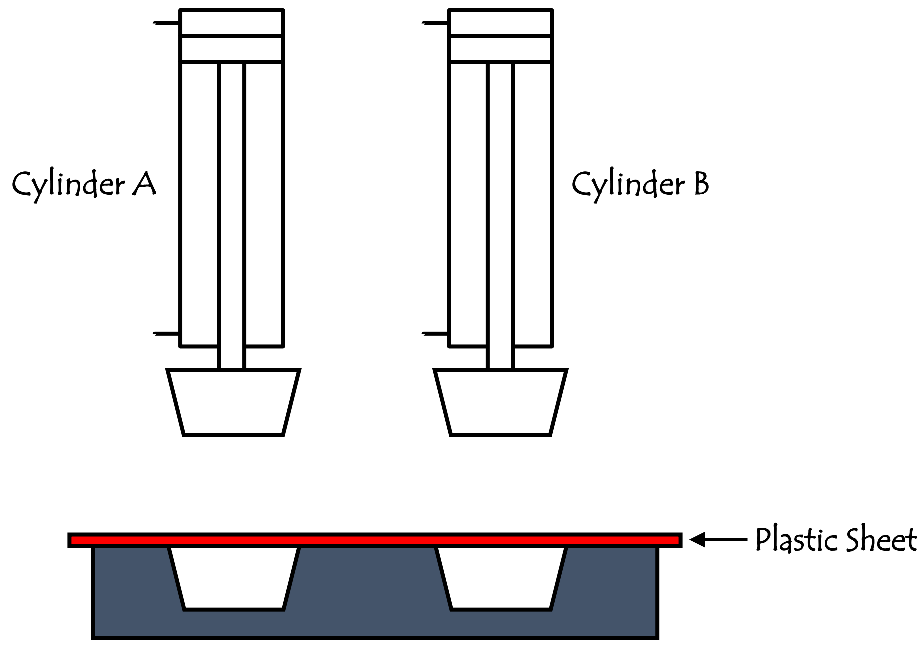
This circuit works by the double acting cylinder instroking. This will activate the roller on the 3/2 Valve (Valve A) and cause the 5/2 valve to change state. This will then outstroke the double acting cylinder. When it is fully outstroked, it trips the roller on the other 3/2 valve (Valve B). This will change the state of the 5/2 valve again, causing the cylinder to instroke. The process then begins over, and will continue to operate in this fashion.

A fully automatic circuit can be interrupted though in case of an accident or emergency. This can be done by putting a lever-lever 3/2 valve in one pilot line. This can then act as an on/off switch.



Sequential Control

Many pneumatic systems are designed to perform a multiple tasks, and design to be completed in a particular sequence. For example, a company uses cylinders to press metal dies into hot plastic to create parts for a children's toy. As each cylinder is lowered individually it presses the plastic into shaped recesses.

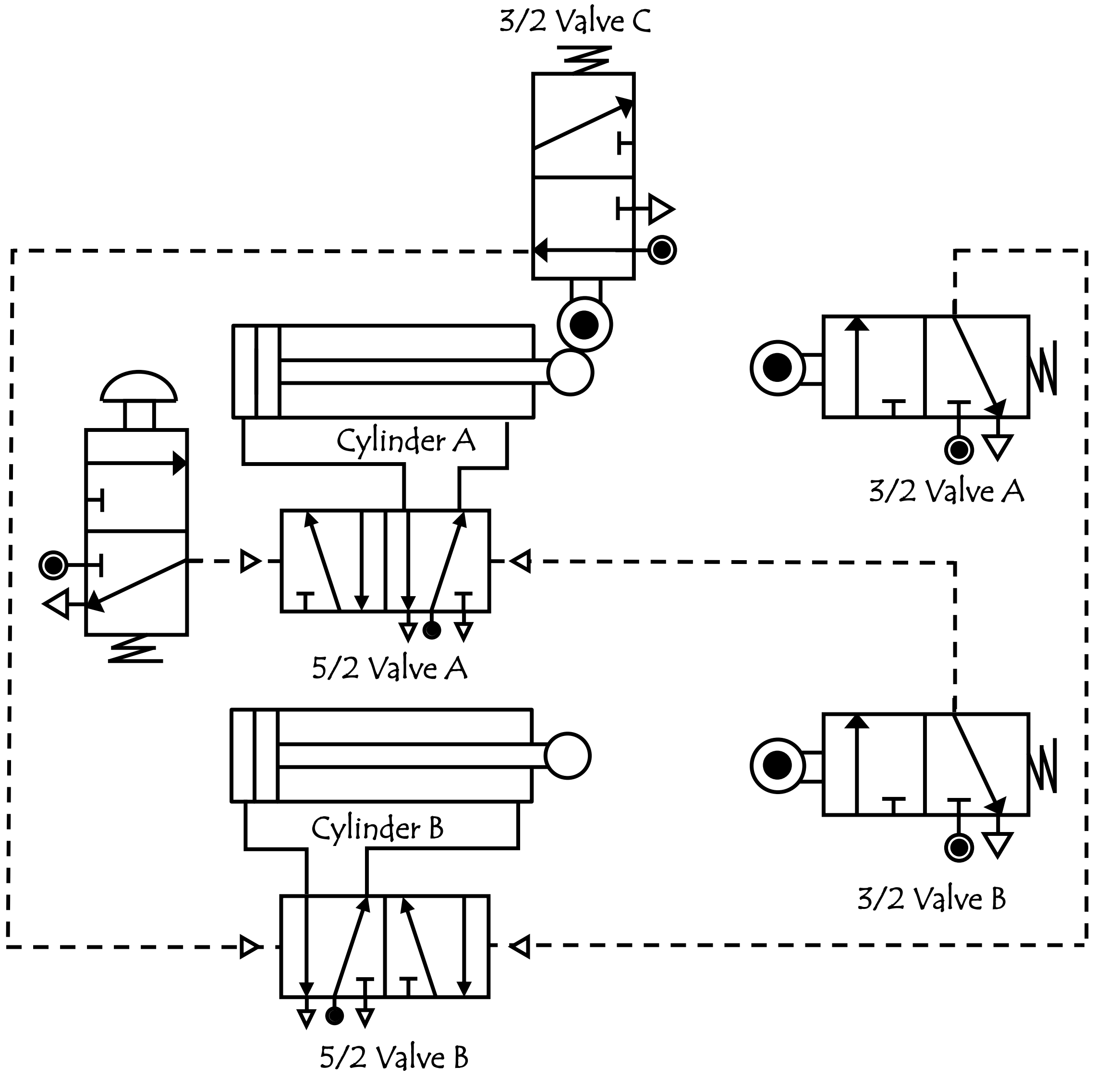


The sequence of operations for this process is as follows.

- An operator pushes a button to start the process.
- Cylinder A lowers
- Cylinder B lowers
- Cylinder A raises
-
- Cylinder B raises

* Sometimes it will describe a cylinder as + or –. If it is + this means it is outstroking. If it is – it means it is instroking.*

The circuit diagram for the circuit is below.

