National 5
Coursework
Assessment Task

National 5 Engineering Science Assignment
Assessment task: mail sorting depot

Specimen — valid from session 2024-25 and until further notice

This edition: September 2024 (version 2.0)

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Introduction

This document contains instructions for teachers, lecturers, and candidates for the National 5 Engineering Science assignment. It must be read in conjunction with the course specification.

There is an additional document that contains the worksheets for this assignment.

This assignment has 50 marks out of a total of 160 marks available for the course assessment.

This is one of two course assessment components. The other component is a question paper.

Whilst this document contains ‘instruction for teachers and lecturers’ and ‘instructions for candidates’, everything in the document can be given to candidates.

Instructions for teachers and lecturers

This assignment is valid for the current session only.

Assessment conditions

You must conduct the assignment under a high degree of supervision and control.

This means:

- all candidates must be within your direct sight
- candidates must not interact with each other
- candidates must not have access to e-mail, the internet or mobile phones
- candidates must complete their work independently — no group work is permitted
- classroom display materials that might provide assistance must be removed or covered
- there must be no interruption for learning and teaching
- candidates must be in a classroom environment

Duration

Candidates have 8 hours to complete the assignment, starting at an appropriate point in the course after all content has been delivered. Once candidates begin their assignment, they must continue in each subsequent class period until the permitted time allocation has been used up.

You have a responsibility to manage candidates' work, distributing it at the beginning and collecting it at the end of each class period, and storing it securely in-between. This activity does not count towards the total time permitted for candidates to complete the assignment.

Resources

This is a closed-book assessment. Candidates must not have access to learning and teaching materials, the internet, notes, exemplar materials, resources on classroom walls or anything similar.

A data booklet containing relevant data and formulae is available on the National 5 Engineering Science subject page on SQA's website. This can be used for the assignment.

Each assessment task includes instructions and details of any equipment or materials required for the assignment. Candidates can also use normal classroom equipment, software and hardware (such as drawing instruments, pneumatics, mechanisms and electronics kit, simulation software, and PCs to run the software) to complete the tasks.

There may be instances where restriction of internet and/or network use is not practical or feasible (for example, a local authority-managed IT network with specific limitations, software that is web-based, or something similar), however, it remains your professional responsibility to make every effort to meet the assessment conditions.

Alteration or adaptation

You must not alter, adapt or modify the assignment in any way — this includes moving the content into a different format. All candidates must undertake the assignment exactly as it has been provided by SQA.

Reasonable assistance

Candidates must progress through each stage of the assignment without your intervention or guidance, having acquired the skills needed earlier in the course.

Once candidates complete the assignment, you must not return it to them for further work. You must not provide feedback to candidates or offer your opinion on the perceived quality or completeness of the assignment response at any stage.

You can provide reasonable assistance to support candidates with the following aspects of their assignment:

- printing, collating and labelling their evidence to ensure it is in the format specified by SQA
- ensuring candidates have all the materials and equipment required to complete the assignment
- understanding the information outlined in these instructions.

Artificial Intelligence

This is not permitted. Please see SQA's website for more information, if needed.

Evidence

This assignment will be electronically marked from image (MFI), which means the following instructions must be followed.

It is your responsibility to ensure that all candidate evidence (whether created manually or electronically) is:

- clear and easy to read (anything handwritten or drawn must be in blue or black permanent ink only)
- without anything else fixed to the pages (for example, photographs glued in place)
- labelled at the top to show the task that it refers to

- labelled at the bottom to show the candidate's Scottish Candidate Number (SCN)
- compiled in task order with our flyleaf as the front cover
- printed or presented on A4 paper and secured with a single staple in the top left corner (prints can be single-sided or double-sided, however we prefer double-sided)

Assignment

This assignment contains a number of tasks. Each task details:

- what the candidate must do (including any specific instructions on how the task must be carried out)
- how many pages of evidence are expected
- an anticipated duration

This ensures that candidates understand how to approach the tasks and do not produce too much or spend too long on a single task (whilst there is a time limit for the assignment, there is no page limit or page count).

Candidates can complete the tasks in the order presented or in an order that helps you manage classroom equipment and resources.

You must ensure that candidates are aware of the assessment conditions for the assignment, and that they understand what they should do for each task.

Instructions for candidates

This assignment has 50 marks out of a total of 160 marks available for the course assessment.

This is a closed-book assessment. Your teacher or lecturer lets you know how to carry out the assignment and they will go over the assessment conditions.

The assignment has a number of tasks and for each task, you are provided with an engineering science context or situation.

In this assignment, you have to:

- analyse a problem
- design a solution to the problem
- build (simulate or construct) your solution
- test your solution
- evaluate your work

Unless otherwise instructed, you should complete all of the tasks in the order presented.

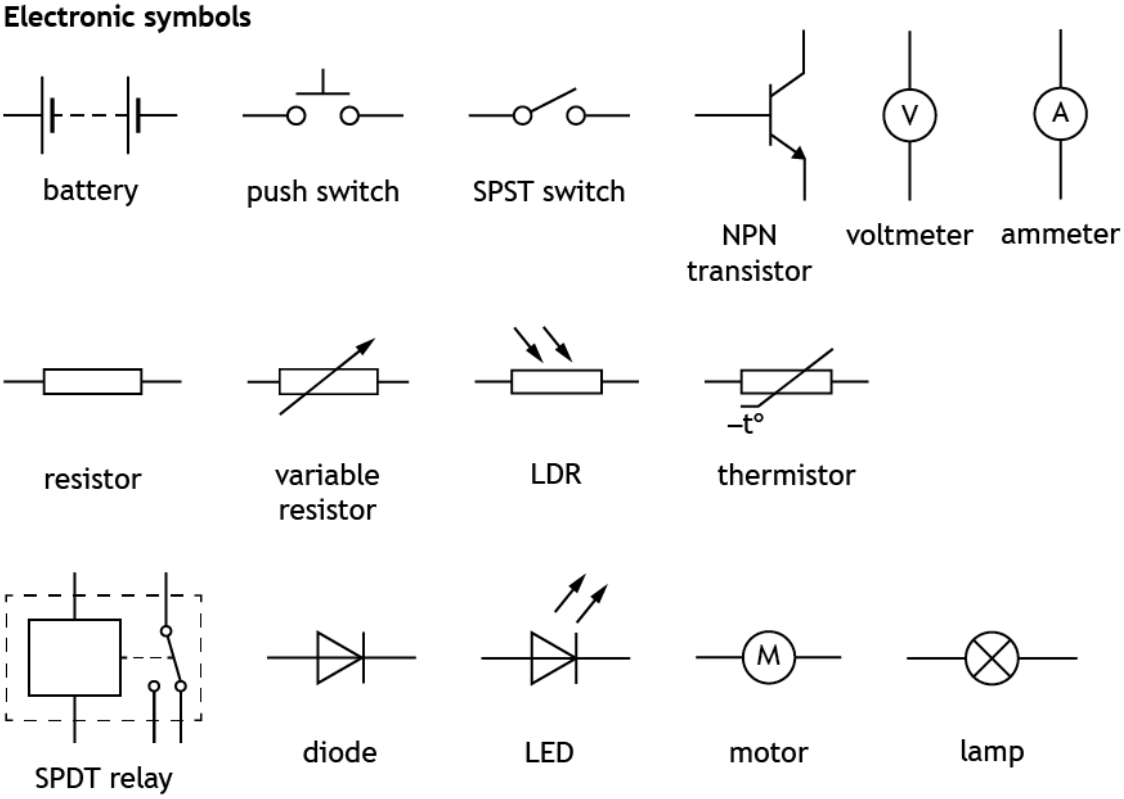
Each page of your response must note the task number at the top of the page and your Scottish Candidate Number (SCN) at the bottom of the page.

