Booklet 6A: Pneumatics

S3 Engineering Science · Lessons 1 to 8

Name _____ **Class** _____

Teacher _____

	I can …	Class	Revision	Test
L1	follow the safety rules and the regulator routine			
	say what the rod does when I press and let go			
	test a circuit in the simulation before I build it			
L2	say what a 3/2 valve does when it is pressed and let go			
	draw a circuit with symbols			
	build a circuit from my own drawing			
L3	slow a cylinder with a flow control valve			
	plan a fair test: keep the same, change one thing			
	say which way the arrow slows the air			
L4	tell a single-acting from a double-acting cylinder			
	build a circuit with a 5/2 valve			
	set a rod's speed with exhaust restrictors			
L5	build a circuit from a diagram with 7 parts			
	explain how the brake stops the door			
	test every way in with a table			
L6	find a fault by checking in order			
	write a fault, its cause and its fix			
	hide a fault safely, with the air off			
L7	use pilot air to work a 5/2 valve			
	say what a pilot valve remembers			
	explain why a pilot valve helps			
L8	make a time delay with a reservoir			
	use an air-bleed sensor safely			
	explain how the sensor works			

Sources & credits: *Circuits, the fault-finding checks and the safety rules are adapted from the Matrix CP2080 Pneumatics Essentials worksheets 1 to 6 and 8 (© Matrix Technology Solutions Limited); each page names its own source. Drawings and topic mark by R Stewart. Harbourlight and Jo Kerr are made up. R Stewart - October 2026*

Lesson 1

Lesson 1: Safety first and last

SAFETY check	☐ Regulator at 0	☐ Goggles on	☐ Air Permit signed

Today's job (tick boxes when done)

Job card 1: The ticket gate	Pass the Safety Licence	Make the gate work on the kit	Fill in Compare and Questions

My role today (circle one)	Safety	Builder	Tester	Recorder

Task 1: Simulate

Go to: sites.google.com/view/nostrainsim/pneumatics

Add the components listed on the bench card in the correct places.

Join them up, and press simulate.

What happens?

Air Permit: no permit, no air

☐ Works in the simulation	☐ Regulator at 0
☐ Tubing checked	☐ Goggles on
Safety Officer:	Teacher:

Task 2: Kit

Build from **bench card 1**. The Safety Officer reads out each step.

Kit: ☐ Built ☐ Tested ☐ Regulator back to 0

SAFETY If you hear a hiss, turn the regulator to 0 at once.

Task 3: Compare

Record what the rod did in the simulation and on the kit.

What you did	In the simulation	On the kit
Pressed and held the button		
Let go of the button		

Task 4: Questions: 3 on your own

1. **Name** the input and the output in the ticket gate circuit. (2)

2. **Describe** what the piston rod does when you press and hold the button, and when you let go. (2)

3. **Explain** why you turn the regulator to 0 before you change a circuit. (2)

Task 5: Key words

Complete the sentences. Use each word from the box once.

squashed	regulator	bar	anyone

Compressed air is air _____ into a small space.

Before you change a circuit, turn the _____ to 0.

Test with the gauge between 1 and 2 _____ (inner numbers).

Never point air at _____.

Lesson 2

Lesson 2: Reading the diagram

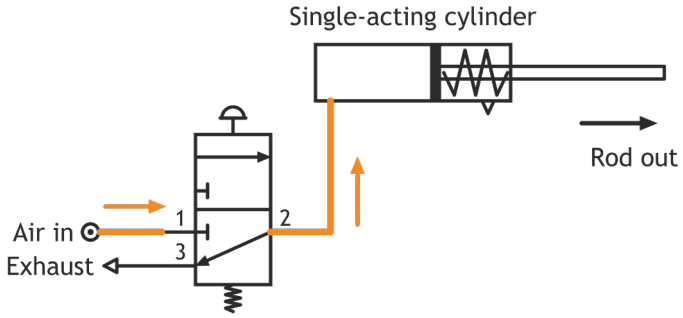
SAFETY check	☐ Regulator at 0	☐ Goggles on	☐ Air Permit signed

Today's job (tick boxes when done)

Job card 2: The park manual	Read a valve symbol	Draw the gate circuit	Build the lever gate

My role today (circle one)	Safety	Builder	Tester	Recorder

Worked example: button pressed



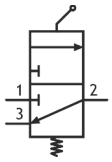
3/2 push-button valve

1 Air flows into port 1 and out of port 2.
2 The air goes into the cylinder and pushes the piston.
3 The piston rod moves out. We say the cylinder **extends**.

Source: circuit from Matrix CP2080 Worksheet 1 (© Matrix Technology Solutions Limited).

Task 1: Now you, then your turn

Now you: a lever valve (with a partner)



A **3/2 lever valve** does the same job. You push a lever instead of a button.

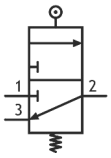
1. Complete lines 2 and 3 for when the lever is pushed. (2)

1 Air flows into port 1 and out of port 2.

2 _____

3 _____

Your turn: a roller valve (on your own)



A **3/2 roller valve** does the same job. A ride train presses the roller as it goes past.

2. Describe what the rod does when the train presses the roller, and when the train has gone. (2)

_____

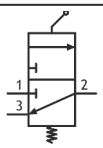
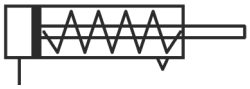
_____

_____

_____

Task 2: Draw the gate circuit

Draw the ticket gate circuit with a **lever valve**. Copy these symbols. Use a ruler for the pipes.

