2012 Mechatronics

Higher

Finalised Marking Instructions

Marks

SECTION A

Attempt ALL questions in this Section (50 marks)

1. *(a)* The list below shows the names of three types of controller used in a mechatronic control system:

- ASIC
- Hardwired
- Microcontroller

State how the controlling action could be altered for **each** type of controller.

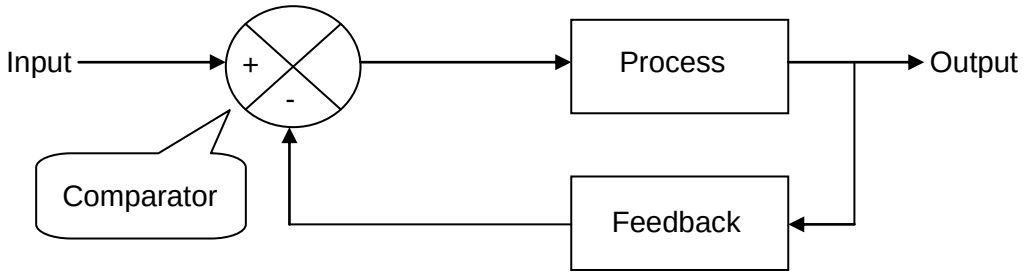
ASIC *Change the ASIC design and re-manufacture/change the ASIC*

Hardwired *Rewire/reconfigure the system*

Microcontroller *Change the program in memory*

(1 mark each, total 3 marks) **3**

(b) Sketch a block diagram of a closed loop control system. Identify each element on your sketch.



(0·5 each element, total 2 marks) **2**

(5)

Marks

2. The diagram in Figure Q2 shows the basic architecture of a microcontroller. Some elements have been labelled with the letters A, B, C and D.

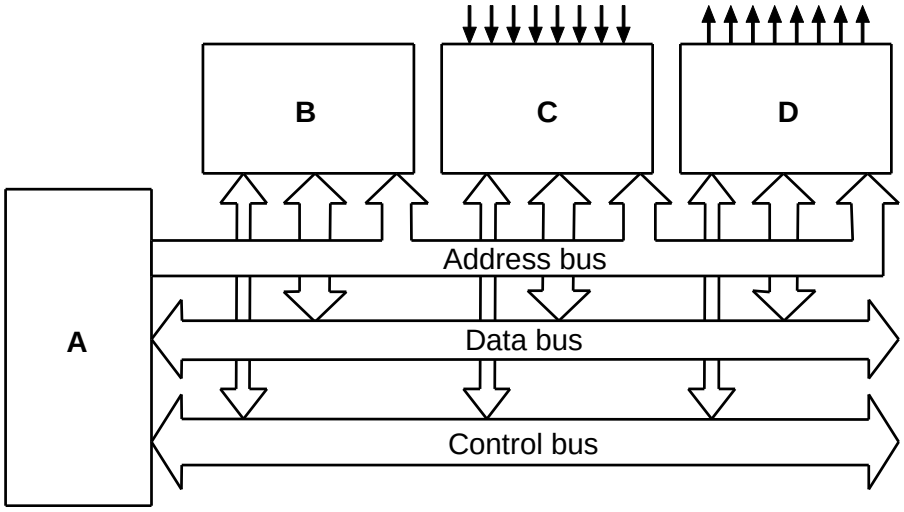


Figure Q2

(a) State the names of the elements labelled A, B, C and D in Figure Q2.

A – *CPU*
B – *Memory*
C – *Input Interface Unit*
D – *Output Interface Unit*

(0·5 each, total 2 marks) **2**

(b) With reference to Figure Q2, state which **one** of the following three statements correctly describes the nature of the data flow on the **data bus** in a microcontroller.

Statement 1: The data flow is omni-directional on the data bus.
Statement 2: The data flow is bi-directional on the data bus.
Statement 3: The data flow is uni-directional on the data bus.

Statement 2 is correct. **1**

(c) A mechatronic control system is used within an industrial environment. Excluding cost, state **two** advantages that a Programmable Logic Controller (PLC) based system has over a Personal Computer (PC) based system.

Any suitable two advantages (except cost), for example,

- *more robust*
- *suited to purpose*
- *I/O ports designed for industrial use.* **2**

(5)

Marks

3. Table Q3(a) shows a selection of 3 bit codes used in Mechatronic Systems.

Decimal	Code name = ***Pure Binary***	Code name = ***Gray Code***
0	000	000
1	001	001
2	010	***011***
3	011	***010***
4	***100***	110
5	***101***	111
6	110	101
7	111	100

Table Q3*(a)*

(a) On **Worksheet Q3*(a)***, complete Table Q3*(a)* by

(i) inserting each of the **two** missing code names.

(1 mark each, total 2 marks) **2**

(ii) inserting each of the **four** missing code values.

(0·5 mark each, total 2 marks) **2**

(b) An encoder disc uses a 3 bit code. On **Worksheet Q3*(b)***, calculate the angular resolution in degrees of the encoder disc.

$\frac{360^\circ}{8} = 45^\circ$ or $\pm 22 \cdot 5^\circ$ **1**

(5)

Marks

4. A mechatronic system uses a mechanical float valve system to sense and maintain the water level in a tank. The mechanical float valve system is to be replaced to allow remote level indication.

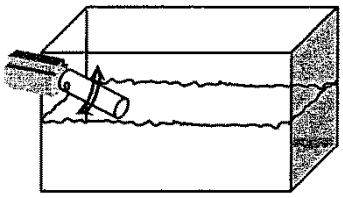
(a) State **one** type of sensor that could be used in the above mechatronic system to sense the water level.

Any suitable sensor to sense water level, for example Float Switch or Ultrasonic sensor. **1**

(b) With the aid of a simple sketch, briefly describe the basic operation of the sensor chosen in Q4*(a)*.

Any appropriate sketch AND description that relates to Q4(a), for example

A Float Switch – a pivoted float moves up and down depending on the water level. This float can operate a switch at a certain level and this signal can be used to send to system.



(1 mark sketch and 1 mark description) **2**

(c) Figure Q4(c) shows a bimetallic sensor used in a control system.

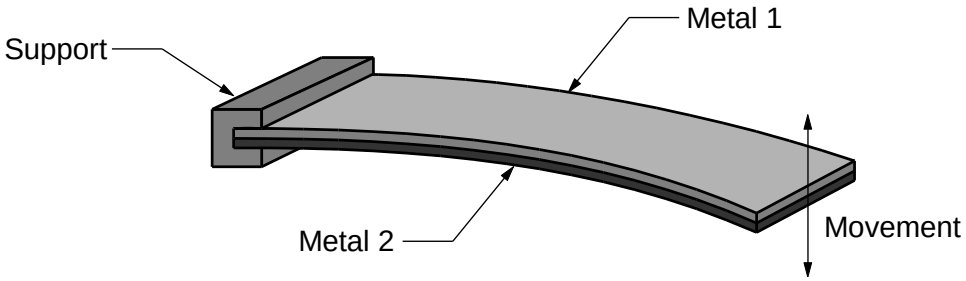


Figure Q4(c) Bimetallic sensor

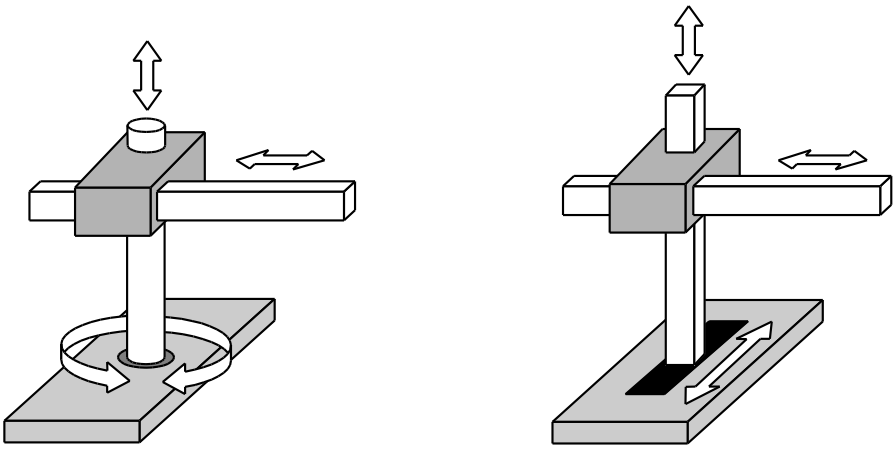
Briefly describe the operation of this type of sensor.

