Candidate 1

Car wash

A team of engineers is involved in several tasks during the development of a new car wash.

These tasks include the development of proposals for the following sub-systems:

Task 1 - car sensor sub-system

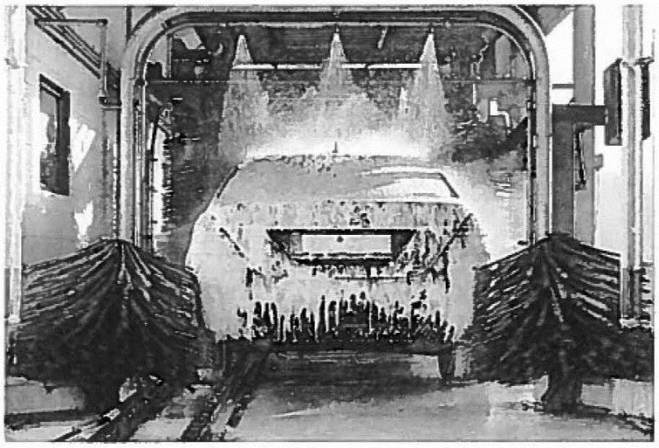
Task 2 - cleaning brushes - rotational movement sub-system

Task 3 - cleaning brushes - horizontal movement sub-system

Task 4 - cleaning brushes - speed control sub-system

Task 5 - water heater sub-system

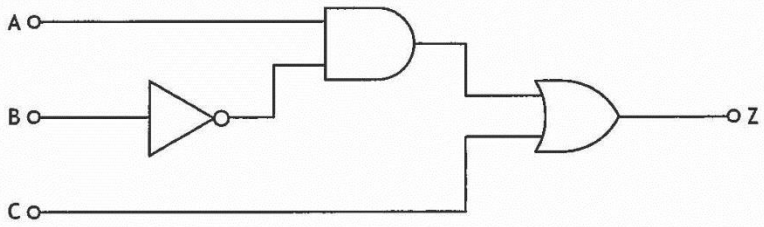
Task 6 - end of wash cycle alert sub-system



Task 1 - car sensor sub-system

The car wash should only operate when a master switch A is on (logic 1) and a sensor B detects a car has driven into the correct position (logic 0). The car wash can also be tested by pressing an override switch C (logic 1).

The design for a logic circuit to control the operation of the car wash is shown below.

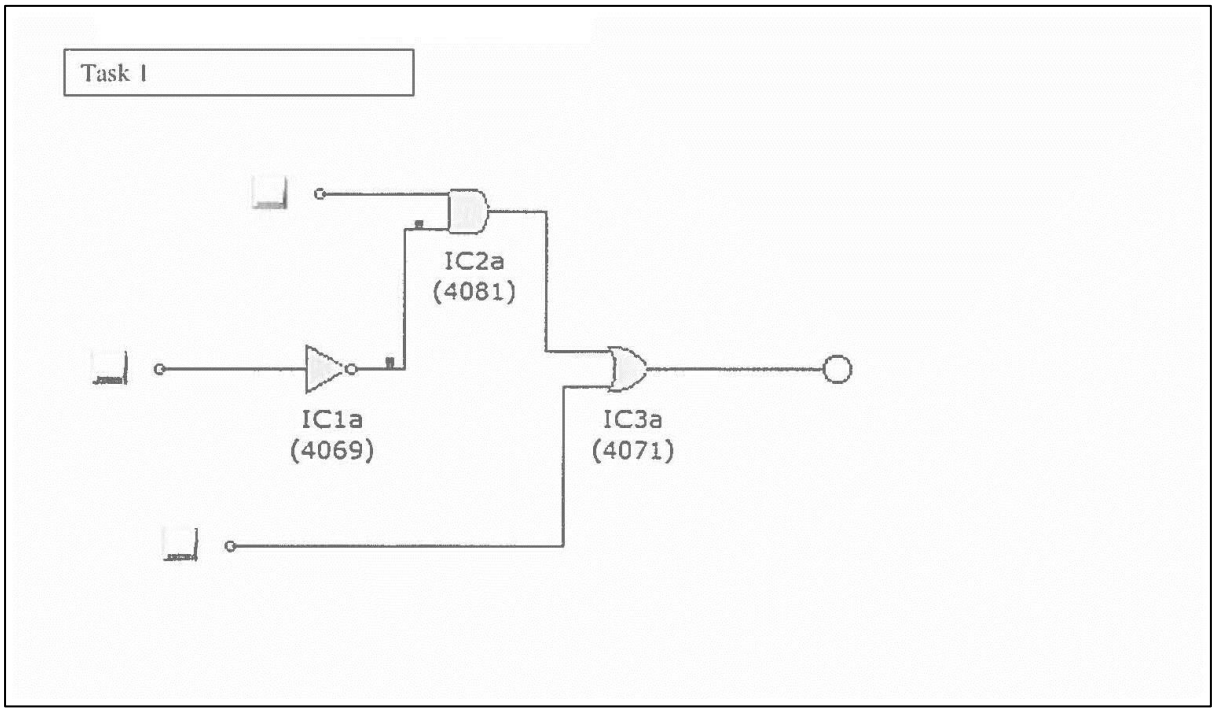


1a Simulate or construct the logic circuit shown above. You must include input devices to allow for testing.

Print the evidence (screenshots or images must be **clear** and **easy** to read) on A4 single sided paper with the task number clearly labelled.

(1 mark)

1a candidate response



Task 1 - car sensor sub-system (continued)

1b Test your simulated or constructed circuit and complete the truth table below with your results for output Z.

(1 mark)

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

1b candidate response

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

Task 2 - cleaning brushes - rotational movement sub-system

Cleaning brushes are required to spin over the car during the cleaning process.

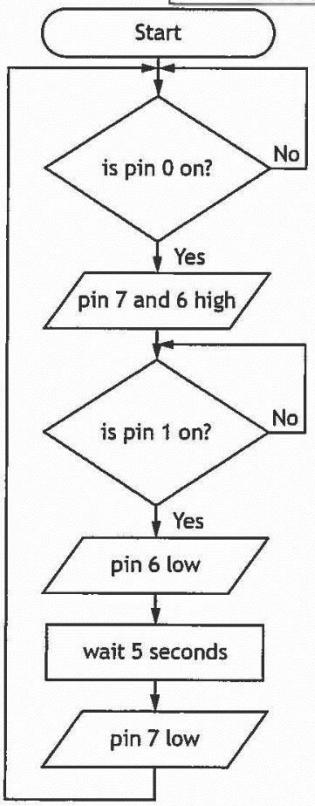
An electronic engineer has designed the flowchart and circuit shown below as a possible solution. The pin numbers used to connect the circuit to the microcontroller are shown in the table below.

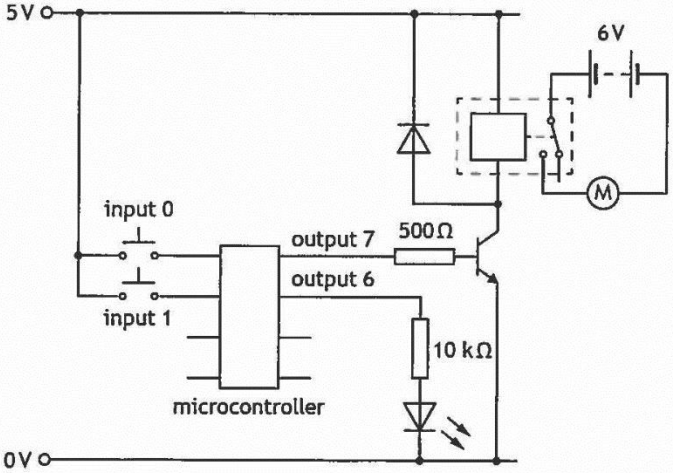
2a Simulate or construct the flowchart and electronic circuit integrated together as shown. A microcontroller of an alternative size may be used but the pin numbers must match the connections given.

Print the evidence (screenshots or images must be clear and easy to read) on A4 single sided paper with the task number clearly labelled.

(5 marks)

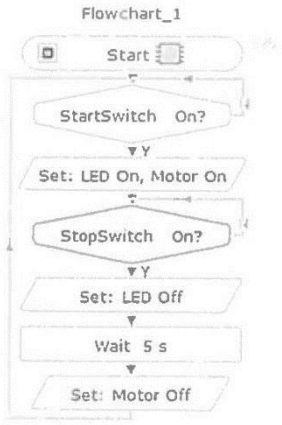
Input Connection	Pin	Output Connection
	7	motor
	6	LED
stop switch	1	
start switch	0	

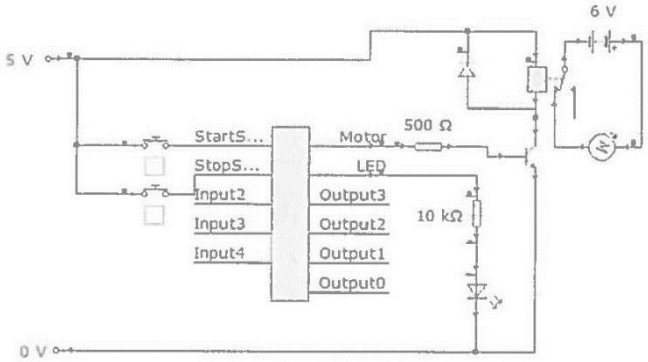




2a candidate response

Task 2a





Task 2 - cleaning brushes - rotational movement sub-system (continued)

The cleaning brushes are to be operated by a microcontroller using the following specification:

i. When a start switch is pressed an LED, protected by a resistor, switches on and an SPDT relay activates a 6V motor, spinning the cleaning brushes.

ii. When a stop switch is pressed the motor turns off and then after a 5 second delay the LED turns off.

iii. The sequence should then repeat.

Errors were found with the design during testing.

2b Complete the testing table shown on the following page, by carrying out the planned tests given, **making amendments as necessary before moving onto the next test.** You must write descriptions of the actual results you observed during testing and appropriate amendments that you made to enable the system to satisfy the specification.

If necessary, print the evidence on A4 single sided paper with the task number clearly labelled.

(5 marks)

2b candidate response

Task 2 - cleaning brushes - rotational movement sub-system (continued)
Task 2 b (continued)

Planned test	Expected result	Actual result	Amendments made
Test 1 Activate the start switch.	The 6V motor should start turning and the LED should turn on.	The 6V motor does turn when the start switch is activated but the LED does not turn on	I have changed the resistance on the resistor connected to the LED for it to turn on
Test 2 Activate the stop switch.	The 6V motor should stop turning and then after 5 seconds the LED should turn off.	The LED turns off straight away and 5 seconds later the motor turns off	I have changed pin 6 and pin 7 on the flow chart so the motor turns off first then the LED
Test 3 Repeat tests 1 and 2 to make sure the sequence is repeatable.	The sequence should loop back to the start and repeat.	For the sequence to be repeated the Start switch must be pressed again and the same as the stop switch	

Task 2 - cleaning brushes - rotational movement sub-system (continued)

2c Your amended flowchart should now match the specification given at the start of task 2.

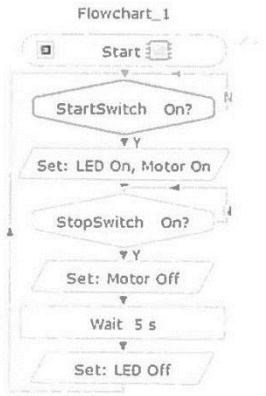
Print the evidence of your **amended flowchart and electronic circuit integrated together** after completing task 2b on A4 single sided paper with the task number clearly labelled.

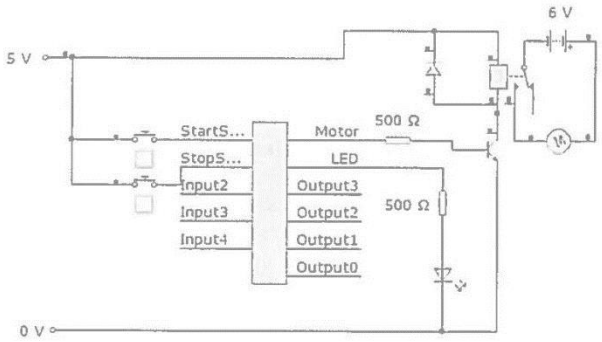
Screenshots or images must be **clear** and **easy** to read.

(2 marks)

2c candidate response

Task 2c





2d Produce high-level microcontroller code to fully match the function described in your amended flowchart from **task 2c**.

If necessary, print the evidence (screenshots or images must be **clear** and **easy** to read) on A4 single sided paper with the task number clearly labelled.

(1 mark)

2d candidate response

```
Main:
Label 0:
    if input 0 is on then label 1 go to label 0
Label 1:
    Switch on 5
    Switch on 4
label 2:
    If input 1 is on then label 3 go to label 2
Label 3:
    Switch off 5
    pause 5000
    Switch off 4
    go to label 0
```

Task 2 - cleaning brushes - rotational movement sub-system (continued)

2e Evaluate the performance of your **amended solution** from **task 2c** against the specification given in **task 2b**, by describing:

- the performance of your **amended solution** to meet **each of the three specification points**, referring to testing and any amendments that you may have made
- the overall effectiveness of your **amended solution** for use in the car wash environment

If necessary, print the evidence on A4 single sided paper with the task number clearly labelled.

(4 marks)

2e candidate response

The problem with this circuit is that somebody has to press the on and off buttons so that the car wash can operate and no car washes have a workers pushing buttons. My solution to this is to put sensors under the car on the floor of the car wash so that the car activates the car wash by its self and stops it by its self without no attendees being there pushing buttons

Task 3 - cleaning brushes - horizontal movement sub-system

A pneumatic system is to be used to move the cleaning brushes into the correct position before they start to spin. The pneumatic system must meet the following specification:

i. When the first electrical actuator receives a signal an adjustable pneumatic time delay occurs.

ii. After the time delay a double acting cylinder (controlled by a 5/2 valve) outstrokes, moving the cleaning brushes into position.

iii. When a second electrical actuator receives a signal the double acting cylinder instrokes.

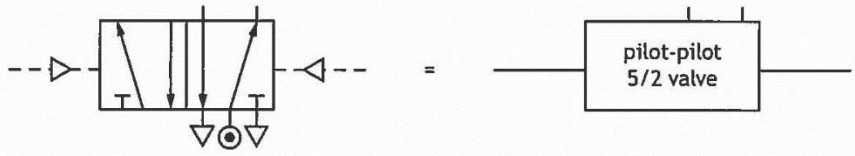
iv. The piston's speed is controlled so that it outstrokes slowly.

3a Design a pneumatic system that will meet the given specification. The name of each component, valve and actuator must be identified and the direction of the piston outstroke must be indicated. Show connections between all components and valves.

