

# AUTOMATICS

Simplifying pneumatics

Electro - pneumatics



CP2079

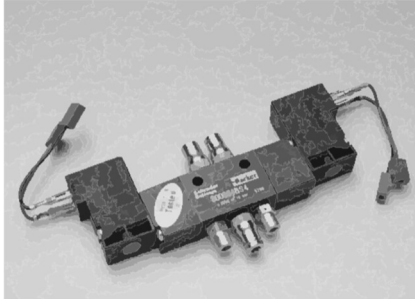
**MATRIX**

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# Worksheet 1

## Electronic control

In the earlier 'Automatics essentials' module, compressed air controlled everything, including the control gear itself. It is often simpler to use electronic circuitry to do the controlling, and use



the compressed air to do the moving. For one thing, electronic components are often smaller than pneumatic actuators.

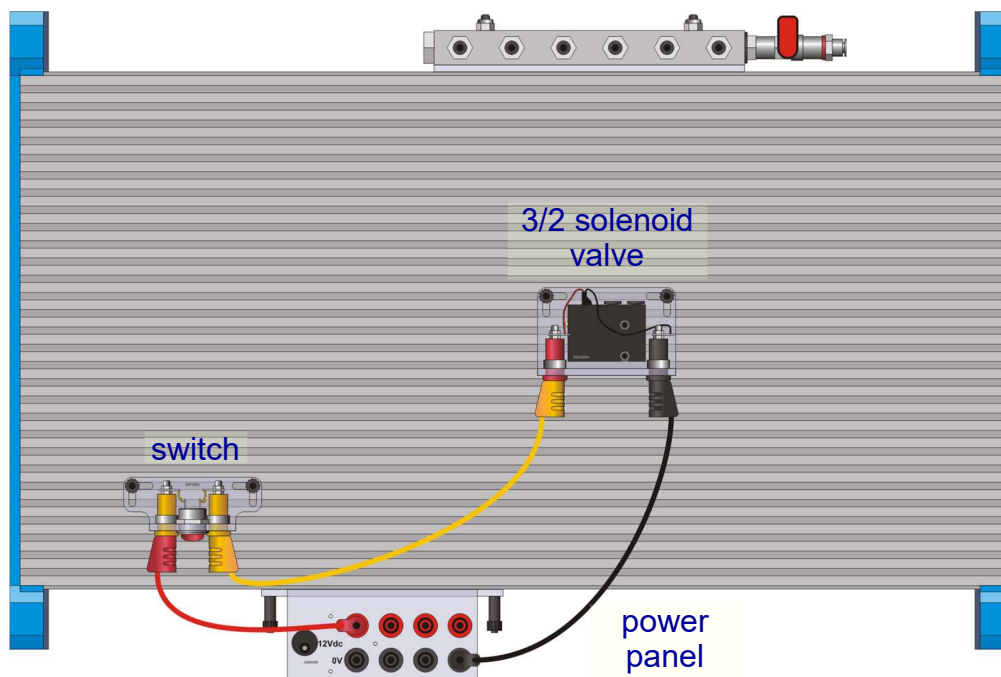
Electronics makes it relatively easy to:

- extend and retract cylinders in any sequence;
- include timing and counting;
- make the system respond to sensors.

The picture shows a 5/2 valve, with exhaust restrictors, controlled by two solenoids.

### Over to you:

- Build the arrangement shown below. It demonstrates electronic control of pneumatic valves. There are no pneumatic connections, only electrical ones!
- Clamp a switch and a 3/2 solenoid valve to the platform.
- Make the following connections:
  - power panel - plug in 12V power supply;
  - switch - one socket to power link panel red - one socket to 3/2 spring solenoid valve red socket;
  - solenoid valve - black socket to power link panel black.
- Plug in the power supply and switch it on
- Press the switch. You should hear the solenoid operate inside the control valve.



# Worksheet 1

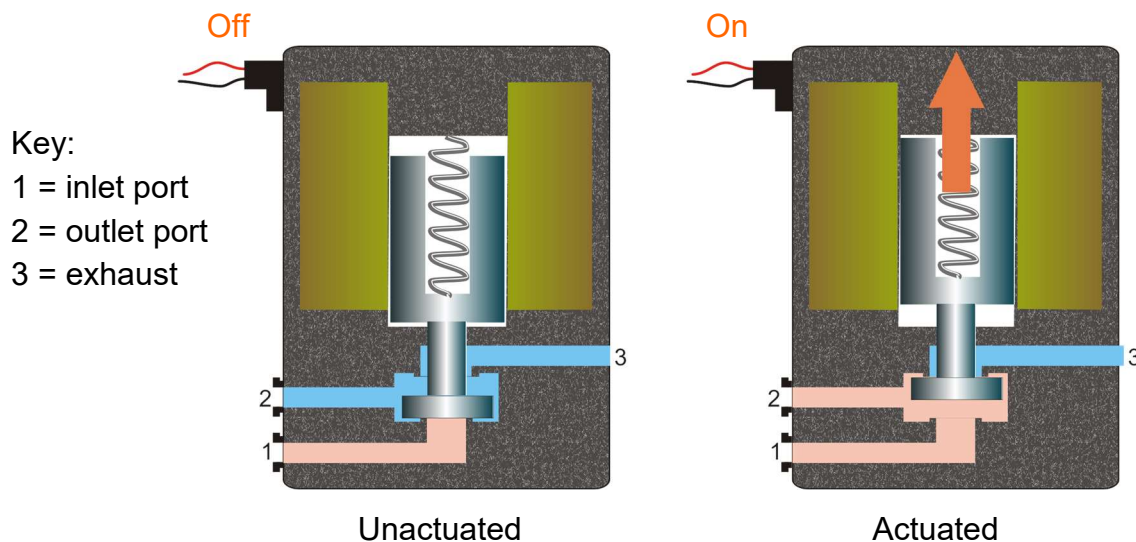
## Electronic control

### So what:

The valve used here is a three port solenoid/spring valve. Pneumatically, it operates in the same way as the one used earlier in the 'Automatics essentials' module. The difference? - it is actuated by a solenoid.

A solenoid is made by inserting an iron core into the centre of a coil of wire. When an electric current passes through the wire, a magnetic field is set up which makes the iron core acts like a magnet. This is called energising the solenoid.

When the solenoid in the valve is energised, it moves the spool into its actuated position. When it is de-energised, a spring inside the valve moves the spool back to its unactuated position.



The diagrams illustrate the principles of solenoid operation.

### For your records:

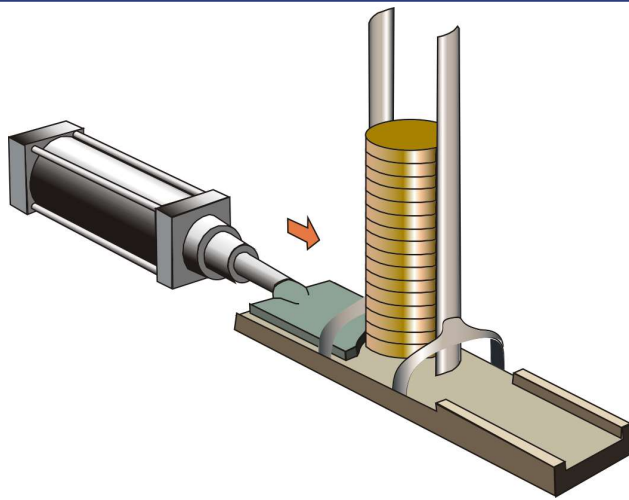
- Set a multimeter to measure voltages up to 12V.
- Use it to measure the voltages listed in the table below.
- Then copy and complete it.