You have 8 hours to complete the assignment. The time to set up and clear away any equipment you will need, and for any printing that is necessary, does not count towards the 8 hours.

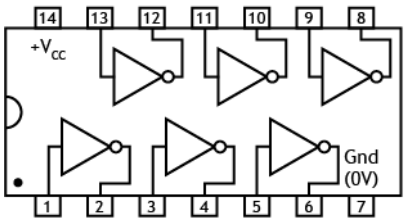
Data sheets — Mail sorting depot

You can use these data sheets and SQA's National 5 Engineering Science data booklet when completing this assignment. **No other resource material is permitted.**

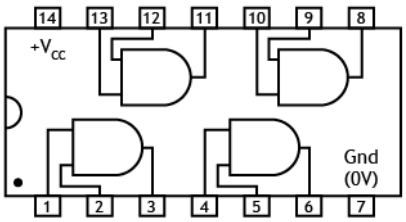
Electronic symbols



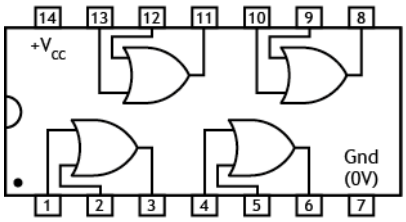
IC pinout diagrams



7404 hex inverter (NOT gates)