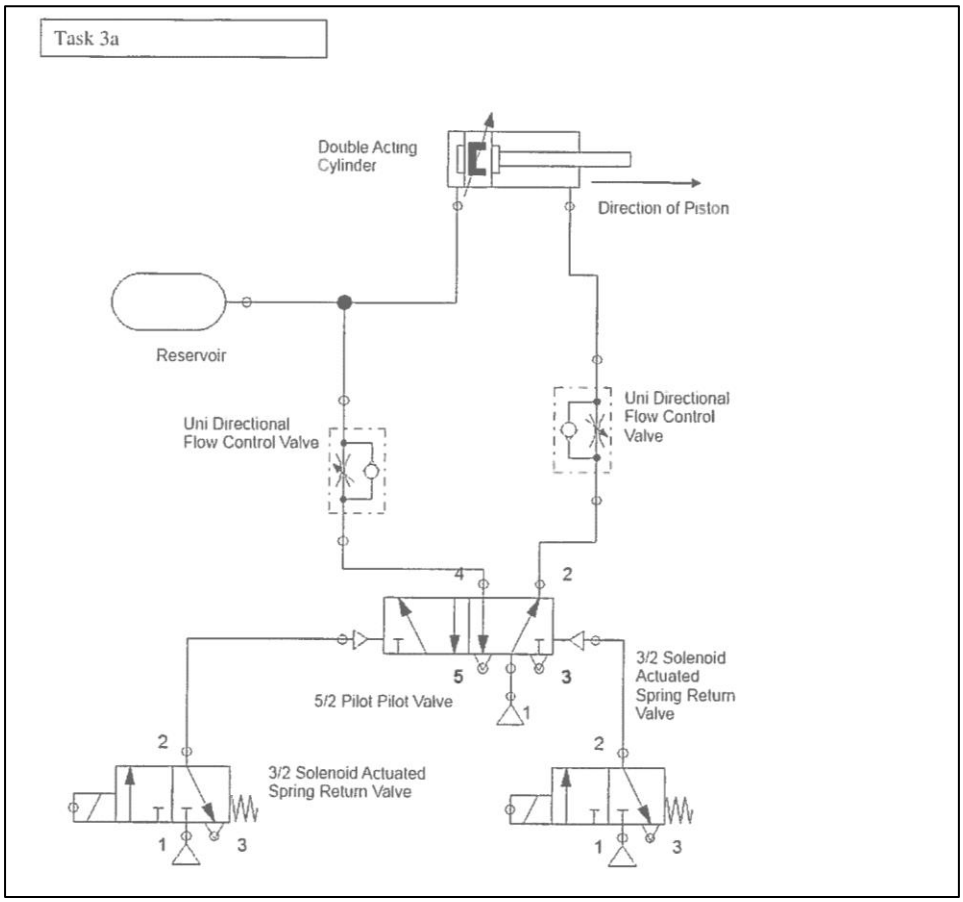
If necessary, print the evidence (screenshots or images must be clear and easy to read) on A4 single sided paper with the task number clearly labelled or securely attach below.

(6 marks)

For example: a 5/2 valve could be simplified as shown below



3a candidate response



Task 3 - cleaning brushes - horizontal movement sub-system (continued)

Electrical actuators and diaphragm actuators with air bleeds were both considered to operate the pneumatic valves within the car wash.

Actuator	Characteristics
Electrical actuator	• allows for flexibility of control • no loss of signal over a distance • safety issues with electrical signal in a wet environment • could be operated by a microcontroller
Diaphragm actuator	• safe for use in a wet environment • air bleed may become blocked • source of pneumatics already at location • non-contact method of sensing

3b Select the most suitable actuator type for the car wash. Explain your choice, giving two reasons.

If necessary, print the evidence on A4 single sided paper with the task number clearly labelled.

(2 marks)

3b candidate response

Selected actuator Diaphragm Actuator

Reason 1 safe to use in wet environment when this actuator will be used in a lot of water so it can still work

Reason 2 because it is non-contact method of sensing so that you don't have to get out your car and push button

Task 4 - cleaning brushes - speed control sub-system

The speed of the motor used to turn the cleaning brushes needs to be reduced. A compound gear train is required that will meet the following specification:

i. Reduce the speed of the motor by **at least** a factor of 25.

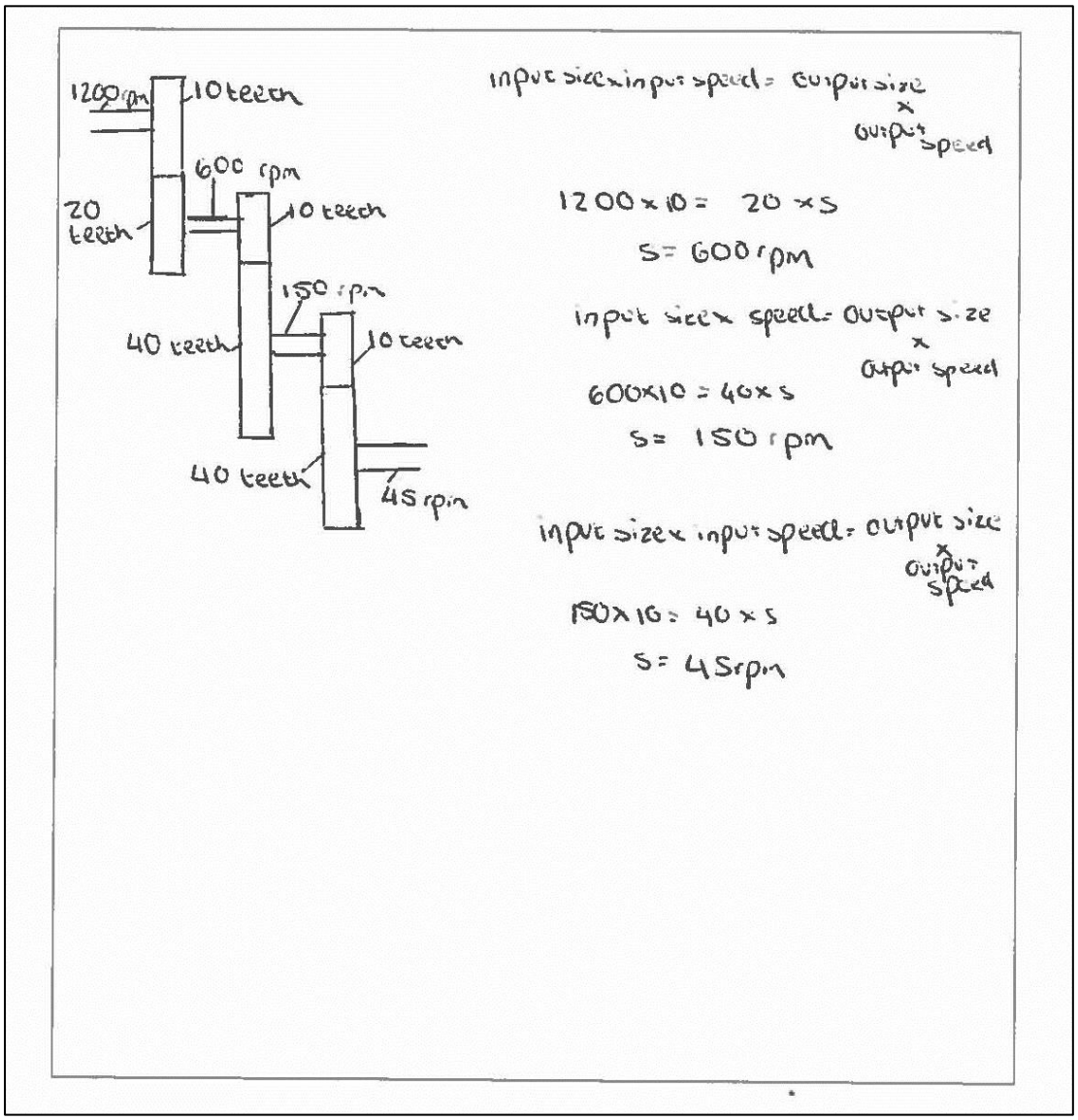
ii. Fit into a compact space inside the car wash.

4a Design a compound gear train that will meet the specification. You must identify the input and output gears and include all gear sizes.

Sketch your design below or on A4 single sided paper with the task number clearly labelled. You must **not** use simulation software to complete this task.

(2 marks)

4a candidate response



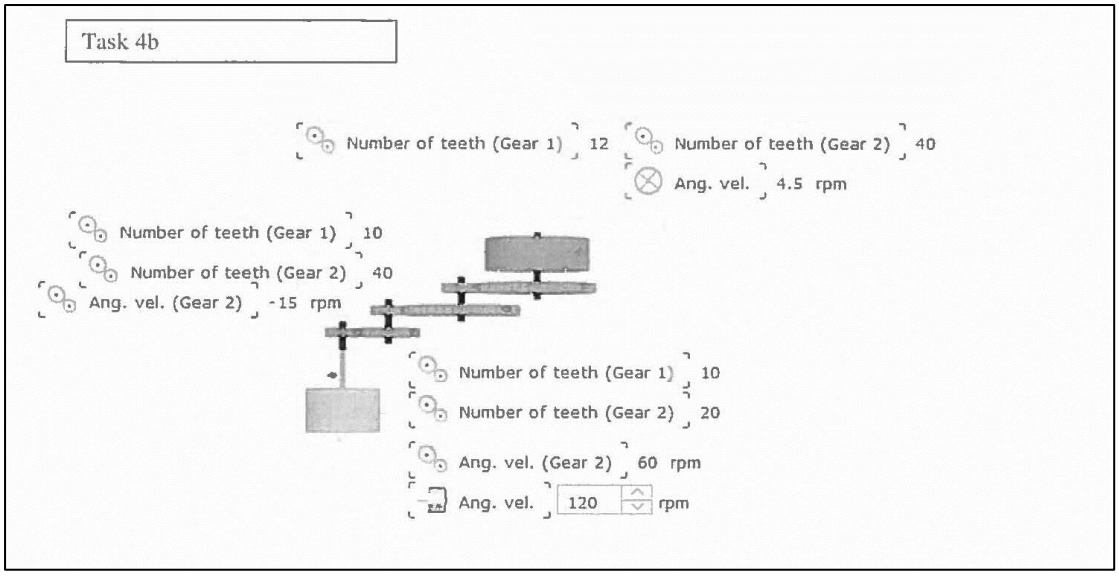
Task 4 - cleaning brushes - speed control sub-system (continued)

4b Simulate or construct your design from task 4a. You must identify the input and output and include all gear sizes. You must include an input component to allow for testing.

Print the evidence (screenshots or images must be clear and easy to read) on A4 single sided paper with the task number clearly labelled.

(2 marks)

4b candidate response



4c Complete the testing table below by entering the actual results for the input and output speeds of the gear system that you observed during simulating or constructing.

(1 mark)

4c candidate response

Planned test	Expected result		Actual result	
	Input speed	Output speed	Input speed	Output speed
Measure the input speed and output speed of the gear system.	25 revs min^{-1} or 25 turns.	No more than 1 revs min^{-1} or 1 turns.	120 rpm	4.5rpm

Task 4 - cleaning brushes - speed control sub-system (continued)

4d Evaluate your solution from task 4b, by describing how well the two specification points were met, referring to testing where appropriate and any amendments that you may have made.

If necessary, print the evidence on A4 single sided paper with the task number clearly labelled.

(2 marks)

4d candidate response

The first specification was met as we have reduced the speed by a factor of 25. The input speed I tested was 120 rpm and we reduced the speed to 4.5rpm, with the factor of 25 in 120 is 4.8 rpm, efficient below that, but as a car wash this amount of revs isn't good enough if the brushes only turn 4.5 times

The second specification was met as all the gears are compacted so they can save space but it can definately made smaller

Task 5 - water heater sub-system

The water used in the car wash must be heated. An input sensing circuit is required to activate a heater, meeting the following specification:

i. When the temperature of the water falls below a set level the heater should switch on.

ii. When the temperature of the water rises above a set level the heater should switch off.

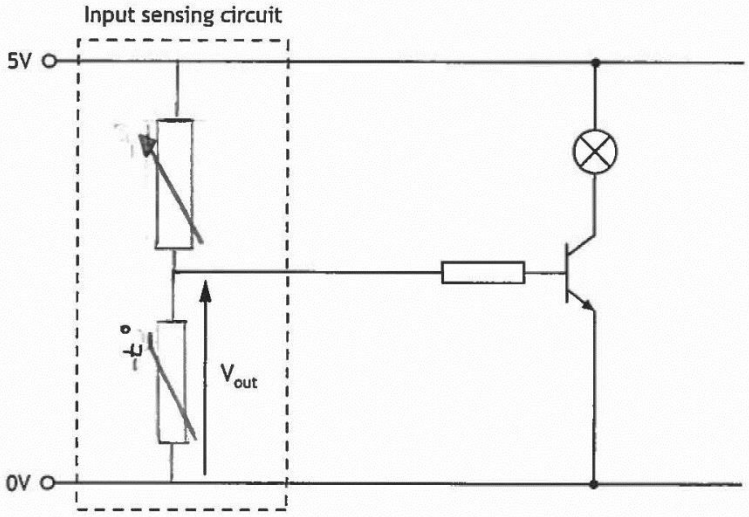
iii. The temperature that the heater switches on at should be adjustable.

To allow the input sensing circuit to be tested a lamp is used instead of a heater and will be activated by a transistor as shown below in task 5a.

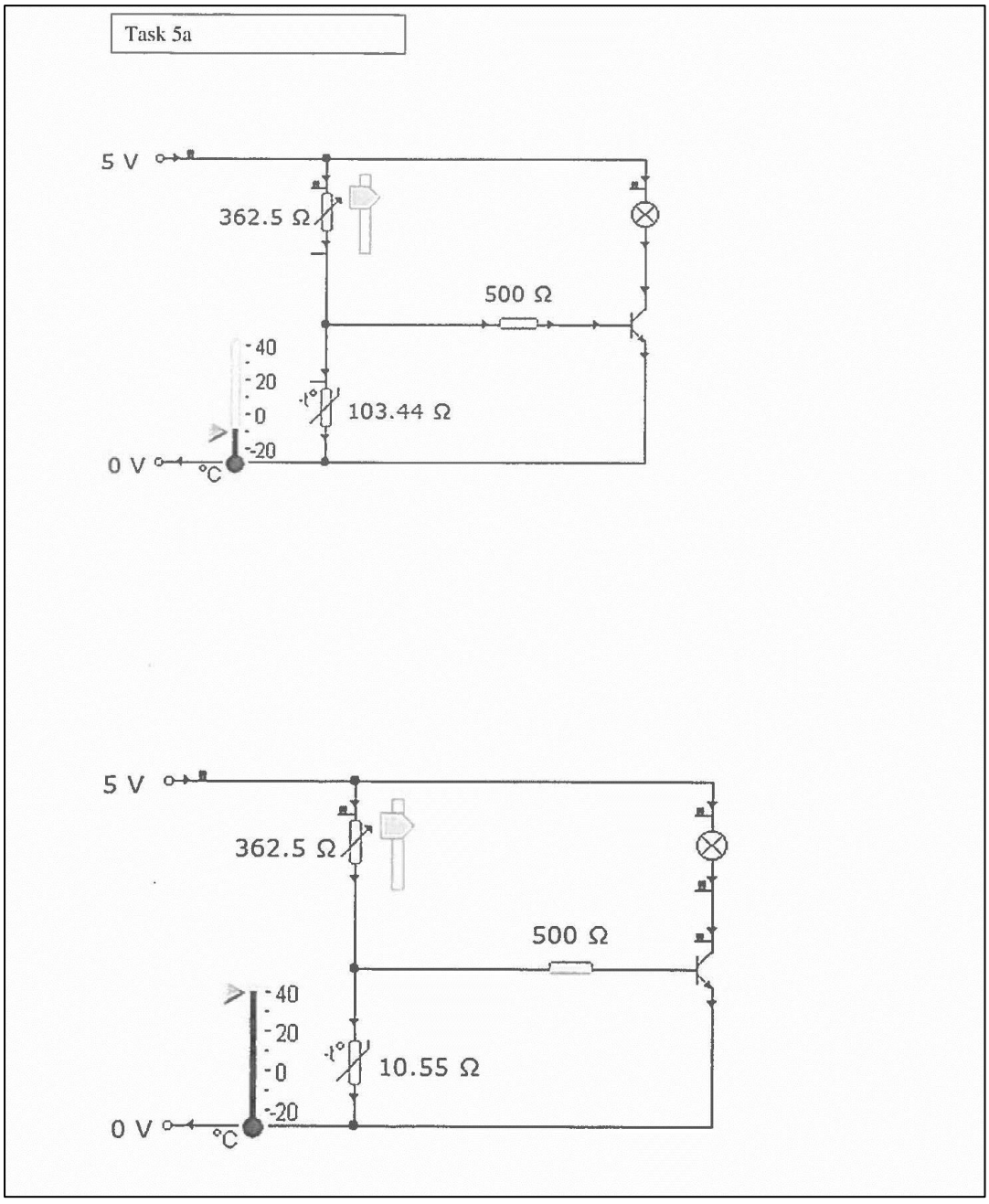
5a Complete the circuit diagram shown below by designing a suitable input sensing circuit that will meet the given specification.