Quantity	Voltage	Solenoid Actuated?
Solenoid red socket - switch not pressed		
Solenoid red socket - switch pressed		

- Write a short explanations, each less than fifty words, to make clear to a fellow-student how:
  - a solenoid works;
  - a solenoid valve works.

# Worksheet 2

## Magazine feed



In automated production, it is often necessary to feed blanks into the process from a store, known as a magazine.

Pneumatics offers a reliable and speedy way to do this, as the diagram illustrates. A single-acting cylinder pushes a new blank onto the conveyor belt, and then retracts.

This worksheet examines how an electronic control system can operate this part of the process.

w2a

### Over to you:

- **Read the safety rules given on the next page before you start.**
- **The red lever on the manifold must be turned off at this stage.**
- Build the arrangement shown on the next page.  
Compare the physical and pneumatic circuit diagrams, as you do so.
  - Clamp a switch and a 3/2 solenoid valve to the platform.
  - Add a flow-control valve, to restrict flow in the direction shown by the arrow.
  - Make the following electrical connections:
    - power panel - plug in 12V power supply;
    - switch - one socket to power link panel red  
- one socket to 3/2 spring solenoid valve red socket;
    - solenoid valve - black socket to power link panel black.
- Plug in the power supply (12V), and switch on.
- Turn on the air supply.
- Press the switch. The cylinder extends.  
This delivers a new blank onto the conveyor.
- Release the switch, The spring retracts the cylinder.  
This returns the cylinder to the start position, ready to start again.
- Adjust the flow control valve so that the cylinder extends at a moderate speed.

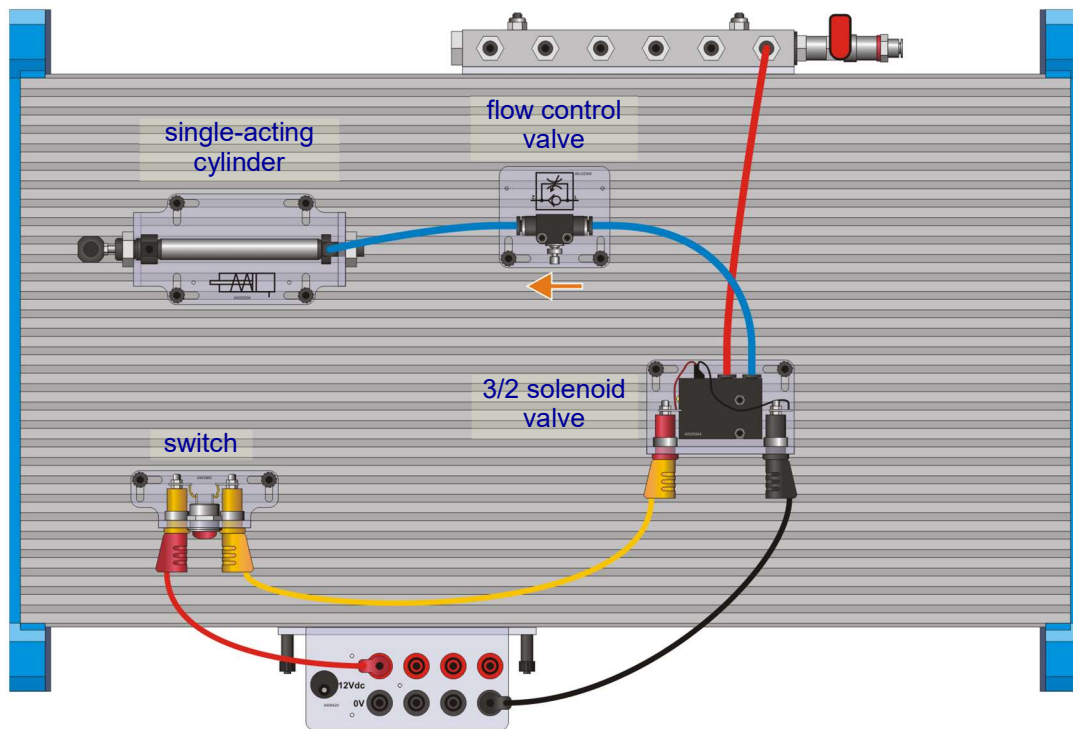


## Safety Rules for Pneumatic Systems

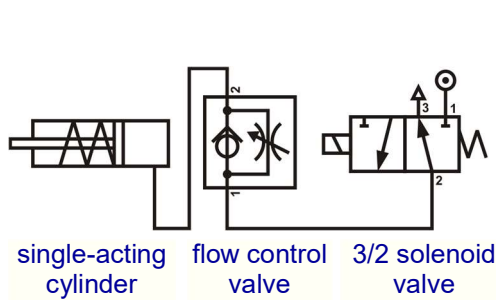
**Remember: compressed air and its components are capable of exerting large forces.**

1. Never blow compressed air at anyone.
2. Don't turn on the air supply until the circuit is complete.
3. If you find an air leak, turn off the air supply at once.
4. Always turn off the air supply before you alter a circuit.
5. Keep fingers clear of moving parts such as piston rods.
6. Wear safety spectacles when building and operating pneumatic circuits.

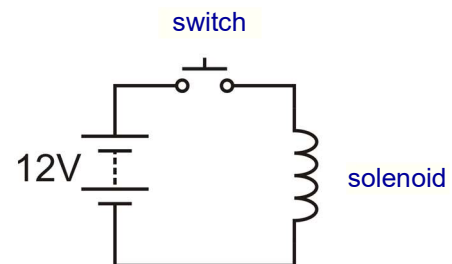
### System for worksheet 2:



Physical layout



Pneumatic circuit diagram



Electrical circuit diagram

w2b

w2c

w2d

# Worksheet 2

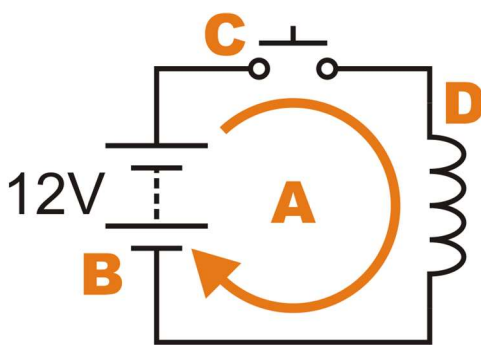
## Magazine feed

So what:

### Electrical circuit diagrams:

- perform the same job for electrical systems as pneumatic circuit diagrams do for pneumatic systems;
- use a different set of symbols.

### Electrical circuit diagram for worksheet 2:



**A** - In a pneumatic system, air is taken from the atmosphere, compressed, used to perform the required task and then exhausted back to the atmosphere.

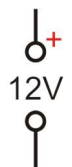
Electrical circuits behave more like hydraulic circuits, in that they contain closed loops. Electricity requires a complete circuit. Electrons leave the power source with excess energy. They transfer this to the components they pass through before returning to the power supply for more energy.

In the circuit diagram, **A** shows this complete circuit.

