GCE

Design and Technology

H004/01: Principles of design engineering

AS Level

Mark Scheme for June 2022

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

MARKING INSTRUCTIONS

PREPARATION FOR MARKING
RM ASSESSOR

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *RM Assessor Assessor Online Training*; *OCR Essential Guide to Marking*.

2. Make sure that you have read and understood the mark scheme and the question paper for this unit. These are posted on the RM Cambridge Assessment Support Portal http://www.rm.com/support/ca

3. Log-in to RM Assessor and mark the **required number** of practice responses ("scripts") and the **number of required** standardisation responses.

YOU MUST MARK 10 PRACTICE AND 10 STANDARDISATION RESPONSES BEFORE YOU CAN BE APPROVED TO MARK LIVE SCRIPTS.

MARKING

1. Mark strictly to the mark scheme.

2. Marks awarded must relate directly to the marking criteria.

3. The schedule of dates is very important. It is essential that you meet the RM Assessor 50% and 100% (traditional 40% Batch 1 and 100% Batch 2) deadlines. If you experience problems, you must contact your Team Leader (Supervisor) without delay.

4. If you are in any doubt about applying the mark scheme, consult your Team Leader by telephone or the RM Assessor messaging system, or by email.

5. **Crossed Out Responses**
   Where a candidate has crossed out a response and provided a clear alternative then the crossed out response is not marked. Where no alternative response has been provided, examiners may give candidates the benefit of the doubt and mark the crossed out response where legible.

Rubric Error Responses – Optional Questions

Where candidates have a choice of question across a whole paper or a whole section and have provided more answers than required, then all responses are marked and the highest mark allowable within the rubric is given. Enter a mark for each question answered into RM assessor, which will select the highest mark from those awarded. *(The underlying assumption is that the candidate has penalised themselves by attempting more questions than necessary in the time allowed.)*

Multiple Choice Question Responses

When a multiple choice question has only a single, correct response and a candidate provides two responses (even if one of these responses is correct), then no mark should be awarded (as it is not possible to determine which was the first response selected by the candidate).
When a question requires candidates to select more than one option/multiple options, then local marking arrangements need to ensure consistency of approach.

Contradictory Responses

When a candidate provides contradictory responses, then no mark should be awarded, even if one of the answers is correct.

Short Answer Questions (requiring only a list by way of a response, usually worth only **one mark per response**)
Where candidates are required to provide a set number of short answer responses then only the set number of responses should be marked. The response space should be marked from left to right on each line and then line by line until the required number of responses have been considered. The remaining responses should not then be marked. Examiners will have to apply judgement as to whether a 'second response' on a line is a development of the 'first response', rather than a separate, discrete response. *(The underlying assumption is that the candidate is attempting to hedge their bets and therefore getting undue benefit rather than engaging with the question and giving the most relevant/correct responses.)*

Short Answer Questions (requiring a more developed response, worth **two or more marks**)
If the candidates are required to provide a description of, say, three items or factors and four items or factors are provided, then mark on a similar basis – that is downwards (as it is unlikely in this situation that a candidate will provide more than one response in each section of the response space.)

Longer Answer Questions (requiring a developed response)
Where candidates have provided two (or more) responses to a medium or high tariff question which only required a single (developed) response and not crossed out the first response, then only the first response should be marked. Examiners will need to apply professional judgement as to whether the second (or a subsequent) response is a 'new start' or simply a poorly expressed continuation of the first response.

6. Always check the pages (and additional objects if present) at the end of the response in case any answers have been continued there. If the candidate has continued an answer there, then add a tick to confirm that the work has been seen.

7 .Award No Response (NR) if:

- there is nothing written in the answer space

Award Zero '0' if:

- anything is written in the answer space and is not worthy of credit (this includes text and symbols).

Team Leaders must confirm the correct use of the NR button with their markers before live marking commences and should check this when reviewing scripts.

8. The RM Assessor **comments box** is used by your team leader to explain the marking of the practice responses. Please refer to these comments when checking your practice responses. **Do not use the comments box for any other reason.**
If you have any questions or comments for your team leader, use the phone, the RM Assessor messaging system, or e-mail.