Component values are not required.

(3 marks)



5a candidate response



Task 5 - water heater sub-system (continued)

5b Write a test plan for the **input sensing circuit** by describing:

- three tests that could be carried out
- the results that would be expected from each test in terms of the output voltage (V_{out}) from the input sensing circuit

If necessary, print the evidence on A4 single sided paper with the task number clearly labelled.

(6 marks)

5b candidate response

Planned test	Expected result
The variable resistor is to the max resistance with the thermistor down to -20°C, to see if the heater turns on	The expected result is that the heater will turn on
The variable resistor is to the maximum resistance with the thermistor up to 40°C to see if the heater turns off	The expected result is that the heater will turn off
The variable resistor is down to the lowest resistance possible, with the thermistor up to 40°C, to see if the heater turns off or on	The expected result is the heater will remain on at the highest temperature

Task 6 - end of wash cycle alert sub-system

The specification for a microcontroller based circuit used to alert the driver that the wash cycle is about to finish is shown below.

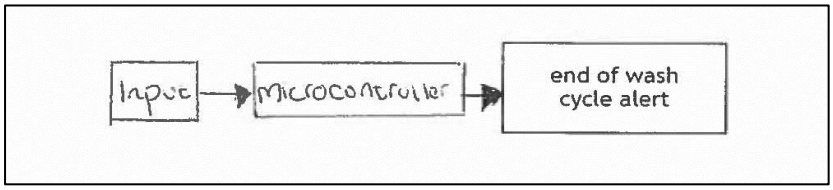
i. When a car is in the correct position it activates a limit switch and a red lamp will flash on and off 20 times.

ii. After the red lamp has finished flashing it will turn off and a green lamp will turn on.

6a Complete the system diagram below with reference to the specification.

(2 marks)

6a candidate response

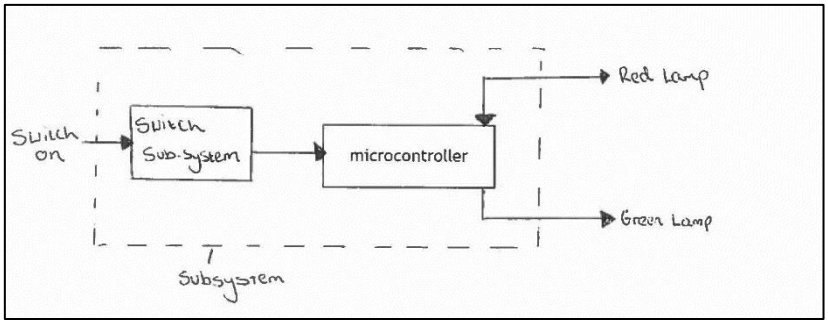


Task 6 - end of wash cycle alert sub-system (continued)

6b Complete the sub-system diagram below with reference to the specification. You must clearly show all sub-systems, the system boundary and interactions between sub-systems.

(5 marks)

6b candidate response



Candidate 2

Car wash

A team of engineers is involved in several tasks during the development of a new car wash.

These tasks include the development of proposals for the following sub-systems:

Task 1 - car sensor sub-system

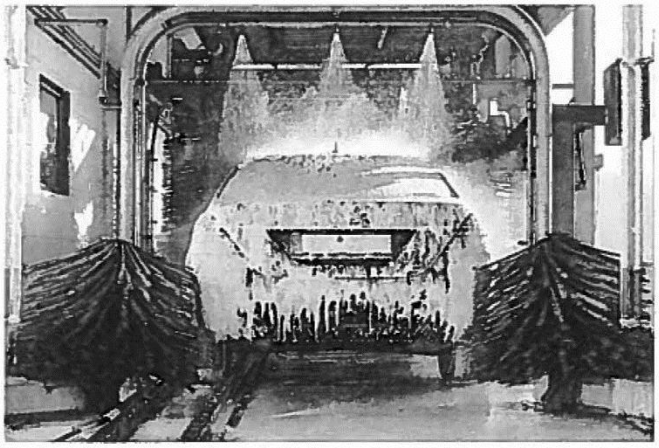
Task 2 - cleaning brushes - rotational movement sub-system

Task 3 - cleaning brushes - horizontal movement sub-system

Task 4 - cleaning brushes - speed control sub-system

Task 5 - water heater sub-system

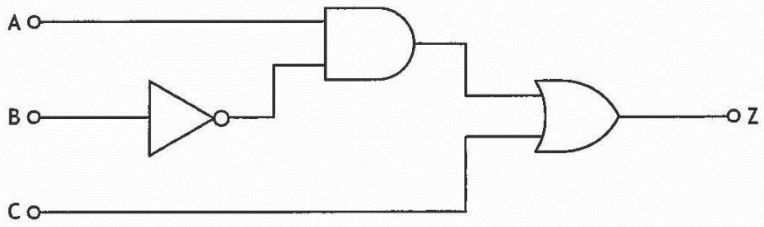
Task 6 - end of wash cycle alert sub-system



Task 1 - car sensor sub-system

The car wash should only operate when a master switch A is on (logic 1) and a sensor B detects a car has driven into the correct position (logic 0). The car wash can also be tested by pressing an override switch C (logic 1).

The design for a logic circuit to control the operation of the car wash is shown below.

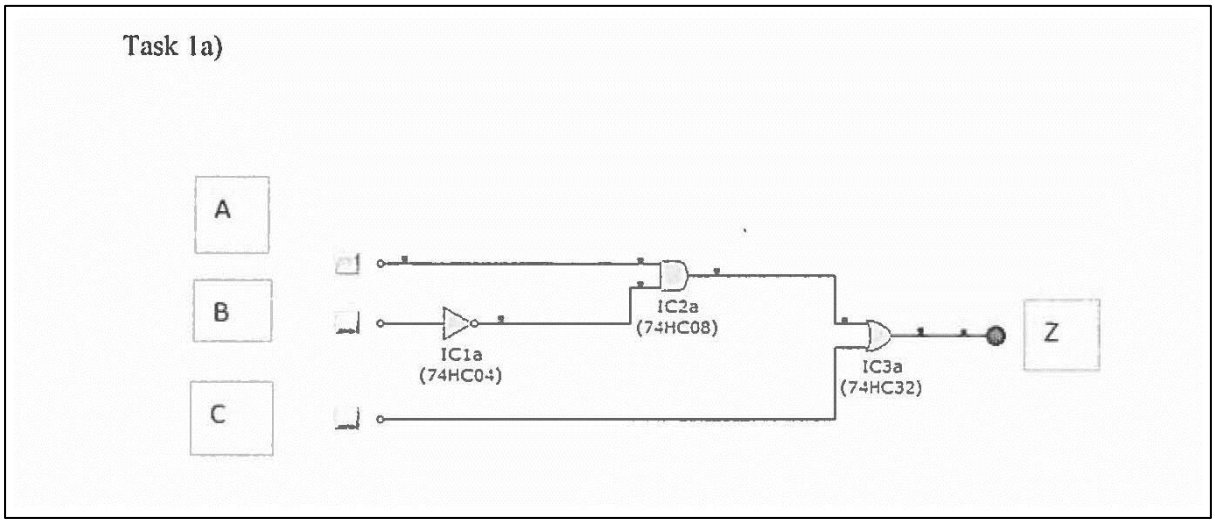


1a Simulate or construct the logic circuit shown above. You must include input devices to allow for testing.

Print the evidence (screenshots or images must be **clear** and **easy** to read) on A4 single sided paper with the task number clearly labelled.

(1 mark)

1a candidate response



Task 1 - car sensor sub-system (continued)

1b Test your simulated or constructed circuit and complete the truth table below with your results for output Z.

(1 mark)

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

1b candidate response

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

Task 2 - cleaning brushes - rotational movement sub-system

Cleaning brushes are required to spin over the car during the cleaning process.

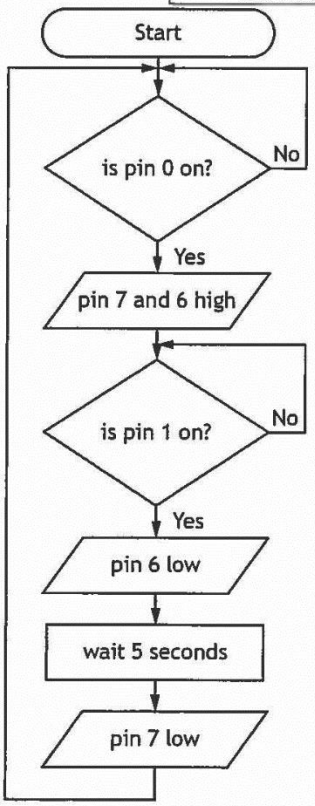
An electronic engineer has designed the flowchart and circuit shown below as a possible solution. The pin numbers used to connect the circuit to the microcontroller are shown in the table below.

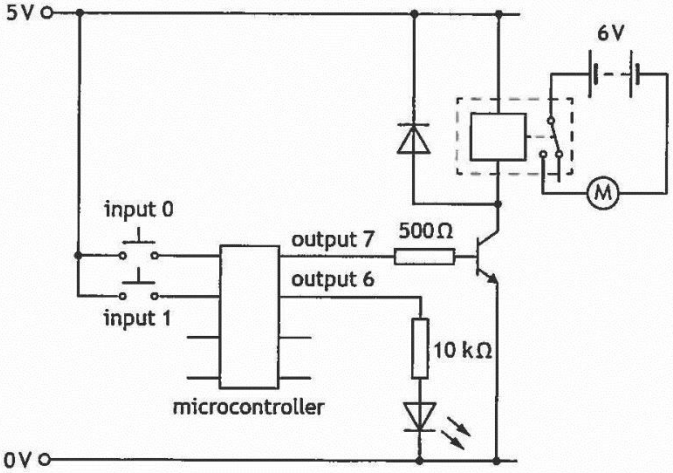
2a Simulate or construct the flowchart and electronic circuit integrated together as shown. A microcontroller of an alternative size may be used but the pin numbers must match the connections given.

Print the evidence (screenshots or images must be clear and easy to read) on A4 single sided paper with the task number clearly labelled.

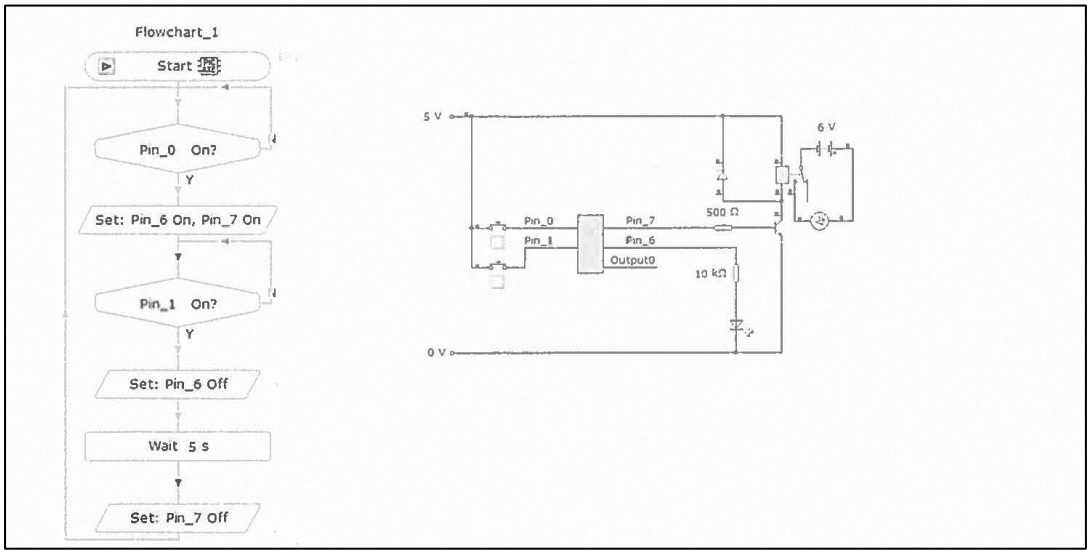
(5 marks)

Input Connection	Pin	Output Connection
	7	motor
	6	LED
stop switch	1	
start switch	0	





2a candidate response



Task 2 - cleaning brushes - rotational movement sub-system (continued)

The cleaning brushes are to be operated by a microcontroller using the following specification:

i. When a start switch is pressed an LED, protected by a resistor, switches on and an SPDT relay activates a 6V motor, spinning the cleaning brushes.

ii. When a stop switch is pressed the motor turns off and then after a 5 second delay the LED turns off.

iii. The sequence should then repeat.

Errors were found with the design during testing.

2b Complete the testing table shown on the following page, by carrying out the planned tests given, **making amendments as necessary before moving onto the next test.** You must write descriptions of the actual results you observed during testing and appropriate amendments that you made to enable the system to satisfy the specification.

If necessary, print the evidence on A4 single sided paper with the task number clearly labelled.

(5 marks)

2b candidate response

Task 2 - cleaning brushes - rotational movement sub-system (continued)
Task 2 b (continued)

Planned test	Expected result	Actual result	Amendments made
Test 1 Activate the start switch.	The 6V motor should start turning and the LED should turn on.	They both came on as they Should	No amendments made
Test 2 Activate the stop switch.	The 6V motor should stop turning and then after 5 seconds the LED should turn off.	The motor turns off before the LED does	Swapped the order in the flowchart
Test 3 Repeat tests 1 and 2 to make sure the sequence is repeatable.	The sequence should loop back to the start and repeat.	Goes back to the beginning ready to start again	I checked the flowchart for any errors, but found none so I didn't have to change it. It's ready to repeat again

Task 2 - cleaning brushes - rotational movement sub-system (continued)

2c Your amended flowchart should now match the specification given at the start of task 2.

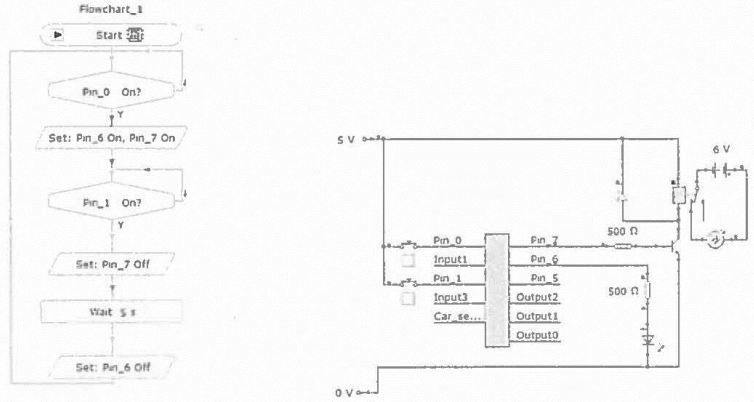
Print the evidence of your **amended flowchart and electronic circuit integrated together** after completing task 2b on A4 single sided paper with the task number clearly labelled.