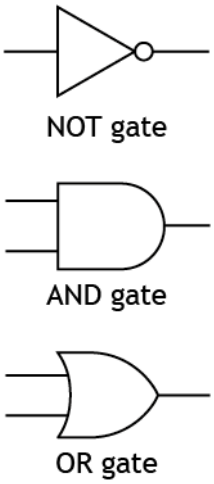


7408 quad 2 input AND gates



7432 quad 2 input OR gates

Logic gates



Pneumatic symbols

Actuators

spring return

pilot air

roller

solenoid

lever

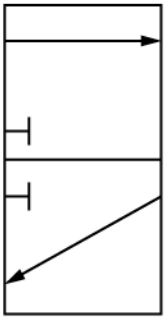
diaphragm

roller trip

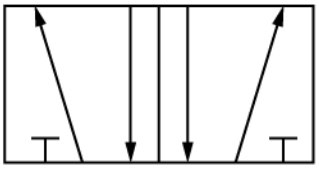
plunger

push button

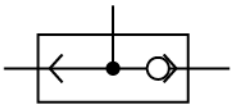
Valves



3/2 valve



5/2 valve

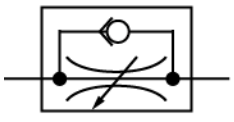


shuttle valve

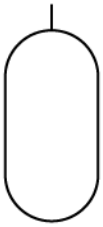
main air

exhaust

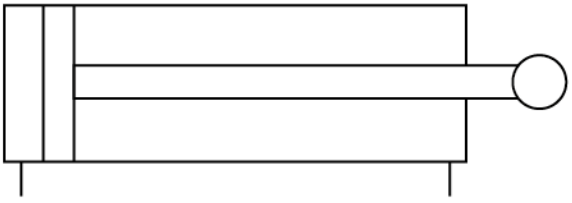
Components and cylinders



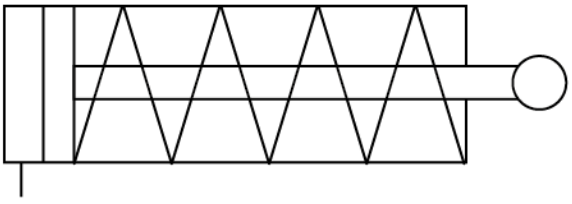
unidirectional restrictor



reservoir

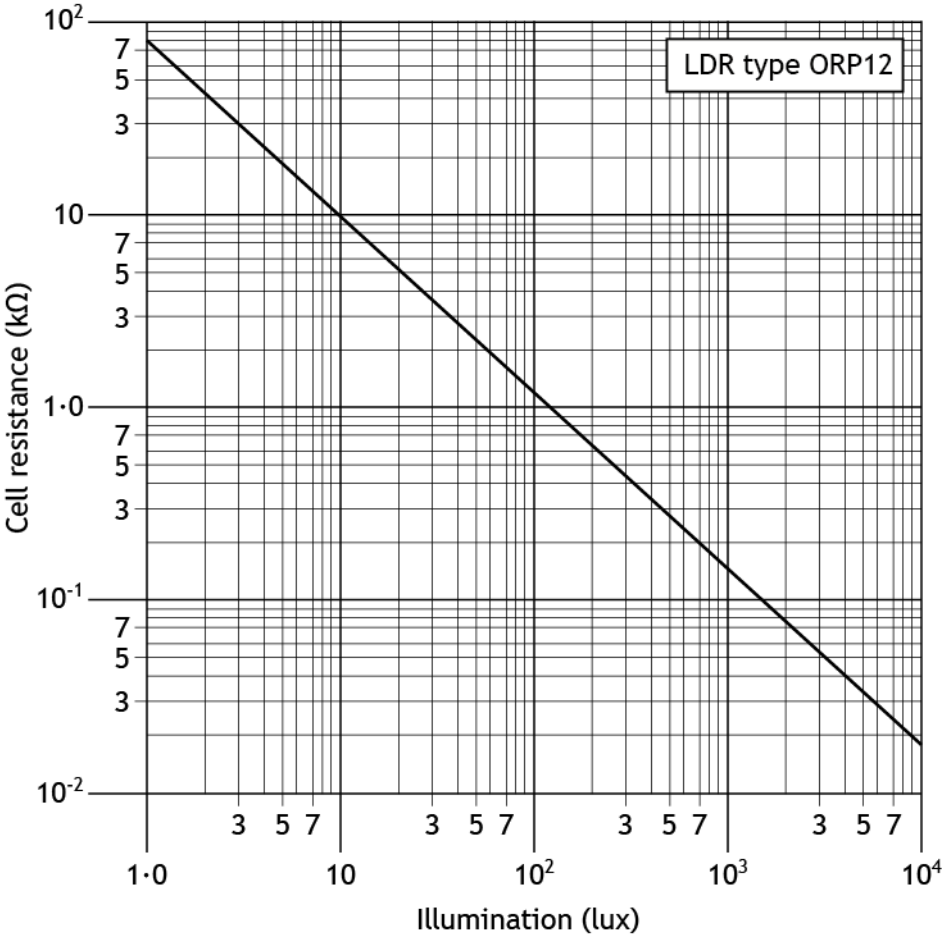


double acting cylinder

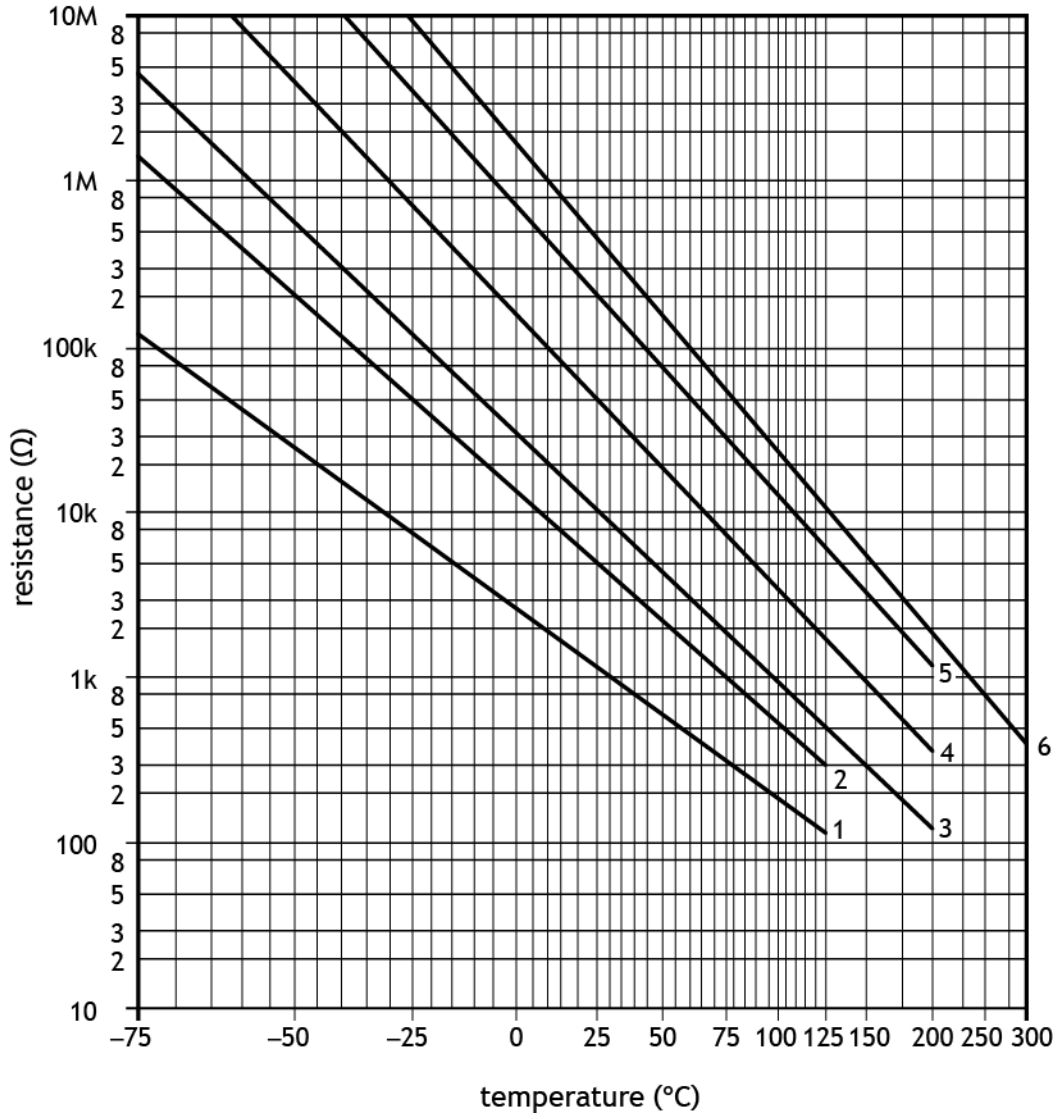


single acting cylinder

Light Dependent Resistor (LDR) graph for an ORP12 LDR



Thermistor graph



Assignment – Mail sorting depot

A team of engineers is involved in several tasks during the planning of a new mail sorting depot.

These tasks include development of proposals for the following systems:

- Task 1 — conveyor belt
- Task 2 — package sorter
- Task 3 — waste compactor
- Task 4 — automatic lighting

Task 1 — conveyor belt (idea 1)

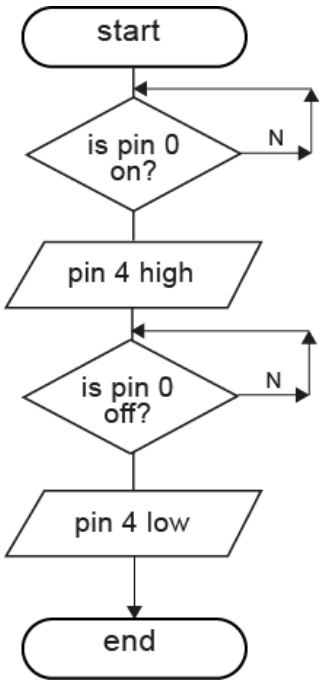
- Notional time: 2 hours 30 minutes
- Volume: completed on up to five single-sided A4 pages
- Worksheet: provided for task 1b

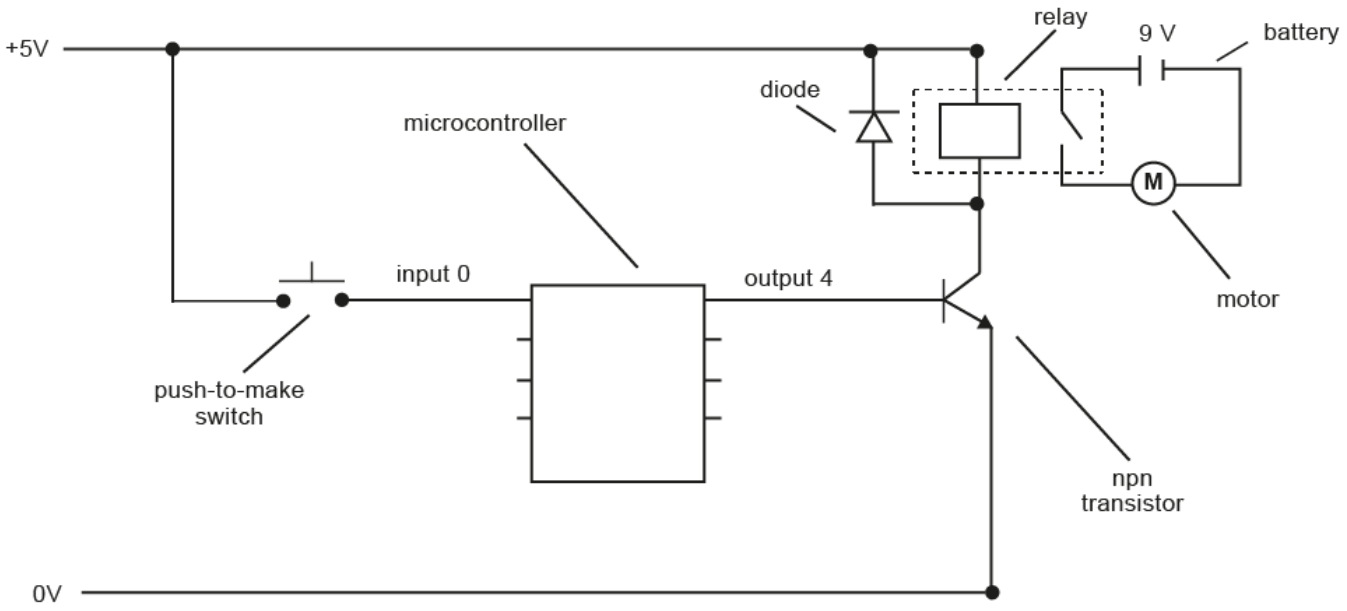
A conveyor belt is required as part of the mail sorting process. It is to be controlled by a microcontroller, using the following specification:

A When the operator presses the master switch, the conveyor belt moves.
B The conveyor belt will stay on until the operator presses the master switch again to turn the system off.
C The system then resets, ready to be used again.

Using the pin numbers shown in the table below, an electrical engineer has proposed the following flowchart and circuit design to satisfy the specification. Errors have been found during testing.

Input connection	Pin	Output connection
	4	conveyor belt motor
master switch	0	





1a Simulate or construct the conveyor belt flowchart and electronic circuit integrated together as shown. **(5 marks)**

1b Complete the testing table on **worksheet 1b** by carrying out the planned tests given. You must write descriptions of the actual results you observed during testing and any amendments you made to enable the system to satisfy the specification. **(5 marks)**

1c Based on your test results, amend your flowchart and/or electronic circuit where necessary.

You must submit a photograph or screenshot as evidence of your circuit following amendments after testing. All amendments must be clearly shown and annotated. **(2 marks)**

1d Produce high-level microcontroller code to fully match the function described in your amended flowchart shown in 1c. **(1 mark)**

1e Evaluate your solution to task 1, by describing:

- how well each specification point was met, referring to testing where possible, and any amendments that had to be made
- the overall effectiveness of your amended conveyor belt (idea 1) design, relative to the original proposal

(4 marks)

Task 2 — conveyor belt (idea 2)

- Notional time: 1 hour 30 minutes
- Volume: completed on up to three single-sided A4 pages
- Worksheet: provided for task 2a(i), 2a(ii) and 2b

The electronic engineer has proposed an alternative design for the operation of the conveyor belt. The following specification has been developed:

A When the master switch is turned on, a lamp lights to indicate the system is active.
B A warning buzzer will beep 10 times with an on time of 0.25 seconds and an off time of 0.25 seconds, then turn off.
C The conveyor belt will then start moving.
D The conveyor belt and lamp will stay on until the master switch is turned off.
E The system then resets, ready to be used again.
F Each output device will require a driver to operate.

2a(i) Analyse the conveyor belt (idea 2) specification by completing the system diagram on **worksheet 2a(i)**. Clearly show all inputs and outputs. **(2 marks)**

2a(ii) Fully analyse the conveyor belt (idea 2) specification by completing the sub-system diagram on **worksheet 2a(ii)**. Clearly show all sub-systems, the system boundary, and interactions between sub-systems.**(4 marks)**

2b Complete the flowchart for the conveyor belt (idea 2) system on **worksheet 2b**, referring to the specification and the pin numbers shown in the table. **(5 marks)**

Input connection	Pin	Output connection
	5	lamp
	4	buzzer
	3	conveyor belt motor
master switch	0	

Task 3 — package sorter

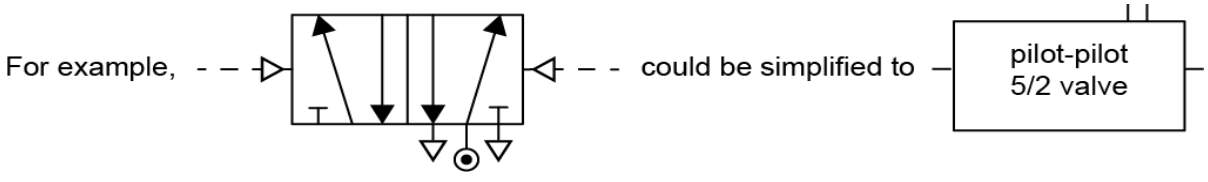
- Notional time: 45 minutes
- Volume: completed on up to one single-sided A4 page

Packages of two sizes will pass along the conveyor belt. A pneumatic system is to be designed that will automatically sort the packages, sensing and ejecting large packages into one dispatch area, while allowing small packages to pass along under the sensor and drop into a different dispatch area.

The following specification has been written for the operation of the package sorter:

A A sensor will monitor if a large package is passing.
B After a large package is sensed, a double-acting cylinder will eject the package.
C The double-acting cylinder will automatically instroke after a short time delay.

Design the pneumatic system referred to in the specification above, by drawing a simplified circuit diagram. **(5 marks)**



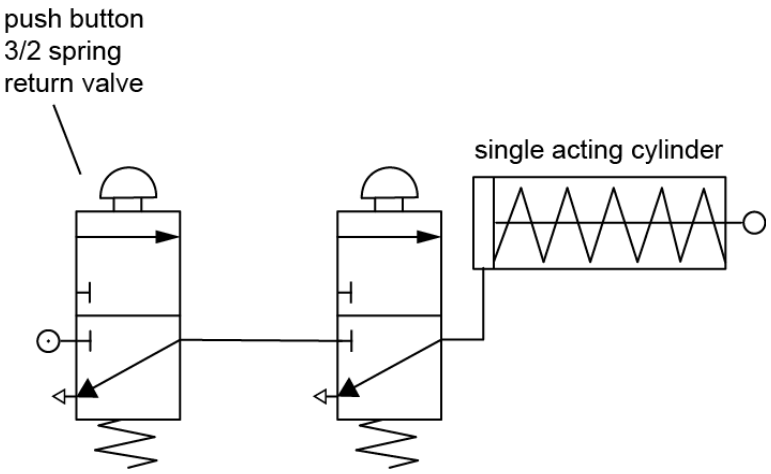
Task 4 — waste compactor

- Notional time: 2 hours 30 minutes
- Volume: completed on up to four single-sided A4 pages
- Worksheet: provided for task 4a

Elsewhere in the depot, a pneumatic waste compactor is to be installed, using the following specification:

A For safety reasons, the compactor can only operate when the operator presses two push buttons simultaneously.
B A piston then outstrokes to compress the waste and only instrokes again when the operator releases one, or both, of the push buttons.
C The system must be repeatable.