 Air supply	 Lever valve	 Single-acting cylinder	 Exhaust

Check: ☐ Ports numbered ☐ Ruler used ☐ Exhaust on port 3

Task 3: Simulate

Go to: sites.google.com/view/nostrainsim/pneumatics
Add the components from your drawing (bench card 2 lists them).
Join them up, and press simulate.
What happens when you push the lever, then let go?

Task 4: Air Permit and kit

Build from **bench card 2**. The Safety Officer reads out each step.

☐ Works in the simulation ☐ Tubing checked

☐ Regulator at 0 ☐ Goggles on

Safety Officer _____ Teacher _____ (no permit, no air)

Kit: ☐ Built ☐ Tested ☐ Regulator back to 0

Task 5: Questions: 2 on your own

3. Explain why this valve is called a 3/2 valve. (1)

---

4. State what the gauge must read before you change a circuit. (Look back: Lesson 1) (1)

Task 6: Key words

Complete the sentences. Use each word from the box once.

ports	states	1	2	exhaust

A 3/2 valve has 3 _____ and 2 _____.

Air comes in at port _____ and goes out to the cylinder at port _____.

Port 3 is the _____: used air leaves here.

Lesson 3: Control the flow

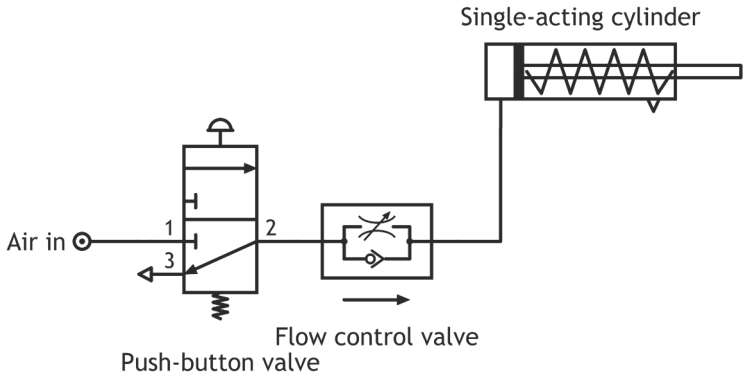
SAFETY check	☐ Regulator at 0	☐ Goggles on	☐ Air Permit signed

Today's job (tick boxes when done)

Job card 3: Stop the slam	Slow the pin with a flow control valve	Do a fair test on speed	Beat the clock

My role today (circle one)	Safety	Builder	Tester	Recorder

The circuit



Source: circuit from Matrix CP2080 Worksheet 2 (© Matrix Technology Solutions Limited).

The arrow under the flow control valve shows the way it slows the air. Here it points to the cylinder.

Task 1: Simulate

Go to: sites.google.com/view/nostrainsim/pneumatics

Add the components listed on the bench card in the correct places.

Join them up, and press simulate.

What happens when you close the flow control valve a little at a time?

Task 2: Air Permit and kit

Build from **bench card 3**. The Safety Officer reads out each step.

☐ Works in the simulation ☐ Tubing checked

☐ Regulator at 0 ☐ Goggles on

Safety Officer _____ Teacher _____ (no permit, no air)

Kit: ☐ Built ☐ Tested ☐ Regulator back to 0

SAFETY You may turn the screw with the air on. Never touch a tube with the air on.

Task 3: Fair test: how fast?

Set the regulator between 1 and 2 bar. **Record** how many seconds the rod takes to go out. Count the seconds.

Flow control screw	Seconds to go out	Coming back: fast or slow?
Right in		
Open 1 turn		
Open 2 turns		
Right out		

1. Write one thing you kept the same to make it a fair test. (1)

Task 4: Beat the clock

Set the pin so it goes out in **3 seconds**, before the timer ends.
Circle your team's target. The timer is on the board.

Bronze	Silver	Gold
1 to 5 seconds	2 to 4 seconds	3 seconds, checked by another team

Task 5: Turn it round

		What to do	Done
1		Turn the regulator to 0. Turn the flow control valve round: arrow away from the cylinder.	
2		The Safety Officer checks every tube is pushed in fully.	
3	⚠	**SAFETY** Set the regulator between 1 and 2 bar. Press and hold the button, then let go.	
4		Turn the regulator back to 0.	

Write fast or slow in each box.

The arrow points	Rod goes out	Rod comes back
To the cylinder		
Away from the cylinder		

Task 6: Questions: 3 on your own

2. Describe what the flow control valve does to the rod. (1)

3. Explain why the rod comes back fast when the arrow points to the cylinder. (2)

4. Draw the symbol for a 3/2 push-button valve. (Look back: Lesson 2) (1)

Task 7: Key words

Complete the sentences. Use each word from the box once.

slows	arrow	freely	restrictor

A flow control valve _____ the air in one direction only.

The _____ under the valve shows the direction it slows.

Air going the other way pushes the ball off its seat and flows _____.

In the exam it is called a uni-directional _____.

Task 8: Exam practice

1. A pneumatic circuit is used in part of a manufacturing process.

The speed of the piston movement needs to be slowed down.



Draw the symbol for a uni-directional restrictor to slow the air flow in the direction shown. (2)

Source: Question 1: N5 Engineering Science 2022, Q15(b). © Qualifications Scotland (SQA).