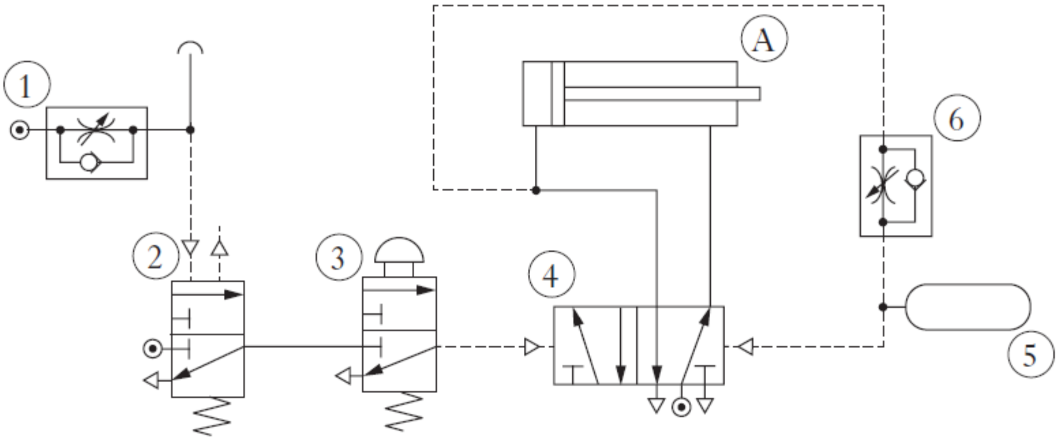


In an exam it is very possible you will be asked to describe how a circuit works. An explanation for this circuit is below.

When the push button, spring return 3/2 valve is activated, it will change the state of 5/2 valve A, causing the double acting cylinder (Cylinder A) to outstroke. This will hit the roller on 3/2 valve A, sending pilot air to 5/2 Valve B. This causes the valve to change state sending air to the double acting cylinder (Cylinder B) causing this to outstroke. This will hit the roller on 3/2 valve B, sending pilot air to 5/2 Valve A. This causes Cylinder A to instroke, hitting the roller on 3/2 Valve C. This in turn sends pilot air to 5/2 Valve B, instroking Cylinder B. The system now waits for a user to press the button again.

Task 11

A pneumatic circuit used in a production line as shown below



(*a*) State the **full** name of the following pneumatic components.

Component 5:

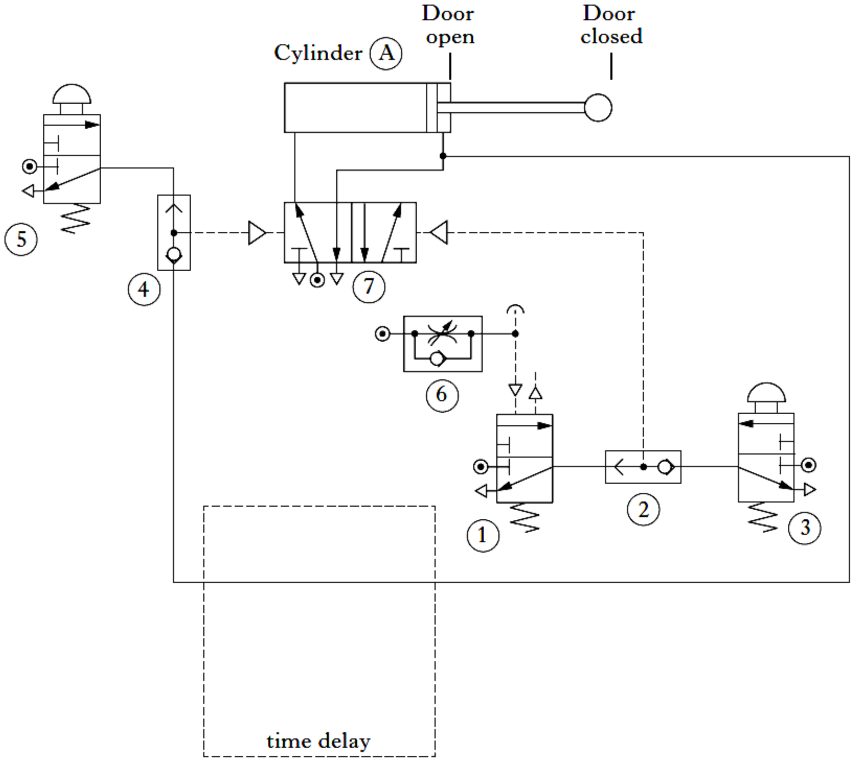
Component 2:

(*b*) Describe, using appropriate terminology, the operation of the pneumatic circuit.

An increase in pressure is sensed . . .

Task 12

The pneumatic circuit for a door system is shown below



(a)State the name of component 1

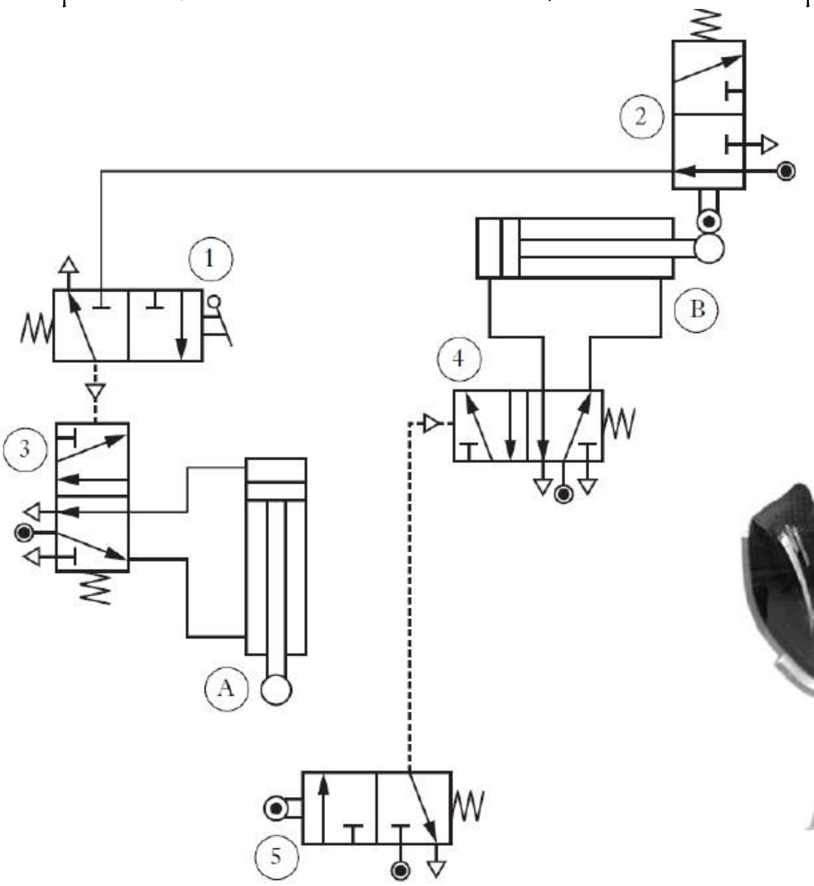
(b) Draw, in the position shown in the above circuit the components required to create a controlled time delay when closing the door.

(c) Describe, using appropriate terminology, the operation of the door system.

When is actuated….

Task 13

The pneumatic circuit shown is used to test the life span of a chair



(*a*) State the **full** name of the following pneumatic components.