**B** - The greater the power supply voltage, the greater the energy given to the electrons. Sometimes, the power supply symbol is shown as two circles -

**C** - This is the symbol for a push (or momentary-acting) switch. When closed (pressed,) it allows the electric current to pass. When open (off,) it blocks any current flow.

**D** - This the circuit symbol for the solenoid (a coil of wire.) Sometimes it is shown, as opposite, with two straight lines running alongside. This signifies that it has an iron core, to intensify the magnetic field.

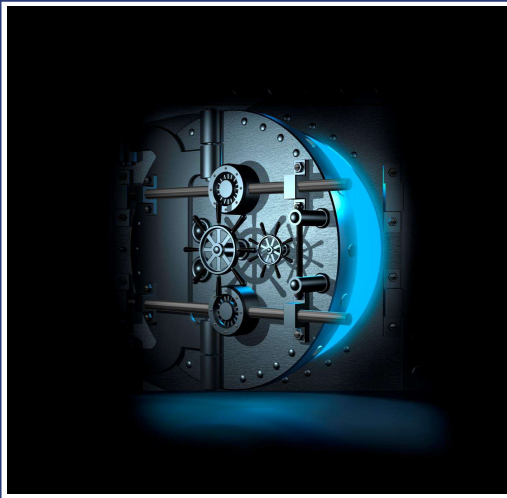


### For your records:

- Copy the pneumatic circuit diagram given above.
- Add an explanation of how the system works, in less than one hundred words.
- How would you make the cylinder extend more quickly?
- How would you modify the system so that it operates only if a safety switch is pressed as well as the operating switch? Draw the electrical circuit diagram for your modified system.

# Worksheet 3

## Bank vault door controller



Bank vaults often have heavy steel doors for enhanced security. Their weight makes them difficult to move manually.

They can be opened and closed pneumatically, using a double-acting cylinder.

This can be linked to an electronic security system, requiring a correct PIN number, finger-print or retina scan.

This worksheet looks at the control system for the pneumatic circuit.

w3a

### Over to you:

- **Make sure that you apply the safety rules given in the previous worksheet!**
- **The red lever on the manifold must be turned off at this stage.**
- Build the arrangement shown on the next page, and once again, compare the physical and pneumatic circuit diagrams.
- Make the following electrical connections:
  - power panel - plug in 12V power supply;
  - switch **1** - one socket to power link panel red  
- one socket to valve **1** red socket;
  - switch **2** - one socket to power link panel red  
- one socket to valve **2** red socket;
  - valve **1** - black socket to power link panel black;
  - valve **2** - black socket to power link panel black.
- Plug in the power supply (12V), and switch on.
- Turn on the air supply.
- Press and hold down switch **1**.  
The cylinder extends, to open the vault door.
- Adjust the flow rate with flow control valve **1** so that it extends at a moderate speed.
- Press and hold down switch **2**.  
The cylinder now retracts to close the door.
- Adjust flow control valve **2** so that it retracts at moderate speed.

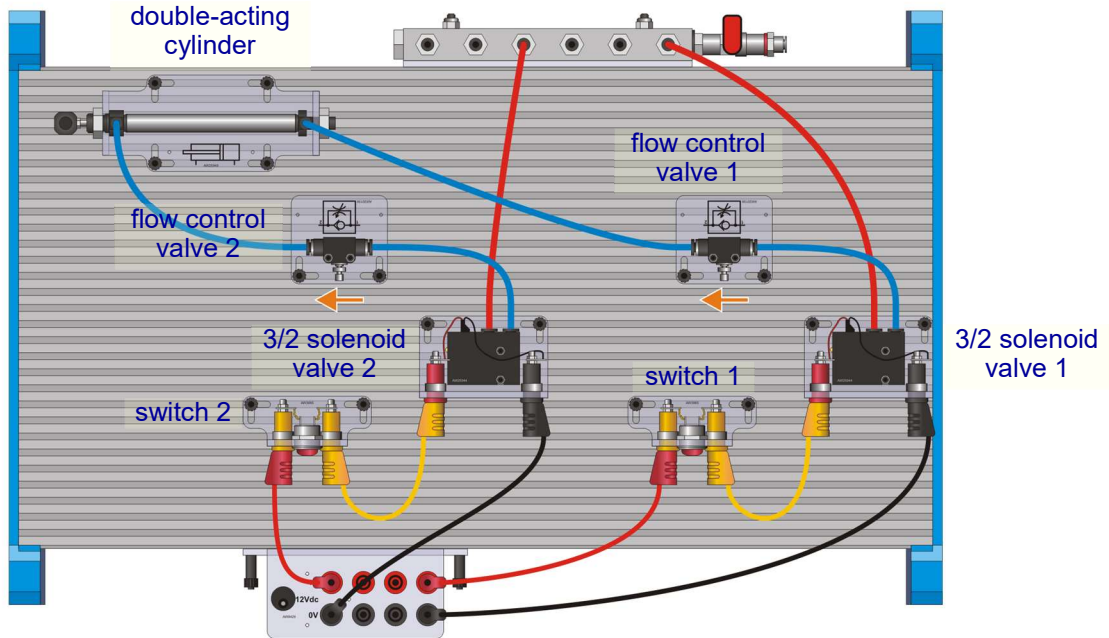


# Worksheet 3

## Bank vault door controller

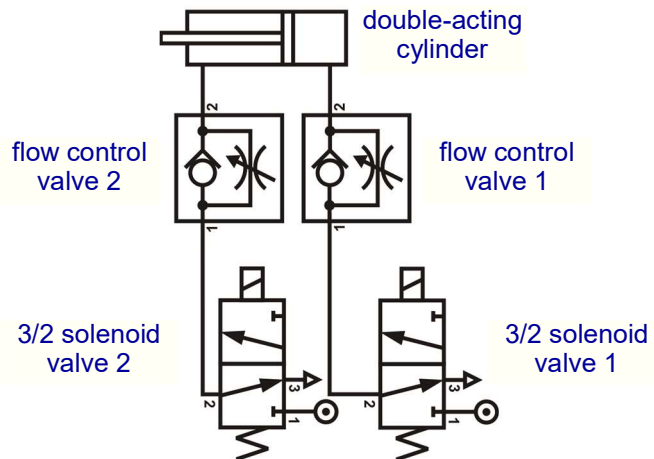
System for worksheet 3:

Physical layout



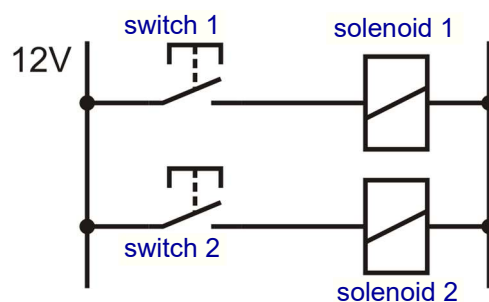
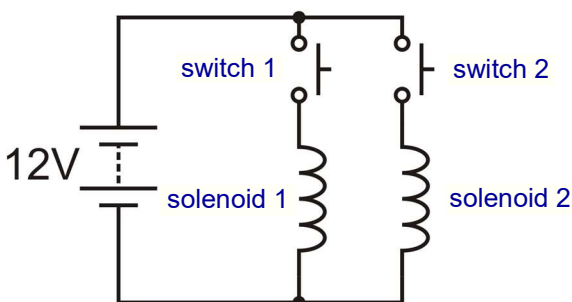
w3b

Pneumatic circuit diagram



w3c

Electrical circuit diagrams



w3d

w3e

# Worksheet 3

## Bank vault door controller

So what:

**Electrical circuit diagrams:**

**Standard circuit diagram:**

The diagram shows two switch / solenoid sets connected 'in parallel.' In this way, they operate independently, as each set is connected directly to the power supply.

