2014 Mechatronics

Higher

Finalised Marking Instructions

Part One: General Marking Principles for: Mechatronics Higher

This information is provided to help you understand the general principles you must apply when marking candidate responses to questions in this Paper. These principles must be read in conjunction with the specific Marking Instructions for each question.

(a) Marks for each candidate response must always be assigned in line with these general marking principles and the specific Marking Instructions for the relevant question. If a specific candidate response does not seem to be covered by either the principles or detailed Marking Instructions, and you are uncertain how to assess it, you must seek guidance from your Team Leader/Principal Assessor.

(b) Marking should always be positive ie, marks should be awarded for what is correct and not deducted for errors or omissions.

GENERAL MARKING ADVICE: Mechatronics Higher

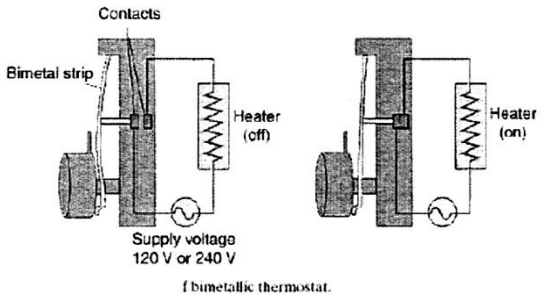
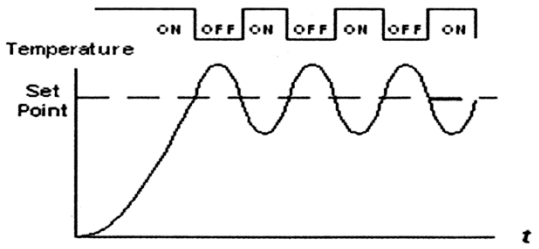
The marking schemes are written to assist in determining the "minimal acceptable answer" rather than listing every possible correct and incorrect answer. The following notes are offered to support Markers in making judgements on candidates' evidence, and apply to marking both end of unit assessments and course assessments.

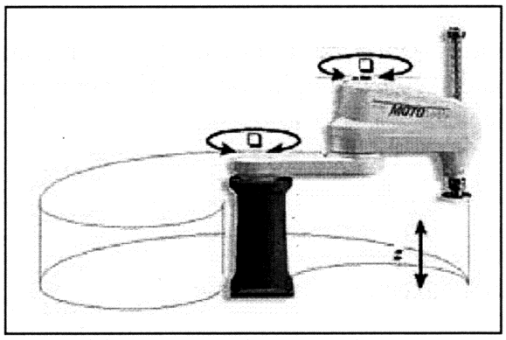
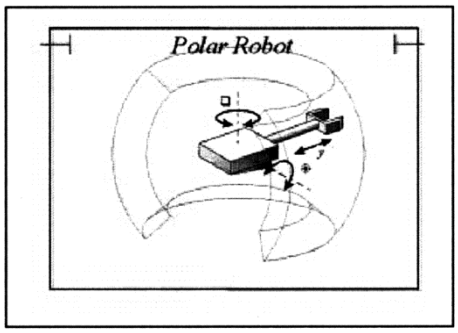
Part Two: Marking Instructions for each Question