Screenshots or images must be **clear** and **easy** to read.

(2 marks)

2c candidate response

I changed the resistance of the resistor and swapped the order of the motor and light so they turn off when supposed to.



2d Produce high-level microcontroller code to fully match the function described in your amended flowchart from **task 2c**.

If necessary, print the evidence (screenshots or images must be **clear** and **easy** to read) on A4 single sided paper with the task number clearly labelled.

(1 mark)

2d candidate response

Flowchart_1 Basic Code for flowchart

```
1
2  main:
3  label0:
4     if Input0 is On then label1
5     goto label0
6  label1:
7     Switch on 5
8     Switch on 4
9  label2:
10    if Input2 is On then label3
11    goto label2
12 label3:
13    Switch off 5
14    pause 5000
15    Switch off 4
16    goto label0
17
```

Task 2 - cleaning brushes - rotational movement sub-system (continued)

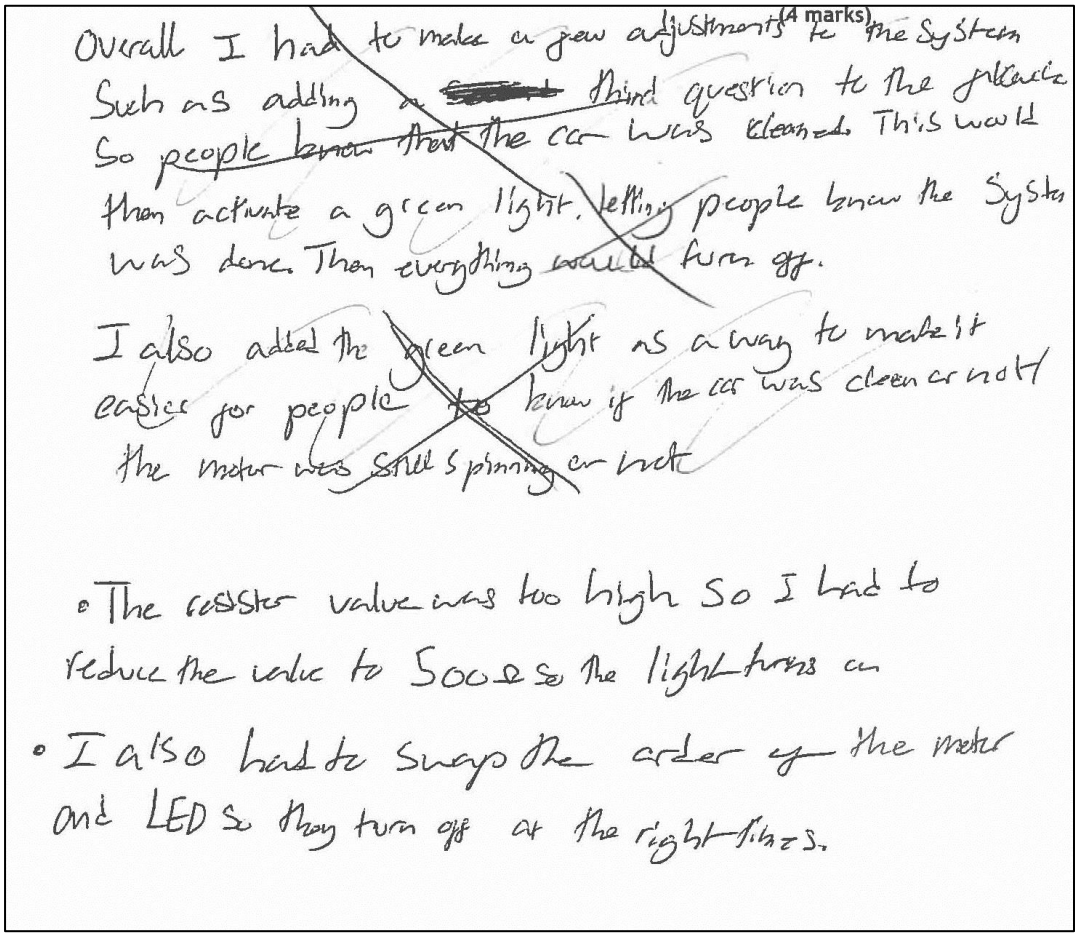
2e Evaluate the performance of your **amended solution** from **task 2c** against the specification given in **task 2b**, by describing:

- the performance of your **amended solution** to meet **each of the three specification points**, referring to testing and any amendments that you may have made
- the overall effectiveness of your **amended solution** for use in the car wash environment

If necessary, print the evidence on A4 single sided paper with the task number clearly labelled.

(4 marks)

2e candidate response



(4 marks)

Overall I had to make a few adjustments to the System such as adding a third question to the flowchart So people knew that the car was cleaned. This would then activate a green light, letting people know the System was done. Then everything would turn off.

I also added the green light as a way to make it easier for people to know if the car was clean or not/ the motor was still spinning or not

- The resistor value was too high so I had to reduce the value to 500Ω so the light turns on
- I also had to swap the order of the motor and LED so they turn off at the right times.

Task 3 - cleaning brushes - horizontal movement sub-system

A pneumatic system is to be used to move the cleaning brushes into the correct position before they start to spin. The pneumatic system must meet the following specification:

i. When the first electrical actuator receives a signal an adjustable pneumatic time delay occurs.

ii. After the time delay a double acting cylinder (controlled by a 5/2 valve) outstrokes, moving the cleaning brushes into position.

iii. When a second electrical actuator receives a signal the double acting cylinder instrokes.

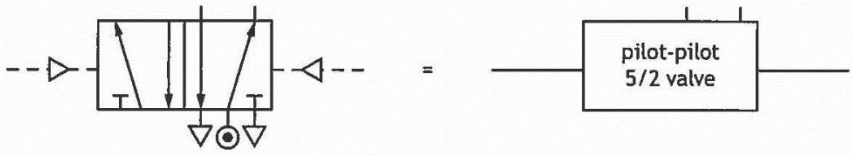
iv. The piston's speed is controlled so that it outstrokes slowly.

3a Design a pneumatic system that will meet the given specification. The name of each component, valve and actuator must be identified and the direction of the piston outstroke must be indicated. Show connections between all components and valves.

If necessary, print the evidence (screenshots or images must be clear and easy to read) on A4 single sided paper with the task number clearly labelled or securely attach below.

(6 marks)

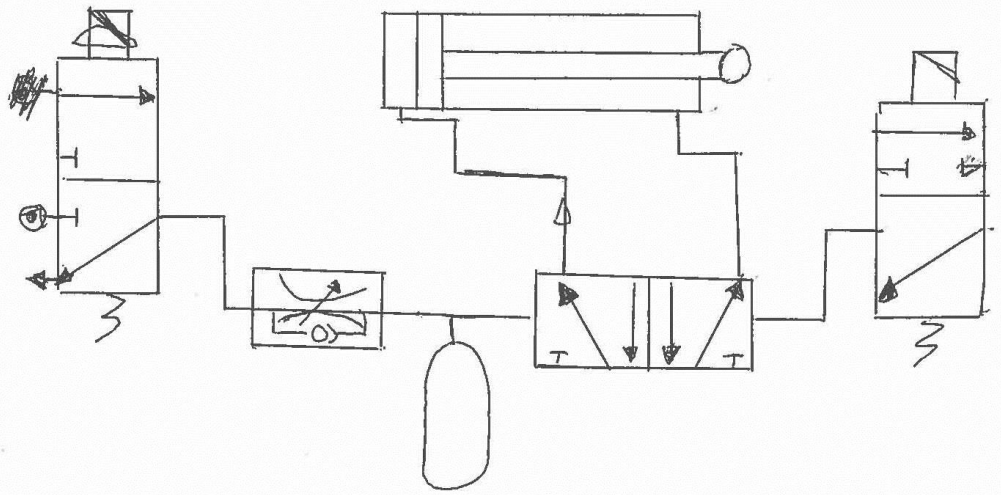
For example: a 5/2 valve could be simplified as shown below



3a candidate response

Task 3)

Pneumatic circuit



This is my pneumatic system with the uni directional restrictor so the piston outstrokes slowly. As shown above.

Task 3 - cleaning brushes - horizontal movement sub-system (continued)

Electrical actuators and diaphragm actuators with air bleeds were both considered to operate the pneumatic valves within the car wash.

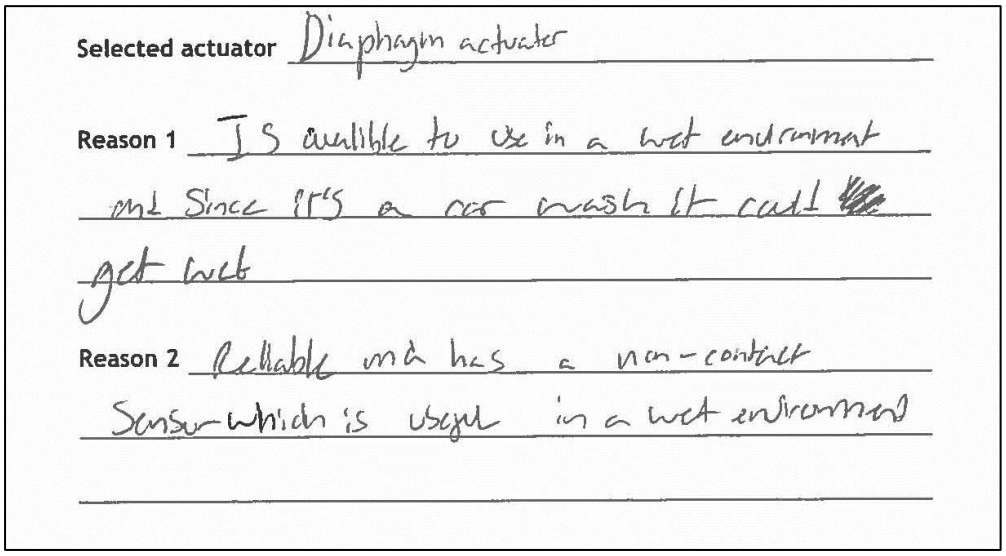
Actuator	Characteristics
Electrical actuator	• allows for flexibility of control • no loss of signal over a distance • safety issues with electrical signal in a wet environment • could be operated by a microcontroller
Diaphragm actuator	• safe for use in a wet environment • air bleed may become blocked • source of pneumatics already at location • non-contact method of sensing

3b Select the most suitable actuator type for the car wash. Explain your choice, giving two reasons.

If necessary, print the evidence on A4 single sided paper with the task number clearly labelled.

(2 marks)

3b candidate response


Selected actuator Diaphragm actuator

Reason 1 IS availible to use in a wet environment Since it's a car wash it could get wet

Reason 2 Reliable and has a non-contact Sensor which is useful in a wet environment

Task 4 - cleaning brushes - speed control sub-system

The speed of the motor used to turn the cleaning brushes needs to be reduced. A compound gear train is required that will meet the following specification:

i. Reduce the speed of the motor by **at least** a factor of 25.

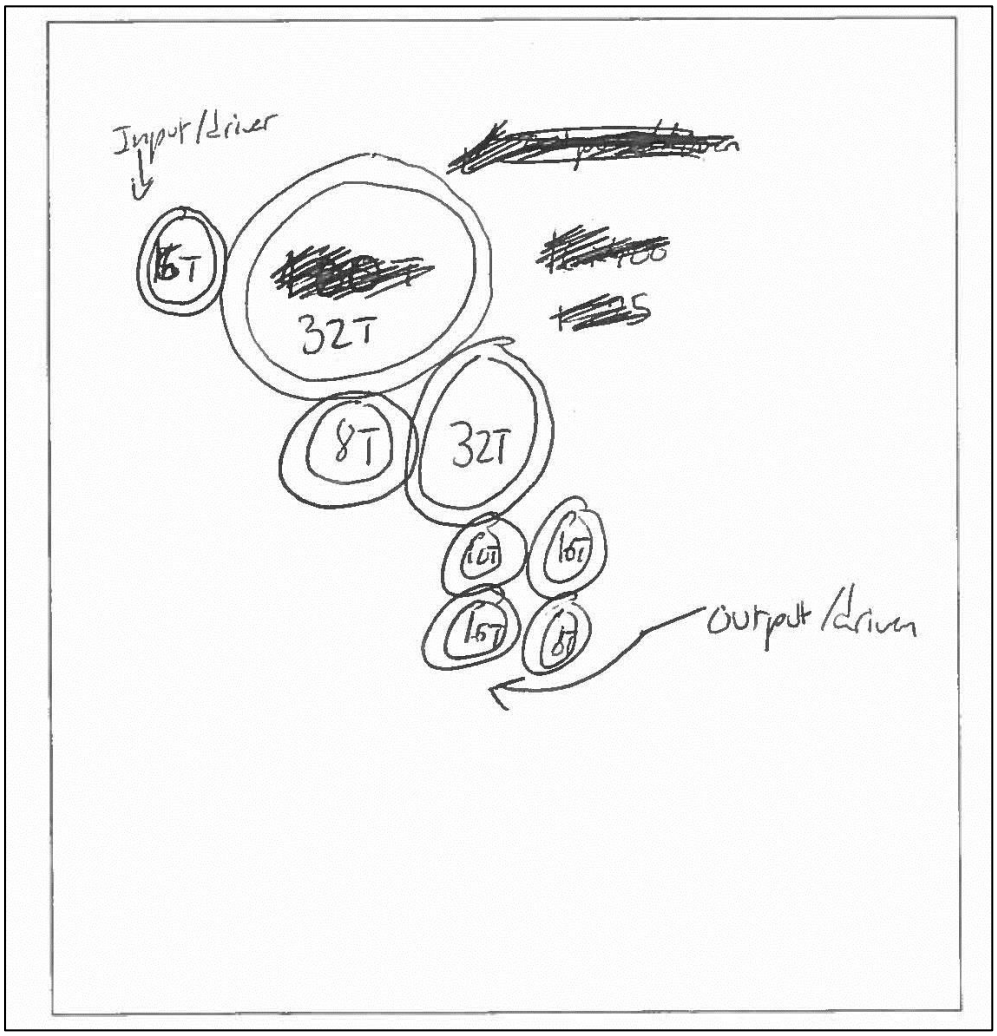
ii. Fit into a compact space inside the car wash.

4a Design a compound gear train that will meet the specification. You must identify the input and output gears and include all gear sizes.

Sketch your design below or on A4 single sided paper with the task number clearly labelled. You must **not** use simulation software to complete this task.

