National 5 Coursework Assessment Task

N5

National 5 Engineering Science Assignment
Assessment task: box sorting system

Specimen — valid from session 2017-18 and until further notice

This edition: August 19 (version 1.1)

Contents

Introduction

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

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.

Instructions for teachers and lecturers

This is a specimen assessment task.

SQA will publish a new assessment task on the secure website each academic year. The task is valid for that year only. Once complete, assignment responses are sent to SQA to be marked.

The assignment must be conducted under a high degree of supervision and control, which means:

♦ all candidates must be within direct sight of the teacher or lecturer
♦ interaction with other candidates must not occur
♦ e-mail, the internet and mobile phones must not be accessed
♦ candidates must complete their work independently (ie no group work is permitted)
♦ display materials, which might provide assistance, must be removed or covered up
♦ with no interruption for learning and teaching
♦ in a classroom environment

Time

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, they must continue in each subsequent class period until the permitted time allocation has been used up.

Teachers and lecturers have a responsibility to manage candidates' work, ie distributing it at the beginning and collecting it at the end of each session, and storing it securely in-between. This 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.

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/network use is prohibited (eg a local authority-managed network with specific limitations, software that is web-based, or something similar), however, it remains the teacher or lecturer's professional responsibility to make every effort to meet the assessment conditions.

Reasonable assistance

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

Once the assignment has been completed, it must not be returned to candidates for further work. Teachers and lecturers must not provide feedback to candidates or offer opinion on the perceived quality or completeness of the assignment response, at any stage.

Reasonable assistance may be provided to support candidates with the following aspects of their assignment:

♦ Printing, collating, stapling 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.

Evidence

All candidate evidence (whether created manually or electronically) must be submitted to SQA in paper-based format.

Each task details what evidence is required and how many pages are expected. This is a guide to ensure that candidates do not produce too much work or spend too long on a single task.

Alteration or adaptation

The assignment must not be altered, adapted or modified in any way (this would include moving the content of the assignment into a different format or workbook). All candidates must undertake the assignment exactly as it is provided.

Submission

Each piece of work must be labelled with the task number, eg task 2a, and the back of each page must be clearly labelled with candidate details.

Volume

There is no word or page count.

Specific instructions for teachers and lecturers: specimen assignment

Teachers and lecturers must ensure that these specific instructions are followed. Candidates must be made aware of the assessment conditions and know what they should do for each task.

This assignment has five tasks, all of which are mandatory and can be completed in the order presented or in an order that would help to manage classroom equipment.

Each task has a notional time allocated to it. This is not mandatory and is provided as an indication of how long candidates should spend on the task.

Task 1 (17 marks)
Notional time: 2 hours 30 minutes
♦ completed on the pro forma provided, or on up to five A4 sheets of paper

Task 2 (11 marks)
Notional time: 1 hour 30 minutes
♦ completed on the pro forma provided, or on up to three A4 sheets of paper

Task 3 (5 marks)
Notional time: 45 minutes
♦ completed on the pro forma provided, or on one A4 sheet of paper

Task 4 (12 marks)
Notional time: 2 hours 30 minutes
♦ completed on the pro forma provided, or on up to four A4 sheets of paper

Task 5 (5 marks)
Notional time: 45 minutes
♦ completed on the pro forma provided, or on up to three A4 sheets of paper

Please note that print-outs of electronically-generated evidence (eg simulations and coding) are included in the expected number of pages for each task, and are part of the submission to SQA.

Instructions for candidates

This assessment applies to the assignment for National 5 Engineering Science.

This assignment has 50 marks out of a total of 160 marks available for the course assessment. It assesses the following skills, knowledge and understanding:

♦ demonstrating engineering science skills and creativity
♦ analysing engineering problems
♦ designing and building/simulating solutions to engineering problems
♦ testing and evaluating solutions to engineering problems

This is a closed-book assessment. Your teacher or lecturer will let you know how the assessment will be carried out and any required conditions for doing it.

In this assessment, you have to:

♦ analyse a problem
♦ design a solution to the problem
♦ 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.