Lesson 4: Push and pull

SAFETY check	☐ Regulator at 0	☐ Goggles on	☐ Air Permit signed

Today's job (tick boxes when done)

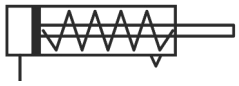
Job card 4: The paint dip	Feel the difference: single and double	Build the paint dip	Set the speeds

My role today (circle one)	Safety	Builder	Tester	Recorder

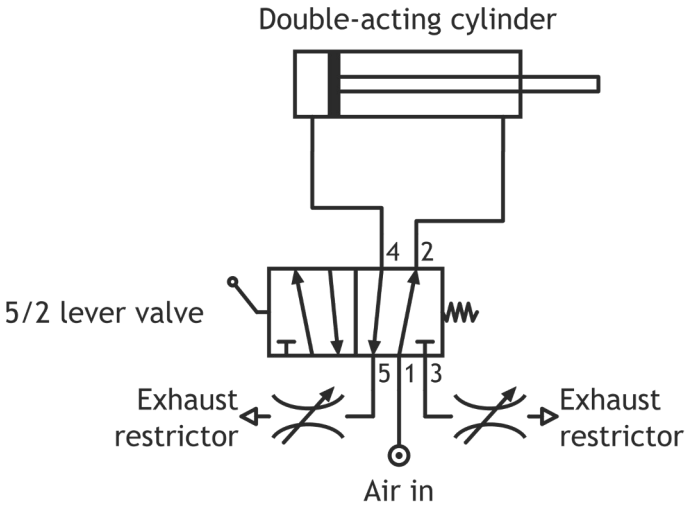
Task 1: Feel the difference

SAFETY Air off. Regulator at 0. No tubes in the cylinders.

Pull each rod out by hand, then let go. **Write** what happens.

Cylinder	What happens when you let go?
 Single-acting	
 Double-acting	

The circuit



Source: circuit from Matrix CP2080 Worksheet 4 (© Matrix Technology Solutions Limited).

Port 4 goes to the back of the cylinder. Port 2 goes to the front. Push the lever: the rod goes out. Let go: the spring moves the valve back, and the rod comes in.

Task 2: Simulate

Go to: sites.google.com/view/nostrainsim/pneumatics

Add the components listed on the bench card in the correct places.

Join them up, and press simulate.

What happens when you push the lever, then let go?

Task 3: Air Permit and kit

Build from **bench card 4**. The Safety Officer reads out each step.

☐ Works in the simulation	☐ Tubing checked
☐ Regulator at 0	☐ Goggles on

Safety Officer _____ Teacher _____ (no permit, no air)

Kit: ☐ Built ☐ Tested ☐ Regulator back to 0

Task 4: Set the speeds

Turn one exhaust restrictor in a little, with the rod still. Test. **Tick** the way the rod slowed. Then do the same with the other one.

Restrictor turned in	Rod out slowed (the dip)	Rod back slowed (the lift)
Port 3	☐	☐
Port 5	☐	☐

Task 5: Compare

Write one thing that was different on the kit.

Task 6: Questions: 3 on your own

1. **State** one difference between a single-acting and a double-acting cylinder. (1)

2. **Explain** why the paint dip needs a double-acting cylinder. (2)

3. **Describe** what a flow control valve does. (Look back: Lesson 3) (1)

Task 7: Key words

Complete the sentences. Use each word from the box once.

one	spring	two	air	outstroke

A single-acting cylinder has _____ port. A _____ pushes the rod back in.

A double-acting cylinder has _____ ports. _____ pushes the rod out and back in.

When the rod moves out, the exam word is _____ (and moving back in is instroke).

Task 8: Exam practice

1. A double-acting cylinder is used to stamp a logo onto products.

The piston in the double-acting cylinder is required to outstroke **slowly** and **smoothly**. The speed of the instroke should not be changed.

Describe how this would be achieved. (2)

Source: Question 1: adapted from N5 Engineering Science 2024, Q15(c). © Qualifications Scotland (SQA).

Lesson 5: Automatic door

SAFETY check	☐ Regulator at 0	☐ Goggles on	☐ Air Permit signed

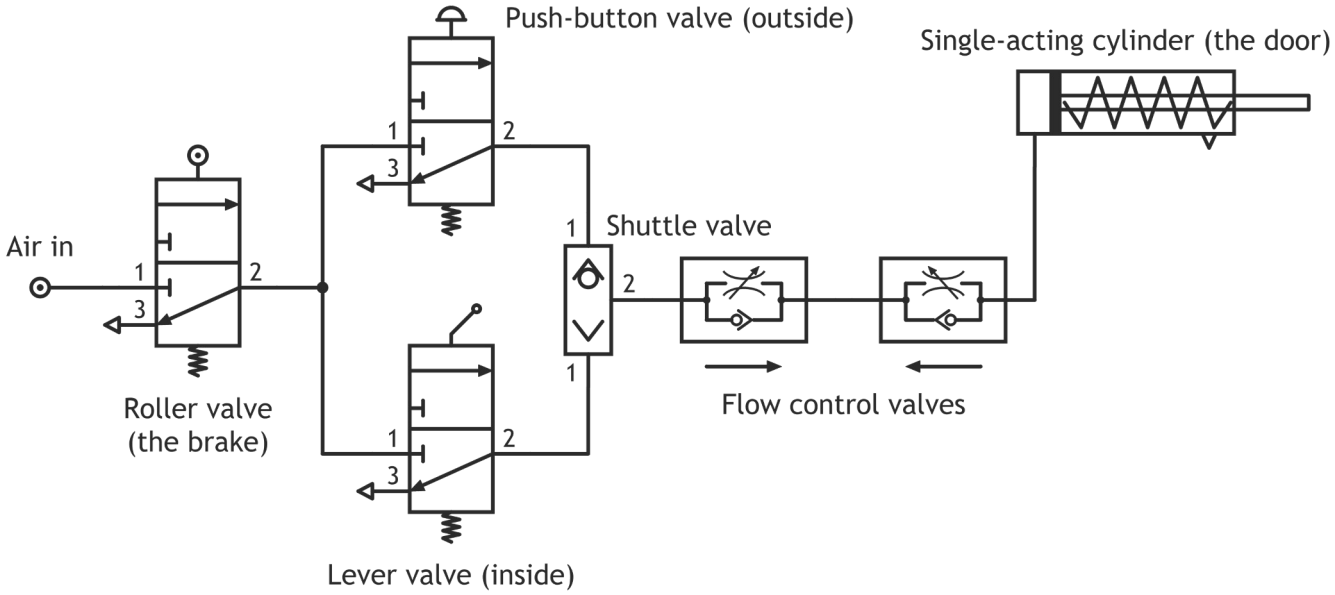
SAFETY New rule: roller valves. Never move, fix or bolt down a roller valve with the air on. You may press the roller to test.