(2 marks)

4a candidate response



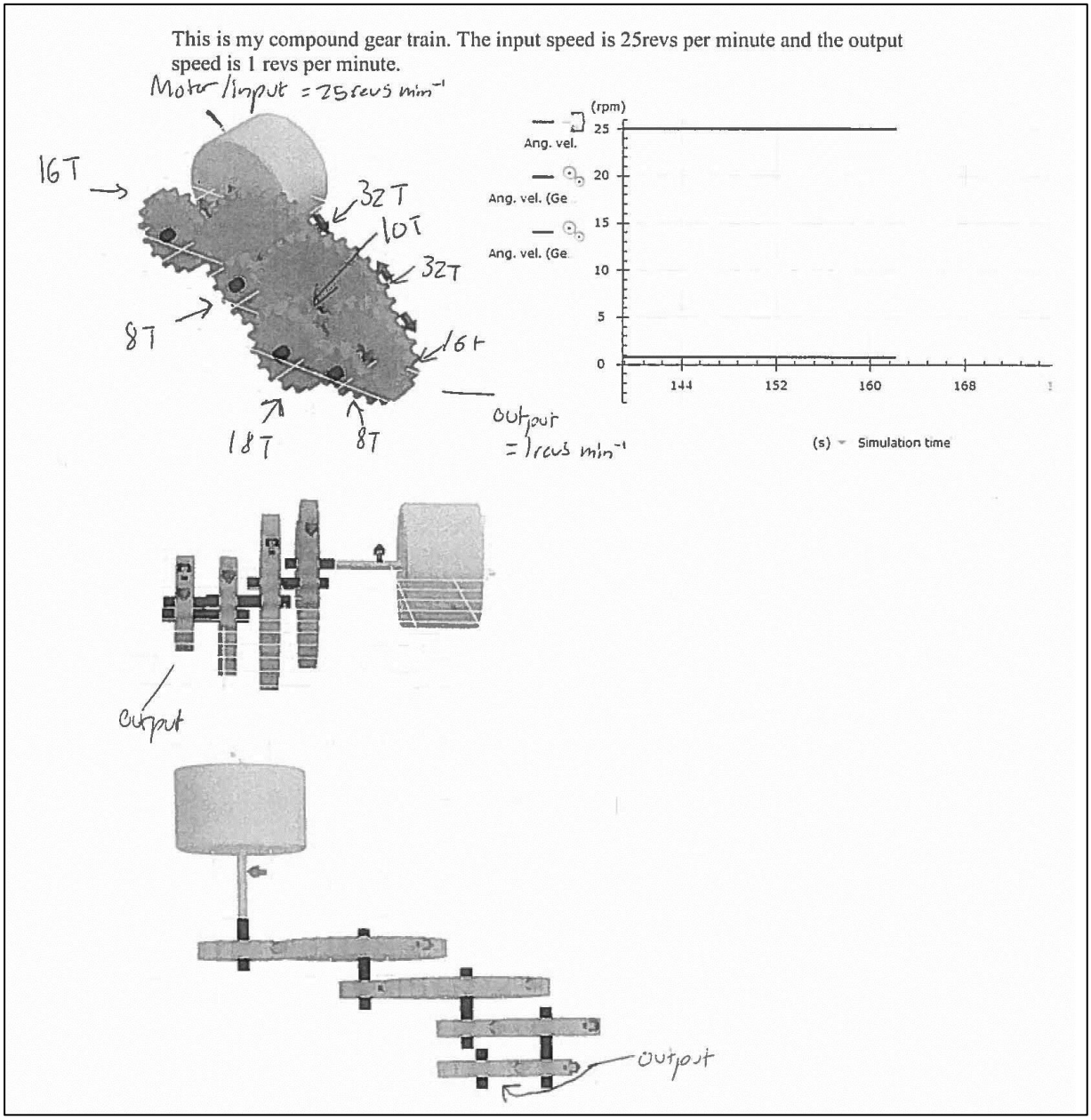
Task 4 - cleaning brushes - speed control sub-system (continued)

4b Simulate or construct your design from task 4a. You must identify the input and output and include all gear sizes. You must include an input component to allow for testing.

Print the evidence (screenshots or images must be clear and easy to read) on A4 single sided paper with the task number clearly labelled.

(2 marks)

4b candidate response



4c Complete the testing table below by entering the actual results for the input and output speeds of the gear system that you observed during simulating or constructing.

(1 mark)

4c candidate response

Planned test	Expected result		Actual result	
	Input speed	Output speed	Input speed	Output speed
Measure the input speed and output speed of the gear system.	25 revs min^{-1} or 25 turns.	No more than 1 revs min^{-1} or 1 turns.	25 revs min^{-1}	1 revs min^{-1}

Task 4 - cleaning brushes - speed control sub-system (continued)

4d Evaluate your solution from task 4b, by describing how well the two specification points were met, referring to testing where appropriate and any amendments that you may have made.

If necessary, print the evidence on A4 single sided paper with the task number clearly labelled.

(2 marks)

4d candidate response

- I think that my Solution was effective because I kept the [redacted] motor at 25 revs min^{-1} and then just had to work on the gear values
- Initially I tried the gear train with only 2 gears before adding more. Since my values were accurate I think I was successful

Task 5 - water heater sub-system

The water used in the car wash must be heated. An input sensing circuit is required to activate a heater, meeting the following specification:

i. When the temperature of the water falls below a set level the heater should switch on.

ii. When the temperature of the water rises above a set level the heater should switch off.

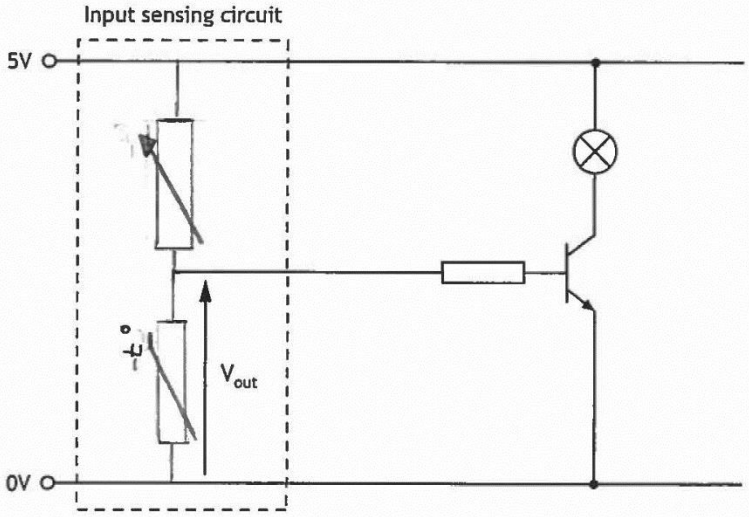
iii. The temperature that the heater switches on at should be adjustable.

To allow the input sensing circuit to be tested a lamp is used instead of a heater and will be activated by a transistor as shown below in task 5a.

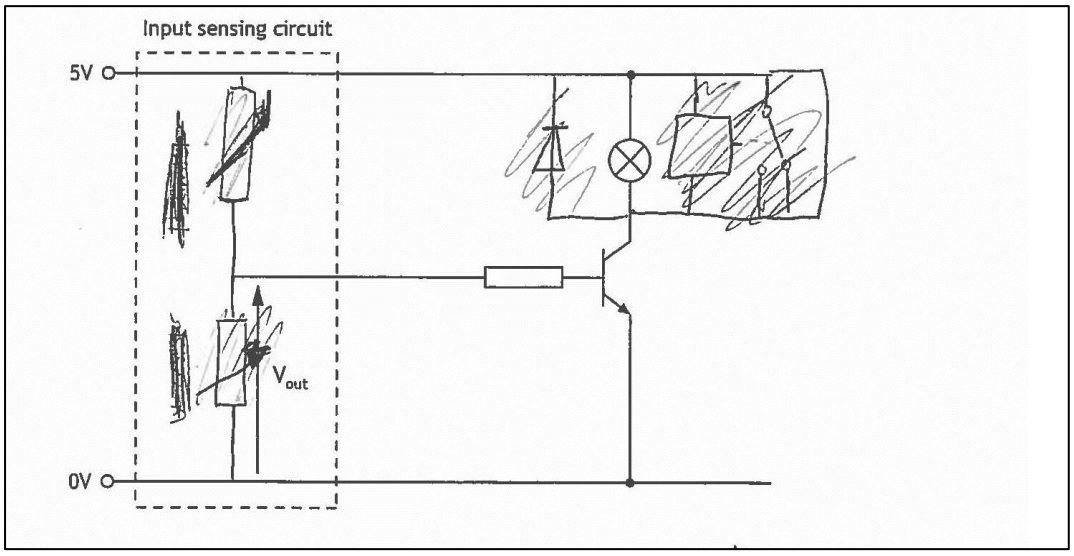
5a Complete the circuit diagram shown below by designing a suitable input sensing circuit that will meet the given specification.

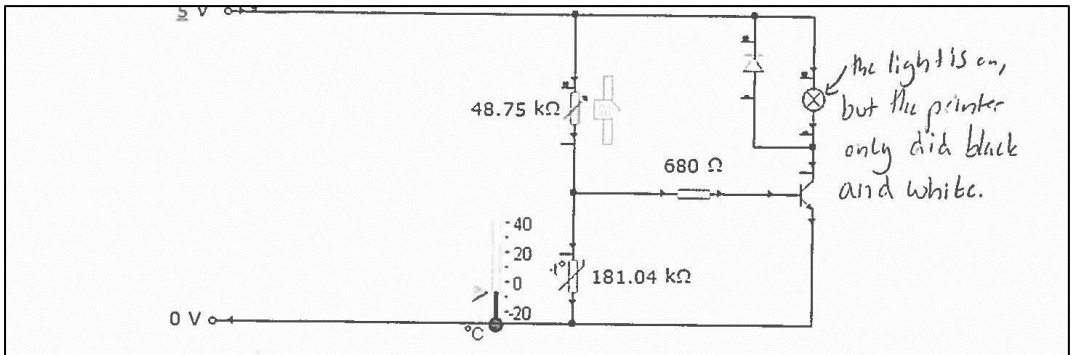
Component values are not required.

(3 marks)

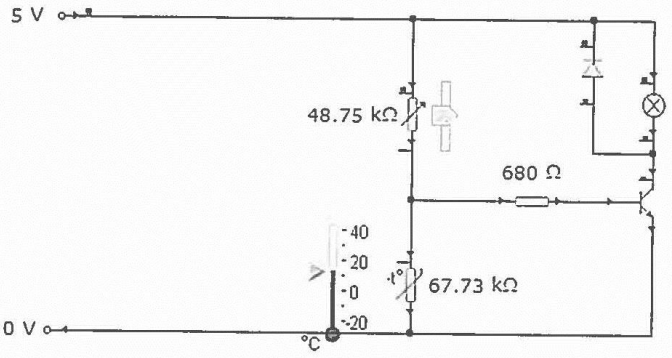


5a candidate response





This is the circuit with the heater on because the temperature is below Zero.



This is the circuit with the heater off because the temperature is too high. The temperature at which the heater comes on at can be changed by altering the value of the variable resistor either up (lower temp) or down (higher temp).

Task 5 - water heater sub-system (continued)

5b Write a test plan for the **input sensing circuit** by describing:

- three tests that could be carried out
- the results that would be expected from each test in terms of the output voltage (V_{out}) from the input sensing circuit

If necessary, print the evidence on A4 single sided paper with the task number clearly labelled.

(6 marks)

5b candidate response

Planned test	Expected result
Heater on - heats up water	Output voltage would increase because the heaters on
Heater off - allows the water to cool	Output voltage would decrease because the heaters off
Heater on but adjusts to required temp either by being on or off	output voltage would [redacted] go up or down depending on whether the heaters on or not. It would also depend on the resistance of the variable resistor

Task 6 - end of wash cycle alert sub-system

The specification for a microcontroller based circuit used to alert the driver that the wash cycle is about to finish is shown below.

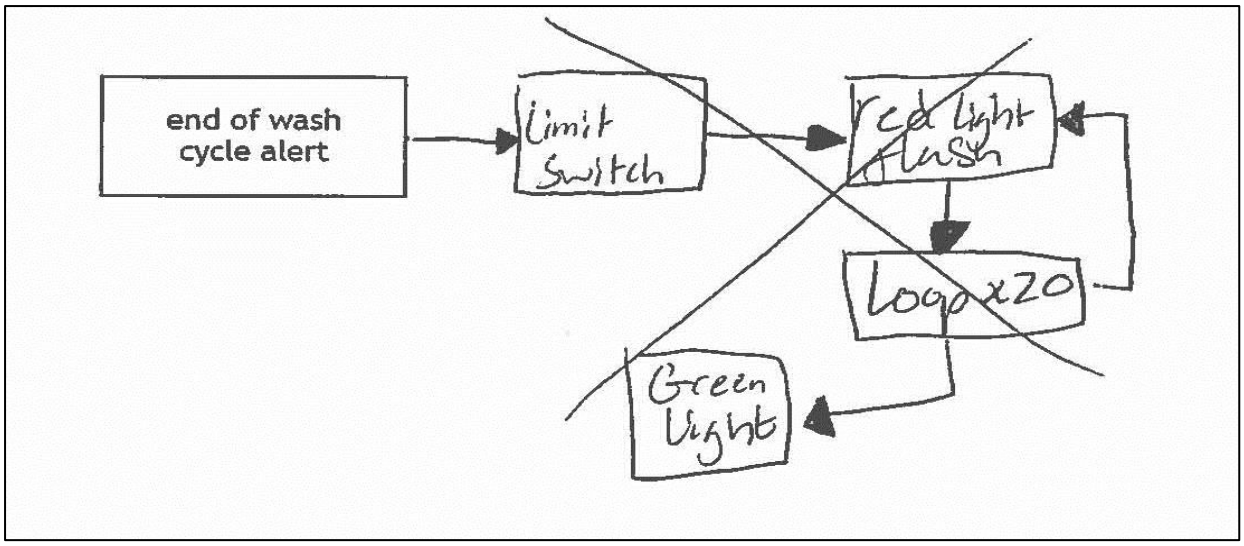
i. When a car is in the correct position it activates a limit switch and a red lamp will flash on and off 20 times.

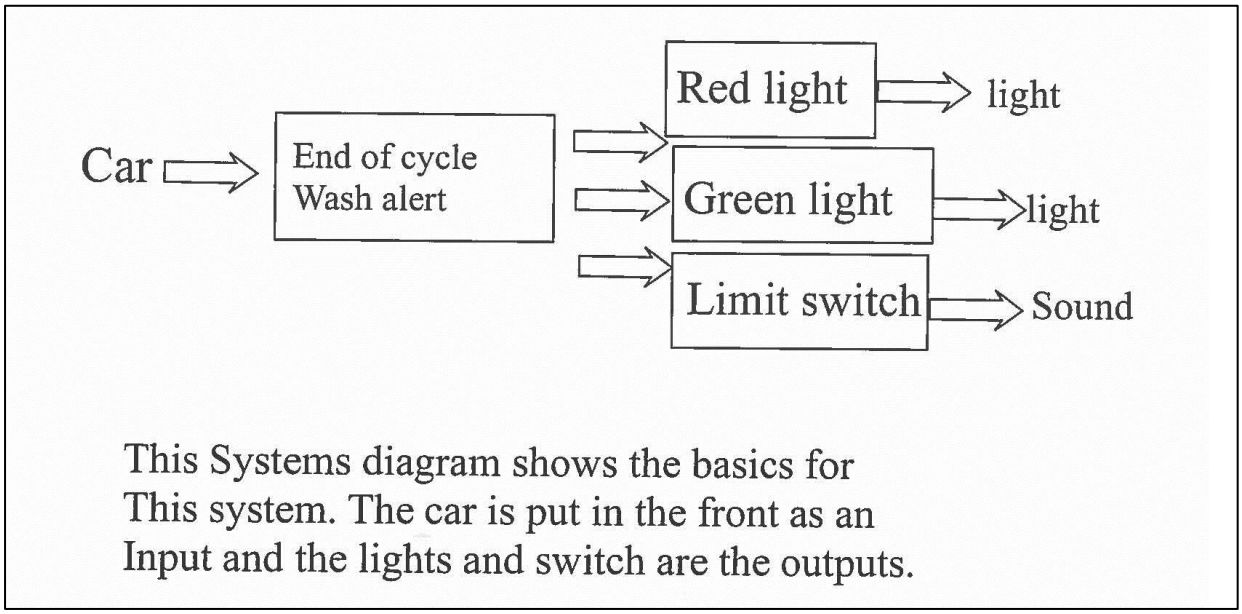
ii. After the red lamp has finished flashing it will turn off and a green lamp will turn on.