You will be allowed 8 hours to complete the assignment, excluding the time required to set up and clear away any equipment you will need, and for any printing that is required.

The assignment has five tasks, with marks allocated as follows:

Task 1 — 17 marks: building, testing and evaluating a solution (electronics) for the conveyor belt
(building = 8 marks, testing = 5 marks, evaluating = 4 marks)

Task 2 — 11 marks: designing and analysing a solution (electronics and programmable control) for the conveyor belt
(designing = 5 marks, analysing = 6 marks)

Task 3 — 5 marks: designing a solution (pneumatics) for the package sorter
(designing = 5 marks)

Task 4 — 12 marks: building, testing and evaluating a solution (pneumatics) for the waste compactor
(building = 3 marks, testing = 4 marks, evaluating = 5 marks)

Task 5 — 5 marks: designing, building and testing a solution (electronics) for the automatic lighting
(designing = 2 marks, building = 1 mark, testing = 2 marks)

For each task, you will be provided with an engineering science brief.

Submitting your work

Your teacher or lecturer will let you know the approximate amount of time to spend on each task, along with an indication of the number of pages of evidence that you should produce.

Each piece of your work must be labelled with the task number (eg task 2a) and the back of each page must be clearly labelled with your:

♦ name
♦ date of birth
♦ Scottish Candidate Number (SCN)
♦ centre name
♦ centre number

Mail 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:

- conveyor belt
- package sorter
- waste compactor
- automatic lighting

Task 1 — conveyor belt (idea 1)

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	
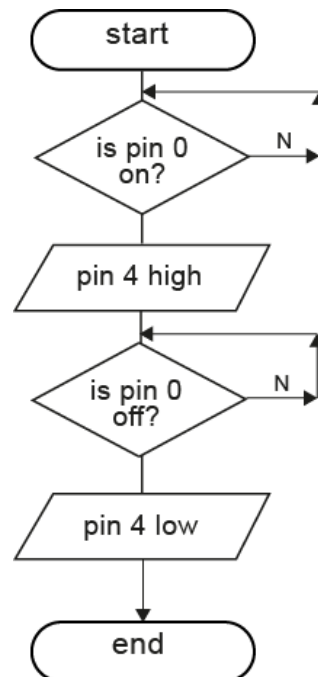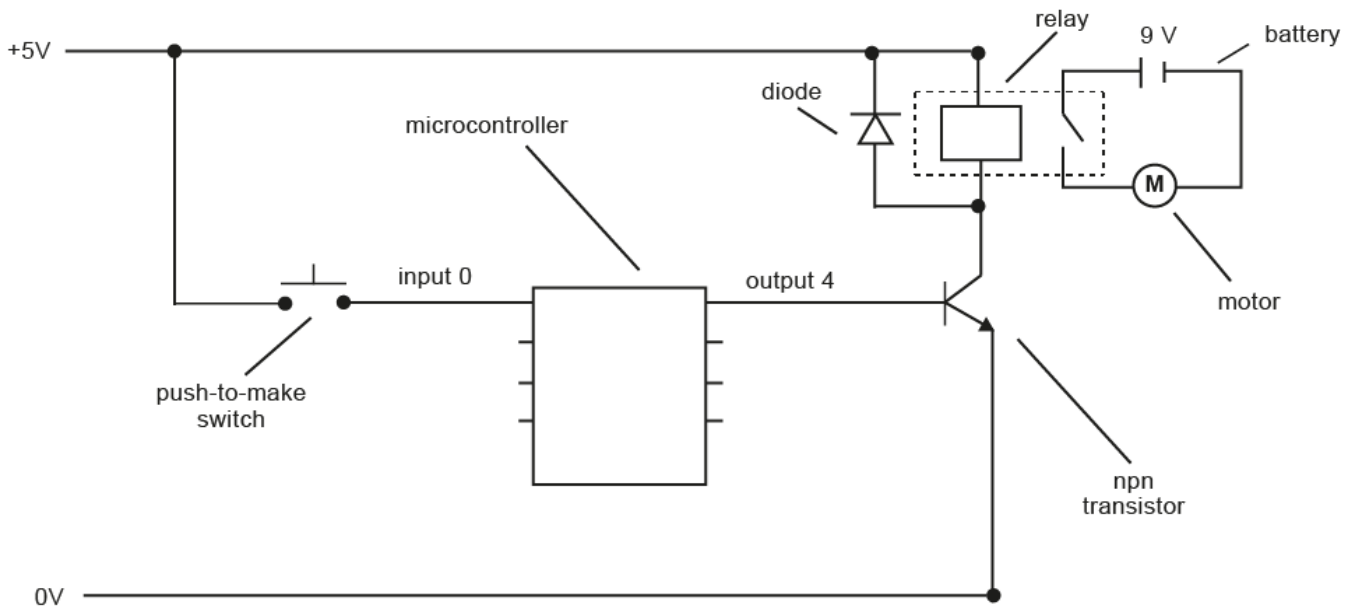
1a   Simulate OR construct the conveyor belt flowchart and electronic circuit integrated together as shown.