**Ladder logic diagrams:**

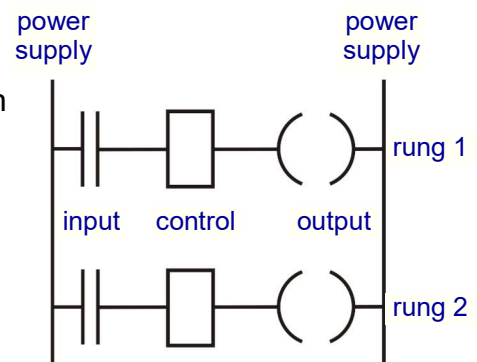
- are simplified circuit diagrams, used originally to design control systems using relays;
- are now more often associated with the use of PLC's (programmable logic controllers,) used to control pneumatic equipment.

(These control systems are studied in detail in the Matrix 'Automatics control' module.)

- resemble ladders, with vertical rails and horizontal rungs; each rung a separate electrical circuit acting independently, in a form of 'parallel processing.'

- consist of five elements:

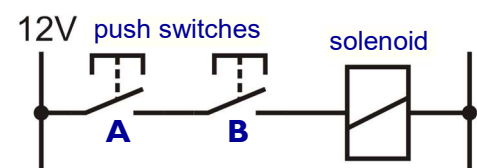
- a power supply - the two vertical rails;
- input devices, e.g. switches, in the left-hand section of the rung;
- control devices, e.g. timers in the centre;
- outputs, e.g. relay solenoids, in the right-hand section;
- interconnecting wires;



- use symbols which vary between PLC manufacturers;

The second ladder diagram shows the modification suggested in the 'For your records' section in the last worksheet.

Here, a safety switch, **A**, must be closed before the operator's switch, **B**, can work.



Switches **A** and **B** are connected in what is known as a 'logical AND' configuration - **A AND B** must be closed to operate the solenoid valve.

**For your records:**

- Explain why a double-acting cylinder is better than a single-acting cylinder for this application.
- The introduction hints at security features that could be incorporated.

Explain, in less than 100 words in total, the advantages and disadvantages of the following forms of security:

- PIN;
- retinal scan.

# Worksheet 4

Feedback needed



The systems created so far operate blindly, without knowing whether the pneumatic cylinders respond or not.

In practical systems, it is often important to know the position of the piston in a cylinder. This requires 'feedback', positional information returned from the actuator to the control system.

There are a number of ways to do this. One uses a reed switch to provide the feedback. This relies on the piston being magnetised

This worksheet demonstrates how to use reed relays in this way.

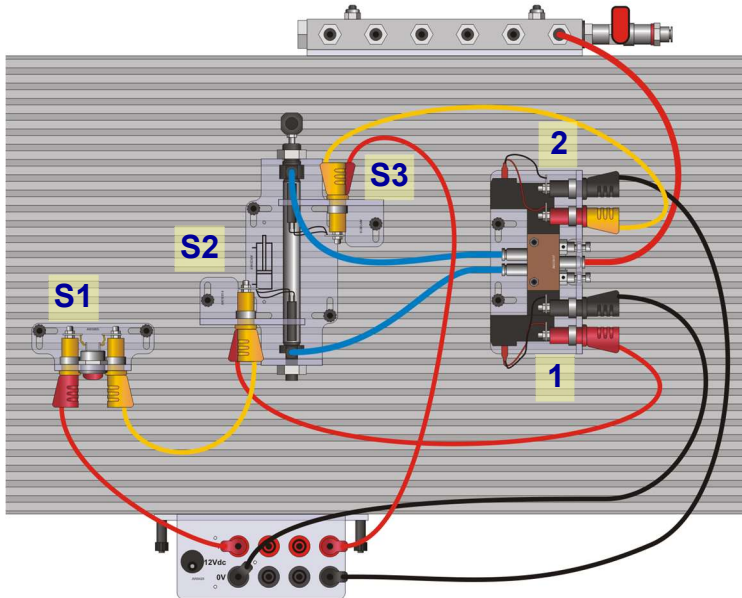
## Over to you:

- **Make sure that you apply the safety rules given earlier!**
- **Make sure that the red lever on the manifold is turned off.**
- Build the arrangement shown on the next page. The physical layout is included to help with the positioning of the reed switches. Compare it with the pneumatic circuit diagram.
- Make the following electrical connections:
  - power panel - plug in 12V power supply;
  - switch **S1** - one socket to power link panel red;  
- one socket to lower socket on reed switch **S2**;
  - reed switch **S2** - upper socket to solenoid **1** red;
  - reed switch **S3** - upper socket to solenoid **2** red;  
- lower socket to power link panel red;
  - solenoid **1** - black socket to power link panel black;
  - solenoid **2** - black socket to power link panel black;
- Plug in the power supply (12V), and switch on.
- Then turn on the air supply.
- Press and hold down switch **S1**. The cylinder should now extend and retract repeatedly, until you release switch **S1**.
- Adjust the exhaust restrictors on the control valve so that the piston moves in and out at a moderate speed.

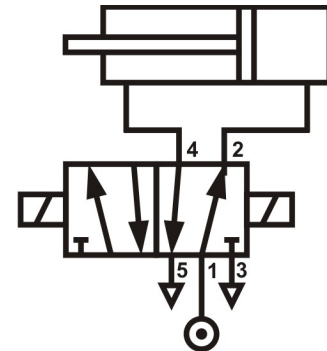
# Worksheet 4

Feedback needed

Physical layout:



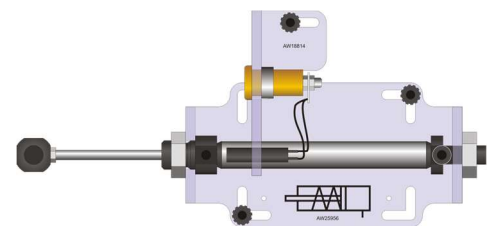
Pneumatic circuit:



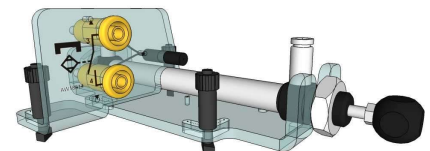
w4b

w4c

The diagrams opposite show in more detail how to connect a reed switch to the cylinder.



w4d



w4e

So what:

- The system uses a 5/2 solenoid/solenoid valve to control the double-acting cylinder. This is similar to the 5/2 pilot/pilot control valve introduced in the 'Automatics Pneumatics' module, the difference being that it uses solenoids instead of pilot pressure lines.
- It also uses two reed switches to detect the position of the piston in the cylinder.

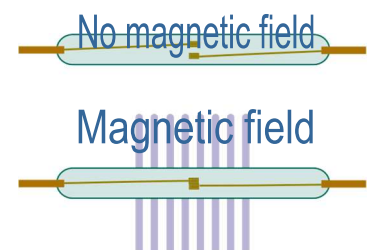
The diagram opposite illustrates the behaviour.

The magnetised piston temporarily magnetises the contacts inside the reed switch, causing them to attract each other, and stick together.