6a Complete the **system diagram** below with reference to the specification.

(2 marks)

6a candidate response



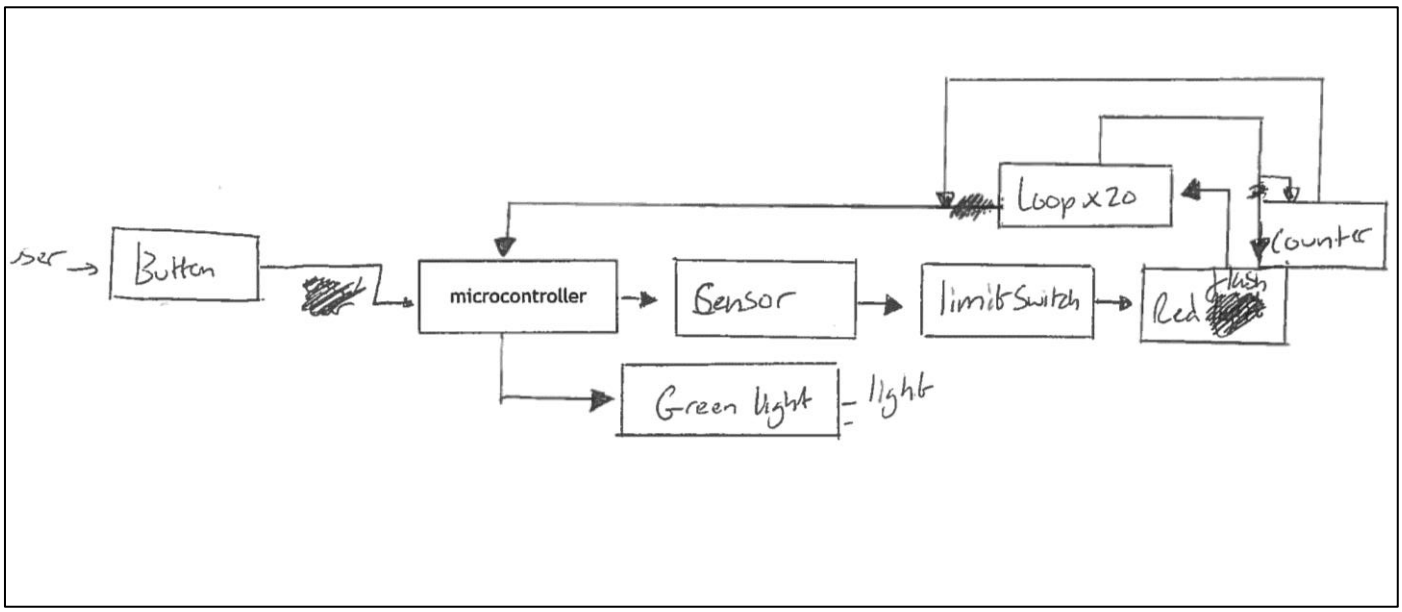


Task 6 - end of wash cycle alert sub-system (continued)

6b Complete the sub-system diagram below with reference to the specification. You must clearly show all sub-systems, the system boundary and interactions between sub-systems.

(5 marks)

6b candidate response



Candidate 3

Car wash

A team of engineers is involved in several tasks during the development of a new car wash.

These tasks include the development of proposals for the following sub-systems:

Task 1 - car sensor sub-system

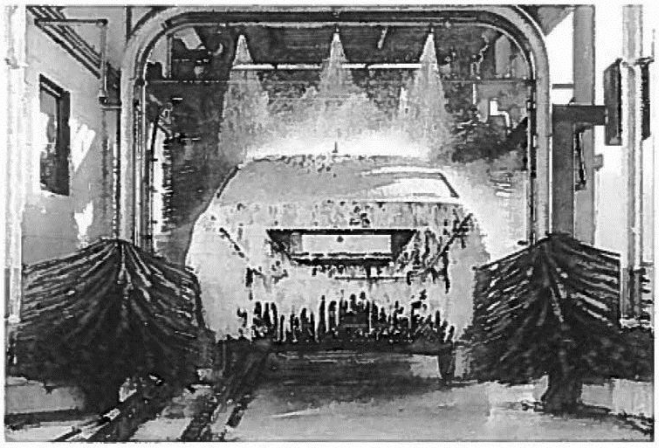
Task 2 - cleaning brushes - rotational movement sub-system

Task 3 - cleaning brushes - horizontal movement sub-system

Task 4 - cleaning brushes - speed control sub-system

Task 5 - water heater sub-system

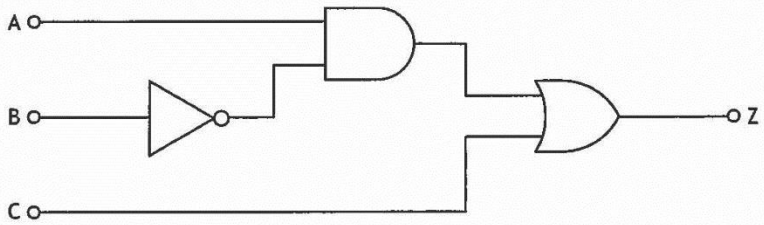
Task 6 - end of wash cycle alert sub-system



Task 1 - car sensor sub-system

The car wash should only operate when a master switch A is on (logic 1) and a sensor B detects a car has driven into the correct position (logic 0). The car wash can also be tested by pressing an override switch C (logic 1).

The design for a logic circuit to control the operation of the car wash is shown below.

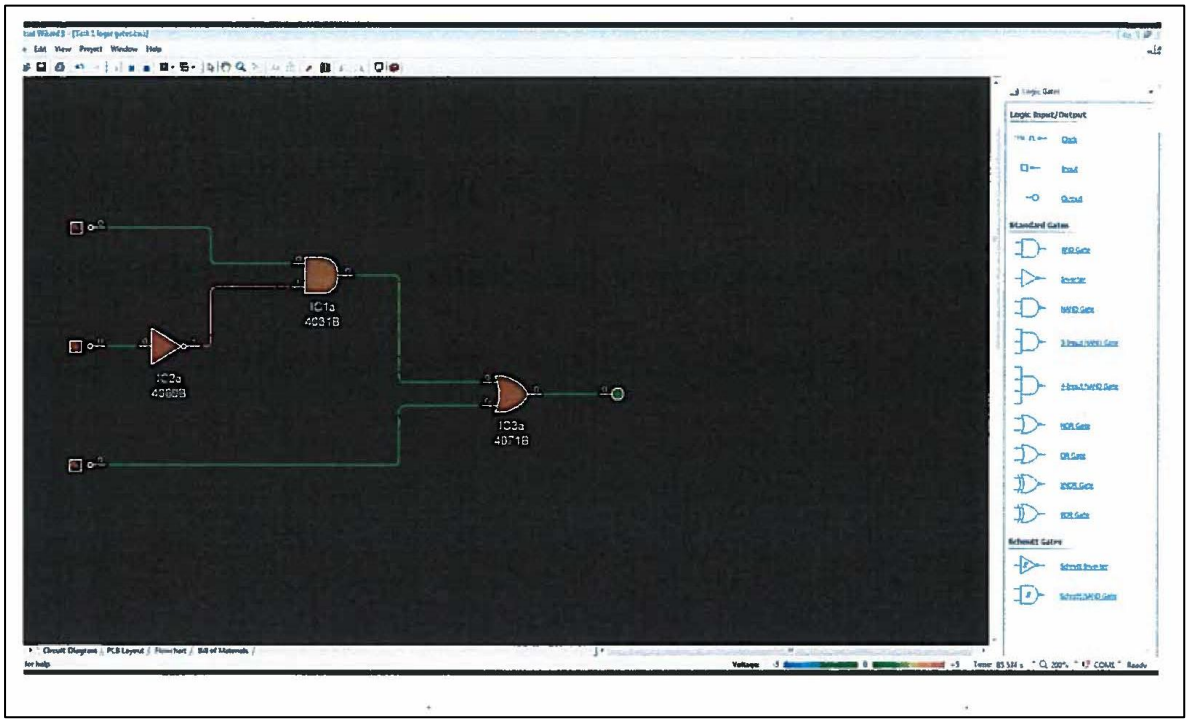


1a Simulate or construct the logic circuit shown above. You must include input devices to allow for testing.

Print the evidence (screenshots or images must be **clear** and **easy** to read) on A4 single sided paper with the task number clearly labelled.

(1 mark)

1a candidate response



Task 1 - car sensor sub-system (continued)

1b Test your simulated or constructed circuit and complete the truth table below with your results for output Z.

(1 mark)

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

1b candidate response

A	B	C	Z
0	0	0	O
0	0	1	|
0	1	0	O
0	1	1	|
1	0	0	|
1	0	1	|
1	1	0	O
1	1	1	|

Task 2 - cleaning brushes - rotational movement sub-system

Cleaning brushes are required to spin over the car during the cleaning process.

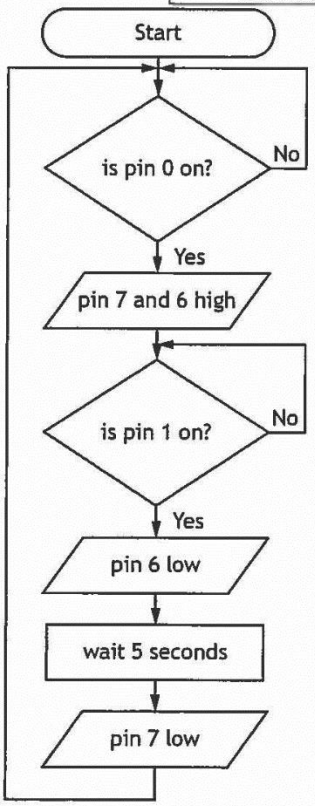
An electronic engineer has designed the flowchart and circuit shown below as a possible solution. The pin numbers used to connect the circuit to the microcontroller are shown in the table below.

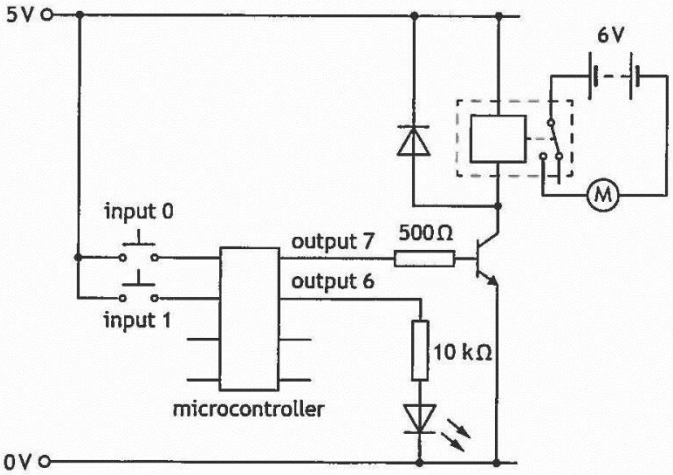
2a Simulate or construct the flowchart and electronic circuit integrated together as shown. A microcontroller of an alternative size may be used but the pin numbers must match the connections given.

Print the evidence (screenshots or images must be clear and easy to read) on A4 single sided paper with the task number clearly labelled.

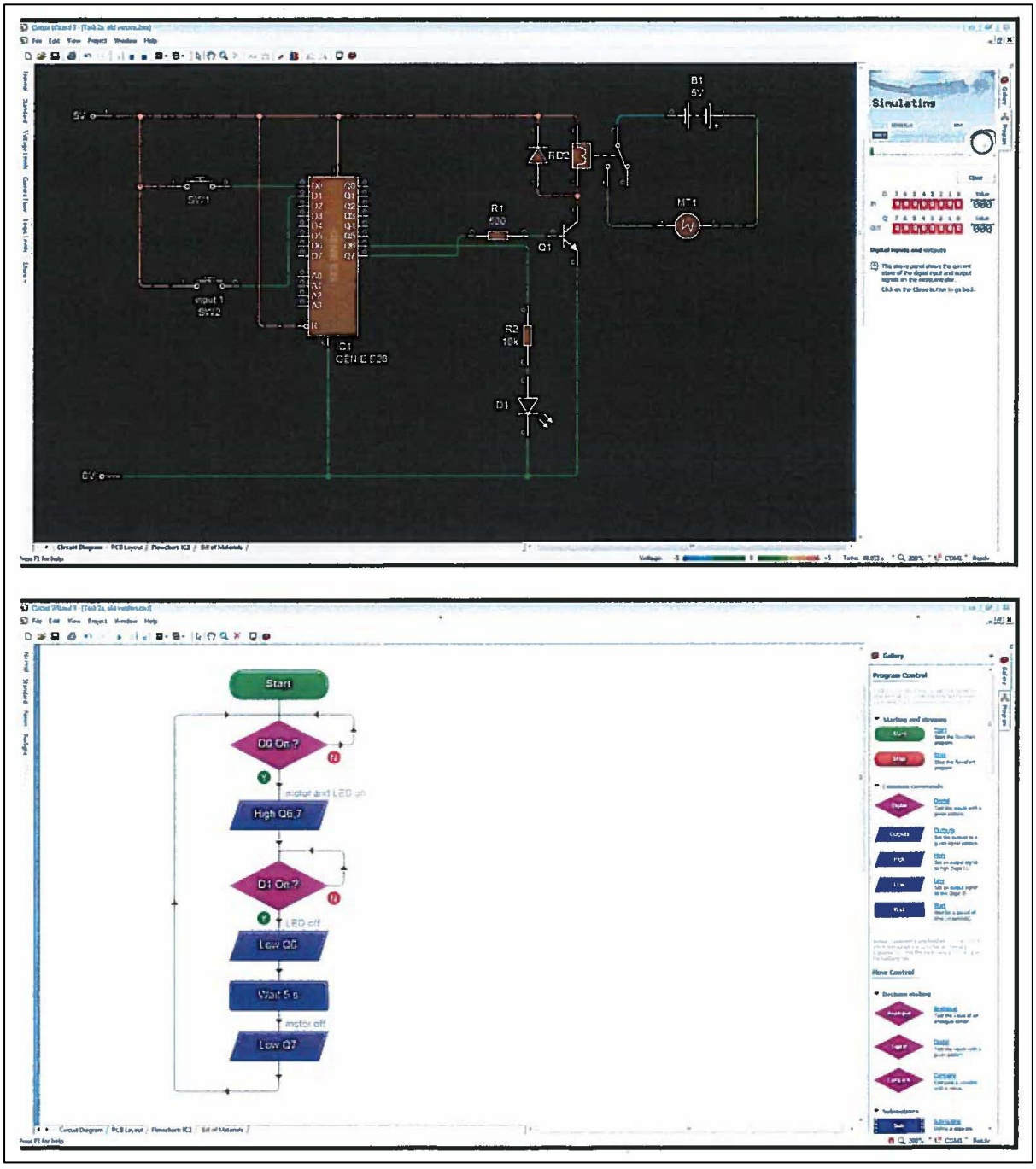
(5 marks)

Input Connection	Pin	Output Connection
	7	motor
	6	LED
stop switch	1	
start switch	0	





2a candidate response



Task 2 - cleaning brushes - rotational movement sub-system (continued)

The cleaning brushes are to be operated by a microcontroller using the following specification:

i. When a start switch is pressed an LED, protected by a resistor, switches on and an SPDT relay activates a 6V motor, spinning the cleaning brushes.

ii. When a stop switch is pressed the motor turns off and then after a 5 second delay the LED turns off.

iii. The sequence should then repeat.