Must mention – two different metals, different expansion/contraction and the movement is used to provide the control signal for example operate a switch or potentiometer. **2**

(5)

Marks

5.



Robot A **Robot B**

Figure Q5*(a)*

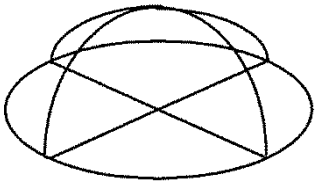
(a) State the robot geometries for Robot A and for Robot B in Figure Q5*(a)*.

Robot A – *Cylindrical*
Robot B – *Cartesian* **2**

(b) Sketch the work envelope for a Polar robot.

A simple sketch showing a Hemispherical external work envelope, the diagram may or may not show the robot dead space within the envelope.

1

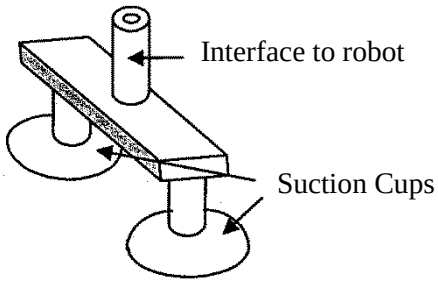


(c) Sketch and briefly describe the basic operation of **either** a Vacuum type **or** a Magnetic type of end effector.

Any appropriate answer which includes brief description AND sketch for example

Vacuum End Effector – a vacuum end effector lifts the components by having a low pressure suction area (vacuum) maintained in suction cups with external air pressure forcing the component onto the gripper. When the vacuum is removed the component is released.

2

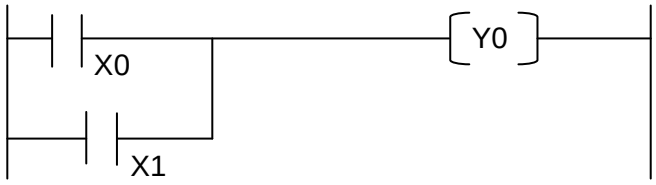


(5)

Marks

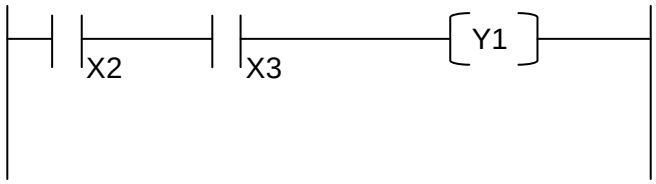
6. A mechatronic control system uses a Programmable Logic Controller (PLC).

(a) Sketch a PLC ladder rung that shows an output, Y0, which is energised by the closure of **either** contact X0 **OR** contact X1.



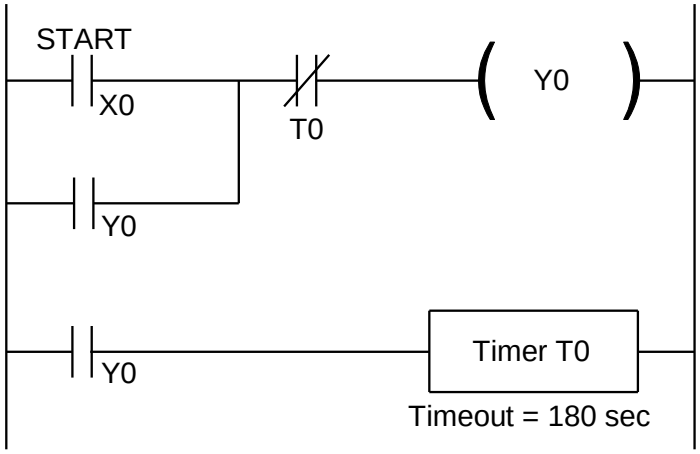
1

(b) Sketch a PLC ladder rung that shows an output, Y1 which is energised by the closure of contact X2 **AND** contact X3.



1

(c) Ladder diagram Q6*(c)* shows a PLC program.



Ladder Diagram Q6*(c)*

Describe the operation of Ladder Diagram Q6(c) starting from the press (and release) of the START button, X0.

Note: the inserted PLC Datasheet Q6/Q11 gives the PLC instruction set.

Press and release of X0 energises output Y0(0·5). Contact Y0 closes thus latching the output Y0(0·5).

Contact Y0 on the 2nd rung energises and starts the timer T0 counting(0·5). After 180 seconds timer T0 times out and opens NC contact T0(0·5) thus unlatching Y0(0·5) and hence contact Y0 which resets the timer(0·5).

3
(5)

Marks

7. Figure Q7 illustrates a box transfer system. It uses two pneumatic cylinders, A to B, to transfer boxes from the level of Conveyor 1 to the level of Conveyor 2. Conveyor 2 runs continuously.

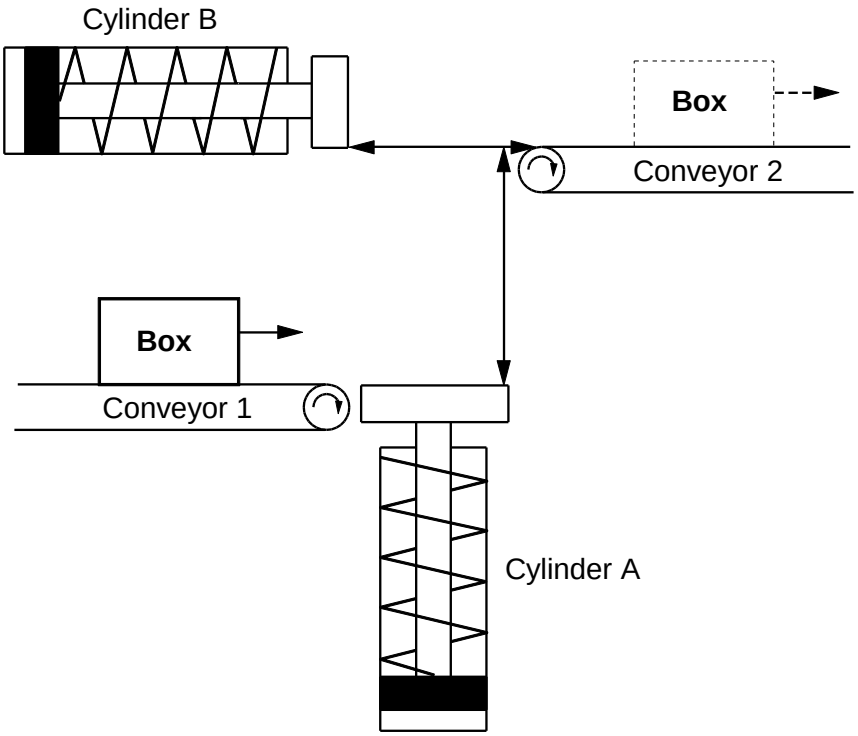
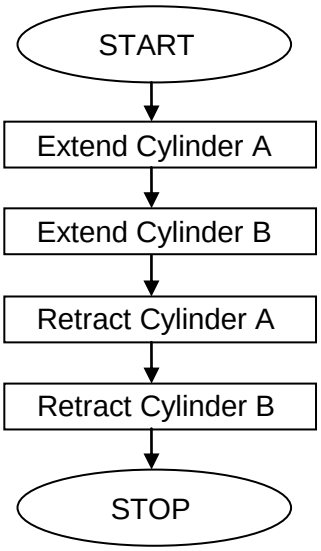


Figure Q7

(a) Sketch a flowchart which shows the sequence for the transfer of one box from Conveyor 1 to Conveyor 2. Begin with Cylinder A being supplied with a box and each cylinder in the position shown in Figure Q7. In your flowchart simply state whether the appropriate cylinder is extended or retracted.