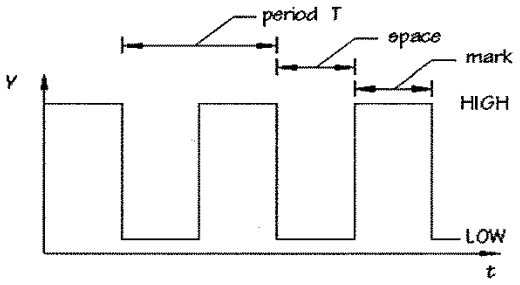
Section A

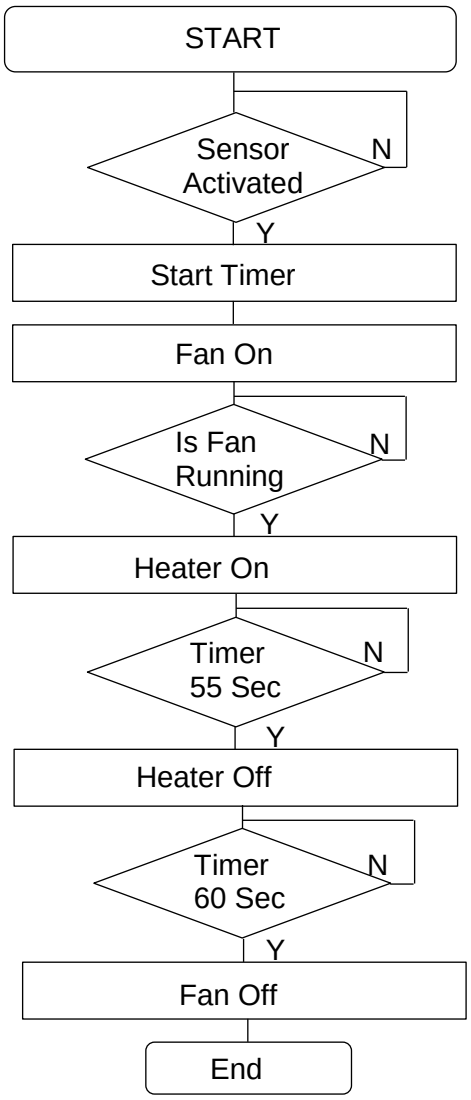
Attempt ALL questions in this Section (50 marks)

Question			Expected Answer(s)	Max Mark	Additional Guidance
1	**a**		A – Address Bus B – Data Bus C – Input Data Interface D – Output Data Interface	**2**	0·5 mark for each correct element
1	**b**		Statement 3	**1**	
1	**c**		Easily replaced, Reprogrammable, Modular, Less space, More compact, Portable Any other suitable answer.	**2**	1 for each correct advantage stated.

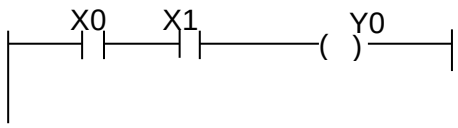
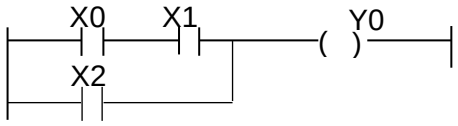
Question			Expected Answer(s)	Max Mark	Additional Guidance
2	**a**		Bi-metallic sensor **or** Any suitable temperature sensor.	**1**	
2	**b**		When the sensor metals heat up the differing expansion rates cause movement of the contacts driving them to open. When the sensor cools down the differing contraction rates closes the contact as the cooling metals move in the opposite direction. Any other suitable explanation and sketch.  f bimetallic thermostat.	**2**	1 for description 1 for sketch
2	**c**		Control Strategy – ON/OFF  Or any appropriate graph.	**2**	1 for strategy 1 for sketch

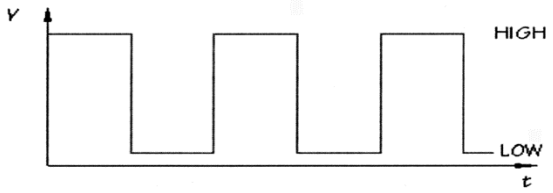
Question			Expected Answer(s)	Max Mark	Additional Guidance
3	a	i	 SCARA: similar to diagram above or kidney shaped 3D work envelope.	2	1 for each correct work envelope.
		ii	 Polar: diagram above or hemisphere shape.		
3	b		The end effector may differ from robot to robot and thus the work envelope would vary depending upon the end effector being used.	1	
3	c		Compact. Readily available in numerous sizes and power ratings. Or any other suitable reasons.	2	1 for each correct reason