Errors were found with the design during testing.

2b Complete the testing table shown on the following page, by carrying out the planned tests given, **making amendments as necessary before moving onto the next test.** You must write descriptions of the actual results you observed during testing and appropriate amendments that you made to enable the system to satisfy the specification.

If necessary, print the evidence on A4 single sided paper with the task number clearly labelled.

(5 marks)

2b candidate response

Planned test	Expected result	Actual result	Amendments made
Test 1 Activate the start switch.	The 6V motor should start turning and the LED should turn on.	The 6V motor started turning but the LED didn't come on.	The size of the resistor in front of the LED was decreased from 10kΩ to 270Ω.
Test 2 Activate the stop switch.	The 6V motor should stop turning and then after 5 seconds the LED should turn off.	The LED turns off imediately and the 6V motor turns off after 5 seconds.	The flowchart was altered so Q7 ~~turns~~ goes low ~~after~~ immediately after input I1 goes high and output Q6 goes low after the 5s wait.
Test 3 Repeat tests 1 and 2 to make sure the sequence is repeatable.	The sequence should loop back to the start and repeat.	The sequence looped back and when the start button was pressed again the LED ~~came on~~ and motor came on and went low at the right time after the stop button was pressed.	none

Task 2 - cleaning brushes - rotational movement sub-system (continued)

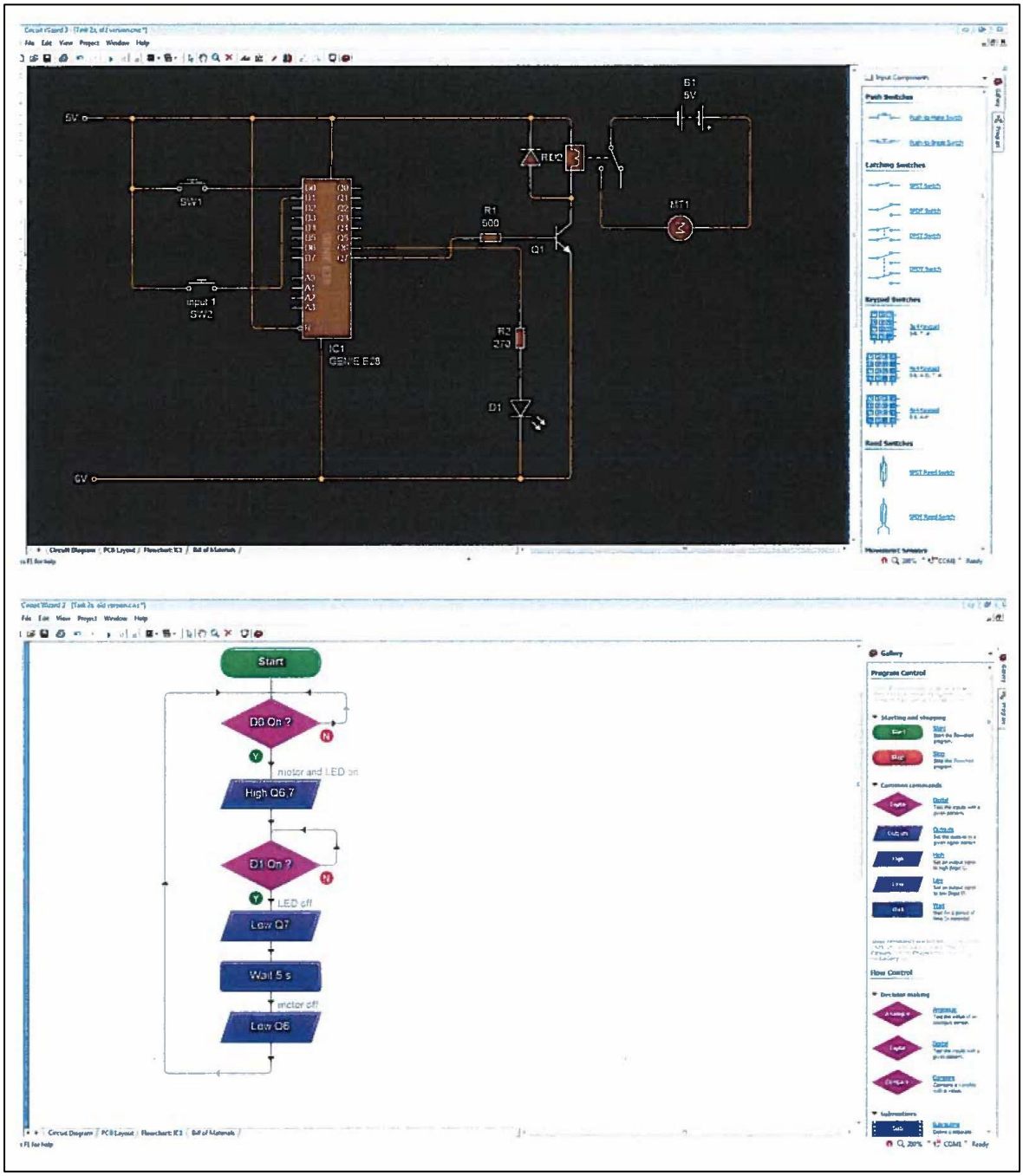
2c Your amended flowchart should now match the specification given at the start of task 2.

Print the evidence of your **amended flowchart and electronic circuit integrated together** after completing task 2b on A4 single sided paper with the task number clearly labelled.

Screenshots or images must be **clear and easy to read.**

(2 marks)

2c candidate response

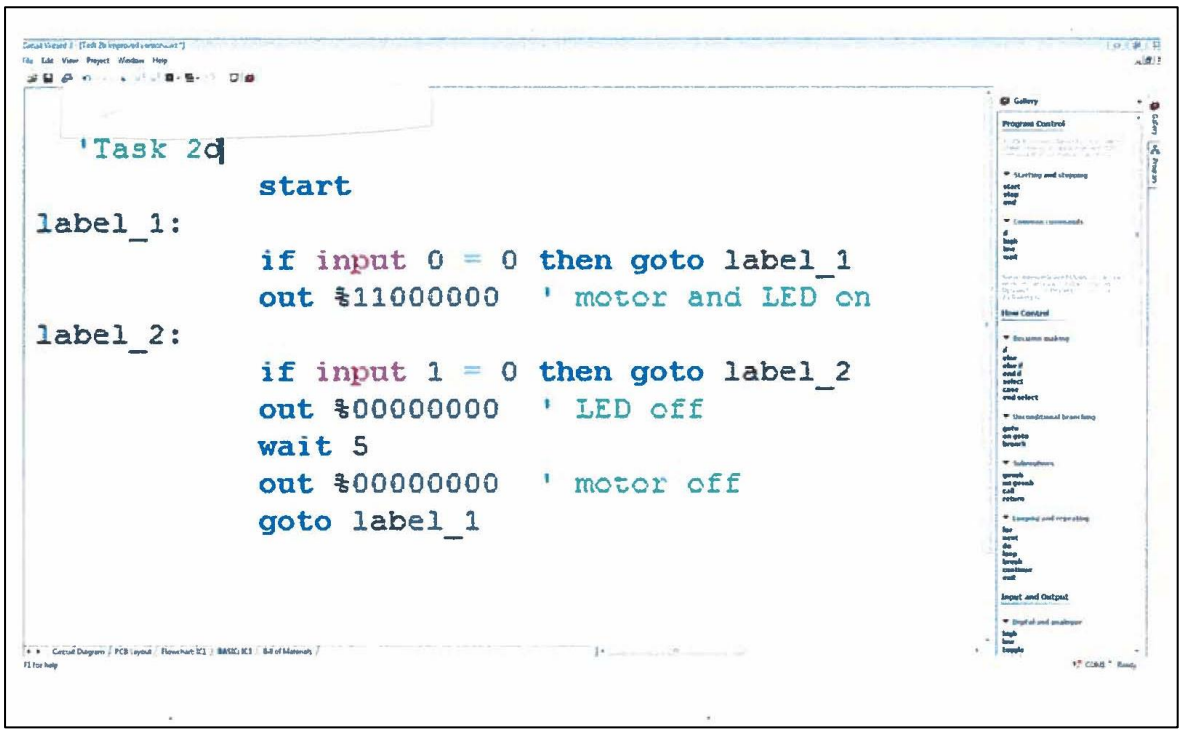


2d Produce high-level microcontroller code to fully match the function described in your amended flowchart from **task 2c**.

If necessary, print the evidence (screenshots or images must be **clear** and **easy** to read) on A4 single sided paper with the task number clearly labelled.

(1 mark)

2d candidate response



```
'Task 2d
        start
label_1:
        if input 0 = 0 then goto label_1
        out %11000000   ' motor and LED on
label_2:
        if input 1 = 0 then goto label_2
        out %00000000   ' LED off
        wait 5
        out %00000000   ' motor off
        goto label_1
```

Task 2 - cleaning brushes - rotational movement sub-system (continued)

2e Evaluate the performance of your **amended solution** from **task 2c** against the specification given in **task 2b**, by describing:

- the performance of your **amended solution** to meet **each of the three specification points**, referring to testing and any amendments that you may have made
- the overall effectiveness of your **amended solution** for use in the car wash environment

If necessary, print the evidence on A4 single sided paper with the task number clearly labelled.

(4 marks)

2e candidate response

Task 2e

Both the amended circuit diagram and flowchart were tested to make sure that all of the specification points were met. In my version the LED switched on and the relay switched on the 6V motor (spinning the cleaning brushes) at the same time. After the stop button was pressed the LED stayed on 5 seconds longer than the motor which turned off immediately after the stop switch was pressed. In every test the LED came on after the 10k resistor was replaced by the 270 ohm resistor. The system also always repeated itself and restarted when the start switch was pressed, I didn't have to run the entire program again.

Overall my amended solution would be pretty effective in car wash environment if soap and water for cleaning the car was supplied either by adding dispensers into the system, supplying it at the petrol station (where the car wash will probably be) or making people bring their own as all of the scrubbers work and the LED would tell other people and cars waiting for the wash if it's still in use. The only thing not yet added is the soap and water dispensers needed.

Task 3 - cleaning brushes - horizontal movement sub-system

A pneumatic system is to be used to move the cleaning brushes into the correct position before they start to spin. The pneumatic system must meet the following specification:

i. When the first electrical actuator receives a signal an adjustable pneumatic time delay occurs.

ii. After the time delay a double acting cylinder (controlled by a 5/2 valve) outstrokes, moving the cleaning brushes into position.

iii. When a second electrical actuator receives a signal the double acting cylinder instrokes.

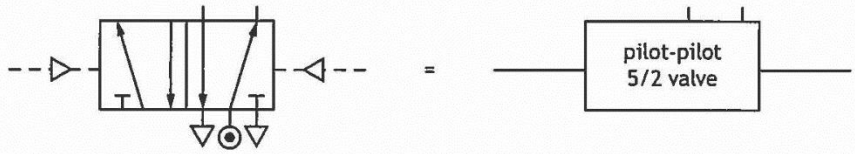
iv. The piston's speed is controlled so that it outstrokes slowly.

3a Design a pneumatic system that will meet the given specification. The name of each component, valve and actuator must be identified and the direction of the piston outstroke must be indicated. Show connections between all components and valves.

If necessary, print the evidence (screenshots or images must be clear and easy to read) on A4 single sided paper with the task number clearly labelled or securely attach below.

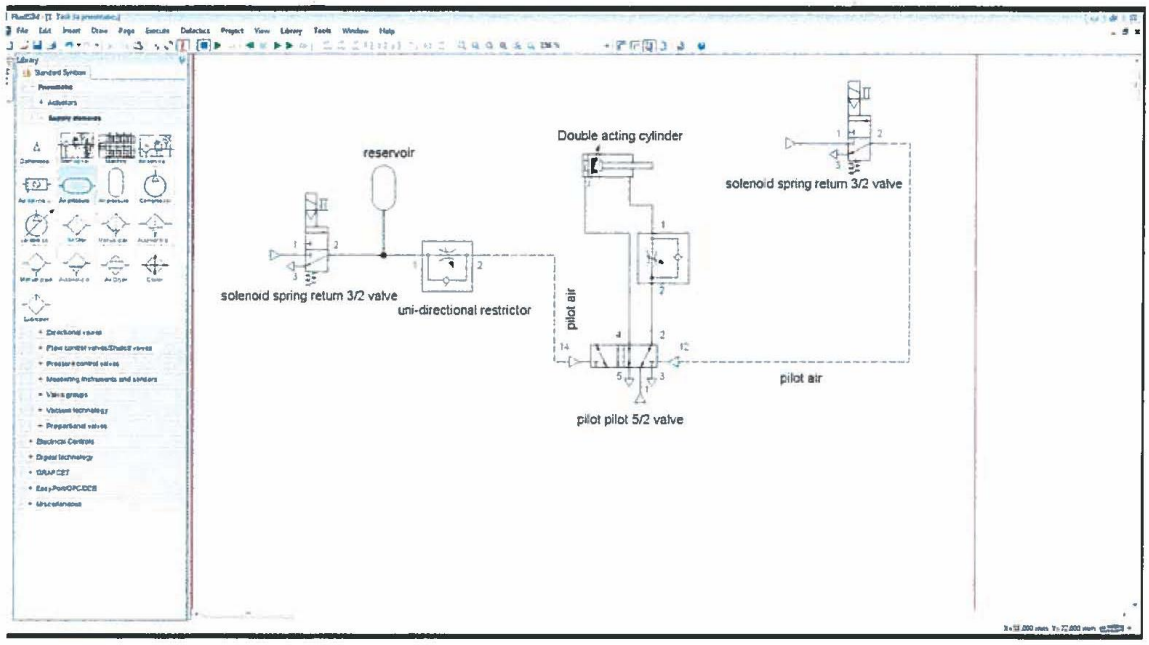
(6 marks)

For example: a 5/2 valve could be simplified as shown below



3a candidate response

Task 3a



Task 3 - cleaning brushes - horizontal movement sub-system (continued)

Electrical actuators and diaphragm actuators with air bleeds were both considered to operate the pneumatic valves within the car wash.

Actuator	Characteristics
Electrical actuator	• allows for flexibility of control • no loss of signal over a distance • safety issues with electrical signal in a wet environment • could be operated by a microcontroller
Diaphragm actuator	• safe for use in a wet environment • air bleed may become blocked • source of pneumatics already at location • non-contact method of sensing

3b Select the most suitable actuator type for the car wash. Explain your choice, giving two reasons.

If necessary, print the evidence on A4 single sided paper with the task number clearly labelled.

(2 marks)

3b candidate response

Selected actuator electrical actuator

Reason 1 all ~~is~~ for use with the microcontroller and eircuit previously designed.

Reason 2 allows to be turned on from further away so person operating wouldn't get wet.

Task 4 - cleaning brushes - speed control sub-system

The speed of the motor used to turn the cleaning brushes needs to be reduced. A compound gear train is required that will meet the following specification:

i. Reduce the speed of the motor by **at least** a factor of 25.