The result is that the reed switch 'switches on'.



w4g



w4f

# Worksheet 4

Feedback needed

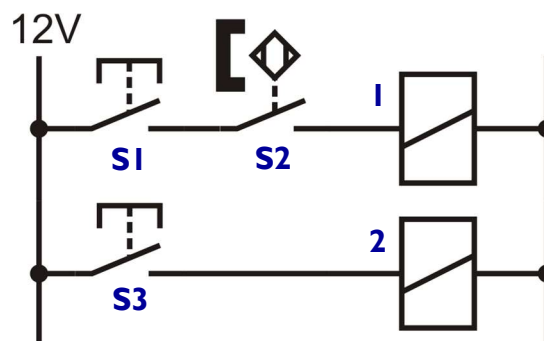
## So what:

The ladder diagram for this system is shown below.

It includes the following symbol for the reed switch:



- Nothing happens until push switch **S1** is closed.
- When reed switch **S2** is closed as well, solenoid **1** is switched on.
- This extends the cylinder, causing reed switch **S3** to close, switching on solenoid **2**.
- This causes the cylinder to retract, opening **S3** and closing **S2**.
- This cycle repeats as long as **S1** is closed.



## For your records:

The reed switch is one form of position sensor but there are other types.

Find out as much as you can about the following categories of proximity and position sensors:

- inductive sensors;
- capacitive sensors;
- optical sensors.

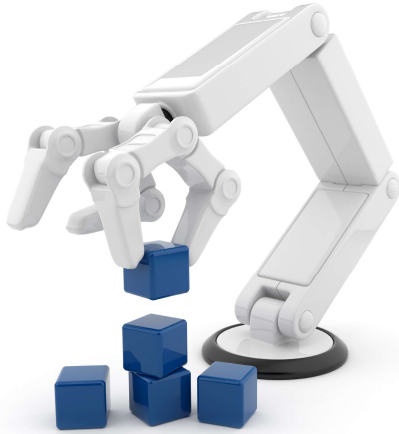
For each, write a short description, including:

- how the sensors work;
- the relative advantages and disadvantages;
- typical applications.

Your descriptions should be no longer than 100 words for each type.

# Worksheet 5

## In sequence



Many applications of pneumatics require two, or more, cylinders to operate together in a sequence.

The next pneumatic control system operates a gripper, which could be part of a robot arm

The gripper reaches out and brings back an object, such as a cup, when a switch is pressed.

It relies on two pneumatic cylinders, A and B, working in the following sequence:

- reach out (A extends);
- grip (B extends);
- bring back (A retracts);
- release (B retracts).

### Over to you:

- **Make sure that you apply the safety rules!**
- **Make sure that the red lever on the manifold is turned off.**
- Build the arrangement shown on the next page.
- The three diagrams show the pneumatic circuit, the ladder diagram (electrical circuit) and a suggested physical layout for the components. The electrical connections are missing from the physical layout to make it clearer.
- Use the ladder diagram to make the electrical connections needed.
- Position the two micro switches carefully. The one labelled **a-** is closed when cylinder **A** is fully retracted, but opens as soon as the cylinder extends. The one labelled **a+** is closed when cylinder **A** is fully extended, but opens as soon as the cylinder retracts. The physical layout shows a 'ghost' image of cylinder **A** extended, to illustrate this.
- Plug in the power supply (12V), and switch on.
- Then turn on the air supply.
- Press and hold down switch **S1**.  
The cylinders should now extend and retract in sequence repeatedly, until you release **S1**.
- Adjust the exhaust restrictors and flow control valves so that the pistons move in and out at moderate speed.



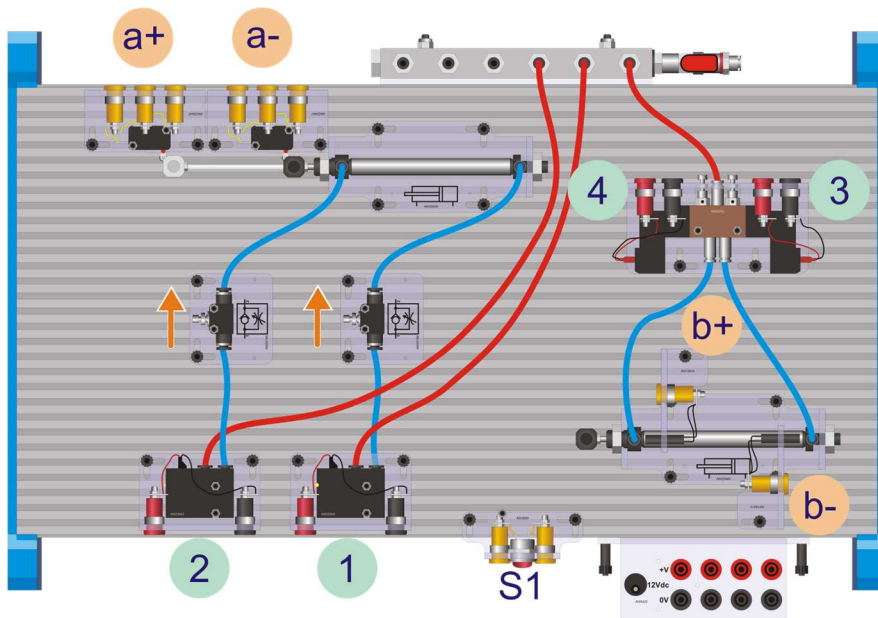
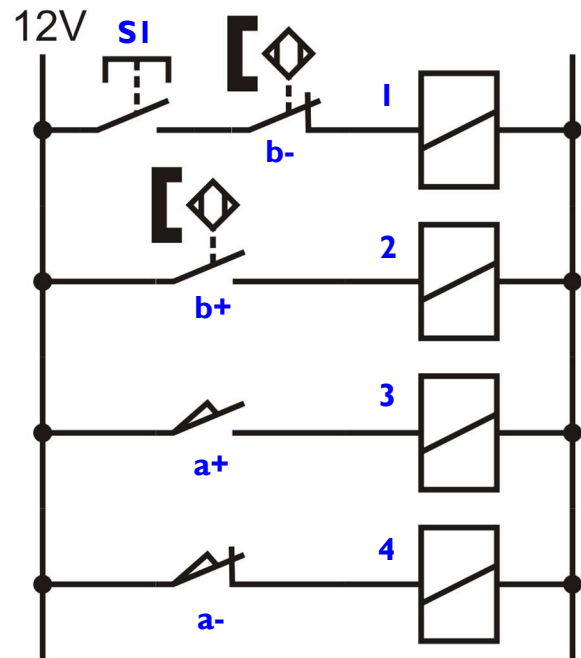
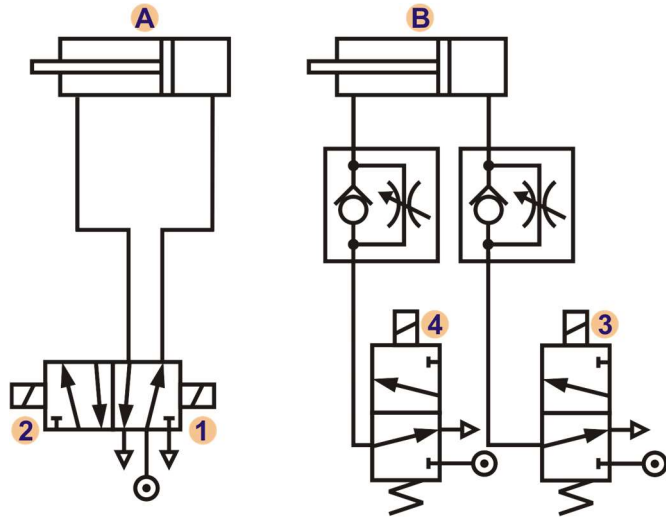
# Worksheet 5