A mechanical engineer came up with the following design for a pneumatic circuit:



4a Write a test plan for the waste compactor system on **worksheet 4a**. Describe four tests that could be carried out in order to test that the system operates as planned. Describe what you will test and how it will be tested.

Once you have simulated or constructed the pneumatic circuit, you can complete the table with the actual results that you observed, including any amendments that you had to make as a result of testing. **(4 marks)**

4b Simulate or construct the waste compactor pneumatic circuit shown. **(3 marks)**

4c Evaluate your solution to task 4 by describing how well it satisfies the original specification, referring to testing where possible. **(3 marks)**

4d Describe and justify improvements that could be made to the operation of the waste compactor system. **(2 marks)**

Task 5 — automatic lighting

- Notional time: 45 minutes
- Volume: completed on up to three single-sided A4 pages
- Worksheet: provided for tasks 5a, 5b and 5d

As the depot will be in operation 24 hours a day, an automatic lighting system is to be designed. It is to be controlled using a logic circuit and operate as follows.

The lamp should turn on (logic 1) automatically when it is dark (logic 0) or when a manual switch is pressed (logic 1).

5a Draw a logic diagram for the operation of the automatic lighting system, as specified above, using the inputs and output below on **worksheet 5a**. **(2 marks)**

5b Complete the truth table on **worksheet 5b** showing the expected results of the system described above. **(1 mark)**

5c Simulate or construct the logic circuit for task 5. **(1 mark)**

5d Test your simulated or constructed logic circuit and complete the truth table on **worksheet 5d** with your results. **(1 mark)**

Marking instructions

Marking instructions are provided for this specimen assessment task. In line with SQA's normal practice, they are addressed to the marker. They will also be helpful for those preparing candidates for course assessment.

Marking instructions **will not** be provided with annual assessment tasks, as candidate evidence will be submitted to SQA for external marking. They will be provided to markers and then published on the SQA website after marking is complete.

General marking principles

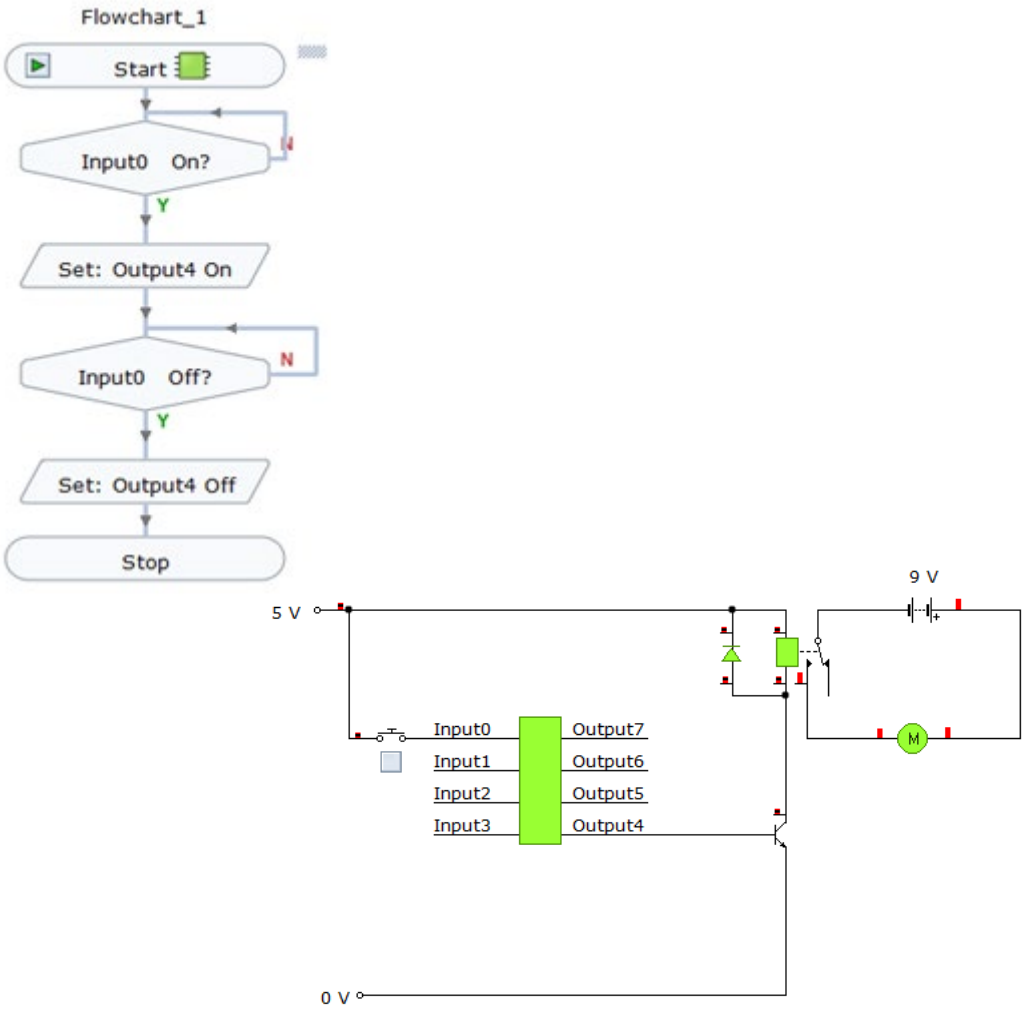
This information is provided to help you understand the general principles that must be applied when marking candidate responses in this assignment. These principles must be read in conjunction with the detailed/specific marking instructions, which identify the key features required in candidate responses.

a Marks for each candidate response must **always** be assigned in line with these general marking principles and the specific marking instructions for this assessment.

b Marking should always be positive. This means that, for each candidate response, marks are accumulated for the demonstration of relevant skills, knowledge and understanding: they are not deducted from a maximum on the basis of errors or omissions.

c If a specific candidate response is not covered by either the general marking principles or detailed marking instructions, you must seek guidance from your team leader.

Task 1 — conveyor belt (idea 1)

Task	Expected answer(s)	Max mark	Additional guidance
1a		5	**Flowchart** simulation/construction: ♦ fully correct (**2 marks**) ♦ partially correct (**1 mark**) ♦ not correct/no evidence (**0 marks**) **Electronic circuit** simulation/ construction: ♦ fully correct (**2 marks**) ♦ partially correct (**1 mark**) ♦ not correct/no evidence (**0 marks**) **Integration** of electronics and flowchart (**1 mark**)

<table>
<tr><th>Task</th><th>Expected answer(s)</th><th>Max mark</th><th>Additional guidance</th></tr>
<tr><td>1b</td><td>
<table>
<tr><th>Planned tests</th><th>Actual results</th><th>Amendments made</th></tr>
<tr><td>Switch the master switch on and check that the conveyor belt motor turns</td><td>The motor turns when the master switch is pressed and held but not when it is pressed quickly.</td><td>No amendments required.</td></tr>
<tr><td>After the motor has been running for a few seconds, switch the master switch off and check that the conveyor belt motor stops</td><td>The motor turned off immediately as soon as I released the master switch.</td><td>I changed the push-to-make (PTM) switch for a single-pole, single-throw (SPST) switch.</td></tr>
<tr><td>Repeat the above processes several times to check that the system restarts and is repeatable</td><td>The system only performed once then stopped.</td><td>I added a continuous loop to the flowchart from the end back to after the start symbol.</td></tr>
</table>
</td><td>5</td><td>Must be descriptive responses.