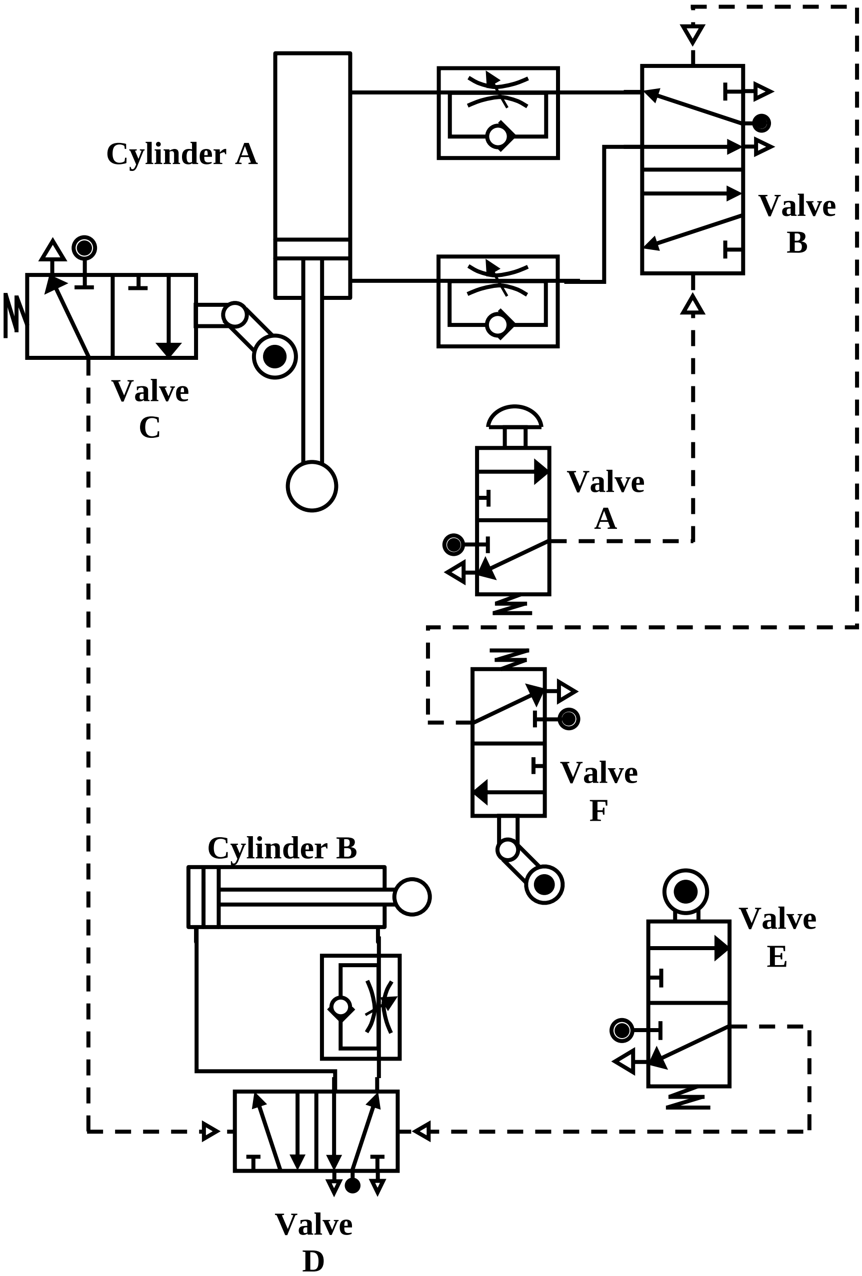
Valve 1:

Valve 3:

(*b*) Describe, with reference to Figure Q8, the operation of the pneumatic circuit.

Valve is actuated….

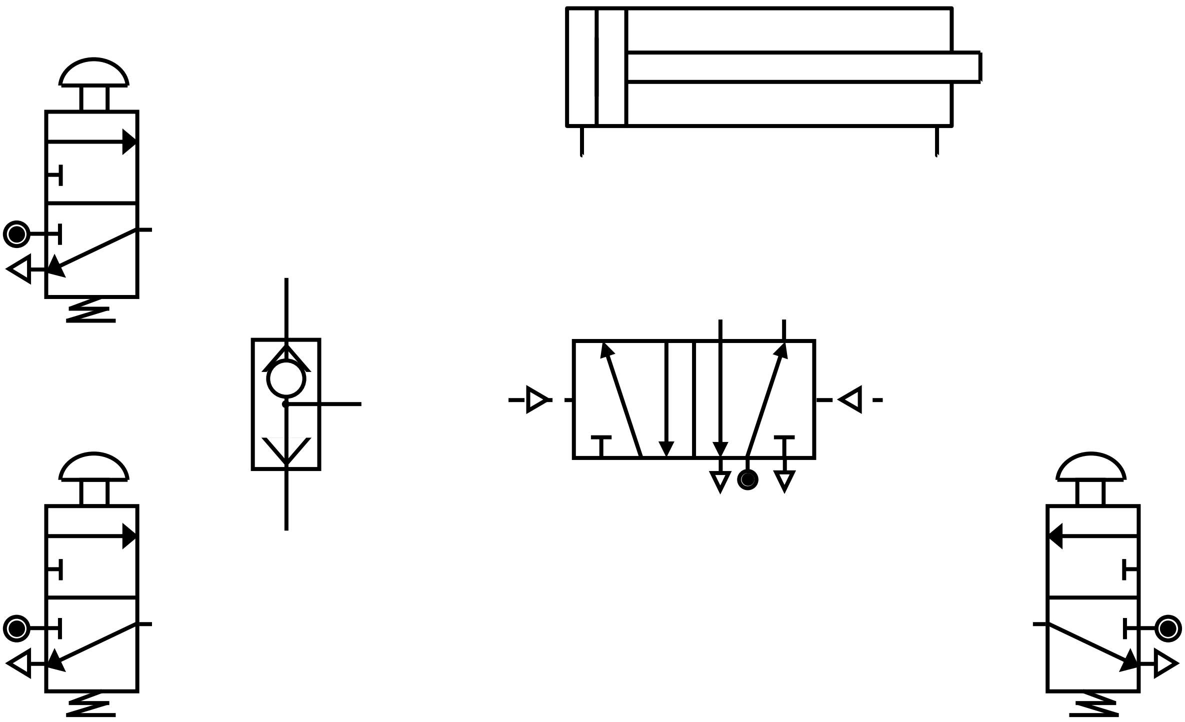
Task 14



Using the proper terminology, explain how this circuit works.

Task 15

A train door is controlled by a pneumatic circuit. It opens when a passenger presses the outside button (valve A) or the outside button (valve B). It closes when the train driver presses the inside button. Complete the wiring of the diagram below, then describe using the appropriate terminology how it works.