9. A*ssistant Examiners will send a brief report on the performance of candidates to their Team Leader (Supervisor) via email by the end of the marking period. The report should contain notes on particular strengths displayed as well as common errors or weaknesses. Constructive criticism of the question paper/mark scheme is also appreciated.*

10. For answers marked by levels of response: Not applicable in F501

a. **To determine the level** – start at the highest level and work down until you reach the level that matches the answer
b. **To determine the mark within the level**, consider the following

Descriptor	Award mark
On the borderline of this level and the one below	At bottom of level
Just enough achievement on balance for this level	Above bottom and either below middle or at middle of level (depending on number of marks available)
Meets the criteria but with some slight inconsistency	Above middle and either below top of level or at middle of level (depending on number of marks available)
Consistently meets the criteria for this level	At top of level

11. **Annotations**

Annotation	Meaning
	Blank Page – this annotation must be used on all blank pages within an answer booklet (structured or unstructured) and on each page of an additional object where there is no candidate response.
	Tick
	Cross
	Confused (replaces the question mark)
	Benefit of doubt
	AO1 – Knowledge and understanding
	AO2 – Apply knowledge and understanding
	AO3 - Analyse
	AO4 - Evaluation
	Omission
	Not answered question
	Noted but no credit given
	Too vague
	Own figure rule

REP	Repetition
L1	Level 1
L2	Level 2
L3	Level 3

12. Subject Specific Marking Instructions

INTRODUCTION

Your first task as an Examiner is to become thoroughly familiar with the material on which the examination depends. This material includes:

- the specification, especially the assessment objectives
- the question paper
- the mark scheme.

You should ensure that you have copies of these materials.
You should ensure also that you are familiar with the administrative procedures related to the marking process. These are set out in the OCR booklet Instructions for Examiners. If you are examining for the first time, please read carefully Appendix 5 Introduction to Script Marking: Notes for New Examiners.

Please ask for help or guidance whenever you need it. Your first point of contact is your Team Leader.

Question	Indicative Content	Marks	Guidance
1a	Possible benefits may include: • Are the materials recyclable (1). • The consumer knows how to dispose of it (1). • Gives information on whether it has been quality checked (1). • Tells you what material it is made from (1). • Any other valid suggestion.	**1**	One mark for identifying a benefit to the consumer of having the listed symbols on the electric hole punching machine. Specific reference to the context in the question is needed for marks to be awarded.
1bi	Possible responses may include: • By turning clockwise this extends the lever (1) and increase the moment acting on it (1). • If the motor turned anti-clockwise it would decrease the moment acting on it (1). • Any other valid suggestion.	**2**	Up to two marks for explanation of why the designer decided that the motor should rotate in a clockwise direction on the electric hole punching machine. Use a mix and match approach in relation to bullet points. Specific reference to the context in the question is needed for marks to be awarded. *Candidates could explain this using maths CWM=ACWM as long at they state more force can be applied because it is a bigger lever.* *15+70 = 85 in CW* *70-15 = 55 in ACW*
1bii	• Motion at lever point A – oscillating (1). • Motion at pin point B – reciprocating (1).	**2**	One mark for identifying each type of motion as indicated. **Do not accept** any other answer because the question states one revolution of the motor, so it can only be these two answers.