Securely attach the evidence of this below or on A4, single-sided paper (eg screenshots or images).

(5 marks)

1b Complete the testing table below 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)

Planned tests	Actual results	Amendments made
Switch the master switch on and check that the conveyor belt motor turns		
After the motor has been running for a few seconds, switch the master switch off and check that the conveyor belt motor stops		
Repeat the above processes several times to check that the system restarts and is repeatable		

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

      Securely attach the evidence of this below or on A4, single-sided paper
      (eg screenshots or images), showing all your amendments.

                                                                    (2 marks)

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

      Securely attach the evidence of this below or on A4, single-sided paper.

                                                                (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

   Securely attach the evidence of this below or on A4, single-sided paper.

(4 marks)
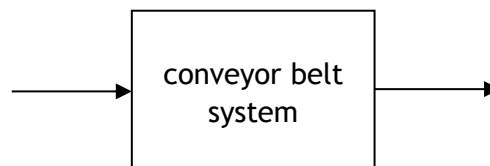
Task 2 — conveyor belt (idea 2)

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 below. Clearly show all inputs and outputs.

Part of the diagram has been drawn for you.
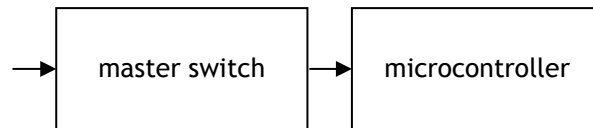
(2 marks)

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

Part of the diagram has been drawn for you.

(4 marks)

```
  ──▶ │ master switch │ ──▶ │ microcontroller │
```
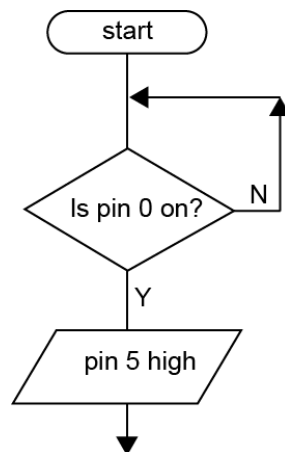
2b Complete the flowchart for the conveyor belt (idea 2) system below,
    referring to the specification and the pin numbers shown in the table.

    Part of the flowchart has been drawn for you.

    (5 marks)

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

start

Is pin 0 on?   N

Y

pin 5 high

Task 3 — package sorter

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.

Securely attach the evidence of this below or on A4, single-sided paper.