Question			Expected Answer(s)	Max Mark	Additional Guidance
4	a	i	The transmitted beam is broken by the rotation of the slotted disc and the receiving sensor detects the pulsed signal.	2	
4	a	ii	 Or any suitable output signal in the form of a pulsed waveform.	1	
4	b		Position encoder on a robotic system. Shaft encoder on a conveyor belt drive system. Print head driver. Any other suitable application.	2	1 for each correct application

Question			Expected Answer(s)	Max Mark	Additional Guidance
5			 Or any other flowchart that correctly describes the operation.	5	1 for decision 0·5 for action

Question			Expected Answer(s)	Max Mark	Additional Guidance
6	**a**		ASIC – change IC PLC – reprogram	**2**	1 for each correct answer
6	**b**	**i** **ii**	Closed Loop Control has higher complexity Closed Loop Control is more Accurate Any suitable answer.	**2**	1 for each correct answer
6	**c**		A digital signal has a number of discrete values whereas an analogue signal does not. Any suitable answer or sketch.	**1**	

Question			Expected Answer(s)	Max Mark	Additional Guidance
7	**a**			**2**	
7	**b**			**1**	
7	**c**		X3 is activated which energises Y1. Contact Y1 latches output Y1. Y1 remains energised until X4, the Normally Closed contact, is opened which in turn deactivates Y1.	**2**	

Question			Expected Answer(s)	Max Mark	Additional Guidance
8	**a**			**1**	
8	**b**		The frequency of the waveform can be converted into linear speed and thus the speed can be calculated or any suitable answer.	**1**	
8	**c**		100Hz = 100 teeth/s = 5*100mm/s = (500/1000) m/s = 0·5m/s	**2**	0·5 mark per step or 2 for correct answer
8	**d**		By the addition of another slightly offset sensor which would allow the waveforms to be compared and the direction obtained, Or any suitable answer.	**1**	

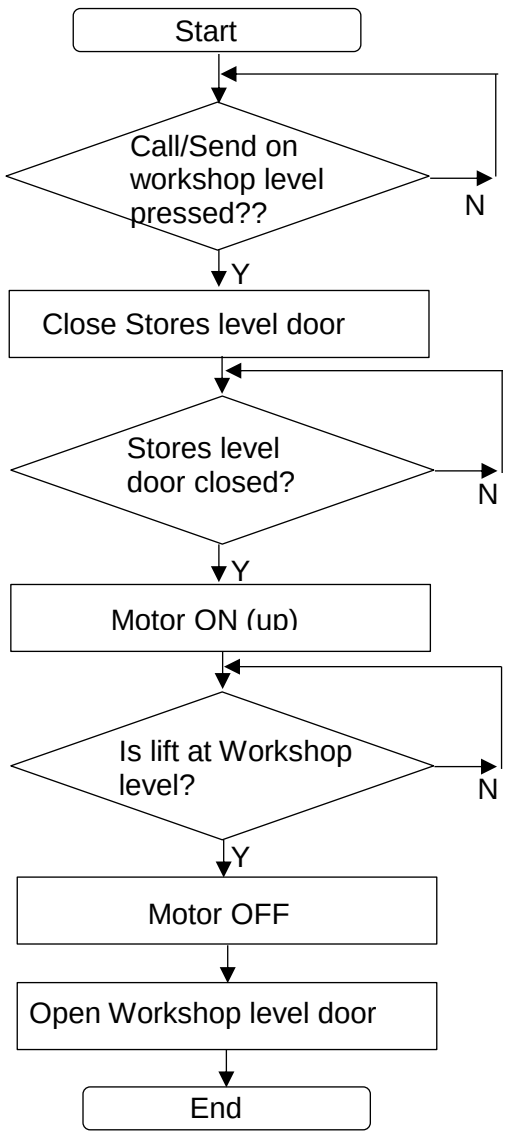
Question			Expected Answer(s)	Max Mark	Additional Guidance
9	**a**	**i**	Gray Code & Binary Coded Decimal	**2**	1 mark for each correct code name
		ii	Gray Code — 0100 & 1110 BCD Codes — 0000 0110 & 0001 0011	**2**	0·5 mark for each correct entry
9	**b**		High power available. Good position control. Hydraulic Position Lock . Readily available in linear and rotary drives. Or any suitable answer.	**1**	
10	**a**		A — Temperature	**1**	
10	**b**		C — Detect motion	**1**	
10	**c**		C — Provide motion	**1**	
10	**d**		B — A microswitch	**1**	
10	**e**		D — A Light Emitting Diode	**1**	