Markers should take account of simulation/construction evidence from task 1a

Correct operation of motor turning (1 mark)

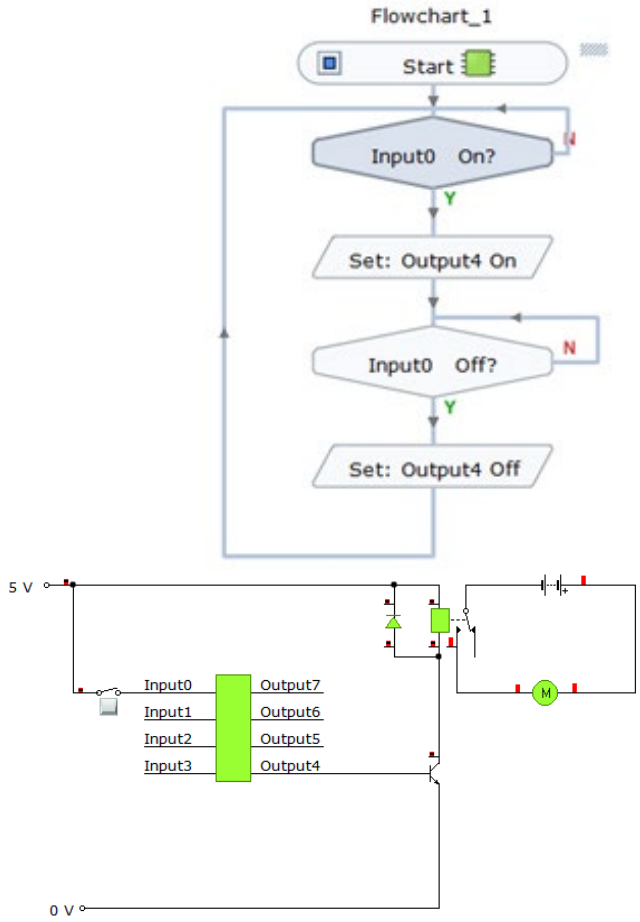
Identification of motor turning off incorrectly using a PTM switch (1 mark)

Identification of system only repeating once (1 mark)

Switch amendment (1 mark)

Continuous loop amendment (1 mark)

Where no evidence is provided (0 marks)</td></tr>
</table>

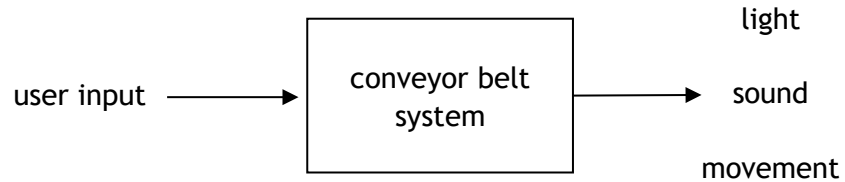
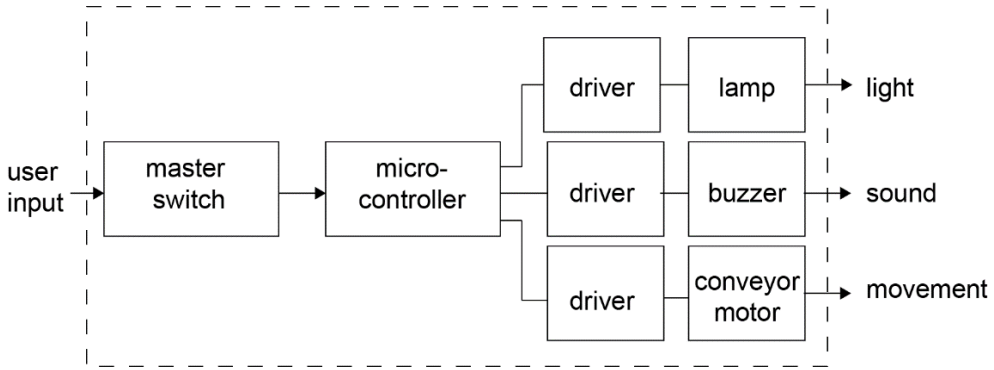
Task	Expected answer(s)	Max mark	Additional guidance
1c		2	Addition of continuous loop and deleting stop symbol (**1 mark**) Correct alteration(s) to circuit (and/or flowchart) to allow correct operation of motor control (**1 mark**) Using a pre-built model without evidence of candidate simulation/construction (**0 marks**) Where no evidence is provided (**0 marks**) Accept alternative working solution amendments to get motor to turn off. Markers should take account of simulation/construction evidence from task 1a and testing evidence from task 1b.

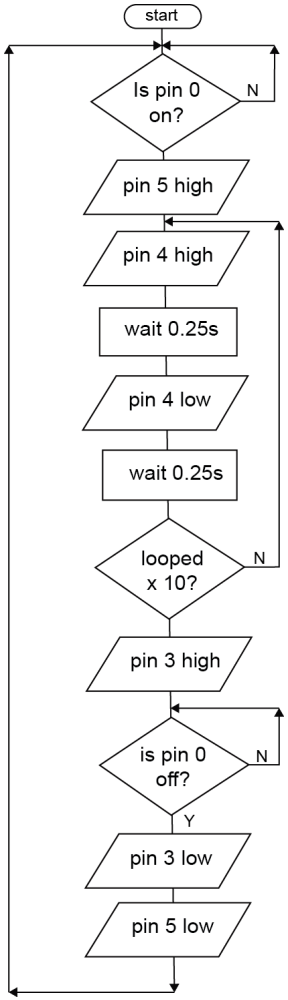
Task	Expected answer(s)	Max mark	Additional guidance

1d	BASIC Viewer
	Flowchart_1
	`symbol Input0 = pin0`
	`symbol Output7 = 7`
	`symbol Output6 = 6`
	`symbol Output5 = 5`
	`symbol Output4 = 4`
	
	`init:  let dirs = %11110000`
	`main:`
	`label0:`
	`  if Input0 = 1 then label1`
	`  goto label0`
	`label1:`
	`  high 4`
	`label2:`
	`  if Input0 = 0 then label3`
	`  goto label2`
	`label3:`
	`  low 4`
	`  goto label0`
		1	Correct code to fully match the flowchart in task 1c (**1 mark**)
			
			Where no evidence is provided (**0 marks**)
			
			Accept manually written or automatically generated.