(5 marks)

For example, could be simplified to
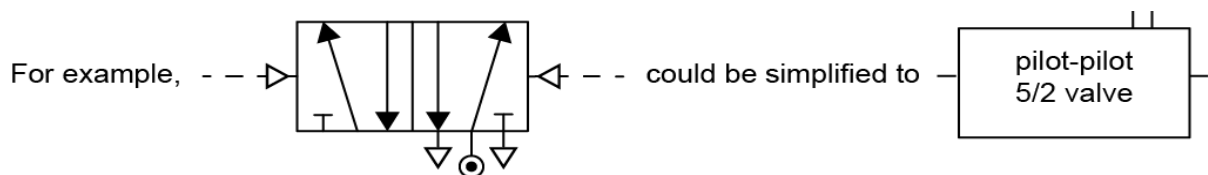
Task 4 — waste compactor

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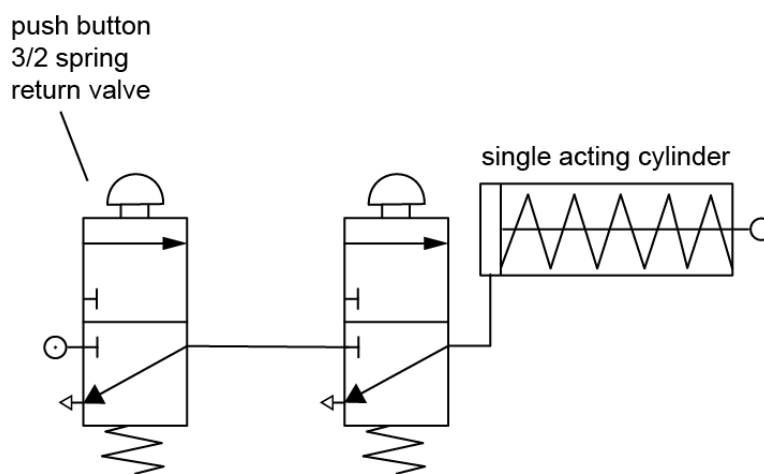
4a   Write a test plan for the waste compactor system. Describe four tests that could be carried out in order to test that the system operates as planned. Describe what you will test and how it will be tested.

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.

Securely attach the evidence of this below or on A4, single-sided paper.

(4 marks)

Planned tests	Actual results	Amendments made

4b   Simulate OR construct the waste compactor pneumatic circuit shown.

        Securely attach the evidence of this below or on A4, single-sided paper
        (eg screenshots or images).

(3 marks)

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

Securely attach the evidence of this below or on A4, single-sided paper.

(3 marks)

4d   Describe and justify improvements that could be made to the operation of the waste compactor system.

Securely attach the evidence of this below or on A4, single-sided paper.

(2 marks)

Task 5 — automatic lighting

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.

(2 marks)

light sensor
(input A) ○

○ lamp
(output Z)

manual switch ○
(input B)

5b   Complete the truth table below showing the expected results of the system described above.

(1 mark)

A	B	Z (expected results)
0	0	
0	1	
1	0	
1	1	

5c   Simulate OR construct the logic circuit for task 5.

        Securely attach the evidence of this below or on A4, single-sided paper
        (eg screenshots or images).
                                                                        (1 mark)