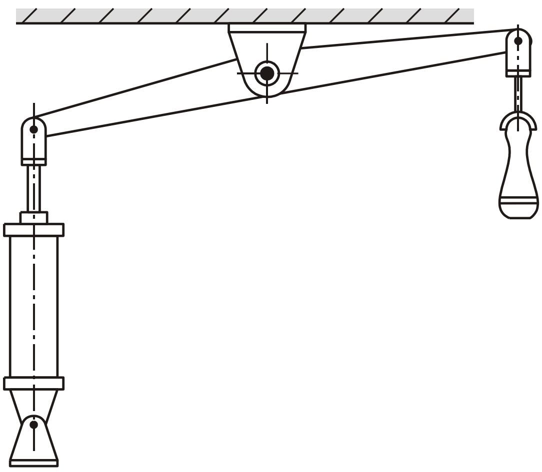


Interfacing and Electronic Control

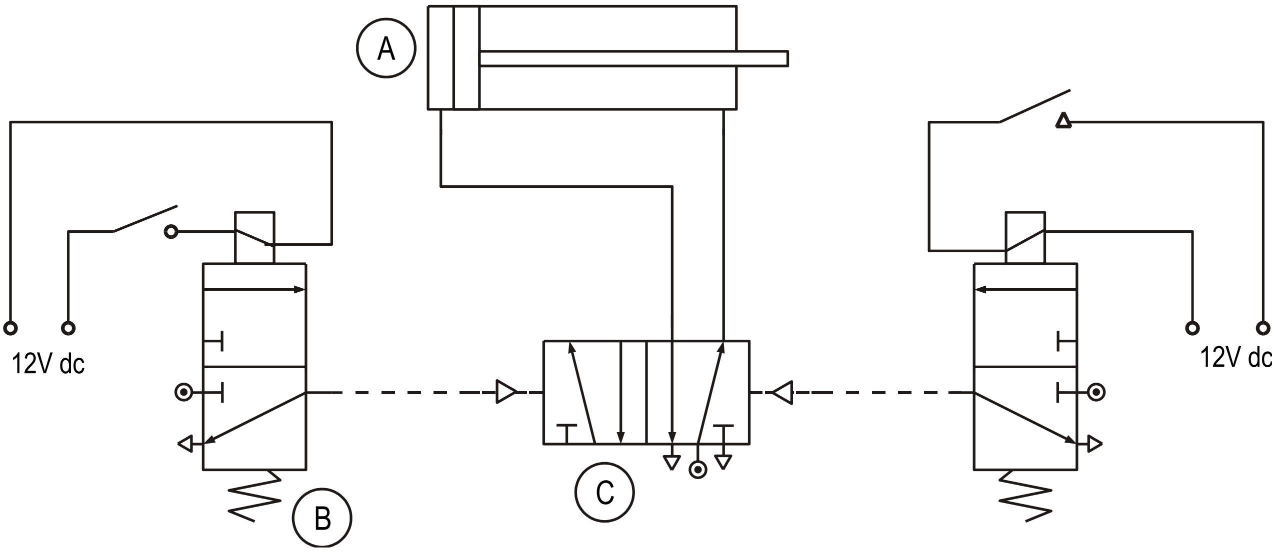
Although pneumatic circuits have many advantages, they can become complicated and expensive when lots of components are needed. They can also be difficult to set up and control. One possible way of overcoming these problems is to use electronics or a computer interface to control the operation of pneumatic circuits. The advantage of this is that electronic signals can be transmitted over much greater distances than pneumatic signals. However, the main advantage is that electronic signals respond faster than pneumatic signals and use less energy.

To control a pneumatic system electronically, we require the use of a solenoid operated 3/2 valve. This valve is actuated when an electric current energises the coil of the solenoid. If we can control the current flowing to the coil, then we can control the operation of the entire circuit. This can be achieved easily by connecting switches or sensors in series with the solenoid.

For example, a ten-pin bowling complex uses double acting cylinders to set up the skittles once they have been knocked down. The cylinder is controlled by an electric switch arrangement which energises solenoid operated 3/2 valves.



The circuit diagram is shown for this system is shown below.



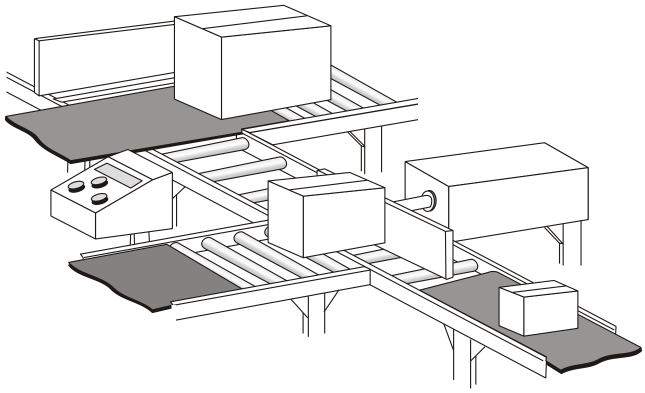
Task 14

a) Build and test the electrical and pneumatic circuit shown above. Attach a photo of your circuit

b) What advantages are there of controlling pneumatic circuits electronically?

Reprogrammable Interfacing

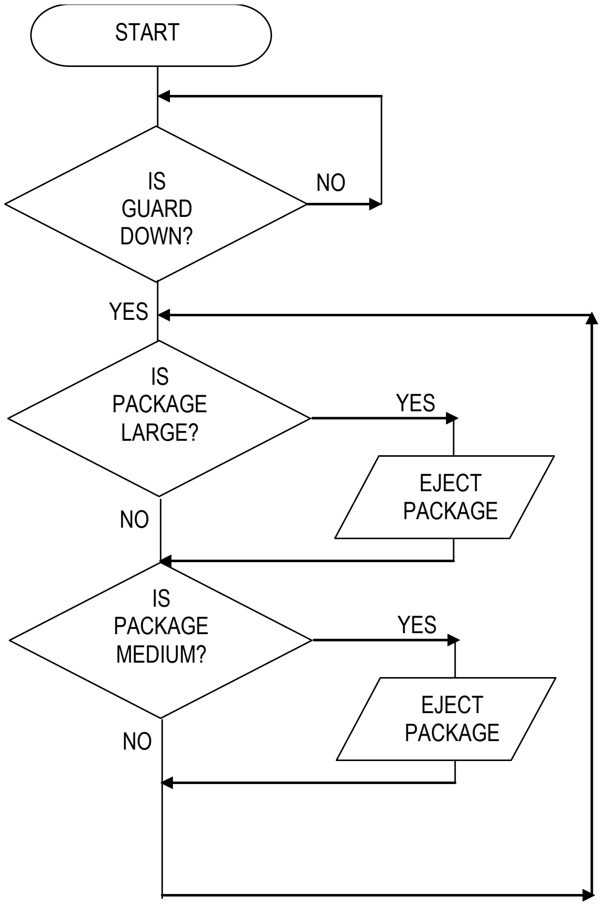
Most industrial pneumatic systems include a number of cylinders working together in sequence. Certain sequences of operation are difficult to control using the equipment we have come across so far. The circuits also become expensive to build and are difficult to set up. However, we can overcome these problems by using a computer interface to control complex tasks.



For example, a post office sorting system is used to separate three different sizes of packages. The packages are carried on a conveyor belt to the first sort. At this point, a single acting cylinder removes the largest packages, which are detected by use of a switch. At the second stage, the medium packages are separated from the smaller size ones, which continue to the end of the conveyor.

As the content of the packages is unknown, they should be removed carefully from the conveyor. For safety reasons, the system should not operate unless the guard around the conveyor is in position.

The operation of this circuit can be summarised in a flow chart.



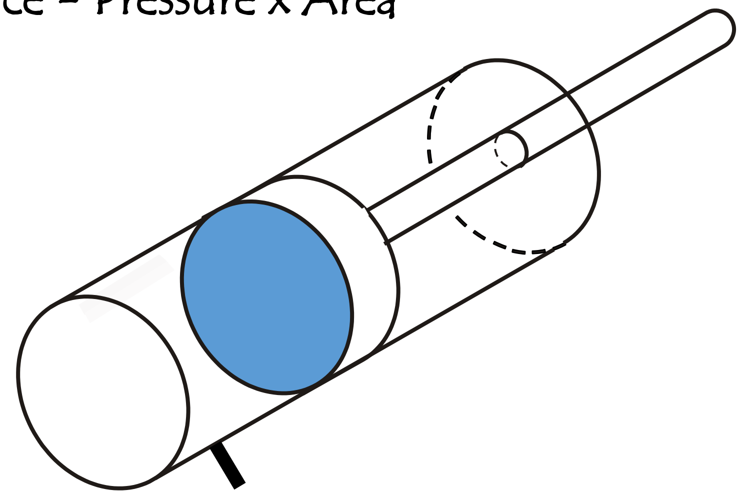
Force in a Single Acting Cylinder

As we know pneumatic components and circuits that are controlled by pressured air. This air pressure is measured in Nm^{-2}. We know the pressure going through the system as there will be a pressure gauge on the compressor that supplies the air. These can be found on any system that relies on compressed gases or fluids. For example it is more than likely there will be one on the boiler in your house for the central heating. This helps to detect leaks, as the pressure in the system would begin to fall if air was escaping from the pipes.