1c	Possible responses may include: • On/off button (PTB/PTM) controls when the motor is moving (1). • Even when there is no high signal from the input the motor will still turn in one direction (1). • Only when the on button is pushed and there is a high signal from the input will the motor change direction (1). • Input pin receives a high signal this travels through the resistor to the base of the transistor (1). The transistor then allows electricity to travel from the collector to the emitter, therefore allow current to travel to the relay (1). • The relay energizes and pulls the contacts to the other position (1) which in turn changes the positive and negative connection to the motor (1) which therefore changes the direct the motor is traveling (1). • Any other valid suggestion.	**5**	Up to five marks for description of how the circuit shown in **Fig. 1.4** operates. Use a mix and match approach in relation to bullet points. If a candidate does not provide a description of the circuit, then MAX four marks can be awarded. MAX two marks to be awarded for description that only includes the input or process or output. At this level generic commentary is not acceptable e.g. 'button is pressed' is not acceptable, but 'PTB/PTM switch is pressed' is acceptable.
1di	Possible thermoplastic materials may include: • Polypropylene (1). • ABS (1). • Polystyrene (1). • Acrylic (1). • PMMA (1). • PVC (1). • Any other valid suggestion.	**1**	One mark for identifying a suitable thermoplastic material. Specific reference to the context in the question is needed for marks to be awarded. Accept incorrect spelling if whole name is written. Accept common abbreviation.
1dii	Possible responses may include: If the answer provided by the candidate is polypropylene: • Durable (1) therefore can withstand being dropped/knocked (1).	**4**	In each case: One mark for stating a property of the thermoplastic material. One mark for justifying why this property makes it suitable for the outer clear casing.

	• Rigid (1) so that when the mechanism is working force can be applied without it bending or snapping (1). • Recyclable (1) so it can be disposed of properly (1)/ prevents landfill waste (1). • It is a thermoplastic that can be melted, and injection moulded (1), making it suitable for batch production (1). • Any other valid suggestion. A similar level of exemplification will be expected from candidates should a different thermoplastic material be given.		Specific reference to the context in the question is needed for marks to be awarded. Properties stated must relate to the material stated in part (d)(i).
1diii	Possible manufacturing methods may include: • Injection moulding (1). • Any other valid suggestion.	**1**	One mark for identifying a suitable manufacturing method. Specific reference to the context in the question is needed for marks to be awarded.
1div	Possible responses may include: If the answer provided by the candidate is injection moulding: • Intricate detail such as the reinforcement can be integrated into the mould (1) reducing stages in production/increasing speed (1). • Integral fixings can be moulded (1) to enable different parts to be jointed without separate fastenings (1). • Accuracy (1). It can include fixtures on the moulding that will accurately meet another adjoining part (1). • It can be used for batch production (1) meaning it is suitable for industrial scale manufacture as it is a quick process and cost effective (1). • The part needs to be produced in large scale, for which injection moulding is suitable (1). Lots of components can be made repeatedly and quickly with one mould (1)	**4**	In each case: One mark for stating a reason for using the manufacturing method given. One mark for justifying the reason given. Specific reference to the context in the question is needed for marks to be awarded. Reasons stated must relate to the manufacturing method stated in part (d)(iii).

	• Any other valid suggestion. A similar level of exemplification will be expected from candidates should a different manufacturing method be given.		
2ai	Total carbon produced by plane: 144 x 300 people = 43200 kg (1) 75% of 300 people: 300 x 0.75 = 225 people (1) 43200/225 (1) = 192 kg/per person (1).	**4**	Award four marks as follows: One mark for calculating the total carbon produced by the plane. One mark for calculating the number of people who would be on the plane when it is operating at 75% capacity. One mark for dividing the total carbon produced by the plane by the number of people who would be on the plane when it is operating at 75% capacity. One mark for calculating how much carbon is produced per person when travelling one way between London and Edinburgh. If correct answer is given without working out shown award full marks. Where an incorrect answer is given working out should be used to credit appropriate marks.

2aii	*192 kg/per person needs to be carried forward from previous question to be used in subsequent calculation. If incorrect answer is carried forward from part (ai) apply follow through for calculations.* Inbound train journey - total carbon produced by train: 29 x 300 people = 8700 kg (1) 75% of 300 people: 300 x 0.75 = 225 people (**no marks awarded as already worked out from previous question)** 8700/225* = 38.67 kg/per person (1) Total kg of carbon per passenger for both journeys: 192*+38.67* = 230.67 kg/per person (1) Two trees absorb 2 x 22 kg = 44 kg per year of carbon (1) 230.67*/44 = 5.24 years (1)	**5**	Award five marks as follows: One mark for calculating the total carbon produced by the train. One mark for calculating how much carbon is produced per person when making the return journey. One mark for calculating the total amount of carbon produced per person when making the inbound and return journey. One mark for calculating how much carbon two trees absorb in a year. One mark for calculating how long it would take in years to 2 decimal places for the two trees to absorb the amount of carbon produced y by the person on this journey. If correct answer is given without working out shown award full marks. Where an incorrect answer is given working out should be used to credit appropriate marks. *Allow error carried forward (ECF) where correct working out is shown.