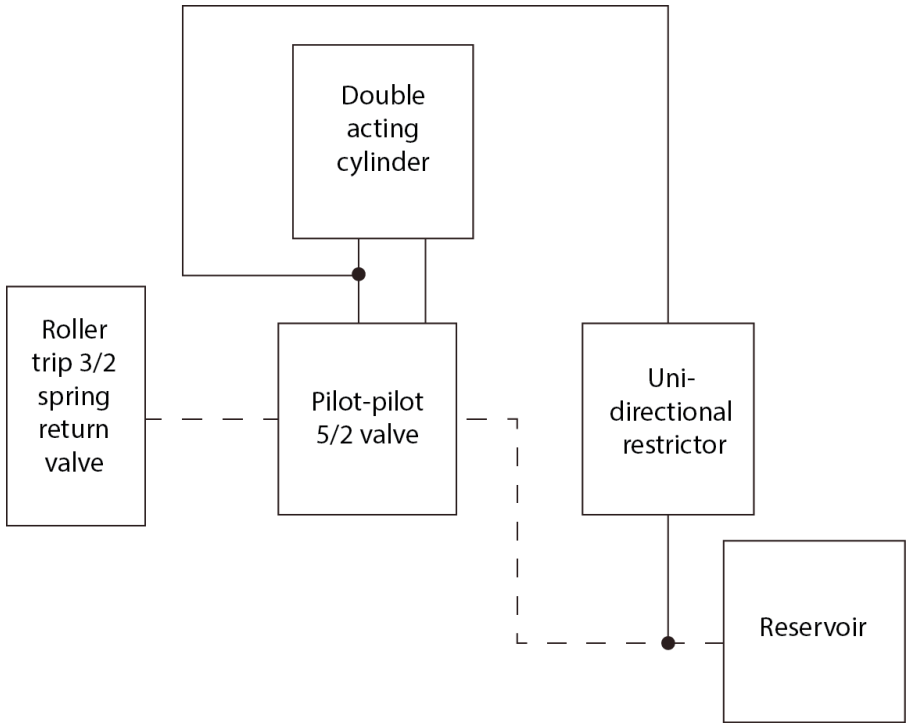
Task	Expected answer(s)	Max mark	Additional guidance
1e	**Specification point** A — The system is successful in turning on the motor when the master switch is pressed. B — Initially the motor turned straight off again when I released the master switch, rather than waiting for the operator to switch the master switch off. This would mean the operator would have to hold the switch on all the time. I solved the problem by changing the PTM switch for a SPST switch. C — At first the system would only run one time. I added a continuous loop from the end to the start of the flowchart and now it repeats continuously. Now that the system has been amended, it matches all the requirements of the specification and would work in a real depot environment.	**4**	Evaluative comment about each specification point (**1 mark**) Evaluative comment on the overall system (**1 mark**) Where no evidence is provided (**0 marks**) Evaluative comments should be descriptive and detail how well the specification point has been met, and the changes that were made. The mark for the overall system could also be awarded in terms of possible improvements.

Task 2 — conveyor belt (idea 2)

Task	Expected answer(s)	Max mark	Additional guidance
2ai		**2**	Input identified **(1 mark)** All three outputs identified **(1 mark)** Where no evidence is provided (**0 marks**)
2aii		**4**	Input and outputs identified **(1 mark)** Driver present for each output **(1 mark)** Lamp, buzzer and motor identified **(1 mark)** Correctly connected sub-systems and presence of system boundary **(1 mark)** Where no evidence is provided (**0 marks**)

Task	Expected answer(s)	Max mark	Additional guidance
2b		**5**	pin 4 high and low with 2 x 0.25s delays **(1 mark)** x 10 decision with correct Y/N and correct entry **(1 mark)** pin 3 high and low **(1 mark)** pin 0 off decision with correct Y/N and correct entry **(1 mark)** pin 5 low and continuous loop **(1 mark)** Where no evidence is provided (**0 marks**) Can be manually drawn or produced on simulation software. Flowchart may refer to pin numbers from task 2b or could be descriptive.

Task 3 — package sorter

Task	Expected answer(s)	Max mark	Additional guidance
3		5	Appropriate choice of package actuator **(1 mark)** Double-acting cylinder with 5/2 valve (**1 mark**) Uni-directional restrictor and reservoir (**1 mark**) Correctly piped to be: ♦ not functioning (**0 marks**) ♦ partially functioning (**1 mark**) ♦ fully functioning solution (**2 marks**) Where no evidence is provided (**0 marks**) Can be manually drawn or produced on simulation software. As this is a design task, there is no requirement for components to be fully named correctly (implied is acceptable).

Task	Expected answer(s)	Max mark	Additional guidance
			Candidates may choose to produce as a block diagram, a circuit diagram or as a hybrid (all are acceptable). No marks are available for naming line types or producing accurate port to port piping.

Task 4 — waste compactor

<table>
<tr><th>Task</th><th>Expected answer(s)</th><th>Max mark</th><th>Additional guidance</th></tr>
<tr><td>4a</td><td>
<table>
<tr><th>Planned tests</th><th>Actual results</th><th>Amendments made</th></tr>
<tr><td>Actuate the push-button valves one at a time and check that the piston does not outstroke</td><td>The piston does not outstroke when only one push-button valve is actuated.</td><td>No amendments required.</td></tr>
<tr><td>Actuate both push-button valves simultaneously and check that the piston outstrokes</td><td>The piston does outstroke when both push-button valves are actuated.</td><td>No amendments required.</td></tr>
<tr><td>While in the outstroke position, release one push-button valve and check that the piston instrokes</td><td>The piston does instroke as soon as either of the push-button valves are released.</td><td>No amendments required.</td></tr>
<tr><td>Repeat the above tests several time to check that the system is repeatable</td><td>The tests were repeated three times and the system worked as expected every time.</td><td>No amendments required.</td></tr>
</table>
</td><td>4</td><td>Test, with results (and amendments where required) for the piston outstroking (1 mark)

Test, with results (and amendments where required) for the piston instroking (1 mark)

Test, with results (and amendments where required) for the system being repeatable (1 mark)

Test, with results (and amendments where required) for any other relevant test (1 mark)

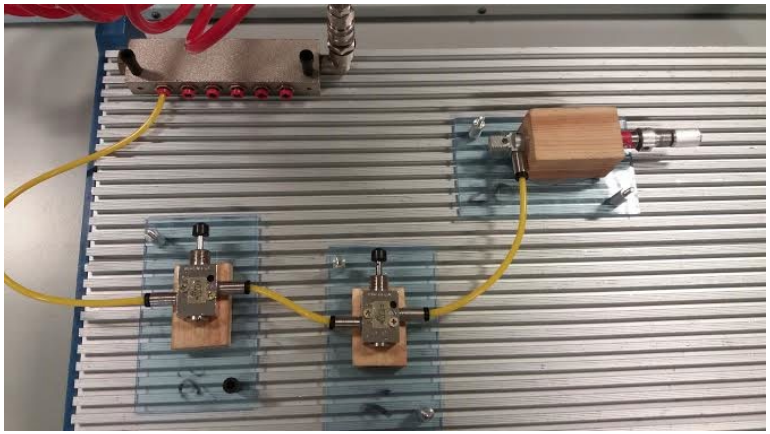
Where no evidence is provided
(0 marks)

Responses must be descriptive and describe what is being tested.