[DF] The unit can change to suit the question. For example if the question uses millimetres, your answer may be in Nmm^{-2}.

The force you get out of a cylinder depends on the air pressure inside it, and the size of the piston. To calculate this pressure we multiply the pressure by the area of the cylinder. This is measured in Newtons.

Force = Pressure x Area

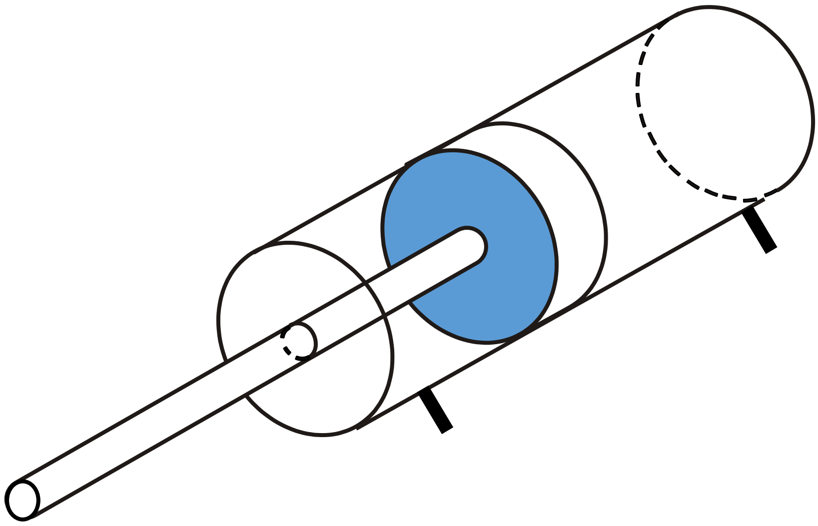


As you can see the surface of the cylinder is circular. This means we have to use one of these calculations to work out the area:

Area = πr^2 **or** $\frac{\pi d^2}{4}$

Force in a Double Acting Cylinder

As we know, a double-acting cylinder is of more use in practical applications due to the fact that both the input and output can be controlled by compressed air. However, the outstroke force is greater than the input force. This is due when it is instroking, the piston is at this side taking up space. This means that there is less area for the compressed air to fill, meaning less force created.



Therefore, we have to find the 'effective area'. This is done by calculating the area of the piston rod and subtracting it from the area of the piston know it.

Effective Area = piston area – piston rod area

EXAMPLE

A car park barrier uses a double acting cylinder to raise and lower the barrier. The cylinder has a diameter of 60 mm, with piston rod being 20 mm in diameter. The air pressure is 0.7 N/mm^2. What forces are produced when the piston outstrokes and instrokes?

OUTSTROKE

$$\text{Area} = \frac{\pi d^2}{4} = \frac{3.14 \times (60 \times 60)}{4} = \frac{3.14 \times 3600}{4} = \frac{11304}{4}$$

$= 2826\ mm^2$

Force = Pressure x Area = 0.7 x 2826 = 1978.2N

INSTROKE

Cylinder area = $2826 mm^2$

$$\text{Cylinder Rod Area} = \frac{\pi d^2}{4} = \frac{3.14 \times (20 \times 20)}{4} = \frac{3.14 \times 400}{4}$$

$= 314 mm^2$

Effective area = Piston area – Piston rod area
= 2826 - 314
=2512 mm^2

Force = Pressure x Effective Area = 0.7 x 2512 = 1758.4N

http://www.youtube.com/watch?v=2xOds3rR5ew

Task 16

Using the Airways software, complete unit 8

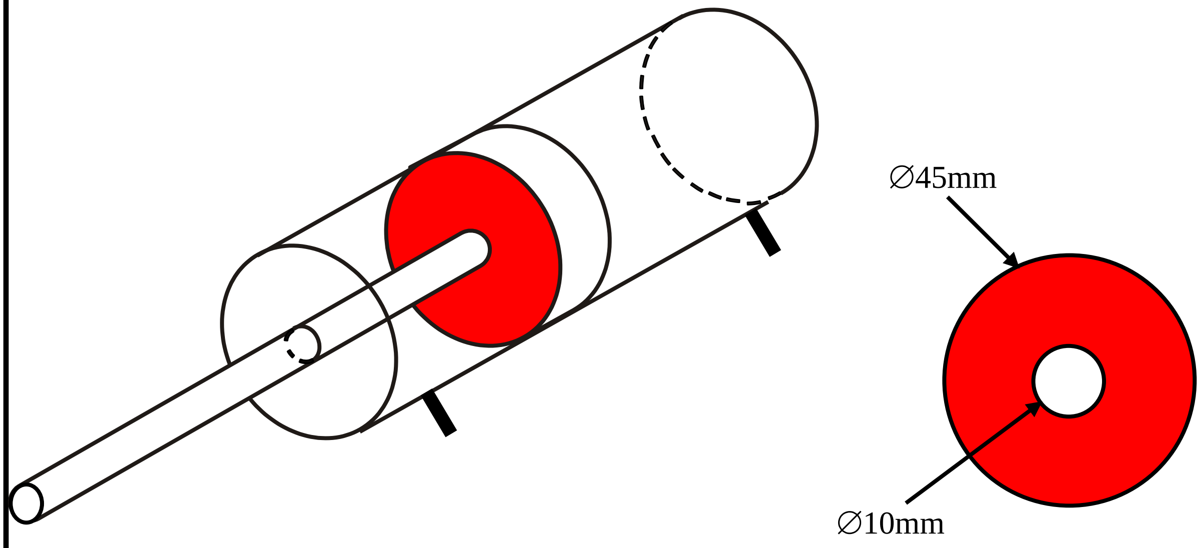
Task 17

A piston has a diameter of 30 mm and is supplied with air at a pressure of 3.2 Nmm^{-2}.

Calculate the outstroking force of the cylinder.

Task 18

The cylinder shown is used to open and close a greenhouse window.



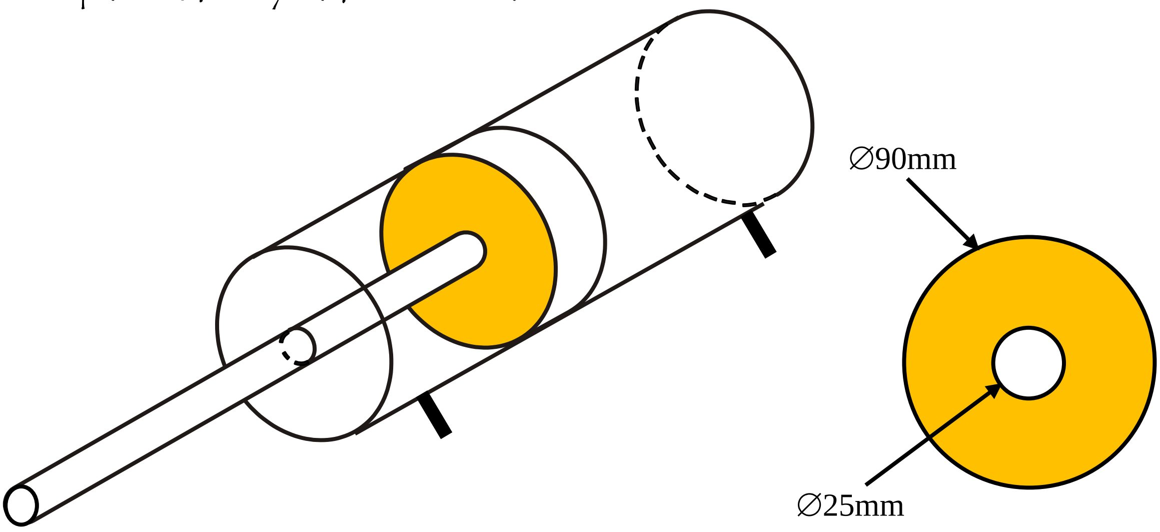
Calculate:

(i) The effective area of the piston when it instrokes.