2b	First revolution: 2πr or πd r = 1.8/2 = 0.9 m (**no marks awarded as candidate could use diameter straight from question so no conversion**) 2 x π x 0.9 = 5.65486677646 (1) Second revolution: 1.8 - 0.08 (1) = 1.72 (1) r = 1.72/2 = 0.86 m 2 x π x 0.86 = 5.40353936417 (1) Two revolutions added together: 5.65486677646* + 5.40353936417* = 11.06 m (1)	**5**	Award five marks as follows: One mark for calculating the length of the veneer sheet after one rotation. One mark for converting two rotations from mm to m. One mark for taking account of thickness of veneer sheet during calculation. One mark for calculating the length of the veneer sheet after second rotation. One mark for calculating the overall length of the veneer sheet in m to 2 decimal places after second rotation. If correct answer is given without working out shown award full marks. Where an incorrect answer is given working out should be used to credit appropriate marks. *Allow error carried forward (ECF) where correct working out is shown.

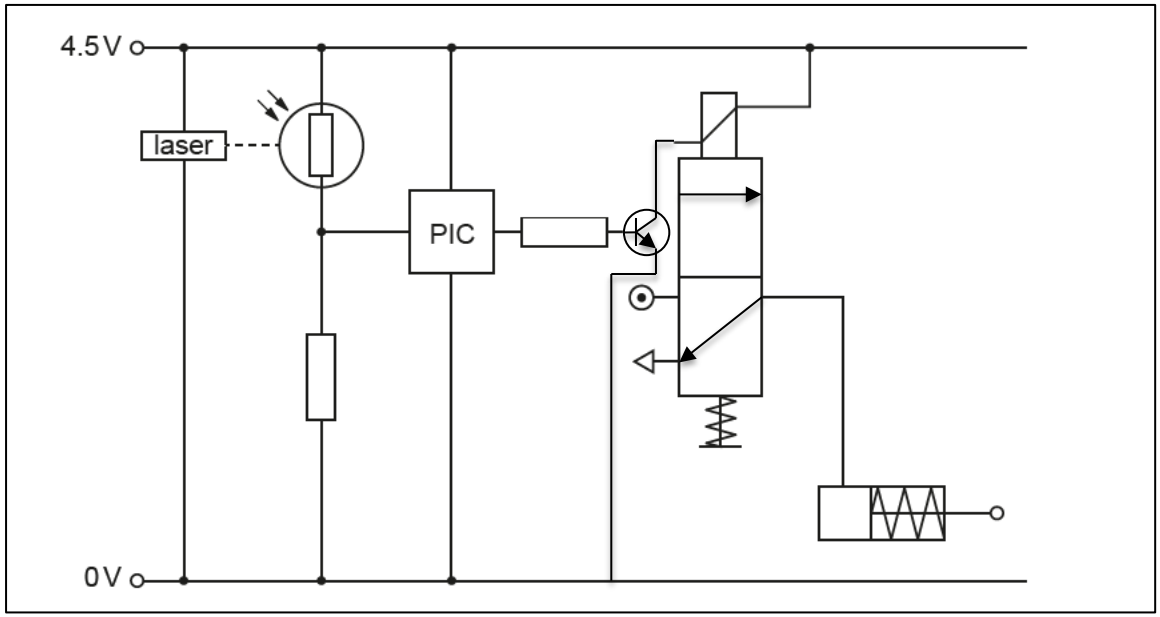
3a	Possible smart materials may include: • Polymorph (1). • Smart memory alloy (1). • Thermochromic (1). • Polarized glass (1). • Smart glass (1). • Photochromic lenses (1). • Any other valid suggestion. If the answer provided by the candidate is polymorph: • expansion linked to function – to make the glasses fit better to the eyes or nose (1). • expansion linked to aesthetics – the user could add extra pieces of polymorph to the frame in order to make the glassed more trendy (1) - e.g if the person liked Harry potter, a lightning bolt could be added (1). • Any other valid suggestion. If the answer provided by the candidate is Photochromic lenses: • expansion linked to function – to shade the user's eyes when it is sunny (1). • expansion linked to aesthetics – have tinted glasses outside could be a fashion accessory/look cool! (1). • Changes colour when outside light levels / light intensity change (1). This provides protection for the eyes in bright light and converts them to sunglasses (1). • Any other valid suggestion. If the answer provided by the candidate is Shape Memory Alloy lenses: • expansion linked to function – if the glasses get dropped and the frame is dented (1), heating the frame would return it to the original shape (1).	**6**	In each case: One mark for identifying a smart material that could be incorporated into the pair of glasses. Up to two marks for explaining how the identified smart material would enhance the function and/or aesthetics of the glasses. Use a mix and match approach in relation to bullet points. If candidate expands their answer and uses one functional point and one aesthetic point in relation to a smart material then award appropriate credit. Specific reference to the context in the question is needed for marks to be awarded. Accept brand names for smart materials e.g. 'Chromo active'