Tests may be observational or software/equipment related.

Accept other relevant tests, such as checking for air escaping.

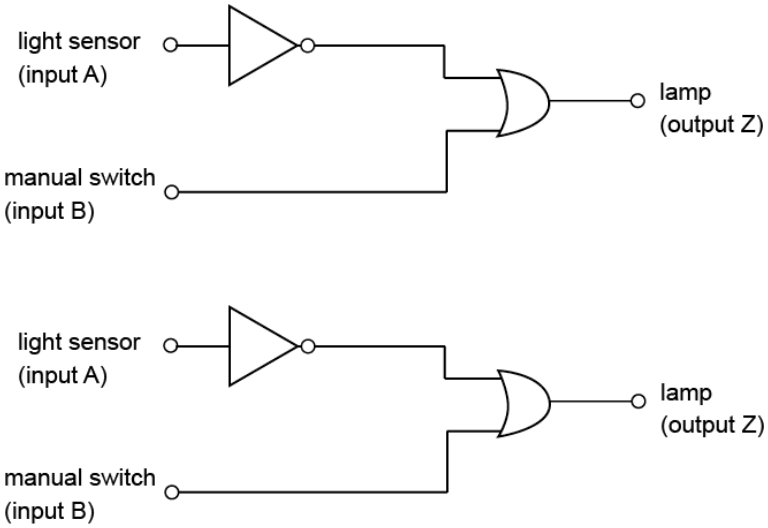
Markers should take account of simulation or construction evidence from task 4b.</td></tr>
</table>

Task	Expected answer(s)	Max mark	Additional guidance
4b		**3**	First push-button 3/2 spring-return valve **(1 mark)** Second push-button 3/2 spring-return valve connected in AND control **(1 mark)** Single-acting cylinder **(1 mark)** Each component must be correctly piped to achieve each mark. If a pre-built model is used, without evidence of candidate simulation/ construction (**0 marks**) Where no evidence is provided (**0 marks**)

Task	Expected answer(s)	Max mark	Additional guidance
4c	The system was successful in only operating when both the push-button valves were actuated simultaneously. I tried actuating one at a time and the piston did not outstroke. The system was successful in only instroking the piston when one or both of the push-button actuators were released. The system was repeatable because I tried it several times and it worked each time.	**3**	Evaluative comment about the conditions for the piston outstroking **(1 mark)** Evaluative comment about the conditions for the piston instroking **(1 mark)** Evaluative comment about the system being repeatable **(1 mark)** Where no evidence is provided (**0 marks**) Evaluative comments should describe how well each point has been met and the changes that were made.

Task	Expected answer(s)	Max mark	Additional guidance
4d	One suggestion for an improvement to the waste compactor system would be to have an audible alarm to warn workers that the compactor is about to start operating. Another recommendation would be to adapt the system so that the piston had a reciprocating action to compact the waste more effectively.	**2**	Two improvements suggested and justified **(2 marks)** OR One improvement suggested and justified **(1 mark)** OR No improvements suggested or justified/no evidence **(0 marks)** Improvements should be descriptive. They may refer to either the system in terms of components used, or to the system in terms of operation (ie safety, energy conservation, environmental concerns or efficiency).

Task 5 — automatic lighting

<table>
<tr><th>Task</th><th>Expected answer(s)</th><th>Max mark</th><th>Additional guidance</th></tr>
<tr><td>5a</td><td> 
</td><td>2</td><td>Fully functioning solution to match (2 marks)

OR

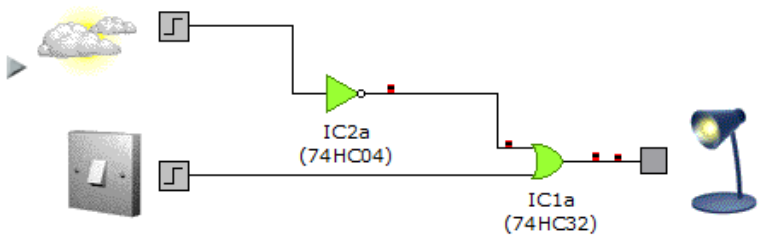
Partially functioning solution to match (1 mark)

OR

No functioning solution/no evidence (0 marks)

Each component must be correctly connected.</td></tr>
<tr><td>5b</td><td><table>
<tr><th>A</th><th>B</th><th>Z (expected results)</th></tr>
<tr><td>0</td><td>0</td><td>1</td></tr>
<tr><td>0</td><td>1</td><td>1</td></tr>
<tr><td>1</td><td>0</td><td>0</td></tr>
<tr><td>1</td><td>1</td><td>1</td></tr>
</table></td><td>1</td><td>Correct expected results in column Z (1 mark)

Where no evidence is provided (0 marks)</td></tr>
</table>

<table>
<tr><th>Task</th><th>Expected answer(s)</th><th>Max mark</th><th>Additional guidance</th></tr>
<tr><td>5c</td><td> 
</td><td>1</td><td>Correctly connected logic gates (as shown in design in task 5b) with appropriately chosen, input and output devices (1mark)

Using a pre-built model without evidence of candidate simulation/ construction (0 marks)

Where no evidence is provided (0 marks)</td></tr>
<tr><td>5d</td><td><table>
<tr><th>A</th><th>B</th><th>Z (actual results)</th></tr>
<tr><td>0</td><td>0</td><td>1</td></tr>
<tr><td>0</td><td>1</td><td>1</td></tr>
<tr><td>1</td><td>0</td><td>0</td></tr>
<tr><td>1</td><td>1</td><td>1</td></tr>
</table></td><td>1</td><td>Correct actual results in column Z (1 mark)

Where no evidence is provided (0 marks)

Markers should take account of simulation/construction evidence from task 5c.</td></tr>
</table>

Copyright acknowledgements

Page 10: box on conveyor roller. 3D Rendering — Shutterstock 514897444

Administrative information

Published: September 2024 (version 2.0)

History of changes

Version	Description of change	Date
1.1	Corrections made to the marking instructions: page 25 — MI for 1a, the bottom 'Set: Output4 On' in the flowchart should read 'Set: Output4 Off' page 27 — MI for 1c, the bottom 'Set: Output4 On' in the flowchart should read 'Set: Output4 Off' page 28 — MI for 1d, line 18 of the program 'high 4' should read 'low 4'	August 2019
2.0	Content of assessment instrument unchanged. Surround and format changed to support Marking from Image. Accessibility amendments made to tables.	September 2024

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