[END OF SECTION A]

Section B

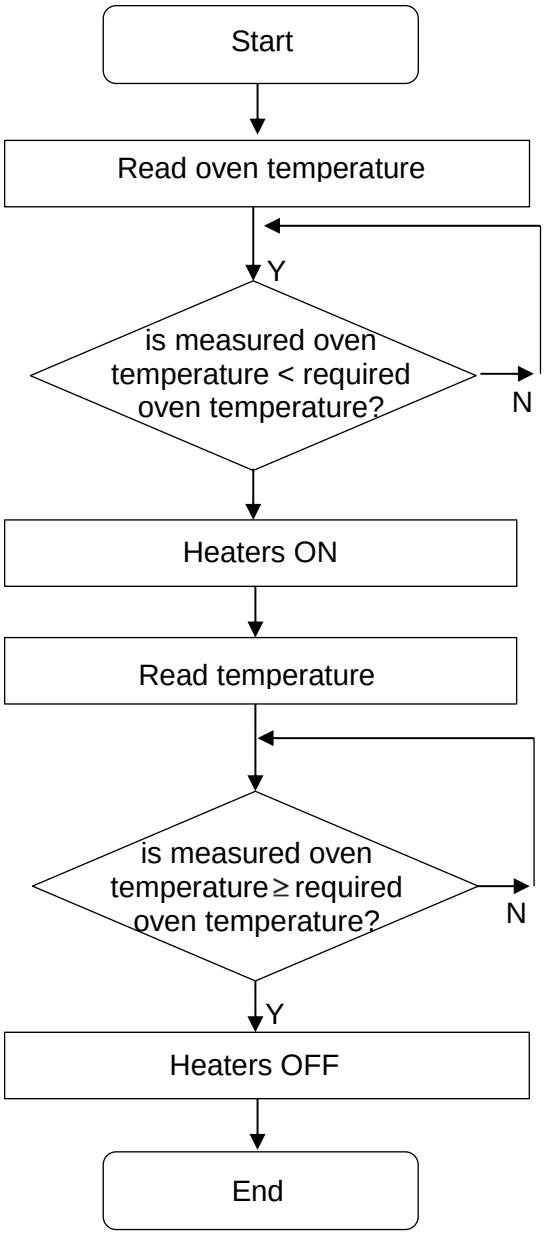
Attempt any TWO questions in this Section (50 marks).

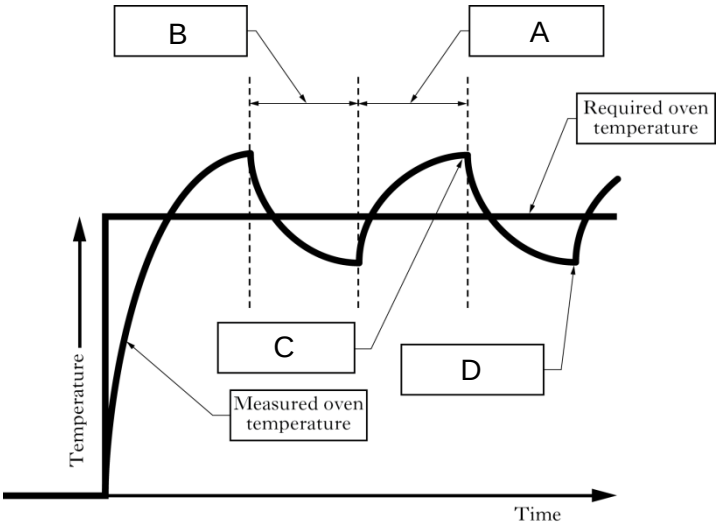
Each question is worth 25 marks.