	• Any other valid suggestion.		
3bi	• Green = wood/timber (1). • Orange = plastic/polymers (1). • Purple = metal (1).	**3**	One mark for identifying each material group as indicated.
3bii*	**Indicative Content:** The importance to design engineers of studying material properties and characteristics when designing a product or component include: • A materials properties/characteristics make it suitable for a given application (1) for example, using aluminium alloy in a car frame because it's a tough and light material (1). • If you chose the wrong material for a component you may increase the cost of the overall product (1) using titanium for the car frame (1) • If you chose the wrong material for a component you could also increase the probability of that component failing when the product is in use (1). Making a metal vice out of mild steel would be an example of this as mild steel is not a hard or strong enough material for this operation (1). • A person's safety could also be an issue (1) for example, if the wrong material was used for a saucepan handle someone could burn themselves as the material is a good thermal conductor (1). • A products shelf life could also be affected if the wrong materials were used (1) for example, using plastic for garden chairs instead of wood will increase the life of the	**8** **For MB3 to be awarded will be two or three statements linked material properties and characteristics need to be covered.** **If candidates do not provide an analytical/ evaluative response then only L1 can be awarded.**	**Level 3 [6-8 marks]** The candidate has a clear understanding of the importance to design engineers of taking into account material properties and characteristics when designing a product or component. They produce a thorough discussion in relation to the question by explaining a number of considerations linked to materials that would be taken into account. The explanation of material properties and characteristics is clear and well-developed and different products or components are used to exemplify the points being made. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated with the use of examples.* **Level 2 [3-5 marks]** The candidate has a reasonable understanding of the importance to design engineers of taking into account material properties and/or characteristics when designing a product or component. They produce a sound discussion in relation to the question by explaining a number of considerations linked to materials that would be taken into account. The explanation of material properties

	garden chairs as plastic is waterproof whereas wood requires constant treatment to maintain it (1). • Any other valid suggestion.		and/or characteristics is sufficient although one or two opportunities are missed in referring to different products or components. *There is a line of reasoning presented with some structure. The information presented is for the most part relevant and supported by some evidence.* **Level 1 [1-2 marks]** The candidate has a basic knowledge of material considerations when designing a product or component. Any reference to properties or characteristics is largely descriptive in nature. The response contains no analysis of evaluation. *The information has some relevance and is presented with limited structure or detail. The information is supported by limited evidence.* **0 marks** No response or no response worthy of credit.