Today's job (tick boxes when done)

Job card 5: The train door	Build the train door	Test every way in	Beat the clock

My role today (circle one)	Safety	Builder	Tester	Recorder

The circuit



Source: circuit adapted from Matrix CP2080 Worksheet 3 (© Matrix Technology Solutions Limited).

The roller valve is the brake. Press the roller: that is the brake on. The shuttle valve lets air from either valve reach the door.

Task 1: Simulate

Go to: sites.google.com/view/nostrainsim/pneumatics

Add the components listed on the bench card in the correct places.

Join them up, and press simulate.

What happens when you test the brake, the button and the lever?

Task 2: Air Permit and kit

Build from **bench card 5**. The Safety Officer reads out each step.

☐ Works in the simulation ☐ Tubing checked

☐ Regulator at 0 ☐ Goggles on

Safety Officer _____ Teacher _____ (no permit, no air)

Kit: ☐ Built ☐ Tested ☐ Regulator back to 0

Task 3: Compare

Write one thing that was different on the kit.

Task 4: Test every way in

Write open or shut for each row, on the kit.

Brake (roller)	Button (outside)	Lever (inside)	Door: open or shut?
Off	pressed	-	
On	pressed	-	
On	-	pushed	
On	-	-	
Off	-	pushed	

Task 5: Beat the clock

Set the flow control valves so the door opens and closes at the **same slow speed**, before the timer ends.

Circle your team's target. The timer is on the board.

Bronze	Silver	Gold
It opens slowly	It opens and closes slowly	Both take the same time, checked by another team

Task 6: Questions: 3 on your own

1. **Explain** why the door will not open when the brake is off. (2)

2. **Describe** what the shuttle valve does. (2)

3. **Name** the cylinder that uses air to push both ways. (Look back: Lesson 4) (1)

Task 7: Key words

Complete the sentences. Use each word from the box once.

shuttle	OR	AND	on

The _____ valve lets air from either of two valves through.

The button or the lever opens the door: this is _____ control.

The brake and a button must both be on: this is _____ control.

The door can only open when the brake is _____.

Lesson 6: Fault-finding

SAFETY check	☐ Regulator at 0	☐ Goggles on	☐ Air Permit signed

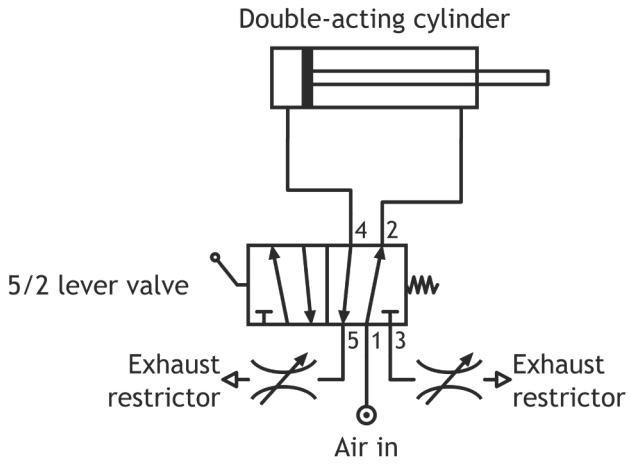
Today's job (tick boxes when done)

Job card 6: Maintenance night	Build the paint dip again	Hide one safe fault	Find, fix and write up a fault

My role today (circle one)	Safety	Builder	Tester	Recorder

Task 1: Build the paint dip

Build the paint dip from **bench card 4**. Test it. Then turn the regulator back to 0.



Source: circuit from Matrix CP2080 Worksheet 4 (© Matrix Technology Solutions Limited).

Air Permit: no permit, no air

☐ Works in the simulation	☐ Tubing checked
☐ Regulator at 0	☐ Goggles on

Safety Officer ____ Teacher ____

Task 2: Hide one fault

SAFETY Regulator at 0 while you hide a fault. Hide **one** fault from this list. Nothing else. Never damage a part.

Tick the fault you hid. Keep it secret.

- ☐ Swap the tubes on port 4 and port 2
- ☐ Screw one exhaust restrictor right in
- ☐ Loosen one bolt on a plate

Fault-find permit: swap benches

A swapped tube can make the rod move the moment the air goes on.