Note: the inserted Flowchart Symbol Sheet Q7/Q11/Q12/Q13 gives a selection of suitable Flowchart Symbols.

Any appropriate flowchart, for example



Note: question does not demand cylinders to be retracted

(0·5 each step, total 2 marks) **2**

Marks

Question 7 (continued)

(b) Describe a potential problem if Conveyor 1 runs continuously and the boxes arrive in a continuous stream.

Any appropriate description, for example

Mentioning if the box arrives when Cylinder A is still extended the box will be crushed. **1**

(c) Describe **one** method of avoiding the potential problem described in Question 7*(b)*.

Any appropriate method related to part (b), for example

Fit a sensor to detect if Cylinder A is retracted and stop Conveyor 1 until Cylinder A is retracted.

*Note: A solution related to method in part (b) whereby a sensor is fitted to detect if Cylinder A is **extended** and stop Conveyor 1 should NOT gain full marks (because such a sensor only detects if Cylinder A is extended, not that it is retracted and it could crush boxes because the Cylinder A may still be part way extended as the boxes arrive on Conveyor A.* **2**

(5)

Marks

8.

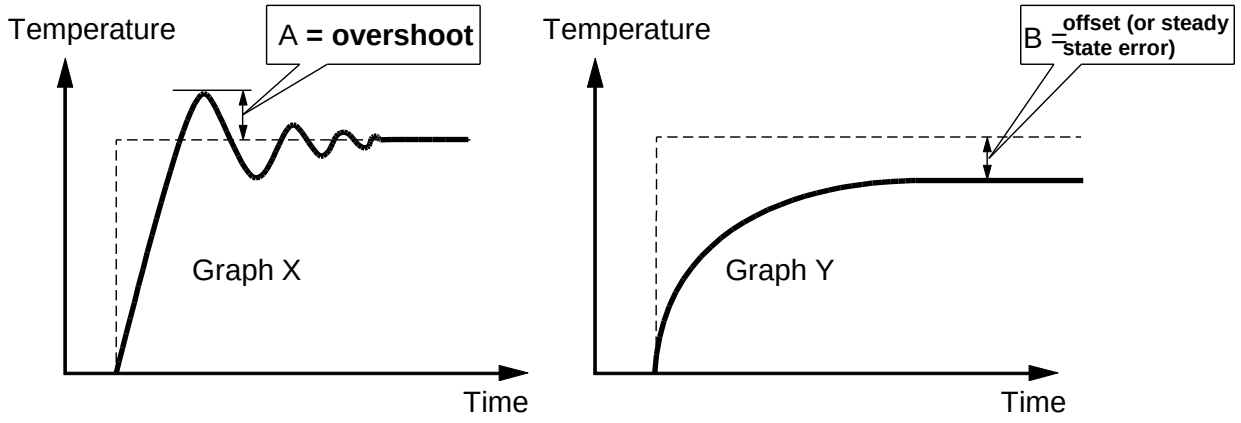


Figure Q8

Two types of control system step input response graphs are shown in Figure Q8.

(a) Referring to Figure Q8, name the feature indicated by

(i) A on graph X.

Overshoot

(ii) B on graph Y.

Offset or steady state error

(1 mark each, total 2 marks) **2**

(b) State which **one** of the following statements is true with reference to the graphs in Figure Q8.

Statement 1 Graph X shows PID control, graph Y shows Proportional control.

Statement 2 Graph X shows PID control, graph Y shows ON/OFF control.

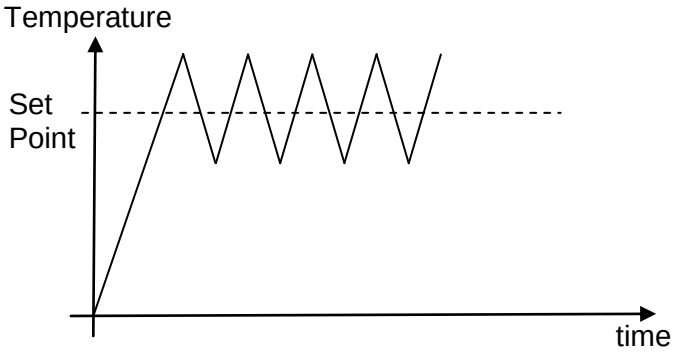
Statement 3 Graph X shows ON/OFF control, graph Y shows Proportional control.

Statement 4 Graph X shows Proportional control, graph Y shows PID control.

Statement 1 **1**

Question 8 (continued)

(c) Briefly describe with the aid of a sketch the term “ON/OFF control” with specific reference to an oven temperature control system



Must have sketch to gain full marks (shape may vary).

The SET point (or desired temperature) is established.

The heater is turned ON and raises the oven temperature towards the SET point$^{(0·5)}$*. The heater is switched OFF when the measured temperature rises above the SET point*$^{(0·5)}$*. Eventually the temperature will fall and when it falls below the SET point the heater will be switched ON again*$^{(0·5)}$ *and the process will repeat*$^{(0·5)}$*.* **2**

(5)

Marks

9. Figure Q9 shows a simplified schematic diagram of a sensing system used in an Olympic swimming pool. The system comprises Starting Block, Lane Pad A, Lane Pad B and Timer which are used to record the start and end times during the swimming events.

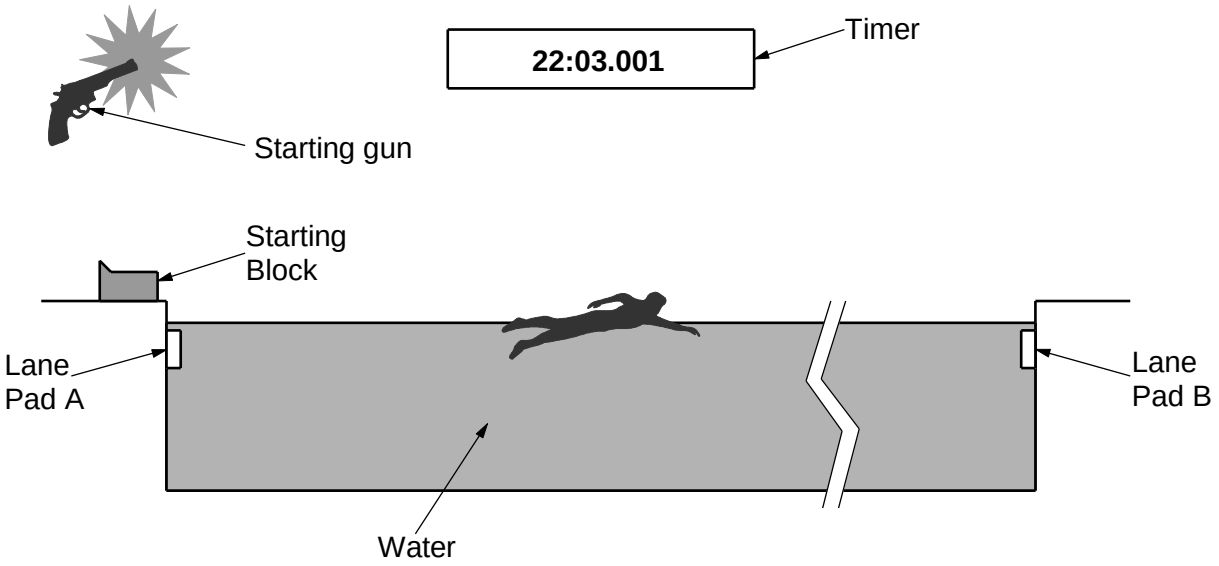


Figure Q9

(a) Traditionally a starting gun is used to start the race but false starts are an issue in this type of event. The sports agreed minimum reaction time of a competitor to the starting gun is 0·16 seconds. Briefly describe **a system** that could detect if a competitor left the Starting Block within 0·16 seconds of the starting gun having been fired.