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

A	B	Z (actual results)
0	0	
0	1	
1	0	
1	1	

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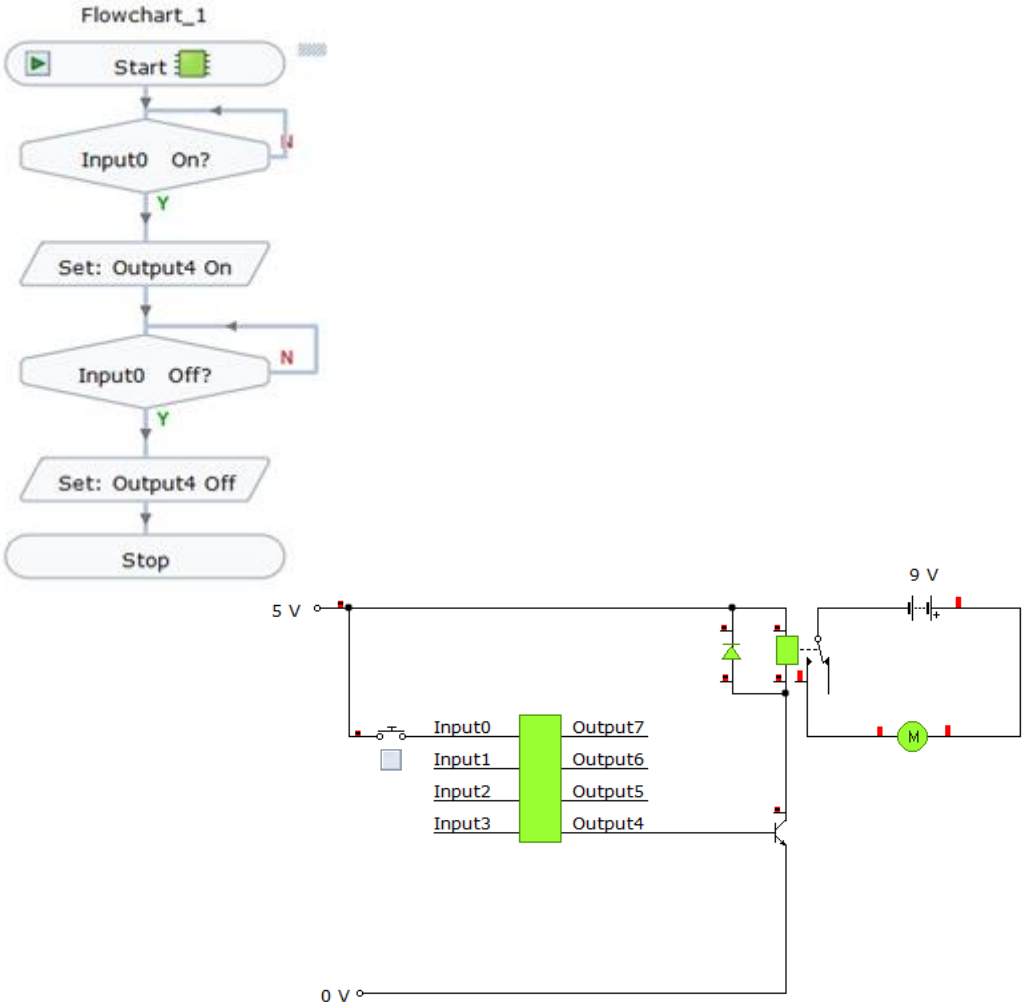
Marking instructions **will not** be provided with annual assessment tasks, as candidate evidence will be submitted to SQA for external marking. They will be provided to markers and then published on the SQA website after marking is complete.

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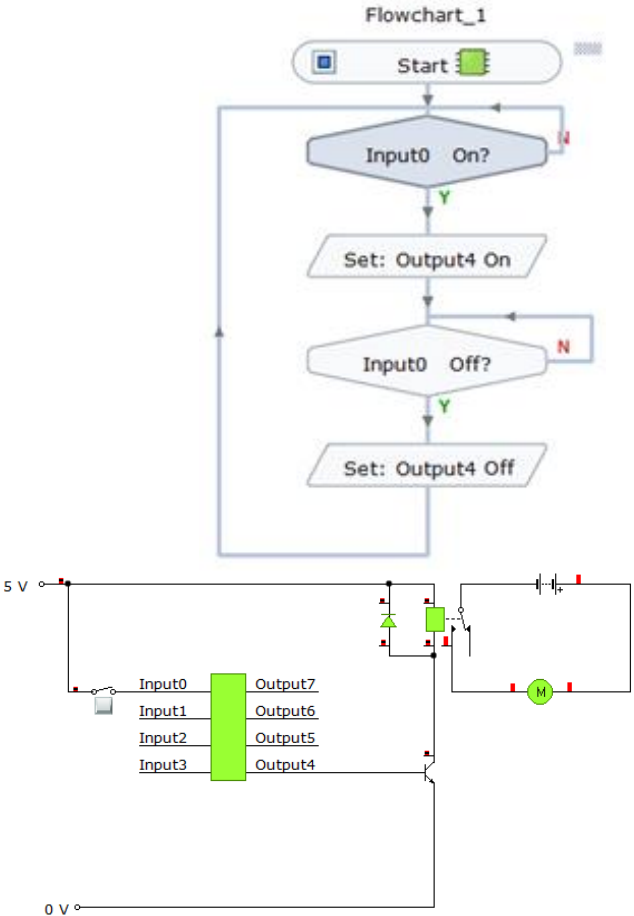
This information is provided to help you understand the general principles that must be applied when marking candidate responses in this assignment. These principles must be read in conjunction with the detailed/specific marking instructions, which identify the key features required in candidate responses.