☐ Air off while we look	☐ Hands clear of the piston rod
☐ Teacher checks before air on	Initials ____

Task 3: Find the fault: check in order

	Check	If no	Done
1	Is the regulator at 0, and are hands clear?	Stop. Do this first.	
2	Is every tube pushed in fully?	Push it in.	
3	Does every tube go to the right port? Check each one against the circuit.	Move it to the right port.	
4	Are both exhaust restrictors open a little?	Open it a little.	
5	Is every part bolted down tight?	Tighten the bolt.	
6	Teacher checks. Set 1 to 2 bar. Test. Does it work now?	Turn the regulator to 0. Start again at check 1.	

Source: checks adapted from Matrix CP2080 Worksheet 8 (© Matrix Technology Solutions Limited).

Task 4: Write it up: fault, cause, fix

Write what you found. Use one row for each fault.

Fault: what went wrong	Cause: why	Fix: what we did

Task 5: Questions: 3 on your own

1. **Explain** why the air must be off while you hide or look for a fault. (2)

2. **Describe** what the rod does if the tubes on port 4 and port 2 are swapped. (2)

3. **Name** the valve that lets either the button or the lever open the door. (Look back: Lesson 5) (1)

Task 6: Key words

Complete the sentences. Use each word from the box once.

0	port	cause

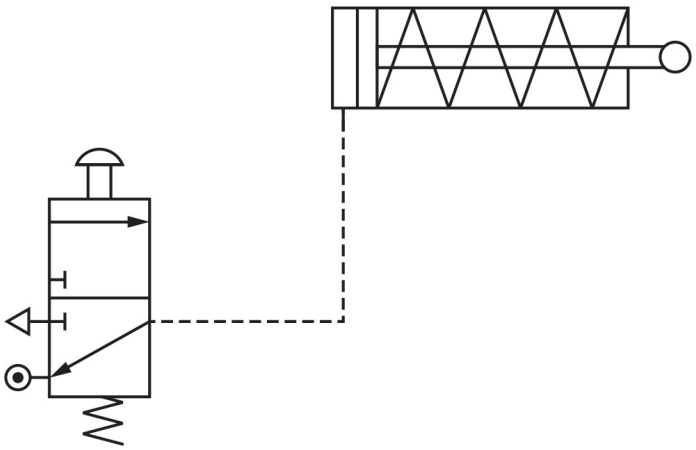
Look for a fault with the regulator at _____.

Check each tube is pushed in fully, then that it goes to the right _____.

Write down the fault, its _____ and its fix.

Task 7: Exam practice

1. A diagram for a pneumatic circuit, designed to outstroke a piston when a push button is pressed on a valve, is shown.



Errors were made in the circuit diagram shown above. **Describe** two errors that were made in this circuit diagram. (2)

Error 1

Error 2

Source: Question 1: N5 Engineering Science 2024, Q3(a). © Qualifications Scotland (SQA).

Lesson 7: More for less

SAFETY check	☐ Regulator at 0	☐ Goggles on	☐ Air Permit signed

Level Up endorsement (separate sheet): 3 out of 3 and the kit check.
No endorsement, no air in Lessons 7 to 10.
☐ Passed Initials _____

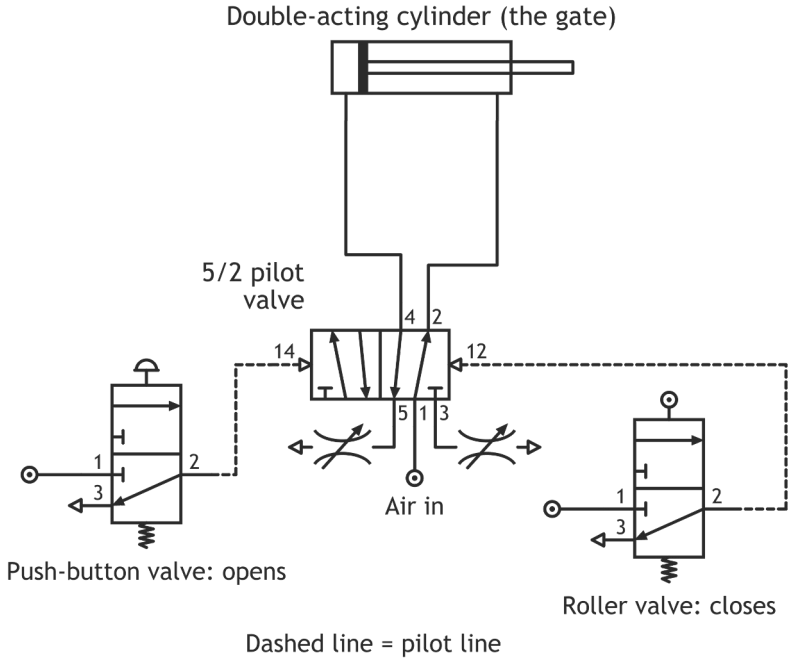
Today's job (tick boxes when done)

Job card 7: The big gate	Pass the Level Up endorsement	Build the big gate	Extension: a gate that closes itself

My role today (circle one)	Safety	Builder	Tester	Recorder

Lesson 7

The circuit



Source: circuit from Matrix CP2080 Worksheet 5 (© Matrix Technology Solutions Limited).

Pilot air (dashed lines) moves the 5/2 valve. Air to port 14: the rod goes out. Air to port 12: the rod comes back. The valve stays where the air put it.