*You would need the **starting gun, a suitable fast acting sensor in the starting block, a timer measuring system** and an **output** (to an audio system). If the reaction time is below a pre-set value then an output is activated which indicates a false start has been committed. If the time between the start being indicated by the sound of the starting gun and the competitors leaving the block is above the required level the race is allowed to continue.* **2**

(b) State a suitable **sensor** that could be incorporated within the Starting Block that would detect when a competitor has left the block.

Any acceptable pressure/force/touch sensor capable of detecting a change when the swimmer has left the starting block, for example

*a **piezoelectric sensor** could be used to detect a change in **pressure** (**force**) as the swimmer left the starting block. This is a very fast acting sensor and highly sensitive device that can detect dynamic force changes and produce a voltage output.*

Note: If the sensor would detect change but is not sufficiently fast then full marks cannot be awarded. (NB 0·5 marks for microswitch) **1**

Marks

(c) In a relay race, the team is disqualified if the waiting swimmer leaves the Starting Block within 0·16 seconds of Lane Pad A being activated by the arriving swimmer.

Describe how the system should respond to the Starting Block and Lane Pad A inputs.

The system works on the logic that the starting block has a swimmer waiting and Lane Pad A is not activated. After the arriving swimmer has touched the pad with the required force, the waiting swimmer leaves the pad. Thus the measured time must be above the ***required 0·16 seconds*** *or a false start is indicated.*

Note: For information the following table shows the required sequence but candidates would NOT be expected to provide this.

Where High = swimmer present:-

Starting Block A	*Low*	*High*	*High*	*Low*
Touch Pad B	*Low*	*Low*	*High*	*(High or Low)*
Status	*OK*	*OK*	*OK*	*OK*
			Must last more than 0·16 seconds	

Candidates would also NOT be expected to comment on particular circumstances such as where an incoming swimmer operates pad and then withdraws which would need a latch to maintain the touch signal.

2
(5)

Marks

10. This question consists of a series of multiple choice questions and answers for a number of mechatronic related themes. On **Worksheet Q10**, answer the multiple choice questions by putting a tick ✓ in the correct box.

(a) In a mechatronic control system, PID stands for

a	Proportionally Integrated Diode	
b	Power Indication Display	
c	Proportional Integral Derivative	✓
d	Phase Inverting Driver	
e	Passive Integrating Device.	

(b) An Event Based Control System

a	uses only timers	
b	must have at least one sensor	✓
c	always uses timers and sensors	
d	must have a timer	
e	is always slow to complete the task.	

(c) The PLC contact shown in Figure Q10*(c)* is

a	a normally open contact	
b	an output	
c	a timer	
d	a normally closed contact	✓
e	a counter.	

Figure Q10(*c*)

(d) A hydraulic ram is

a	a sensor	
b	a type of pneumatic motor	
c	a control strategy	
d	a mechatronic actuator	✓
e	a coding system	

(e) An example of a visual indicator is

a	a buzzer	
b	a thermistor	
c	a thermocouple	
d	a Light Emitting Diode	✓
e	a strain gauge.	

5

SECTION B

Attempt any TWO questions in this Section (50 marks)

Each question is worth 25 marks

11. A sports stadium goods entrance uses a roller shutter door as shown in Figure Q11. Exit by this door is **not** allowed. The roller shutter door is controlled by a Programmable Logic Controller (PLC) using sensors and actuators.

To raise the roller shutter door, the reversible motor turns in the Forward (F) direction and an upper limit sensor senses when the door has reached the fully open position. To lower the roller shutter door, the motor turns in the Reverse (R) direction and a lower limit sensor senses when the door has reached the fully closed position.

The sensors and actuators have been carefully positioned and are identified by the letters A to E in Figure Q11. One of the sensors, B, is a complete truck length inside the door.

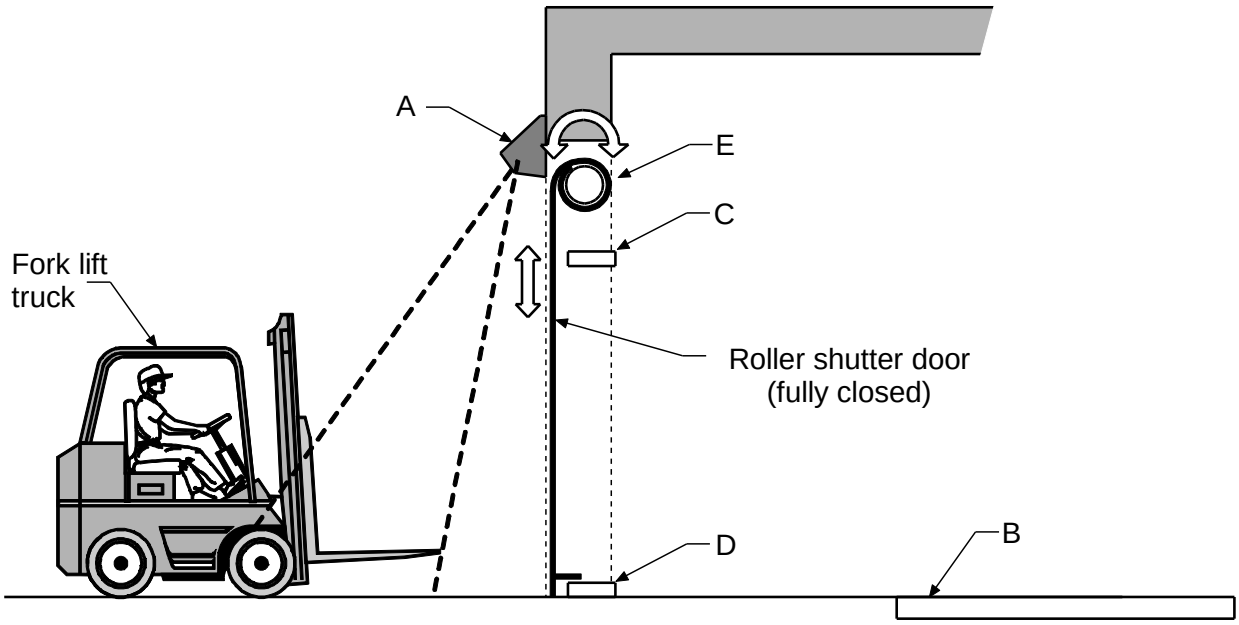


Figure Q11

The basic operation of the entrance control system is as follows:

When the approach of a fork lift truck is sensed, the roller shutter door will be moved UP to the fully open position by the reversible motor. The motor then stops. The truck can now enter.

When the fork lift truck is sensed to be fully inside, the roller shutter door will be moved DOWN to the fully closed position by the reversible motor. The motor then stops.

A basic ladder diagram program for use with the PLC in this application is shown in Ladder Diagram Q11.

Question 11 (continued)

Sensors and actuators are specified in Table Q11.

Sensors/Actuators	Details
Microswitch 1	Normally Open (NO) contact.
Microswitch 2	Normally Open (NO) contact.
Pressure pad	When truck is fully sited on the pad, it provides a logic 1 to the PLC.
Ultrasonic detector	When it detects any movement, provides a logic 1 to the PLC.
Reversible motor	There are 2 control connections, Forward (F) and Reverse (R). F R 0 0 – motor stops 1 0 – moves the door UP 0 1 – moves the door DOWN 1 1 – motor stop (alarm)

Table Q11

(a) With reference to the above information, on **Worksheet Q11**, in Table Q11*(a)*:

(i) in the **Letter** column, enter the letters A to D shown against each device in Figure Q11.

(ii) in the **Reason** column, state one reason why each sensor is placed in the position shown in Figure Q11.

(iii) in the **PLC I/O** column, allocate the I/O to the sensors and actuators.

Note: the inserted PLC Datasheet Q6/Q11 gives the PLC instruction set.