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
1	**a**		**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**)

Task		Expected answer(s)			Max mark	Additional guidance
1	b				5	Must be descriptive responses.

Planned tests	Actual results	Amendments made
Switch the master switch on and check that the conveyor belt motor turns	The motor turns when the master switch is pressed and held but not when it is pressed quickly.	No amendments required.
After the motor has been running for a few seconds, switch the master switch off and check that the conveyor belt motor stops	The motor turned off immediately as soon as I released the master switch.	I changed the push-to-make (PTM) switch for a single-pole, single-throw (SPST) switch.
Repeat the above processes several times to check that the system restarts and is repeatable	The system only performed once then stopped.	I added a continuous loop to the flowchart from the end back to after the start symbol.

Additional guidance:

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**)

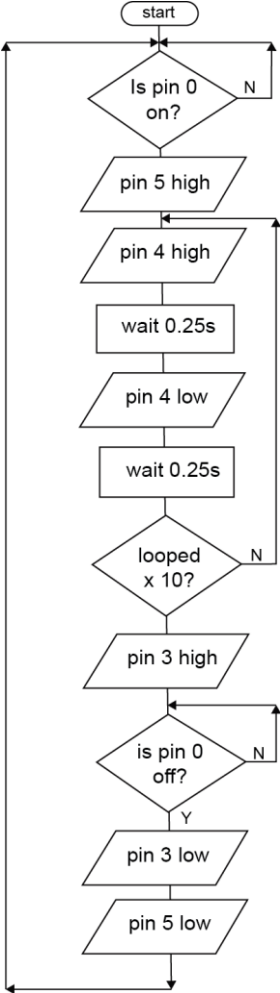| Task		Expected answer(s)	Max mark	Additional guidance
1	**c**		**2**	Addition of continuous loop and deleting stop symbol (**1 mark**) Correct alteration(s) to circuit (and/or flowchart) to allow correct operation of motor control (**1 mark**) Using a pre-built model without evidence of candidate simulation/construction (**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
1	**d**	BASIC Viewer Flowchart_1 ``` 1 symbol Input0 = pin0 2 symbol Output7 = 7 3 symbol Output6 = 6 4 symbol Output5 = 5 5 symbol Output4 = 4 6 7 init: let dirs = %11110000 8 main: 9 label0: 10 if Input0 = 1 then label1 11 goto label0 12 label1: 13 high 4 14 label2: 15 if Input0 = 0 then label3 16 goto label2 17 label3: 18 low 4 19 goto label0 20 ```	**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.