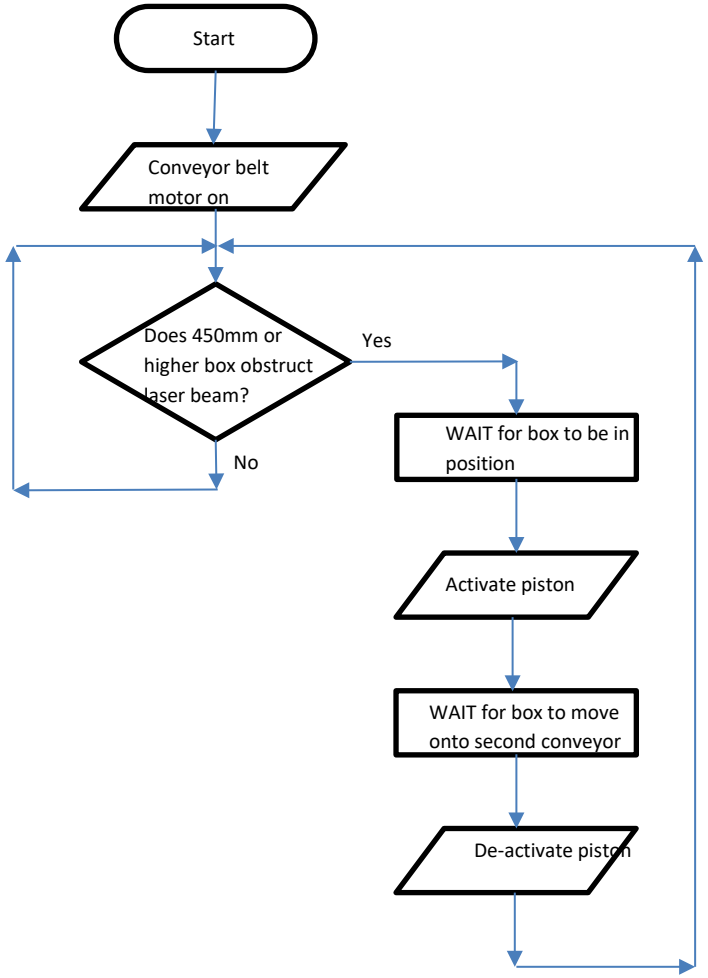
4ai	Possible advantages may include: • Returns without having to apply any additional systems or forces (1). • Less cables/pipes/components in the system (1). • Fewer parts required (1). • More cost effective (1). • Any other valid suggestion.	**2**	In each case: One mark for identifying an advantage of using a single acting pneumatic cylinder compare to a double acting pneumatic cylinder to push boxes to a second conveyor. Specific reference to the context in the question is needed for marks to be awarded.
4aii	Area = Force/Pressure (1) 21.2N/0.3MPa = 70.6666667 mm^2 (1) A = $[\pi D^2]/4$ rearranged to D = $\sqrt{(4A/\pi)}$ (1) $\sqrt{[(4)(70.6666667*/ \pi)]}$ = 9.48554661246 = 9.49 mm (1)	**4**	Award four marks as follows: One mark for recalling the appropriate formula. One mark for calculating the area of the piston head. One mark for rearranging the formula and putting the correct numbers to calculate the radius of the piston head. One mark for calculating the diameter of the piston head to 2 decimal places. If correct answer is given without working out shown award full marks. Where an incorrect answer is given working out should be used to credit appropriate marks. *Allow error carried forward (ECF) where correct working out is shown. There are different methods that can be used to calculate the diameter of the piston head.