(a) (i) & (ii) & (iii)

Device	Letter	Reason	PLC I/O
Microswitch 1	*C*	*This position detects when the door is fully open.*	*X1*
Microswitch 2	*D*	*This position detects when the door if fully closed.*	*X2*
Pressure pad	*B*	*This position detects when the vehicle is fully inside the building.*	*X3*
Ultrasonic detector	*A*	*This position scans the entrance area for approaching vehicles.*	*X4*
Motor Forward (F)	E	This position matches where the motor can move the door up and down.	*Y1*
Motor Reverse (R)			*Y2*

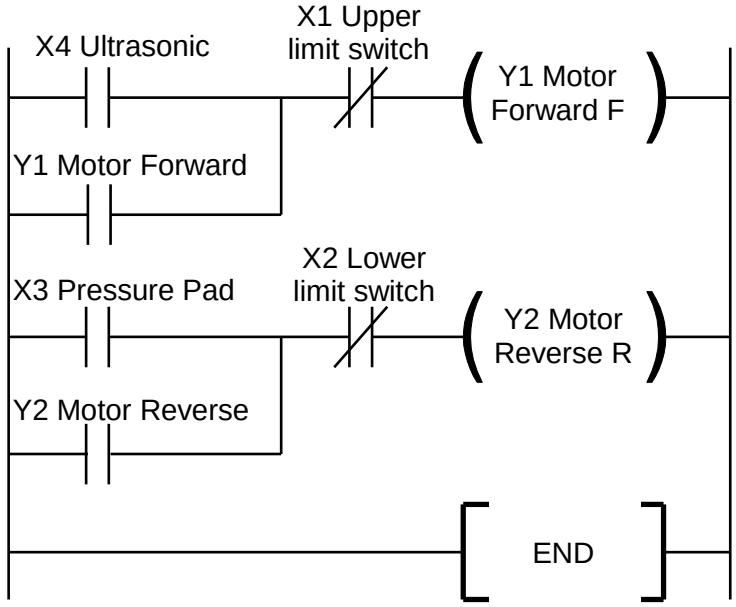
Table Q11*(a)*

2 marks for correct letters
2 marks for appropriate reasons
2 marks for all four I/O allocations **6**

Marks

Question 11 (continued)

(b) On **Worksheet Q11**, complete the labelling of the Ladder Diagram Q11*(b)* using your PLC I/O allocations from **your** Table Q11*(a)*.



Ladder Diagram Q11

1

(c) On **Worksheet Q11**, describe the operation of the Ladder Diagram Q11*(b)* in relation to the application.

On detecting a vehicle, the ultrasonic detector closes contact X4(0·5). This in turn energises output Y1 which makes the motor go in the Forward direction thus moving the roller door up(0·5) and closes contact Y1 which latches output Y1(0·5). When the roller door is fully open, the upper limit switches normally closed contact X1 open which unlatches(0·5) output Y1 thus stopping the reversible motor(0·5).

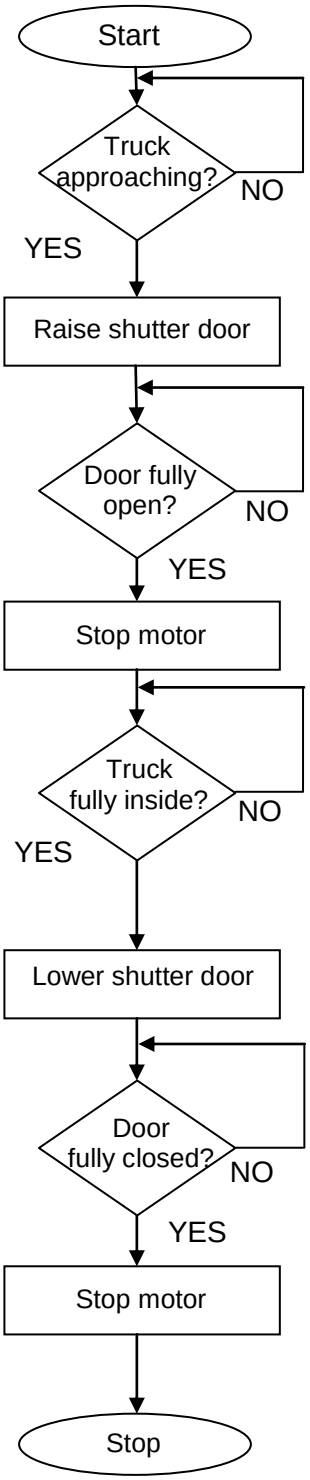
As the vehicle enters the building it will cross the pressure pad. When the vehicle is fully on the pad it will close contact X3(0·5). This in turn will energise output Y2 which makes the motor go in the Reverse direction thus moving the roller door down(0·5) and closes contact Y2 which latches output Y2(0·5). When the roller door is fully closed, the lower limit switches normally closed contact X2 open which unlatches(0·5) output Y2 thus stopping the reversible motor(0·5).

5

Question 11 (continued)

(d) **In your workbook**, sketch a flowchart of the desired sequence of operations for one complete cycle. Assume that the roller shutter door is initially closed and the fork lift truck is approaching the entrance control system.

Note: the inserted Flowchart Symbol Sheet Q7/Q11/Q12/Q13 gives a selection of suitable Flowchart Symbols.



1 mark each decision
0·5 marks for each action box
OR
any correct alternative solution

6

Question 11 (continued)

(e) Explain the nature of the hazardous conditions which could arise if fork lift trucks arrive in quick succession.

*A vehicle pressure pad would cause door to descend. An approaching vehicle would cause door to open. This would stop door motion due to **BOTH** Y1 and Y2 being energised, OR any other appropriate hazard.* **(1)**

A vehicle approaching as another vehicle enters the doorway could be under door when first vehicle reaches pressure pad. Door would start to descend while second vehicle is under OR any other appropriate hazard. **(1)**

2

(f) To meet a design change, the roller shutter door is to remain open to allow closely following fork lift trucks through. State what changes would be required to the system hardware and/or PLC program.

*The pressure pad alone would not be used to tell the PLC to close the door. Instead, the door would ONLY be closed **IF** there was no vehicle detected by the ultrasonic detector AND any vehicle already going inside would need to be fully on the pressure pad. A sensor to detect a vehicle under the door might be required OR any correct alternative solution.* **2**

(g) Safety is an important consideration in the design of this system.

(i) State and briefly describe **one** suitable sensor that could detect if the lower edge of the closing roller shutter door makes contact with an obstacle.

Any suitable sensors – microswitch, proximity sensor, light gate and appropriate description. **2**

(ii) Suggest **one** further change to the system that will improve its safety.

Emergency stop button to stop and/or open the roller shutter door OR if the roller shutter door hits a vehicle or person when the door is opening, suitable sensor to detect this condition OR any correct alternative change. **1**

(25)

Marks

12. Figure Q12 illustrates a schematic diagram of a fully automated bicycle frame assembly station.

Each frame design assembled can be EITHER a Frame type X or a Frame type Y. Each frame type consists of 3 frame tubes and 3 housings. The main assembly station components are an assembly jig, two revolute robots (Robot 1 and Robot 2), Housing feeders, Tube feeders and a Completed frame conveyor.