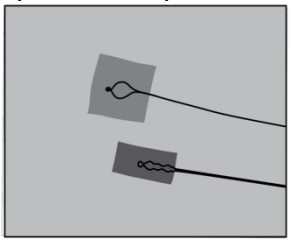
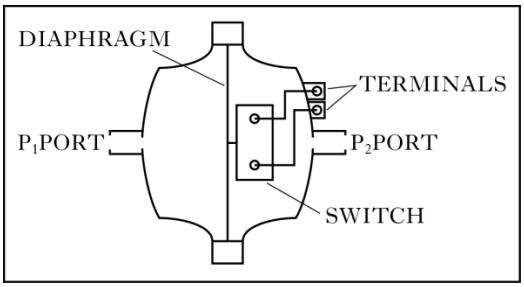
Question			Expected Answer(s)	Max Mark	Additional Guidance
11	**a**	**i**	Inputs — 2 Call/Send buttons, 2 Door closed sensors, 2 Lift cage sensors	**5**	
		ii	Outputs — 1 reversible motor, 2 door actuators		1 for each type, total 5 marks
11	**b**		 Or any other suitable flow chart.	**5**	1 mark for decision, 0·5 for action, total 5 marks

Question			Expected Answer(s)	Max Mark	Additional Guidance
11	**c**		A strain gauge incorporated into the cable system to measure the force on the lift cable could be used. A strain gauge is a small resistive device that, when a stretching force is applied, changes resistance. Incorporated into a suitable circuit the force on the cable could be measured and, if exceeded, a suitable cut off and alarm actuated. Or any suitable sensing system.	**3**	
11	**d**		A microswitch could be used as a Door closed sensor. This is a tactile sensor that would be operated by physical contact with the door. A sketch may be given instead of a description. Or any suitable sensor with sketch or description.	**2**	1 mark for state and 1 for description and/or sketch – total 2 marks
11	**e**		Pneumatic linear actuators could be used as they provide adequate power for this task and are relatively clean in this environment, **Or** Electrical linear actuators could be used as the power supply is readily available. Or any suitable answer.	**2**	1 mark for state and 1 for reason – total 2 marks.
11	**f**		The doors open and close automatically and could trap something between them. An emergency stop should be fitted at both levels to ensure the system can be shut down if something was trapped in the doors. It is difficult to tell where the lift is and what is happening with the system. Some form of audible and visual indication of the state of the lift system would solve this problem. Or any suitable hazard and potential solution.	**4**	1 mark for each safety concern, 1 mark for each potential solution, total 4 marks