Task 1: Simulate

Go to: sites.google.com/view/nostrainsim/pneumatics

Add the components listed on the bench card in the correct places.

Join them up, and press simulate.

What happens when you press the button, then the roller?

Task 2: Air Permit and kit

Build from **bench card 7**. The Safety Officer reads out each step.

☐ Works in the simulation ☐ Tubing checked

☐ Regulator at 0 ☐ Goggles on

Safety Officer _____ Teacher _____ (no permit, no air)

Kit: ☐ Built ☐ Tested ☐ Regulator back to 0

Task 3: Test it: does the valve remember?

Write what the rod does each time.

What you do	What the rod does
Press the button, then let go	
Press the roller, then let go	
Press both at once	

Task 4: Compare

Write one thing that was different on the kit.

Task 5: Questions: 3 on your own

1. **Explain** why a small button can work a big valve. (2)

2. **Describe** what the rod does after you let go of the button. (1)

3. **State** the first check when a circuit does not work. (Look back: Lesson 6) (1)

Task 6: Key words

Lesson 7

Complete the sentences. Use each word from the box once.

pilot	14	back	remembers

A pilot valve is moved by a little _____ air, not by a hand.

Air to pilot port _____ makes the rod go out.

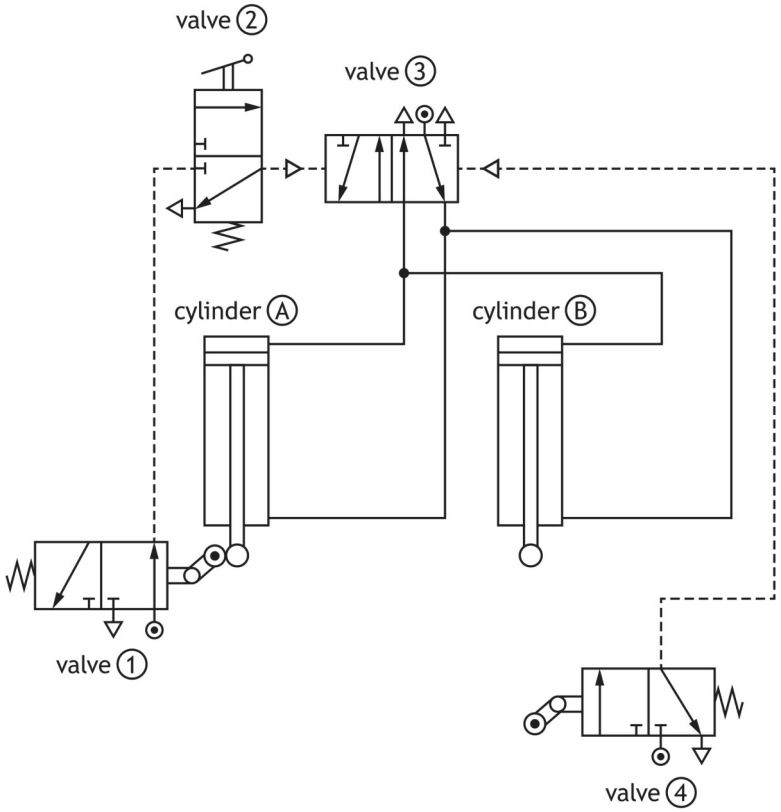
Air to pilot port 12 makes the rod come _____.

With no air at either pilot port, the valve stays put: it _____.

Task 7: Exam practice

1. A pneumatic test rig is used to test the handlebar of a bike.

The pneumatic circuit used in the test rig is shown below.



State the type of control created by the piping of valves 1 and 2. (1)

Source: Question 1: adapted from N5 Engineering Science 2025, Q8(a). © Qualifications Scotland (SQA).

Task 8: Extension: a gate that closes itself

Only when the main job is done and signed off. Move the roller to the end of the rod: **bench card 7, side 2**.

Kit: ☐ Built ☐ Tested ☐ Regulator back to 0

4. **Describe** what the gate does now when you press the button once. (1)