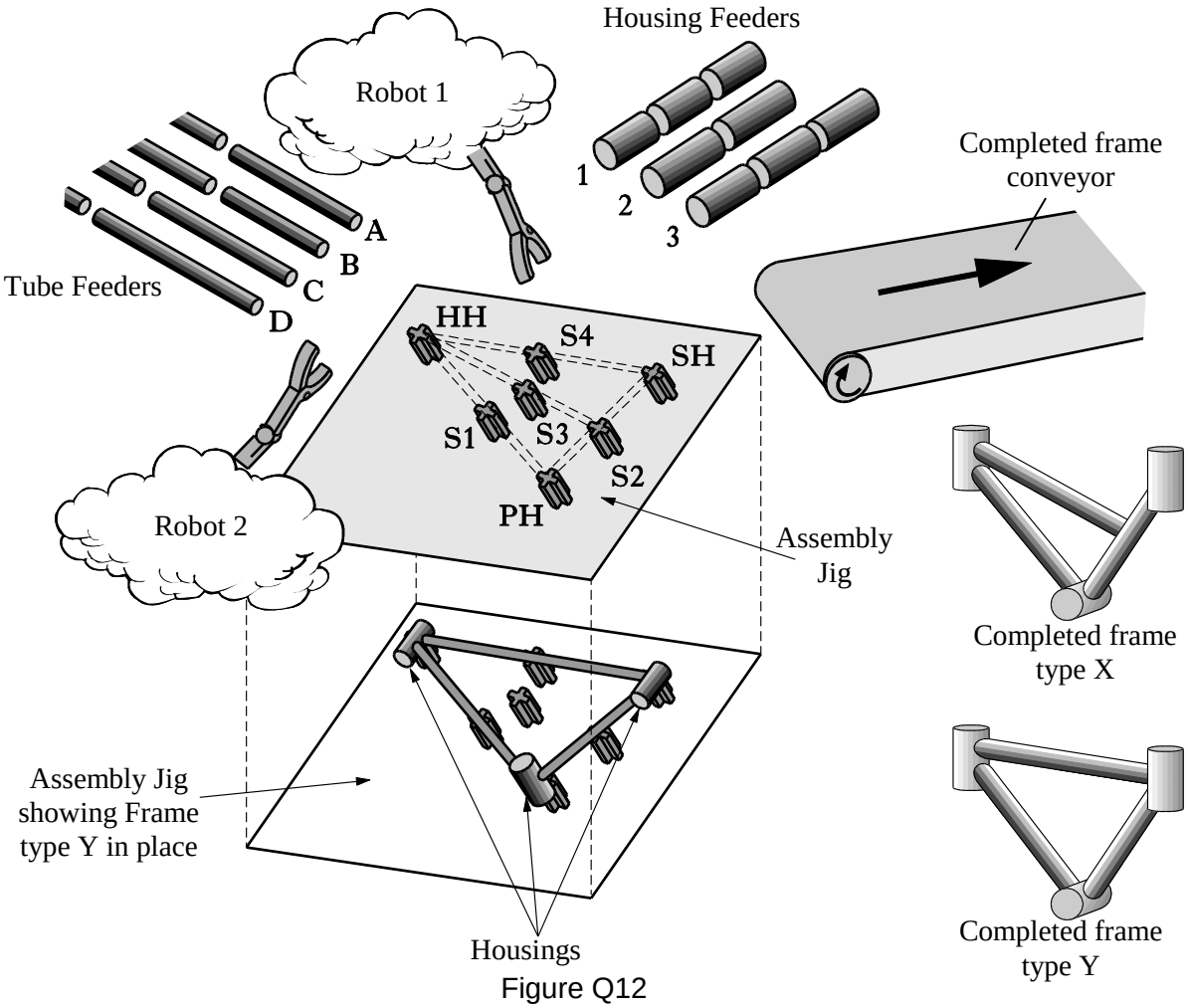


Figure Q12

The system operates in the following way:

Before the assembly process starts, an initial system check is performed. This system check ensures that all feeders have parts, both robots are in their home position and the assembly jig is empty. If these conditions are met, then the assembly process starts. If any of the conditions are not met, then an alarm is sounded and manual intervention is required.

Robot 1 selects and places the handlebar housing in location HH, seat housing in location SH and pedal housing in located PH on the assembly jig. These housing parts are supplied via the Housing feeders 1, 2 and 3 respectively.

The system controller generates a frame design signal (X or Y) which informs Robot 1 which 3 of the 4 possible frame tube types are needed. Robot 1 selects the three frame tubes from the Tube Feeders (A, B and **either** C **or** D) and places them into position on the assembly jig. Root 1 homes.

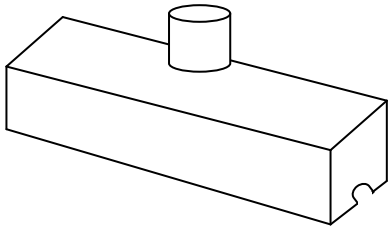
12. (continued)

The assembly jig has 4 microswitch tube sensors, labelled S1, S2, S3 and S4 which detect the presence of frame tubes A, B, C and D respectively.

All components are manufactured from mild steel.

Upon receiving a signal from Robot 1, Robot 2 welds the joints between the housings and the frame tubes. The position of the welds will differ depending upon which type of frame, X or Y, is being produced. Upon completion of the welding task, Robot 2 homes and signals Robot 1 which then removes the completed assembly and places it on the Completed frame conveyor. Robot 1 homes.

(a) Sketch and describe a suitable gripper which could be used for Robot 1 to transfer the housings and frame tubes to the assembly jig.



*A **magnetic type gripper** that can be turned **on/off** by a **simple digital signal** would be ideal for this task as the components are manufactured from **mild steel** (**magnetic**) and enough weight to fall away from the gripper when deactivated. A flat type plate with a circular recess to enable the tubes to be located would ensure easy lifting and transporting into the assembly jig. The gripper is also used to remove the completed assembly to the rack system.* **3**

(b) The assembly jig has 4 microswitch tube sensors.

(i) On **Worksheet Q12**, briefly describe the operation of this sensor system to ensure all frame tubes are in place for the frame design (X or Y) selected before welding commences.

*The **sensors** will **detect** if the parts have been **placed correctly** by the robot and sends the signals to the control system which will decide **if** the welding task should be started, **ALL hub sensors** and the **correct combination** of the frame sensors **must be correct** to initiate the welding task.* **1**

(ii) On Worksheet Q12 complete the sensor activation Table Q12(b) to show which tube sensors need to be activated prior to the correct welding program being activated.

Tube Sensor	Frame X	Frame Y
Sensor 1 (S1)	ON	ON
Sensor 2 (S2)	***ON***	***ON***
Sensor 3 (S3)	***ON***	***OFF***
Sensor 4 (S4)	***OFF***	***ON***