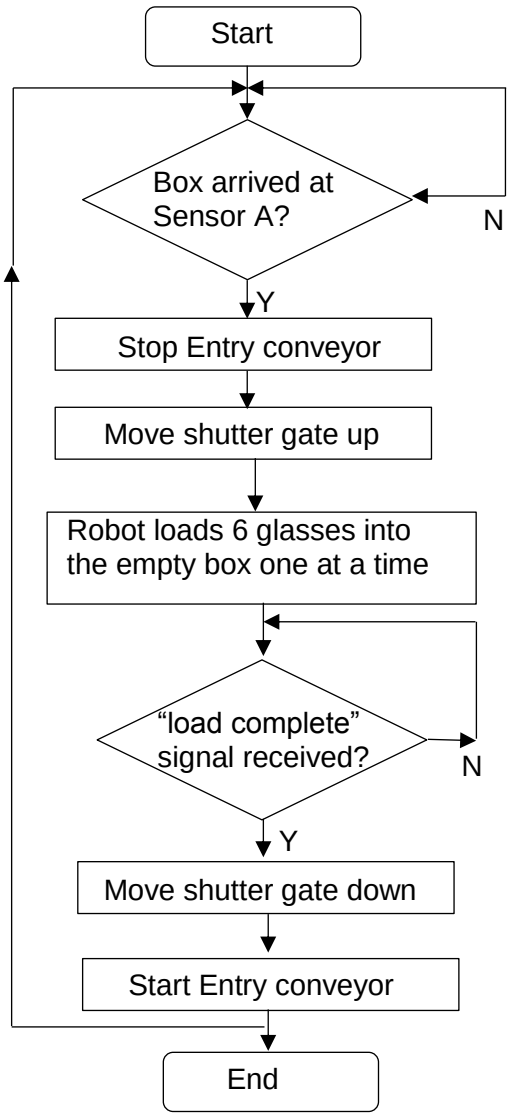
Question			Expected Answer(s)	Max Mark	Additional Guidance
11	**g**	**i**	A PLC based control is relatively easy to reprogram, a visual interface could be used to show a schematic of the system, PLCs are easily upgraded, Or any suitable answer.	**2**	1 mark for each, total 2 marks
11	**g**	**ii**	The high power of an industrial electric motor requires relays/switchgear to be operated by low power PLC signals, **Or** Electrical noise/interference when starting and stopping the motor, **Or** PLCs work very fast in comparison to a slow electrical motors and this must be allowed for in the control system, Or any suitable answer.	**2** **(25)**	1 mark for state and 1 for description- total 2 marks

Question			Expected Answer(s)	Max Mark	Additional Guidance
12	a	i	Inputs — Temperature sensor, Safety interlock, Differential pressure sensor. Allocated to C, D & E.	5	
		ii	Outputs — Heating elements. Fan, Allocated to G & H. Or any suitable allocations.		1 mark each, total 5 marks.
12	b		 Or any appropriate flowchart.	4	1 mark for decision, 0·5 mark for action and order, total 4 marks.

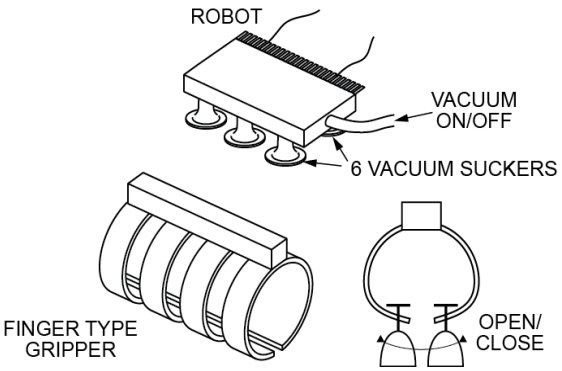
Question			Expected Answer(s)	Max Mark	Additional Guidance
12	**c**		**A. Heaters ON time** **B. Heaters OFF time** **C. Maximum temperature level reached during ON/OFF cycle** **D. Minimum temperature reached during ON/OFF cycle**	**2**	0·5 mark each, total 2 marks
			 Figure Q12(*c*)		
12	**d**	**i**	A microswitch will detect if a tray with bread on it is in the oven.	**2**	
12	**d**	**ii**	The heating elements' power input could be reduced by lowering the supply voltage to the heating elements or, if the heating elements were in separately connected banks, a number of the elements could be switched off, thus reducing the power consumed. Or any other suitable answers.	**3**	3 marks for description.