(ii) The force supplied to the cylinder when the air pressure is 0.7 Nmm^{-2}.

Task 19

A pneumatic cylinder is shown below

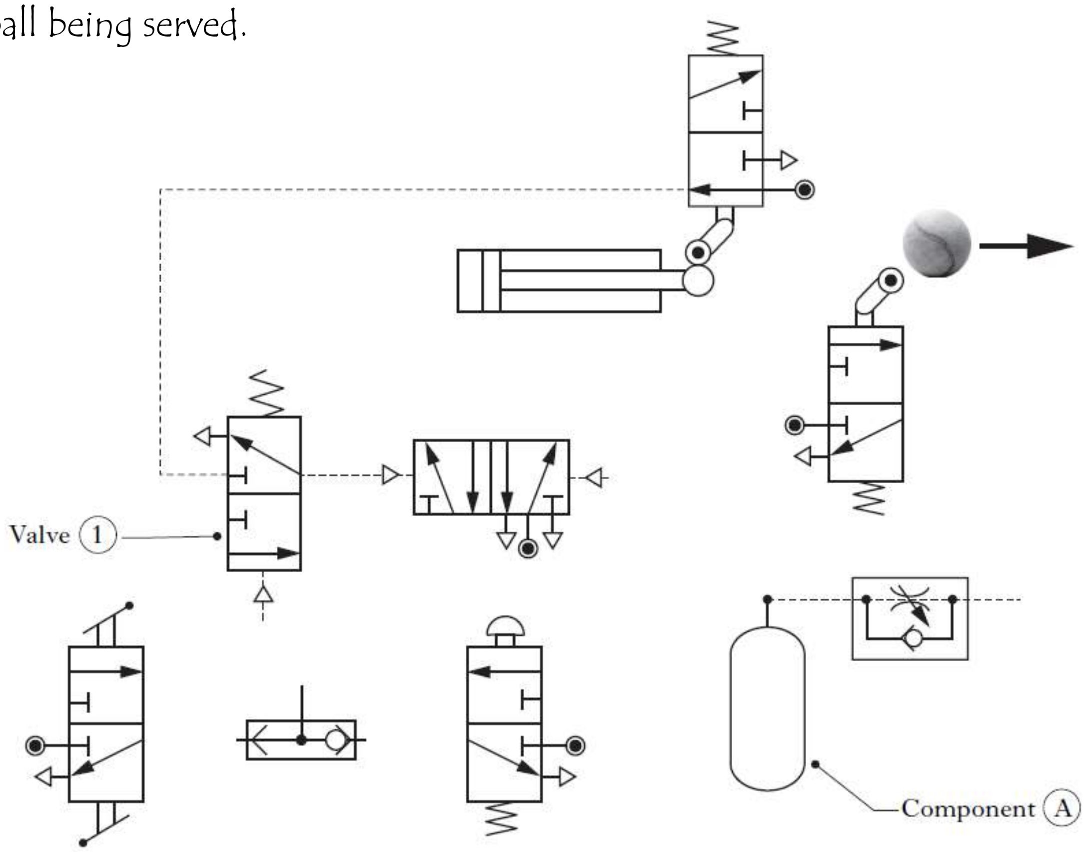


Calculate the air pressure required to produce an instroking force of 2450 N.

<u>Task 20</u>

A pneumatic circuit is used to serve tennis balls during practice sessions.

The system will serve automatically when a lever is actuated or manually each time a button is pressed. There is a delay between each ball being served.



(*a*) Complete the piping of the pneumatic circuit.

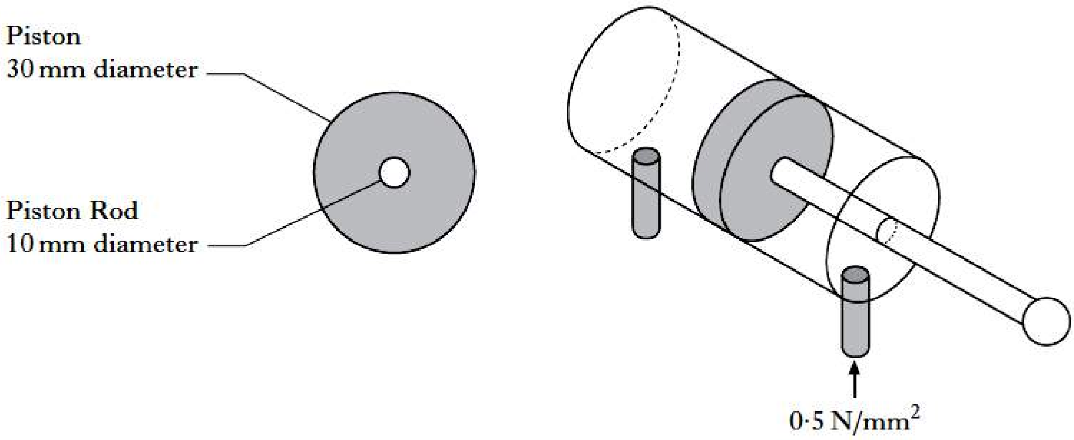
(*b*) State the full name of the following components.

Component A:

Valve 1:

Task 20 (Continued)

The piston below **instrokes** when air is supplied at a pressure of 0.5N/mm2 to the cylinder.



(c) Calculate the in-stroking force.

(d) Describe **two** ways of reducing the **out-stroking** force applied by a piston.

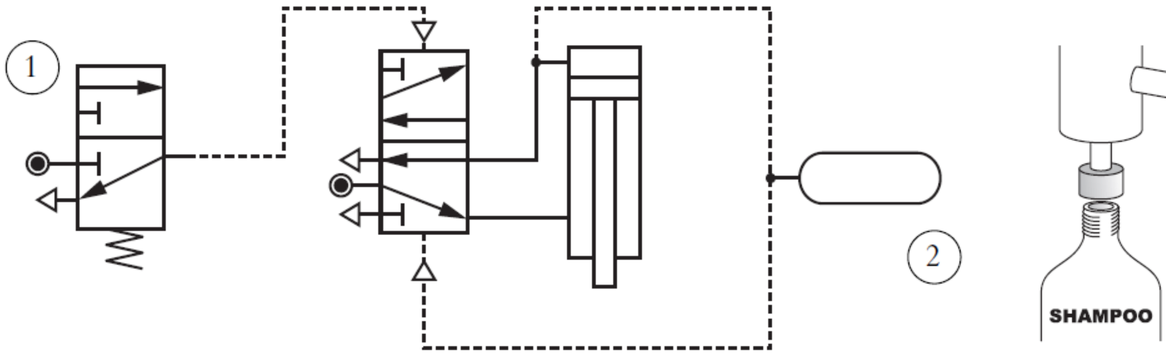
1 ____________________________________

2 ____________________________________

http://www.bbc.co.uk/apps/ifl/schools/gcsebitesize/design/quizengine?quiz=pneumaticstest&templateStyle=design

Task 21

Below shows an incomplete pneumatic circuit used to fix tops on shampoo bottles.