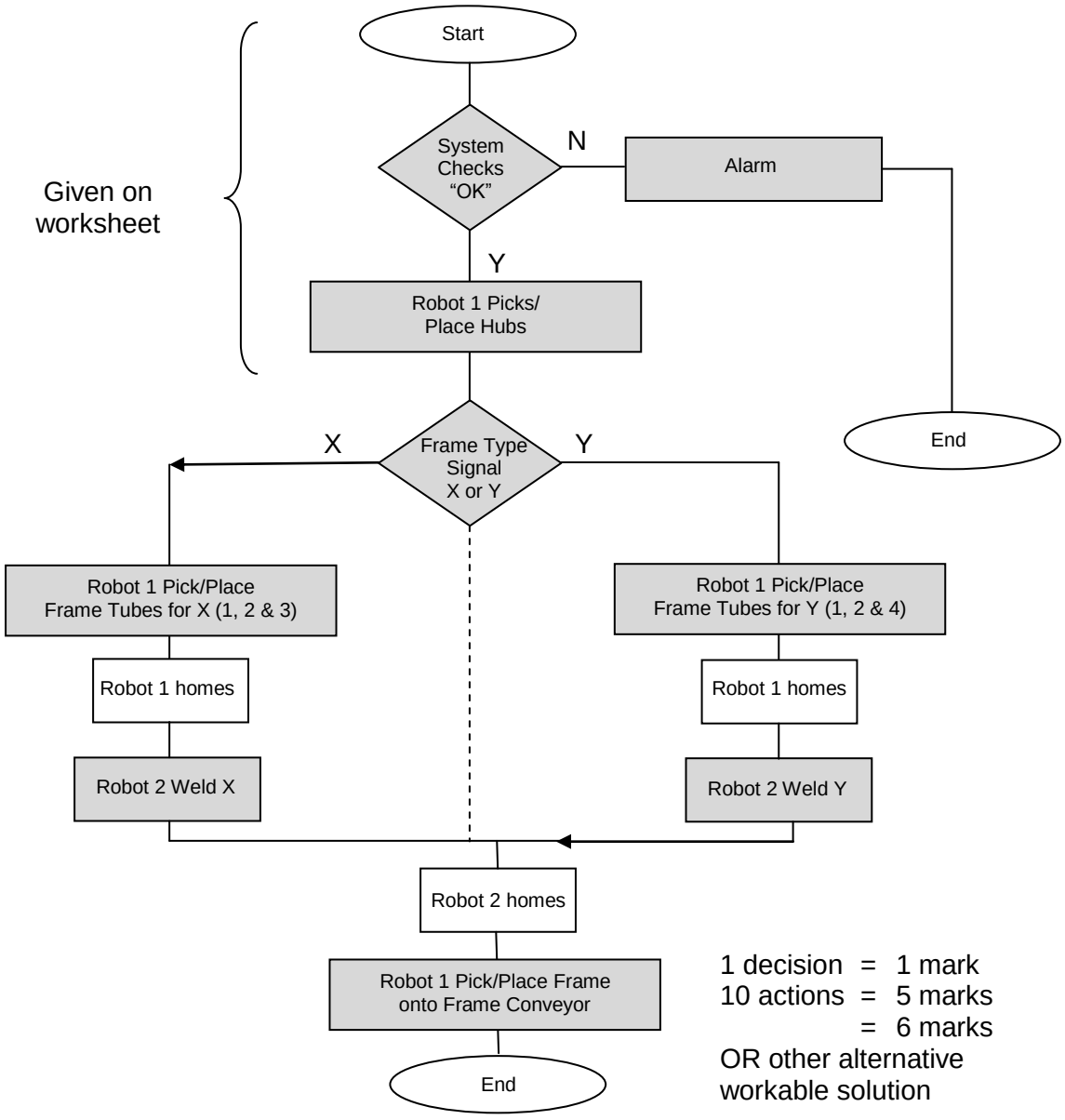
3

Table Q12*(b)*

12. (continued)

(c) On **Worksheet Q12**, complete the flowchart for the assembly process, for **one** frame, ensuring the initial system check is carried out.

Note: the inserted Flowchart Symbol Sheet Q7/Q11/Q12/Q13 gives a selection of suitable Flowchart Symbols.



1 decision = 1 mark
10 actions = 5 marks
= 6 marks
OR other alternative workable solution

6

NB solution only needs to show flowchart for one frame. That is X or Y. Both are shown above.

12. (continued)

(d) **In your workbook** state **two** reasons why revolute robots have been chosen for this assembly station.

*Any **two** reasons why revolute robots have been chosen for this assembly station, for example*

*Revolute robots have **good movement properties** which are ideal for following complex welding curves. There are numerous differing **sizes and power capabilities** of this type of robot available.* **2**

(e) Robot 2 was programmed to weld each joint using the "**lead by nose**" technique. Describe this method of programming a robotic arm.

*"Lead by nose" is where the robot is **manually led** through the required welding task by a skilled operator and many **points recorded at discreet intervals** by the control system. This motion can then be repeated (**played back**) by the robot at the **required speed to replicate the welding task.***

2

(f) State **two** potential safety hazards with this type of automated assembly system and briefly describe how they could be addressed at the design stage.

*Any **two** suitable answers, for example*

*Automated robotic system which may **start/stop unexpectedly** thus the system should be contained within a **safe area** which cannot be entered. Welding produces **heat and light hazards** and **suitable screens** must be in place to ensure safety.* **4**

(g) The designers have decided to incorporate a suitable inspection system into the assembly station to verify the housings and frame tubes have been placed in the correct location and orientation. Briefly describe a suitable system and identify any additional hardware requirements.

*A simple **vision system** could be used which incorporates a **camera and software** to be used in the **visual inspection process**, but this would provide a visual impression of the parts location and orientation to **check against known** templates.*

Or any other suitable brief description and identified hardware requirements. **2**

(h) Robots 1 and 2 use electric motors for drive. State **two** reasons why electric motors are suitable for this application.

*Any **two** reasons, for example*

*Electric motors are **readily available** in various **sizes/powers** and the **power supply** is also readily obtained.* **2**

(25)

13. Figure Q13 illustrates a Microcontroller controlled semi-automatic injection machine, which manufactures plastic gears. The Injector is pneumatically actuated and the Die assembly mechanism is hydraulically actuated.

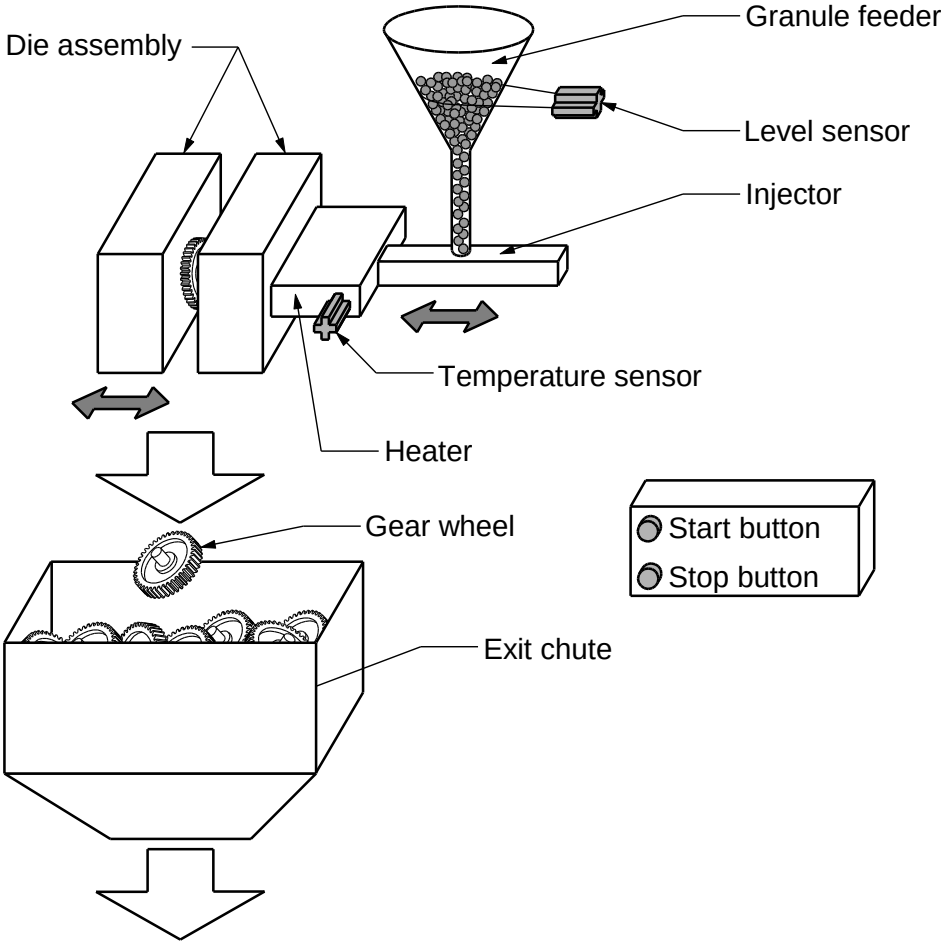


Figure Q13

The system is initially activated with a Start button. The system is then initialised with the Injector retracted and the Die assembly closed.

After initialisation, a pre-determined volume of granules are gravity fed from the feeder into the pneumatic Injector. The injector Heater is switched on and the granules melt when the required temperature is reached. The Injector is then extended and the hot melt is forced under pressure into the Die assembly. The injector Heater is switched off and after 20 seconds the Injector is retracted. The Die assembly opens and the plastic gear wheel falls into the Exit chute. The Die assembly then closes and the cycle is repeated.

A single production run of the system produces plastic gear wheels until the feeder is empty. The system will then stop and sound an alarm. The feeder must be refilled before the process is restarted.

Marks

13. (continued)

(a) Produce a list of:

(i) the system Inputs
(ii) the system Outputs

that will require interfacing to the microcontroller.