In sequence

Pneumatic circuit:

Ladder diagram:

Physical layout (excluding electrical connections):



# Worksheet 5

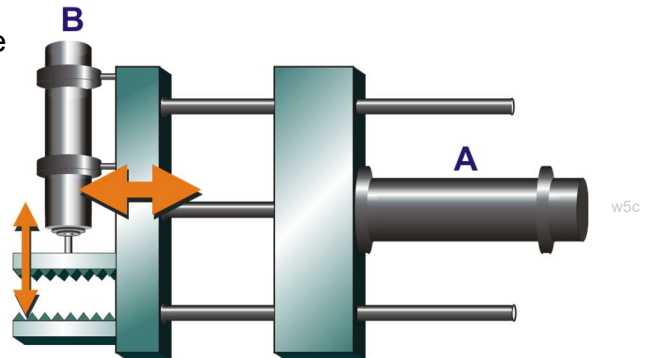
## In sequence

### So what:

The two cylinders that control the gripper operate in the sequence:

- reach out (**A+**);
- grip (**B+**);
- bring back (**A-**);
- release (**B-**).

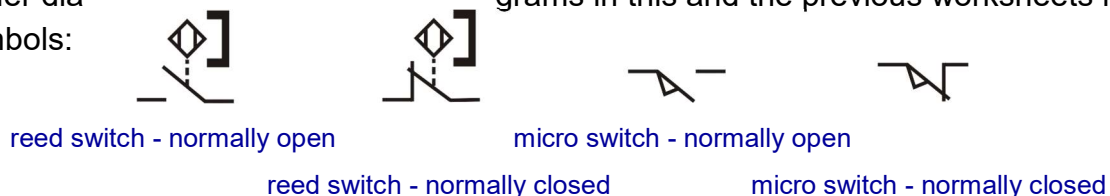
It is important to identify clearly the four switches (**a-**, **a+**, **b+** and **b-**.) and the four solenoids (**1**, **2**, **3** and **4**.) on your assembly.



- Solenoid **1** extends cylinder **A**;
- Solenoid **2** retracts cylinder **A**;
- Solenoid **3** extends cylinder **B**;
- Solenoid **4** retracts cylinder **B**.

The sequence is determined by how you connect these switches to the solenoids. The ladder diagram shows that, here, switch **b-** controls solenoid **1**, **b+** controls solenoid **2**, **a+** controls solenoid **3** and **a-** controls solenoid **4**.

The ladder diagrams in this and the previous worksheets include new symbols:



### For your records:

- Copy the ladder logic symbols for:
  - a push switch;
  - a solenoid;
  - a reed switch (normally open);
  - a micro switch (normally open.)
- Draw the ladder diagram, for the same physical layout, to generate the following sequence when switch **S1** is pressed:

**A+ A- B+ B-**

Build and test your design.

- What sequence would be required to control an air lock, where cylinder **A** operates the outer door, and cylinder **B** the inner door?




Draw a ladder diagram for your proposed solution, and explain each stage of the sequence as part of your answer.

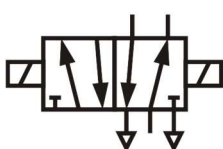
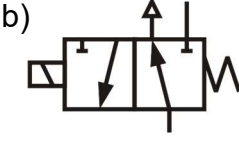
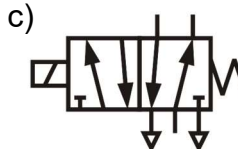
## About these questions

These questions are designed to be a useful aid to revision.

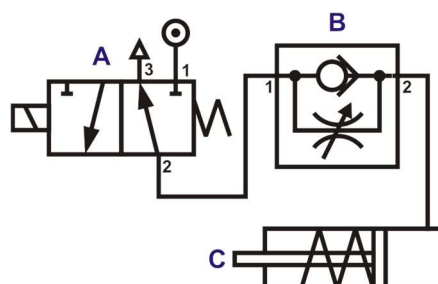
Allow 25 minutes to answer them and then check your answers with those given on page 26.

For questions 1 to 6, choose the correct answer (a, b or c).

- Electrically operated pneumatic valves are operated by a:
  - solenoid
  - lever
  - permanent magnet
- Which is the correct description of a 'normally-open' push switch, connected in a circuit?
  - It has no cover on it.
  - It has a very low resistance when pressed.
  - it has a high voltage across it when pressed, and a low voltage when not pressed.
- What kind of switch is actuated by the magnetic piston ring of a cylinder?
  - reed switch
  - push switch
  - toggle switch
- Which is the correct symbol for a normally open micro switch?
  - 
  - 
  - 

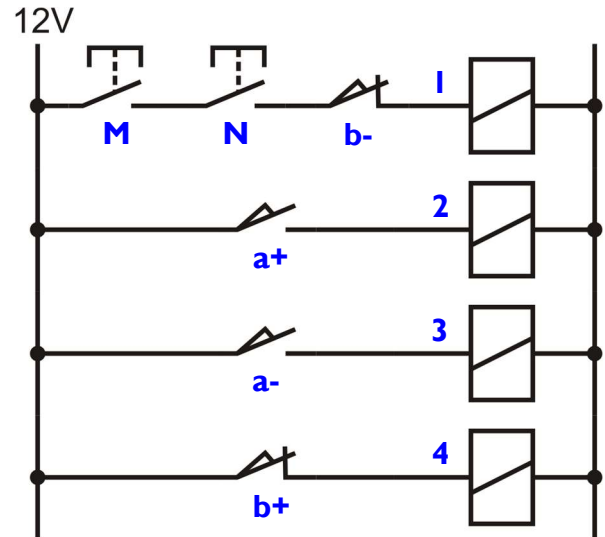
- Which is the correct symbol for a solenoid operated, spring return 5/2 control valve?
  - 
  - 
  - 

- Which statement is true for the pneumatic circuit below?
  - Port 3 on valve **A** is an exhaust port.
  - Flow control valve **B** is connected the wrong way round to control the flow of air into cylinder **C**.
  - When valve **A** is actuated, cylinder **C** will retract.



7. Look at the ladder diagram opposite.

- a) Which of the following statements is **NOT** true:
- (i) The sequence repeats as long as both switches **M** and **N** are kept closed.
  - (ii) Switches **M** and **N** are connected in a logic AND configuration.
  - (iii) The system contains two push switches and four reed switches.
- b) The system is piped so that:
- Solenoid 1 extends cylinder A.
  - Solenoid 2 retracts cylinder A
  - Solenoid 3 extends cylinder B
  - Solenoid 4 retracts cylinder B.