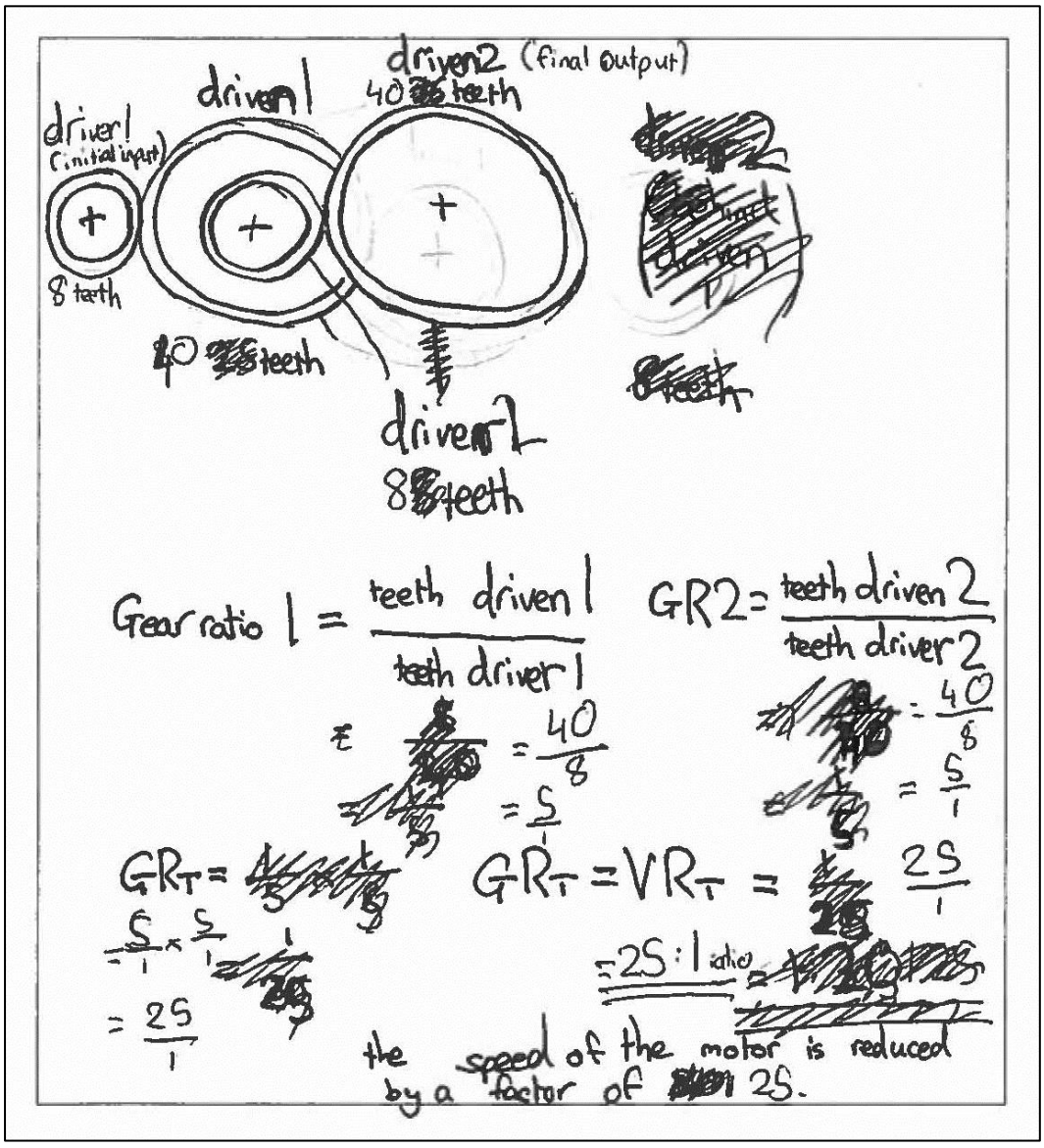
ii. Fit into a compact space inside the car wash.

4a Design a compound gear train that will meet the specification. You must identify the input and output gears and include all gear sizes.

Sketch your design below or on A4 single sided paper with the task number clearly labelled. You must **not** use simulation software to complete this task.

(2 marks)

4a candidate response



Task 4 - cleaning brushes - speed control sub-system (continued)

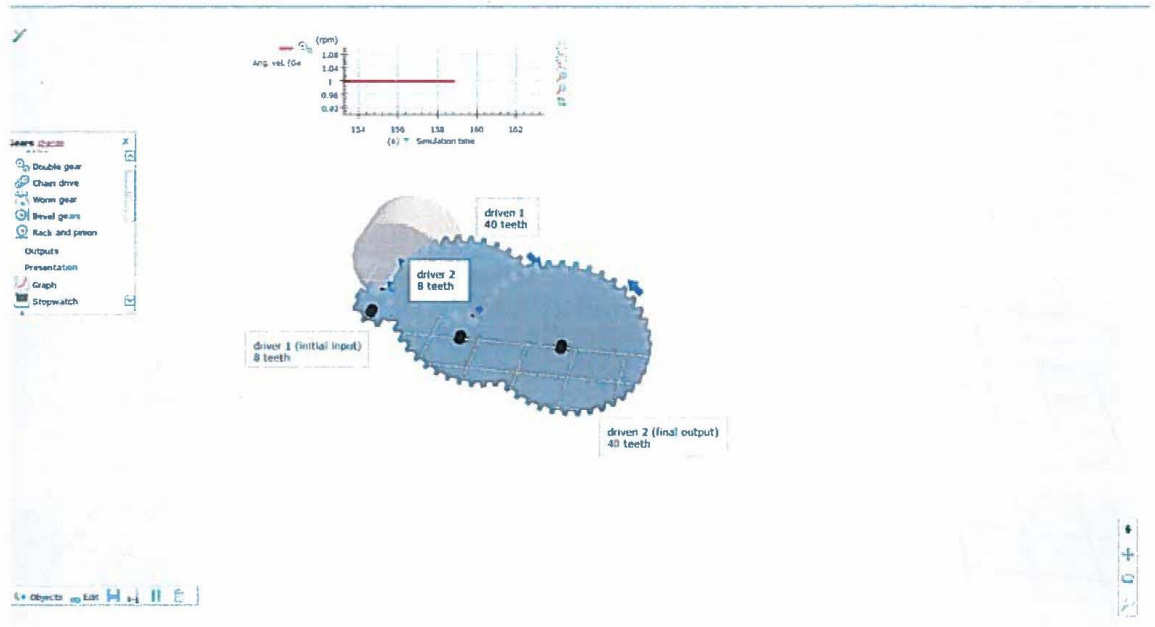
4b Simulate or construct your design from task 4a. You must identify the input and output and include all gear sizes. You must include an input component to allow for testing.

Print the evidence (screenshots or images must be clear and easy to read) on A4 single sided paper with the task number clearly labelled.

(2 marks)

4b candidate response

Task 4b



4c Complete the testing table below by entering the actual results for the input and output speeds of the gear system that you observed during simulating or constructing.

(1 mark)

4c candidate response

Planned test	Expected result		Actual result	
	Input speed	Output speed	Input speed	Output speed
Measure the input speed and output speed of the gear system.	25 revs min^{-1} or 25 turns.	No more than 1 revs min^{-1} or 1 turns.	25 revs min^{-1}	1 rev min^{-1}

Task 4 - cleaning brushes - speed control sub-system (continued)

4d Evaluate your solution from **task 4b**, by describing how well the two specification points were met, referring to testing where appropriate and any amendments that you may have made.

If necessary, print the evidence on A4 single sided paper with the task number clearly labelled.

(2 marks)

4d candidate response

Task 4d

The design I made reduced the speed of the motor by a factor of 25. To test this the speed of the motor was set to 25 in the simulation and a graph was added to measure and record the speed of the final output gear driven 2. The graph showed that the final output speed was 1 revolution per minute, showing a reduction in speed by a factor of 25- meeting the first specification point. The gears used had either 8 or 40 teeth, making them as small as possible with the gears still being able to mesh and turn- meeting specification point 2.

Task 5 - water heater sub-system

The water used in the car wash must be heated. An input sensing circuit is required to activate a heater, meeting the following specification:

i. When the temperature of the water falls below a set level the heater should switch on.

ii. When the temperature of the water rises above a set level the heater should switch off.

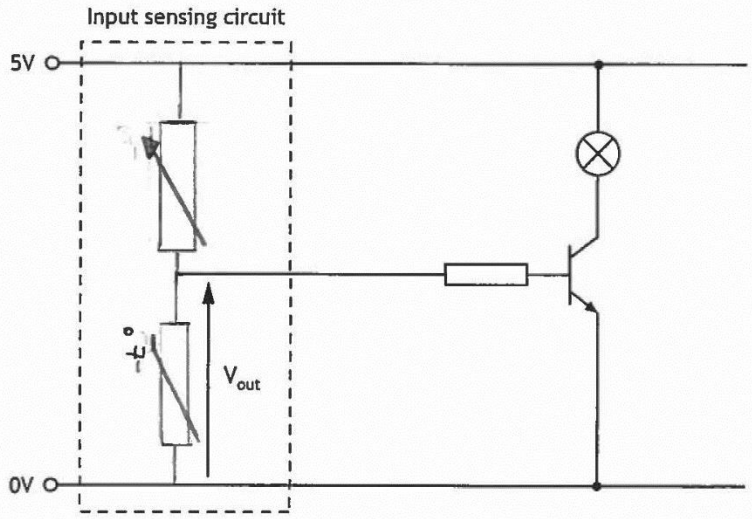
iii. The temperature that the heater switches on at should be adjustable.

To allow the input sensing circuit to be tested a lamp is used instead of a heater and will be activated by a transistor as shown below in task 5a.

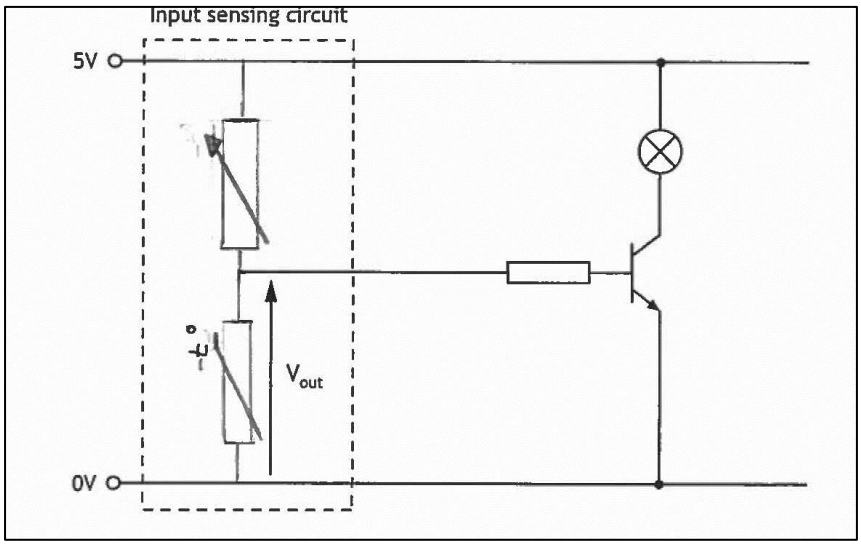
5a Complete the circuit diagram shown below by designing a suitable input sensing circuit that will meet the given specification.

Component values are not required.

(3 marks)



5a candidate response



Task 5 - water heater sub-system (continued)

5b Write a test plan for the **input sensing circuit** by describing:

- three tests that could be carried out
- the results that would be expected from each test in terms of the output voltage (V_{out}) from the input sensing circuit

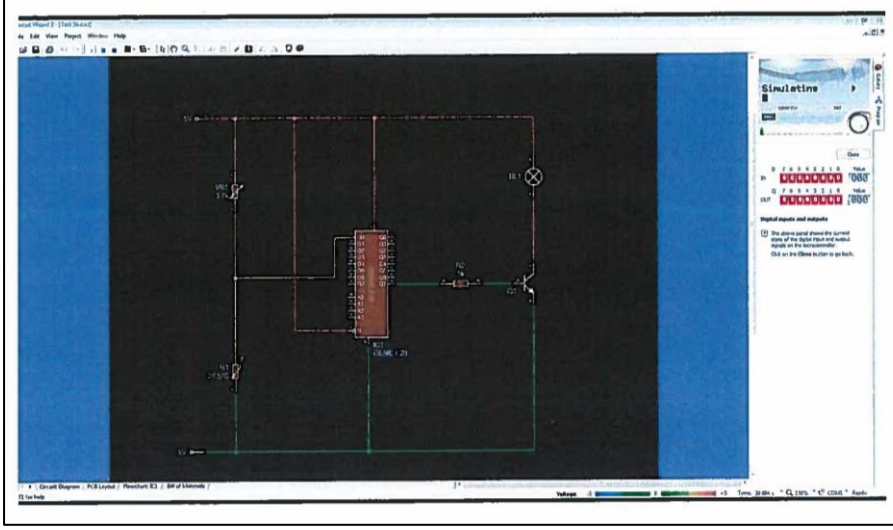
If necessary, print the evidence on A4 single sided paper with the task number clearly labelled.

(6 marks)

5b candidate response

Planned test	Expected result
Test that when the tempeature falls to a colder temperature the bulb comes on.	When the temperature is reduced to below a certain temperature the bulb comes on. should
Test that when the temperature rises above a certain temperature the bulb goes off.	When the temperature is increased above a certain temperature the bulb should go low.
Test that the sensitivity of the thermistor can be adjusted using the variable resistor.	When the value of the resistance across the variable resistor is adjusted the tempeature at which the heater comes on at also changes.

Task 5b



Task 6 - end of wash cycle alert sub-system

The specification for a microcontroller based circuit used to alert the driver that the wash cycle is about to finish is shown below.

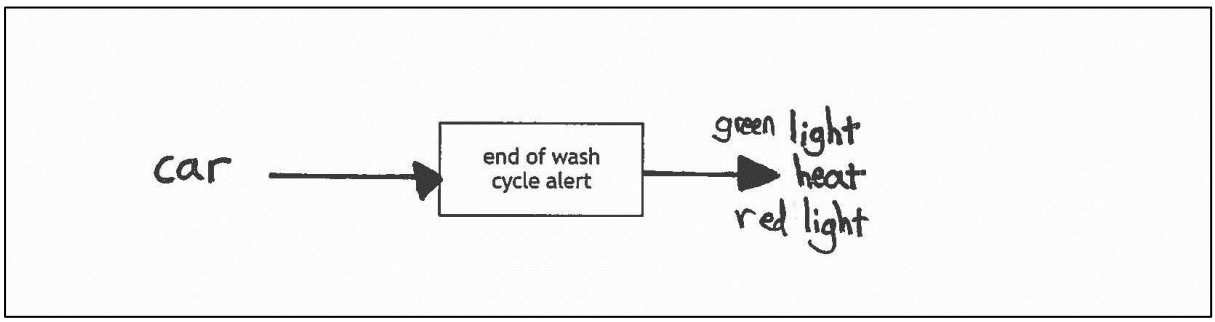
i. When a car is in the correct position it activates a limit switch and a red lamp will flash on and off 20 times.

ii. After the red lamp has finished flashing it will turn off and a green lamp will turn on.

6a Complete the **system diagram** below with reference to the specification.

(2 marks)

6a candidate response



Task 6 - end of wash cycle alert sub-system (continued)

6b Complete the **sub-system** diagram below with reference to the specification. You must clearly show all sub-systems, the system boundary and interactions between sub-systems.

(5 marks)

6b candidate response