Valve is to be actuated by an **electrical** signal.

(*a*) (i) State the name of this actuator.

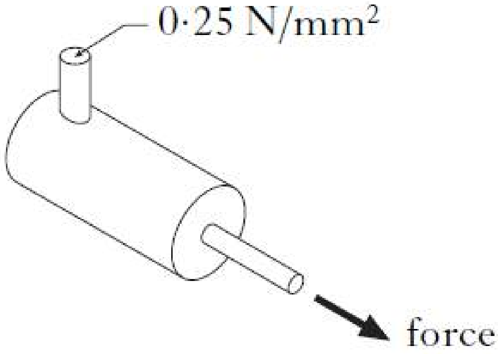
(ii) Sketch the symbol for this actuator **below**.

(*b*) (i) Sketch **on the circuit above** the pneumatic device that will create an **adjustable** time delay after the piston outstrokes.

(ii) State the name of component

Task 21 (Continued)

A 10 mm diameter cylinder has air supplied at a pressure of 0.25N/mm2.



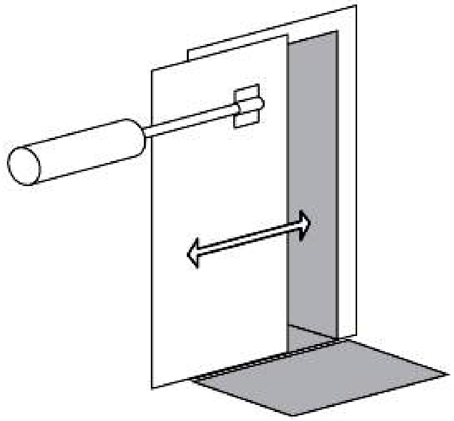
(*c*) Calculate the force of the piston as it outstrokes.

(*d*) Explain why the in-stroke force of the piston will be **less** than the out-stroke force.

(*e*) State a reason, other than cost, for using pneumatic systems in an industrial environment.

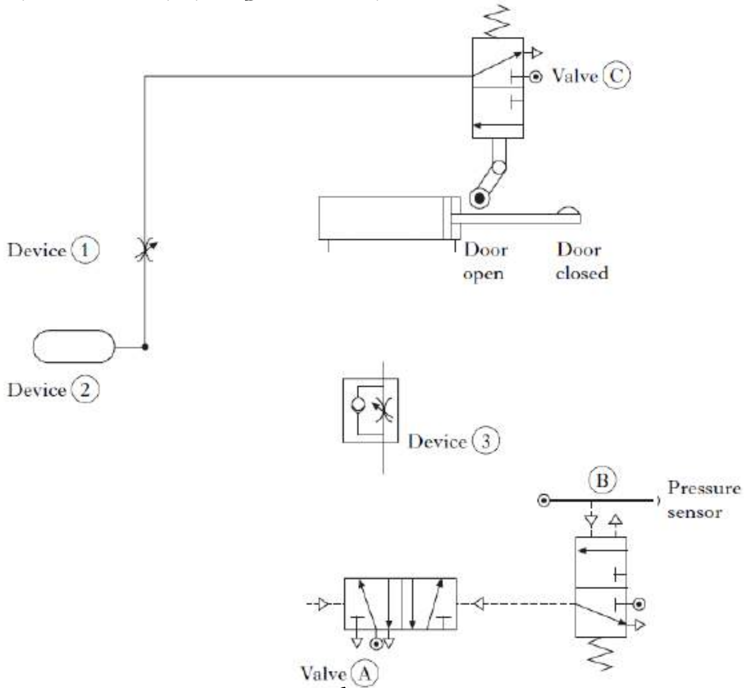
Task 22

A pneumatic circuit is used to control the operation of an automatic door

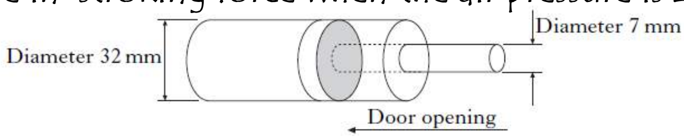


When a person steps on to the pressure sensor, the piston will in-stroke and open the door. After an 8 second delay, the piston will automatically outstroke and slowly close the door.

(a) Complete the piping of the pneumatic circuit below.



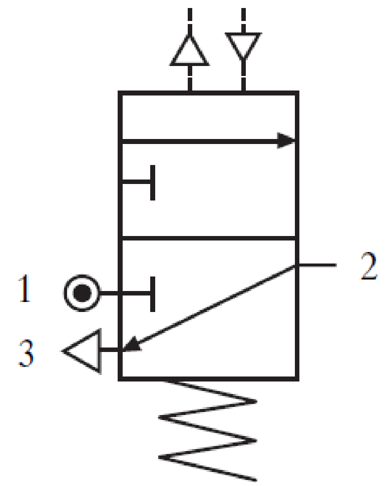
b) Calculate the in-stroking force when the air pressure is 2.32 N/mm^2.



http://www.youtube.com/watch?v=clvwU-tVGtM

Task 23

The symbol for a pneumatic valve is shown below



(a)

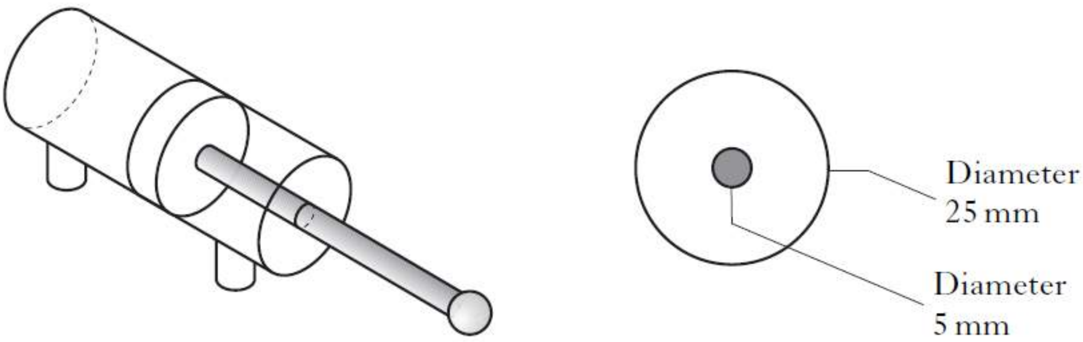
(i) State the **full** name of the pneumatic valve.

(ii) Complete the table below for the valve ports.

Port	Connection
1	
2	Output port
3	

Task 23 (Continued)

Below shows the dimensions of a double acting cylinder.



(*b*) Calculate:

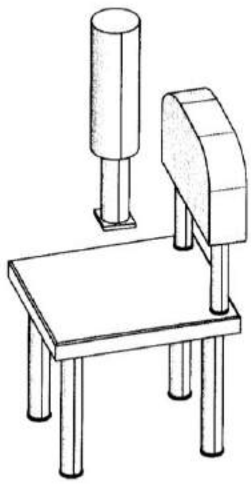
(i) The effective area of the piston as it in-strokes;

(ii) the **in-stroking force** of the piston if air is supplied at a pressure of 0·6N/mm2.

Task 24

An engineering lab tests the materials and construction used in a range of furniture to see if they conform to the European Union's safety standards.

As part of this process, the lab runs a series of automatic pneumatic test rigs which have reciprocating piston rods simulating different wear and loadings on the furniture.