Lesson 8: Delay and bleed

SAFETY check	☐ Regulator at 0	☐ Goggles on	☐ Air Permit signed

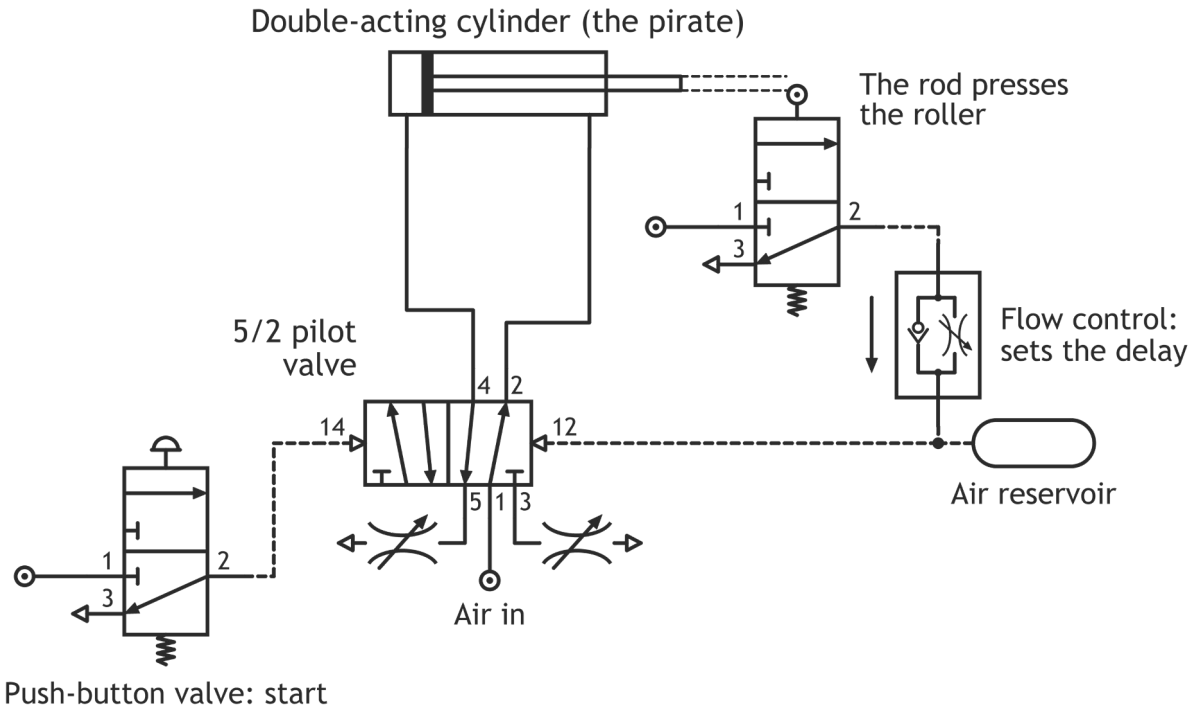
SAFETY Bleed pipe rule. Block the bleed pipe with the end of a pen or pencil. Never a finger.

Today's job (tick boxes when done)

Job card 8: The pop-up pirate	Stage 1: the pirate hides by itself	Set the delay	Stage 2: the visitor sensor

My role today (circle one)	Safety	Builder	Tester	Recorder

Stage 1: the pirate hides by itself



Source: circuit from Matrix CP2080 Worksheet 6 (© Matrix Technology Solutions Limited).

The rod presses the roller. Pilot air goes through the flow control valve into the reservoir. When the reservoir has filled, the pilot air moves the 5/2 valve back.

Task 1: Simulate

Go to: sites.google.com/view/nostrainsim/pneumatics

Add the components listed on the bench card in the correct places.

Join them up, and press simulate.

What happens after you press the button and let go?

Task 2: Air Permit and kit

Build from **bench card 8**. The Safety Officer reads out each step.

☐ Works in the simulation ☐ Tubing checked

☐ Regulator at 0 ☐ Goggles on

Safety Officer _____ Teacher _____ (no permit, no air)

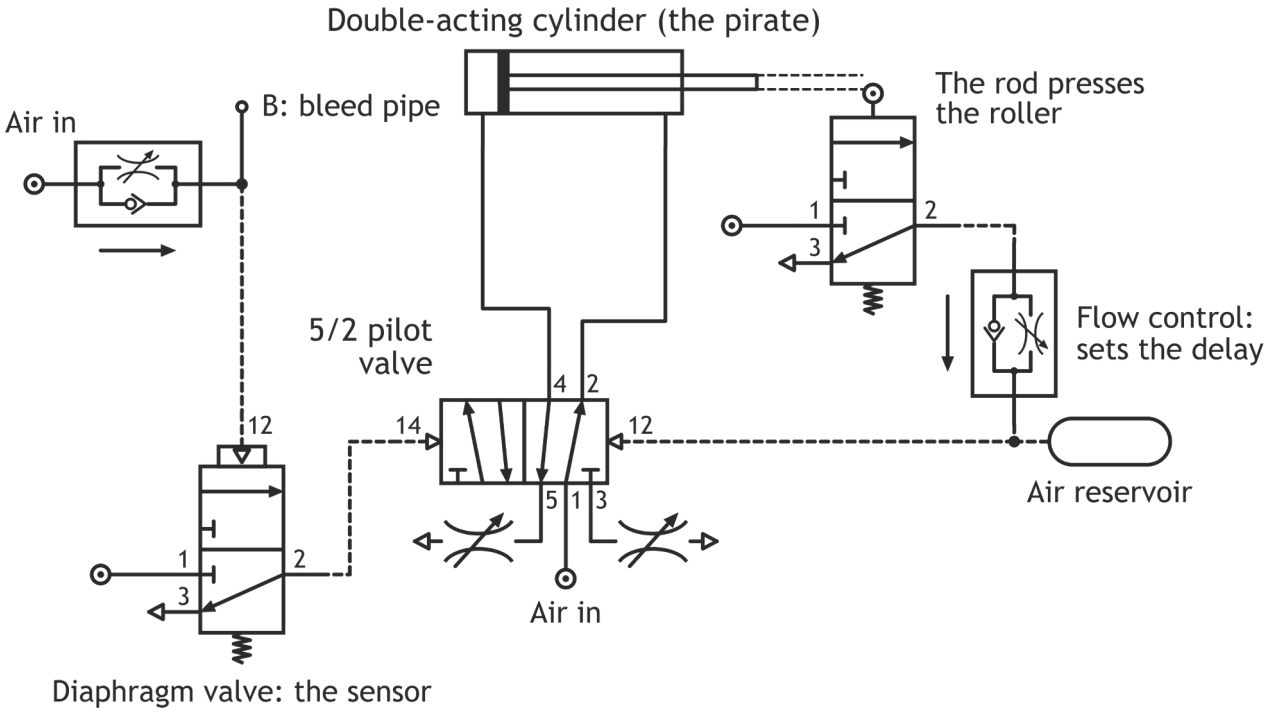
Kit: ☐ Built ☐ Tested ☐ Regulator back to 0

Task 3: Set the delay

Press the button and let go. **Record** how many seconds the pirate waits before it hides. Count the seconds.