(i)

Inputs
Start button
Temperature sensor
(Feeder) level sensor
Stop button

(ii) the system Outputs

Outputs
Die assembly
Injector
Heater
Alarm

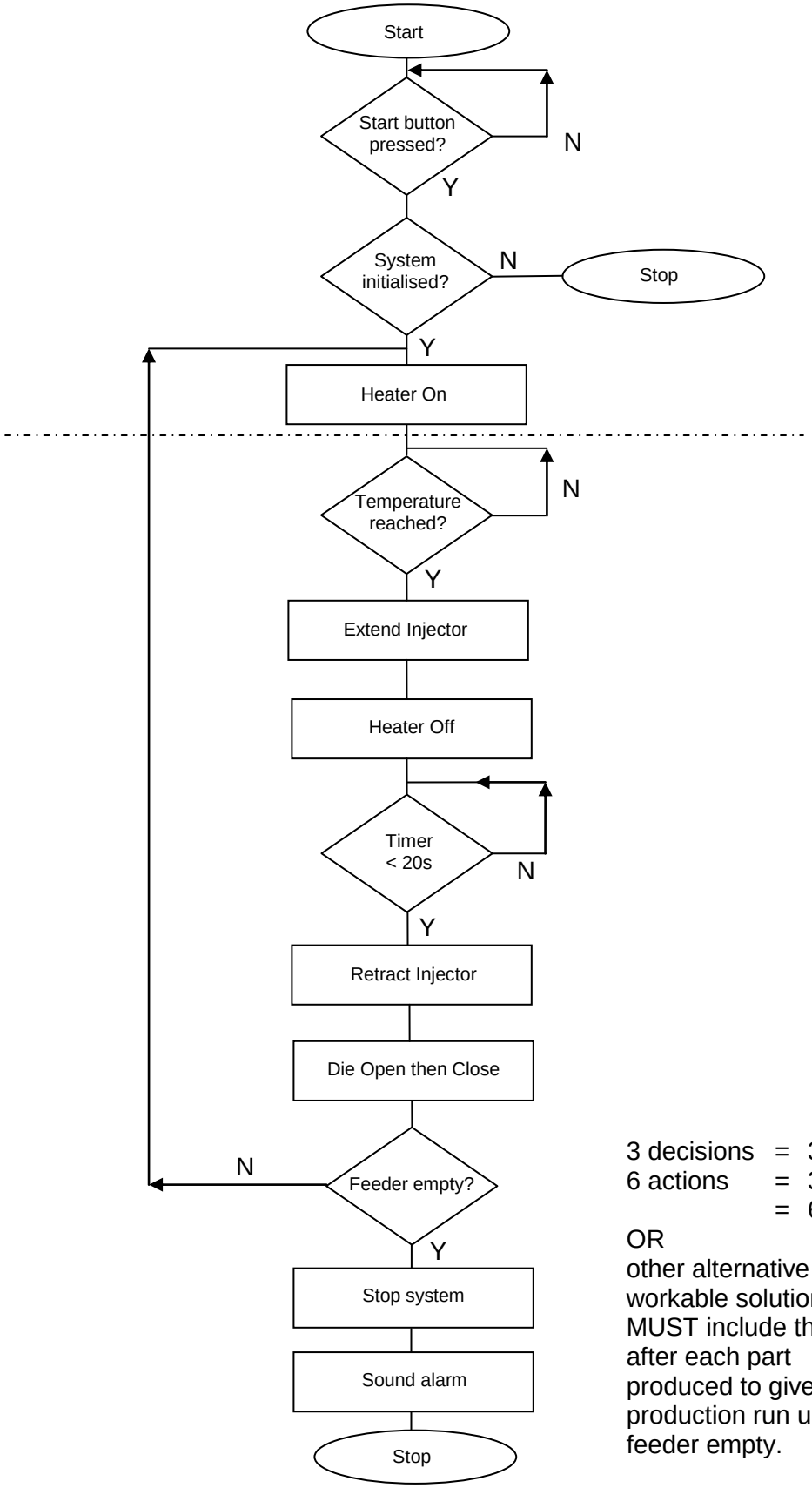
3

Marks

13. (continued)

(b) On **Worksheet Q13*(b)*** complete the flow chart one single production run of the system.

Note: the inserted Flowchart Symbol Sheet Q7/Q11/Q12/Q13 gives a selection of suitable Flowchart Symbols.



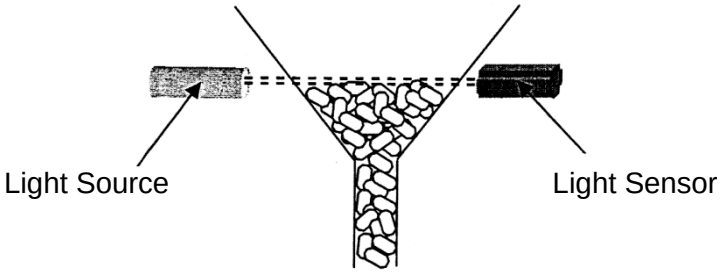
3 decisions = 3 marks
6 actions = 3 marks
= 6 marks

OR
other alternative workable solution but MUST include the loop after each part produced to give production run until feeder empty.

6

13. (continued)

(c) **In your workbook**, state and briefly describe a suitable sensor that may be used to monitor the level of granules in the Granule feeder.



*Any suitable answer such as a **light** based sensor could be used, this type of device operates on the principal that a directed beam is interrupted if there are granules present in the feeder. If there are/are not granules present the sensor produces a simple 0/1 signal to the control system.* **2**

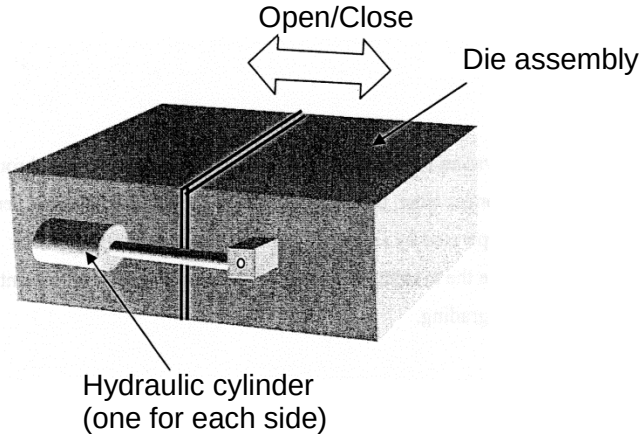
(d) State **three** advantages, excluding cost, of using pneumatics compared with using hydraulics within the injection system.

*Any **three** advantages of pneumatics compared with using hydraulics, for example*

*Pneumatics provide a relatively **simple, medium power source compared with hydraulics**. They tend to be **readily available** and if a leak does occur it will **not contaminate** the system which can be a problem with hydraulics.* **3**

(e) Sketch and briefly describe a suitable actuator system that could be used to clamp/unclamp the Die assembly and state **one** reason why hydraulics is a suitable choice for this system.

*Any suitable answers that contain a sketch, description and **one** reason, for example*



*Simple **linear actuators** could be used to open/close the die. They would require careful positioning to ensure a **smooth linear operation** and also **not interfere** with the product removal. **Hydraulic actuators** provide **high powers** and they can easily be **locked in position** due to the fact the hydraulic fluid cannot be compressed.* **3**

Marks

13. (continued)

(f) List **three** potential safety risks associated with this injection machine and clearly state how **two** of these risks could be addressed at the system design stage.

*Any **three** potential safety risks associated with this system and any descriptions of how **two** of these risks could be addressed at the system design stage, for example*

*There is a risk of **trapping danger** from the auto clamping device and this should be protected by a **cover**. The **hot plastic melt** could also be a hazard and people should be excluded from the area by a suitable **fencing system**. The **automated nature** of the system could also be a hazard to people unfamiliar with the system.* **5**

(g) During operation, it has been found that the plastic gear wheels have a tendency to stick in the Die when it is opened. Briefly describe a modification to overcome this problem. You may wish to use a sketch to illustrate your modification. List any additional hardware required and clearly identify any Input and/or Output signal changes.

Any suitable description of a modification to overcome this problem, list of any additional hardware required and clearly identified I/O signal changes.

*Note: a **sketch is optional** not mandatory*

For example

*A **simple air ejection and cleaning** system could be added which using compressed air through small holes in the die ejects the component when the die is open after the required cooling period. A **simple solenoid valve** (hardware) operated by an **on/off** signal from the system controller (output signal) could be used to operate the system. The required air supply is already present on the injector system but may require upgrading.* **3**

(25)

[END OF MARKING INSTRUCTIONS]