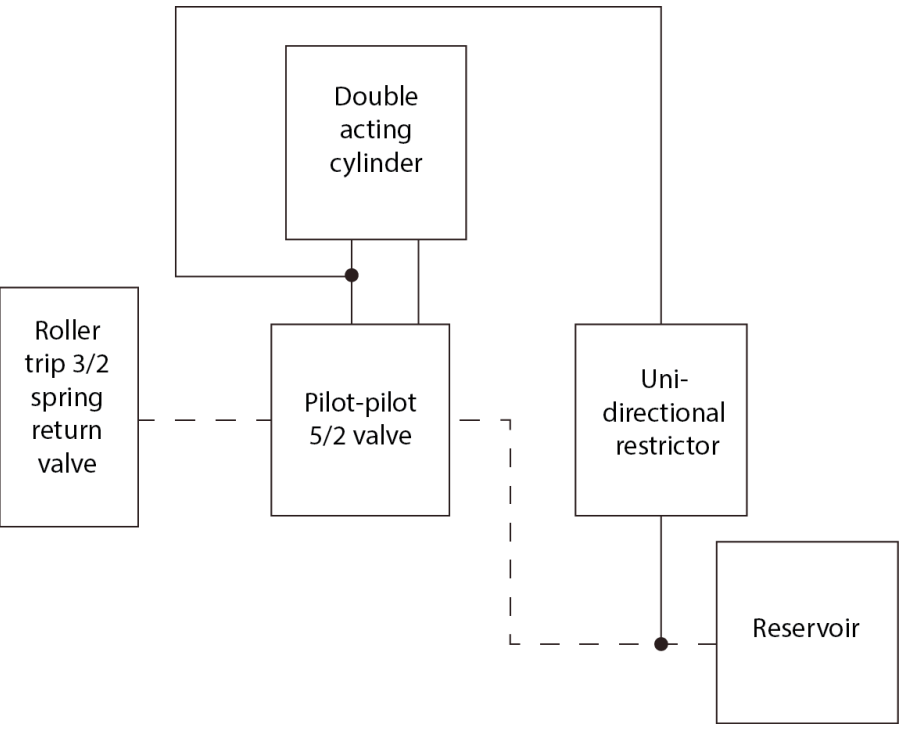| Task		Expected answer(s)	Max mark	Additional guidance
1	**e**	**Specification point** A — The system is successful in turning on the motor when the master switch is pressed. B — Initially the motor turned straight off again when I released the master switch, rather than waiting for the operator to 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
2	a	i	user input → conveyor belt system → light, sound, movement	2	Input identified **(1 mark)** All three outputs identified **(1 mark)** Where no evidence is provided **(0 marks)**
2	a	ii	user input → master switch → micro-controller → driver → lamp → light; driver → buzzer → sound; driver → conveyor motor → movement	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
2	**b**		**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	 Double acting cylinder Roller trip 3/2 spring return valve Pilot-pilot 5/2 valve Uni-directional restrictor Reservoir	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

Task		Expected answer(s)			Max mark	Additional guidance
4	**a**				**4**	Test, with results (and amendments where required) for the piston outstroking **(1 mark)**
		Planned tests	**Actual results**	**Amendments made**		Test, with results (and amendments where required) for the piston instroking **(1 mark)**
		Actuate the push-button valves one at a time and check that the piston does not outstroke	The piston does not outstroke when only one push-button valve is actuated.	No amendments required.		Test, with results (and amendments where required) for the system being repeatable **(1 mark)**
		Actuate both push-button valves simultaneously and check that the piston outstrokes	The piston does outstroke when both push-button valves are actuated.	No amendments required.		Test, with results (and amendments where required) for any other relevant test **(1 mark)**
		While in the outstroke position, release one push-button valve and check that the piston instrokes	The piston does instroke as soon as either of the push-button valves are released.	No amendments required.		Where no evidence is provided (**0 marks**) Responses must be descriptive and describe **what** is being tested.
		Repeat the above tests several time to check that the system is repeatable	The tests were repeated three times and the system worked as expected every time.	No amendments required.		Tests may be observational or software/equipment related. Accept other relevant tests, such as checking for air escaping.

Task		Expected answer(s)	Max mark	Additional guidance
				Markers should take account of simulation/construction evidence from task 4b.
4	b		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
4	**c**	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
4	**d**	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

Task		Expected answer(s)	Max mark	Additional guidance
5	a		2	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.
5	b		1	Correct expected results in column Z **(1 mark)** Where no evidence is provided **(0 marks)**

For 5b:

A	B	Z (expected results)
0	0	1
0	1	1
1	0	0
1	1	1

Task		Expected answer(s)	Max mark	Additional guidance
5	c		1	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)**
5	d		1	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.

Table for 5d:

A	B	Z (actual results)
0	0	1
0	1	1
1	0	0
1	1	1

Copyright acknowledgements

Page 7: box on conveyor roller. 3D Rendering — Shutterstock 514897444

Administrative information

Published: August 2019 (version 1.0)

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

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