Flow control screw	Seconds the pirate waits
Right out	
Half way in	
Nearly in	

Stage 2: the visitor sensor



Source: circuit from Matrix CP2080 Worksheet 6 (© Matrix Technology Solutions Limited).

Air leaks out of the bleed pipe, B. Block B and the pressure rises. The diaphragm valve opens and sends pilot air to port 14.

Task 4: Simulate

Go to: sites.google.com/view/nostrainsim/pneumatics

Swap the push-button valve for the sensor parts on the bench card (side 2).

Join them up, and press simulate.

What happens when you block B with a pen end?

Task 5: Stage 2: Air Permit and kit

Build stage 2 from **bench card 8, side 2**. The Safety Officer reads out each step.

☐ Works in the simulation	☐ Tubing checked
☐ Regulator at 0	☐ Goggles on

Safety Officer _____ Teacher _____ (no permit, no air)

Kit: ☐ Built ☐ Tested ☐ Regulator back to 0

SAFETY Block the bleed pipe with the end of a pen or pencil. Never a finger.

Task 6: Compare

Write one thing that was different on the kit.

Task 7: Questions: 4 on your own

1. **Explain** why you block the bleed pipe with a pen, not a finger. (2)

2. **Describe** how to make the pirate wait longer. (1)

3. **Explain** how the pirate knows that a visitor is there. (2)

4. **State** what a pilot valve remembers. (Look back: Lesson 7) (1)

Task 8: Key words

Complete the sentences. Use each word from the box once.

reservoir	more	pen	rises	diaphragm

A _____ that fills slowly makes a time delay.

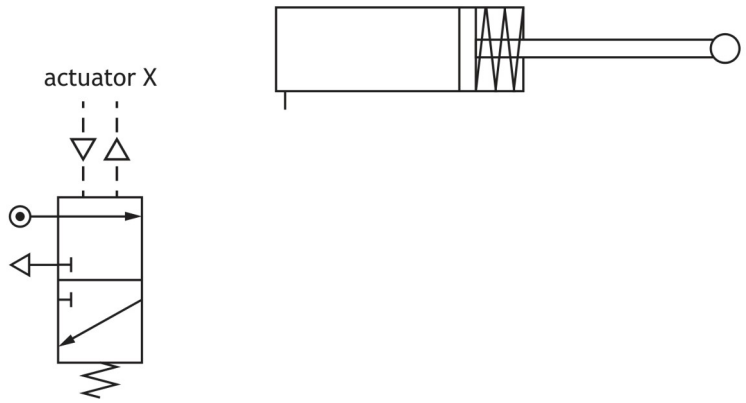
To make the delay longer, close the flow control valve _____.

Block the bleed pipe with the end of a _____, never a finger.

When the bleed pipe is blocked, the pressure _____ and works the _____ valve.

Task 9: Exam practice

1. An incomplete pneumatic circuit is shown.



(a) Complete the piping between the valve and cylinder to keep the piston outstroked. (1)

(b) State the name of actuator X. (1)

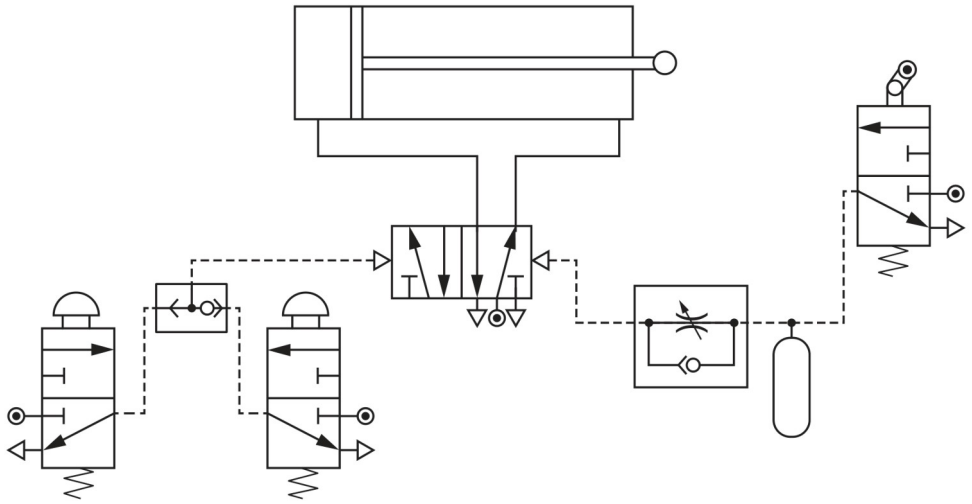
Source: Question 1: N5 Engineering Science 2021, Q3. © Qualifications Scotland (SQA).

Lesson 8

2. A prototype system to compress plastic bottles is operated by pneumatics.

For safety reasons, two buttons must be pressed before the plastic is compressed by a pneumatic cylinder. After a set period of time, the piston must instroke automatically.

A proposed design for the system is shown below but it has been found to have two faults.



(a) Describe the two faults in the circuit design. (2)

(b) The reservoir and the uni-directional restrictor perform the delay function of the system. **Describe** how the length of the delay could be increased. (1)

Source: Question 2: adapted from N5 Engineering Science Specimen Question Paper, Q16(a) and (c). © Qualifications Scotland (SQA).