Design a pneumatic circuit to control the operation of a furniture test rig.

The sequence for the pneumatic circuit is as follows:

- A 5/2 valve will operate a double acting cylinder and cause the piston rod to out-stroke. (The speed of this out-stroking movement must be adjustable.)
- An actuator will sense when the piston rod has fully out-stroked and the 3/2 valve will send a signal to cause the piston to in-stroke at full speed.
- The sequence will repeat until the air supply is switched off.

a) Apply your knowledge to design a possible solution to the problem brief.

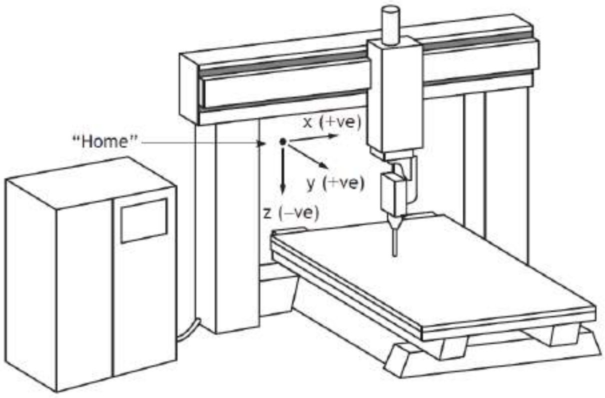
Task 24 (Continued)

b) Build a model of your solution.
Attach a photo below

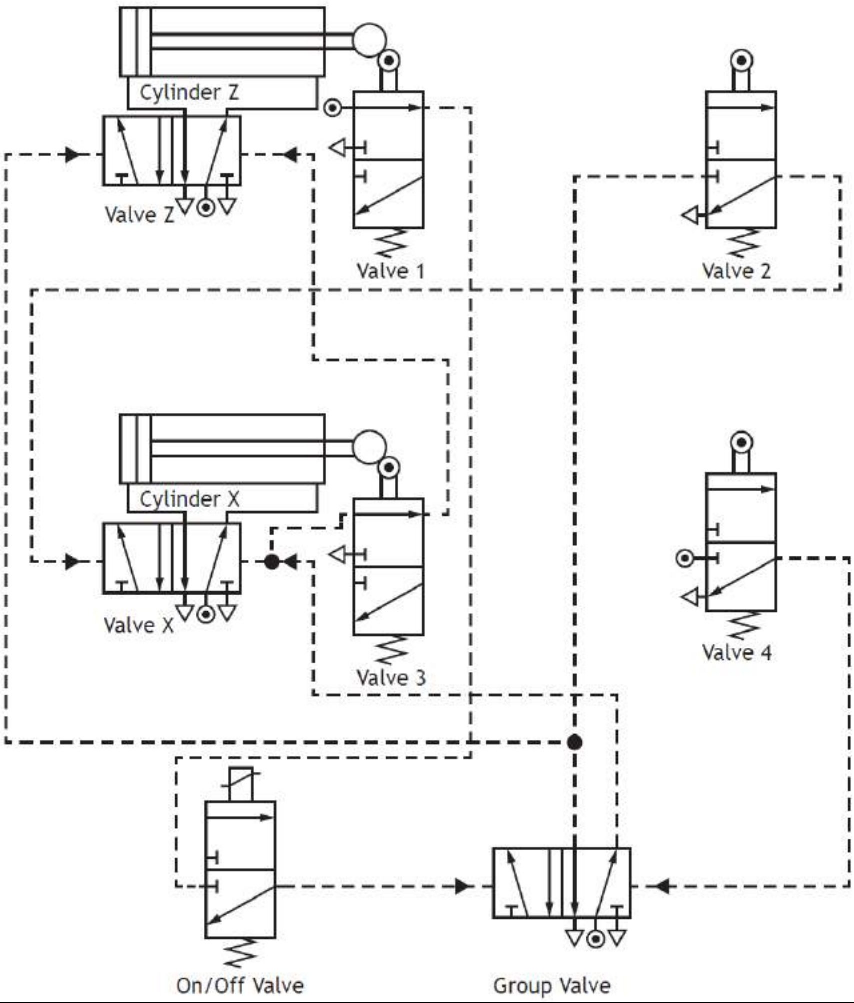
c) Describe the tests you carried out and how the solution actually performed. Suggest possible improvements or further work.

Task 25

The computer-controlled milling machine shown below uses a rotating head to cut multiple slots. A motor moves the cutter head horizontally in the x-axis into the correct position. Two pneumatic cylinders manoeuvre the cutter to cut the slot.



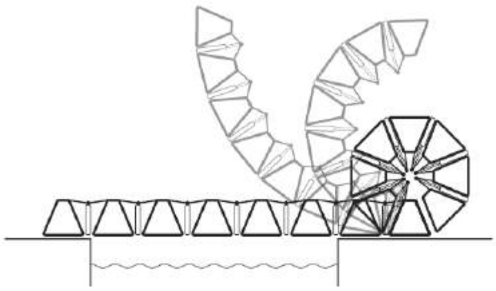
Cylinder Z moves the cutter down in the z-axis to make a hole in the work piece and then cylinder X moves the cutter in the x-axis to mill out a slot. Cylinder X then returns the cutter to the start of the slot and cylinder Z retracts the cutter up out of the work. To achieve this, the cylinders are controlled sequentially in the order Z+, X+, X−, Z− using the pneumatic circuit shown below.



Task 25 (Continued)

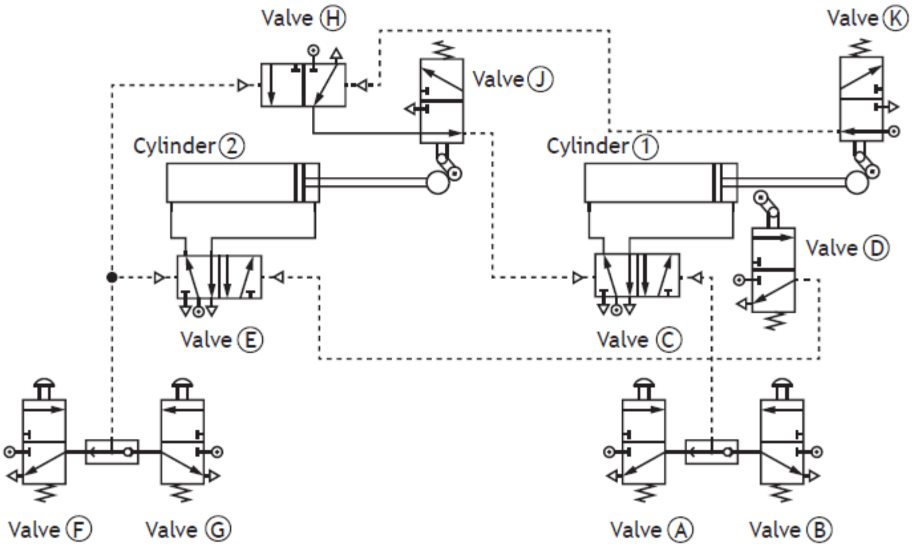
Describe, using appropriate terminology, how the circuit shown achieves the given sequence.

__Task 26__



A pneumatically operated bridge is designed to allow pedestrians to cross a canal. It can be extended or retracted by pressing buttons on either side.

The diagram below is a simplified circuit that shows how two of the bridge's cylinders are controlled. As the cylinders instroke the bridge will retract.



(a) Describe, using appropriate terminology, the operation of the pneumatic circuit.

b) Describe **two** modifications that would allow the pneumatics to be controlled electronically.