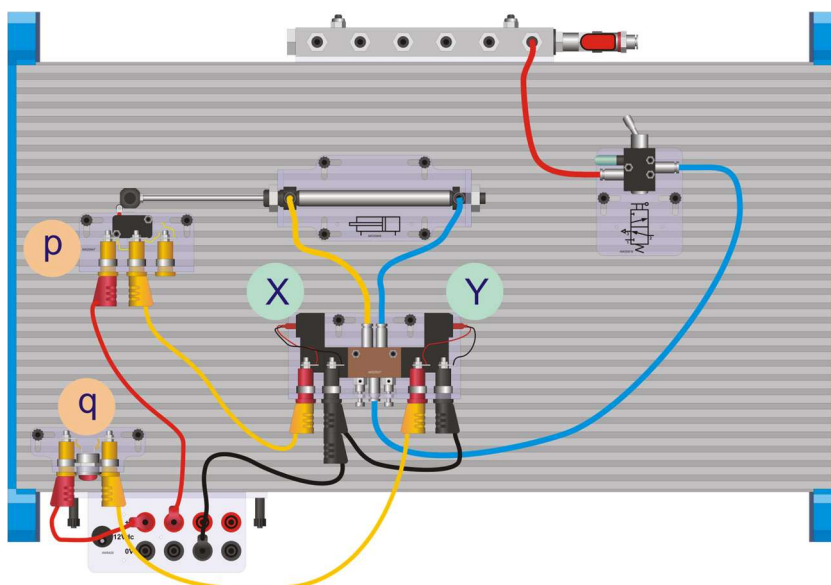


q7

What sequence will be produced by implementing the ladder diagram?

8. For the system shown below, draw

- a) the **pneumatic** circuit diagram;
- b) the **ladder diagram**, using the labels **p**, **q**, **X** and **Y** correctly.



q8

Design pneumatic systems to satisfy the requirements set out in the following three letters. For each, provide a pneumatic circuit diagram and a ladder diagram, like those in the worksheets, together with a description of how the system works.

## *SpeedRail UK*

### Internal memo

From: Customer Relations department  
To: Design department

As you know, carriage doors on a train are operated by pneumatic cylinders. At present, all doors open every time the train stops at a station.

We have received complaints from passengers that this makes carriages very cold and draughty in winter. They find it especially annoying when only one or two passengers actually get on or off.

Can you please design a new system which allows each door to be opened separately by passengers

either from inside or outside the carriage? This will mean that only those doors that are needed will be opened.

*FUNLAND  
RESORTS*

Dear Designer

We are updating the shooting gallery in our amusement arcade, and fitting it out with a new range of targets, with more modern themes.

We would like to feature some 'pop-up' moving targets in the new gallery.

There is a supply of compressed air in the arcade, and so we would like to use an electro-pneumatic system to move the targets up and down.

Please send us suggestions as to how this may be done.

Yours faithfully,

*I. Greaves*

*FUNLAND  
RESORTS*

Dear Designer

Thank you for the designs you supplied for our new shooting gallery. I wonder if you could also help with our House of Horrors revamp.

This contains several moving waxworks, operated by electro-pneumatic systems. For example, we have Dracula rising from his coffin, 'the killer shark' and many more.

I recently had the idea for a French Revolution exhibit, with a working guillotine, but I need advice on how to design the operating system. The guillotine blade and victim's head will be operated by pneumatic cylinders.

The sequence is:

- lights are off;
- switch operates to turn on lights;
- blade comes down;
- victim's head comes off;
- lights go out;
- blade and head return to original position;
- system ready for next performance.

I think this could be a valuable addition to the House of Horrors, and look forward to receiving your designs for the exhibit as soon as possible.

Yours faithfully,

*I. Greaves*

## Answers to revision questions (see page 17)

1. a)

2. b)

3. a)

4. c)

5. c)

6. a)

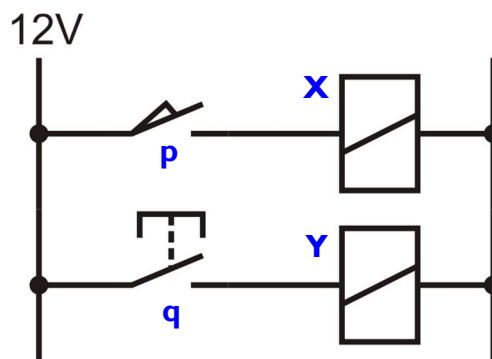
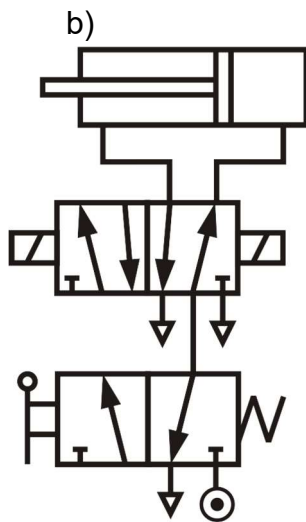
7.

a) (iii)

b) **A+, A-, B+, B-**

8.

a)



q8Aans

q8Bans



## About this course

### Introduction

This workbook provides practical activities and investigations which complement courses such as:

- BTEC Nationals in Engineering, Unit 15, "Electro, Pneumatic and Hydraulic Systems and Devices"
- BTEC Higher Nationals in Mechanical Engineering, Units 9 and 26: "Applications of Pneumatics and Hydraulics".

The learning aims are to:

- identify industrial electro pneumatic components, and use them correctly and safely;
- design, build and test control systems for pneumatic circuits to meet a given specification;
- read and draw pneumatic circuit diagrams using CETOP standard symbols;
- know how pneumatic systems are used in industry, transport and leisure contexts.

Automatics equipment makes it quick and easy to construct and investigate basic pneumatic circuits, which, thanks to the symbols printed on each component carrier, look exactly like the pneumatic circuit diagram.

### Prior Knowledge

Students should have followed the 'Automatics essentials' course, or have equivalent knowledge, and have the study skills and mathematical competence required to use these worksheets effectively.

### Learning Objectives

On successful completion of this course the student will have learned to:

- apply six safety rules when building and using pneumatic circuits;
- turn on a solenoid operated pneumatic control valve using an input device such as a switch;
- use a flow-control valve to modify the speed of a cylinder while either extending or retracting;
- describe two electronic security features for an electronic door control system;
- describe the basic operation of a solenoid -controlled pneumatic valve;
- build a pneumatic system given a pneumatic circuit diagram;
- make electrical connections needed, using a ladder diagram;
- understand that a ladder diagram is a simplified form of electrical circuit diagram, containing input, control and output sections;
- connect two push switches in a 'logical AND' configuration;
- draw ladder diagram symbols for a push switch, a solenoid, a reed switch (normally open) and a micro switch (normally open);
- set up and control a reciprocating pneumatic cylinder;
- describe the advantages of incorporating feedback into a control system;
- use a reed relay to provide feedback in a 'proof of position' situation;
- construct a ladder diagram to meet the specification for a given sequence of two cylinders.

## What students will need:

The Automatics electro-pneumatics add-on kit contains the equipment shown in the table.

Qty	Code	Legacy Code	Description
2	AU8030	AW-ESWP	Switch, push-to-make
2	AU6010	AW-V32ES	Valve, 3/2, solenoid-spring
1	HP2666	HP2666	Power supply
2	AU8025	AW-ERS	Reed switch and holder
1	AU6015	AW-V52EE	Valve, 5/2, double-solenoid
2	AU8015	AW-EMS	Microswitch
1	AU8020	AW_EPD	Power panel
4	LK5603	LK5603	Lead, 4mm to 4mm, red
4	LK5604	LK5604	Lead, 4mm to 4mm, black
5	LK5607	LK5607	Lead, 4mm to 4mm, yellow

This kit is intended as a supplement to the equipment provided in the Automatics essentials solution, so you may also require the following items:

Qty	Code	Legacy Code	Description
1	AU9020	AW20801	Automatics essentials solution
1	AU1050	AW30100	Compressor
1	LK1110	LK1110	Multimeter

Please note: New product codes for Automatics products were created in January 2015. The "legacy codes" in the tables above refer to the part numbers prior to this date and are included as a convenience for customers who bought products before the part number change.