Question			Expected Answer(s)	Max Mark	Additional Guidance
12	**e**		A thermocouple is a device that measures temperature by the amount of voltage produced at a junction between two different materials. The junction is often in the form of a small bead and the output from the device is an analogue signal normally in the millivolt range. Or any suitable description. Thermocouple — accept a suitable sketch. 	**2**	1 mark for sketch, 1 mark for description — total 2 marks.
12	**f**		A differential pressure sensor is a device which detects the difference in pressures acting upon either side of a diaphragm. This pressure difference deflects the diaphragm which operates the microswitch. The movement, once calibrated, closes the contact when the switch is operated. Or any suitable description. 	**3**	1 mark for sketch, 2 marks for description — total 3 marks.

Question			Expected Answer(s)	Max Mark	Additional Guidance
12	**g**		The high temperature of the system is a hazard. A cool down time could be added at the end of the baking cycle, the heaters turned OFF whilst circulating air and the Safety interlock used to prevent the door opening until the system has reached a safe temperature. The loading/unloading operation presents a hazard. A suitable sliding shelf arrangement could be designed to remove the need for a paddle to load/unload the product. Or any suitable answer.	**4** **(25)**	1 mark for each hazard, 1 mark for each description — total 4 marks

Question			Expected Answer(s)	Max Mark	Additional Guidance
13	**a**		 Or, any appropriate flowchart.	**5**	1 mark for decision box, 0·5 for action box and loop, total 5 marks.

Question			Expected Answer(s)	Max Mark	Additional Guidance
13	**b**		A reflective light beam sensor would detect a box arriving at the locating jig by sensing the reflection of a transmitted beam from the surface of the box. **Or** A light beam sensor across the conveyor system would detect a box arriving at the Box locating jig. A beam of light is projected across the conveyor and this beam is detected at the other side and when a product breaks the beam it is detected by the sensor. Or any suitable type and description.	**2**	2 marks for description.
13	**c**		An electrical solenoid linear actuator could be used to move the shutter gate up and down as the forces required are small and an electrical supply is readily available. Or any suitable type and reasons.	**3**	1 mark for type and 1 mark for each reason, total 3 marks.
13	**d**	**i**	The addition of the **shaft encoder** which produces an **output signal corresponding to the conveyor speed.**	**1**	
13	**d**	**ii**	The measured conveyor speed is then **compared to the set conveyor speed** and hence a **corrective control signal** can be implemented to regulate the speed. A **closed loop** speed control system is required. A **variable speed motor** will be required. Or any suitably worded description that covers the above descriptions.	**2**	0·5 mark for each bold statement, total 3 marks.
13	**e**		Revolute because it is the flexible choice, readily available, easily programmable. Or any suitable choice and appropriate reasons. Cylindrical, rectangular or polar.	**2**	1 mark for robot geometry and 1 mark for justification, total 2 marks

Question			Expected Answer(s)	Max Mark	Additional Guidance
13	**f**	**i**	As the damage could vary from a broken stem to a scratch on the surface of the glass an ideal system would be a **vision system** which inspected the glasses prior to packaging. The system would require the appropriate cameras and software.	**1**	
		ii	The **robot system needs to be re-programmed** to reject the glasses on a **signal from this visual inspection system.** Or any suitable system.	**2**	1 mark for each bold statement, total 3 marks.
13	**g**		 The top gripper in the above diagram is used as a vacuum sucker type which attaches to the base of each glass. The glasses are provided in the correct orientation by the feeder system to allow transfer of six at a time. **Or** The finger type shown in the diagram above or any suitable alternative answer.	**3**	2 marks for sketch and 1 mark for description, total 3 marks.

Question			Expected Answer(s)	Max Mark	Additional Guidance
13	**h**		The automated operation and the unpredicted movement of the robots present a hazard and the system should be enclosed in a suitable cage/lock system. The system is automatic but problems could arise if a jam or serious fault occurred and thus an alarm system/ Emergency Stop could be added to the automatic station. Or any alternative hazard and appropriate solutions.	**4** **(25)**	1 mark for each hazard, 1 mark for each description, total 4 marks.

[END OF MARKING INSTRUCTIONS]