## Using this course:

It is expected that the worksheets are printed / photocopied, preferably in colour, for the students' use. Students should retain their own copy of the entire workbook.

Worksheets usually contain:

- an introduction to the topic under investigation and its practical application;
- step-by-step instructions for the investigation that follows;
- a section headed 'So What?' which aims both to challenge learners by questioning their understanding of a topic and also to provide a useful summary of what has been learned. It can be used to develop ideas and as a trigger for class discussion.
- a section headed 'For Your Records' which provides important summary information that students should retain for future reference, and extension exercises.

This format encourages self-study, with students working at a rate that suits their ability. It is for the tutor to monitor that students' understanding is keeping pace with their progress through the worksheets and to provide additional work that will challenge brighter learners. One way to do this is to 'sign off' each worksheet, as a student completes it, and in the process have a brief chat to assess the learner's grasp of the ideas involved in it.

A set of revision questions has been provided to conclude the work in this unit. These are of mixed difficulty and are designed to help students identify topics which might need more work. It is recommended that students attempt these questions under examination conditions and without the use of notes.

Finally, three scenarios are included for students to use as realistic design problems (without solutions, as there are a number of valid approaches to each). These can be used as homework tasks if the instructor so wishes.

## Time:

It will take most students between five and eight hours to complete the practical work and exercises in the worksheets. It is expected that a further, similar length of time will be needed to support the learning in a class, tutorial or in a self-study environment.

Worksheet	Notes for the Tutor	Timing
1	<p>This worksheet introduces the student to hybrid electro-pneumatic systems, where control is achieved using electronic components.</p> <p>It also revisits the method used to attach components to the Automatics platform. In carrying out the assembly, students should consult the component layout on page 3.</p> <p>The following page outlines the operation of the solenoid-controlled pneumatic valve. It then asks students to make some voltage measurements using a multimeter. Some students may have limited or no experience of using multimeters, and instructors may need to help them with this task.</p>	20 - 30 minutes
2	<p>This worksheet starts with a reminder of the safety rules that apply to pneumatic circuits. Instructors should emphasise the importance of these and enforce them strictly.</p> <p>The task involves setting up a reciprocating cylinder. The action is initiated by pressing a switch, though it is pointed out that, in practice, this may be an emergency stop button, attached to a safety guard, for example.</p> <p>On page 6, there are three diagrams - one shows a suggested physical layout for the components, one the pneumatic circuit diagram, and the third the electrical circuit diagram. The students should take time to relate these. Soon, worksheets will offer only the pneumatic and electrical circuit diagrams, and so the student must be adept at converting these into actual pneumatic systems. The instructor should stress that these circuit diagrams are abstract representations, that do not attempt to suggest the actual position of the components on the platform, but, instead, show the connections between them.</p> <p>Some students will have previous experience of electrical circuit diagrams. Others may not, and so the instructor will need to judge how much preparation / assistance to give to allow students to apply these.</p> <p>The student should be encouraged to use coloured pipes and a wiring colour scheme to make the layout clear. (One useful convention is to use red pipes in all connections to the manifold.)</p>	30 - 50 minutes

Worksheet	Notes for the Tutor	Timing
3	<p>Next, attention moves to the double-acting cylinder, as the return spring in the single-acting cylinder is unlikely to be strong enough to operate the door mechanism.</p> <p>Incorporating two flow-control valves allows control of the piston both while extending and while retracting. Again, diagrams show the physical layout, the pneumatic circuit diagram and the electrical circuit diagrams. The ladder diagram is introduced as a simplified form of electrical circuit diagram. This format is widely used in industry, often in conjunction with Programmable Logic Controllers (PLCs.)</p> <p>One issue with this is that different manufacturers use different symbols for these diagrams. The 'Automatics' kit uses a standard set of symbols both in the worksheets and on the hardware itself. Where institutions have PLCs, instructors may wish to introduce other symbols at this point, and could demonstrate the use of the PLC, programmed via ladder logic.</p> <p>The 'So what' section includes a description of a 'logical AND' connection of two switches. Again, the instructor must judge how far to take this. Comparison with the 'OR' configuration may be appropriate here, allowing, for example, a machine to be operated from one of two locations.</p> <p>The worksheet ends with a research project in which students investigate electronic security features which could be incorporated into a more elaborate control system.</p>	40 - 60 minutes
4	<p>The introduction makes the point that often some kind of feedback is needed to ensure that a particular part of the process has taken place. This involves the use of a sensor, here a reed switch.</p> <p>This is mounted onto cylinder A, and detects whether or not it has extended. (The piston inside the cylinder is magnetised, and closes the reed relay contacts when in close proximity.)</p> <p>The instructor could demonstrate the action of the reed switch by connecting a multimeter, set on the resistance range, to show that the reed switch operates when the piston extends.</p> <p>The output of the reed switch is used to operate the solenoids in a 5/2 control valve. This is similar to the pilot-air controlled valve used in the 'Automatics Pneumatics' module. Instructors should contrast the behaviour of these two devices, as otherwise students may confuse them.</p> <p>The electrical circuit may need some explanation. The reed switch is simply that - a switch. To operate the solenoid, this must be connected to a power source, as well as to the solenoid itself. This is shown on page 13 in the form of a ladder diagram, using new symbols for the reed switch.</p>	40 - 60 minutes

Worksheet	Notes for the Tutor	Timing
5	<p>This worksheet demonstrates that the behaviour of a standard set of pneumatic components can be changed radically by changing the controlling electrical circuit.</p> <p>In the earlier module, a sequence of cylinder operations was created entirely pneumatically. However, to change that sequence required changes to the physical layout of the components. Here, change can be achieved by altering the electrical circuit that controls the system.</p> <p>First of all, the system generates the sequence, A+, B+, A-, B-, which could control part of a robot arm assembly. The student then re-designs the control system to generate a new sequence, A+, A-, B+, B-. If time allows, the students should then build and test the design.</p> <p>In a more open design problem, the student is asked to identify the sequence of cylinder operations required to control an airlock, and to then draw the corresponding ladder diagram. The instructor could require the students to build and test this system</p>	40 - 60 minutes
	<p>Three design scenarios are presented on page 19.</p> <p>These are a challenging test of the student's understanding of this module. There is no single solution to each. The instructor should look for refinements in the solutions, such as the use of flow control valves or exhaust restrictors to manage the speed of movement of the pistons.</p> <p>Students can be asked to deliver their solution to the class as a formal presentation, or to document it for the instructor. Equally, the tasks could be completed within the class or be set as homework, as the instructor sees fit.</p>	



**About this document:**

Code: AW2079-80-01

Developed for product code AW20792 – Automatic electro-pneumatics add-on

Date	Release notes	Release version
January 2013	First version released	AW2079-80-01
January 2015	New part numbers	AW2079-80-02

10 08 23 Reformatted to new style

22 01 24 changed lead count on page 22