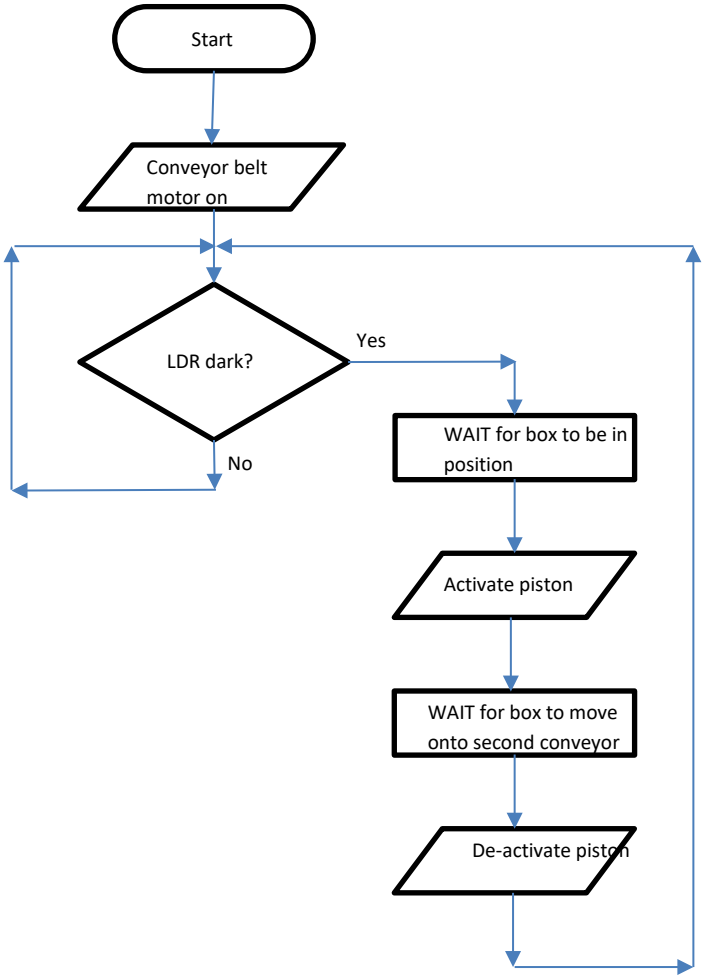
4bi	See below:	**3**	One mark for correctly connecting the legs of the transistor to the resistor, ground and base. One mark for drawing a transistor correctly One mark for completing the internal drawing of the 3/2 valve.

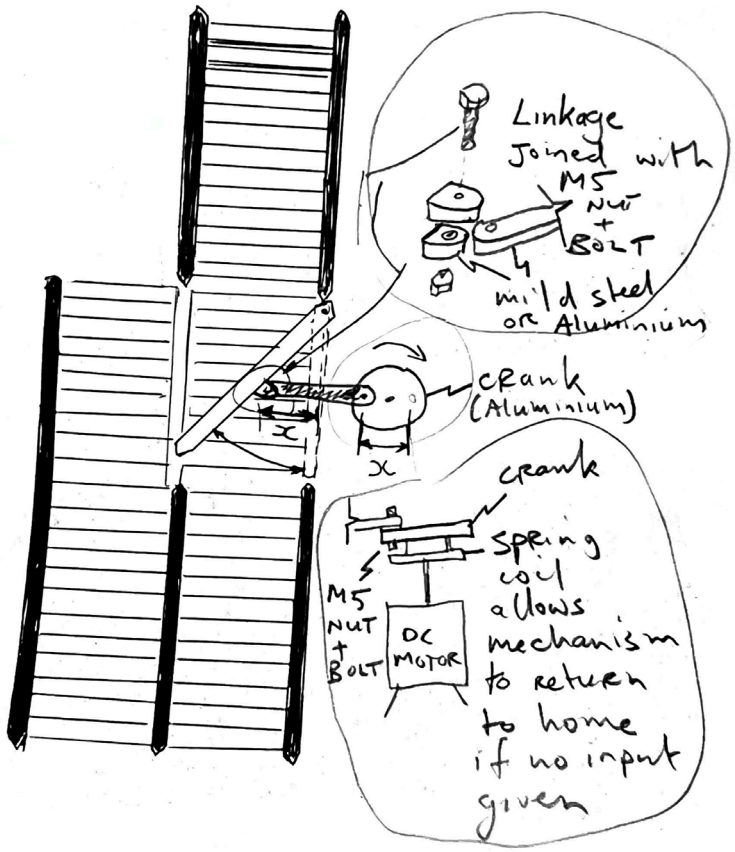


4bii	See examples below:	**5**	One mark for decision box correctly labelled. One mark for activating the piston. One mark for deactivating the piston. One mark for wait commands (both needed).

			One mark for correct arrows and shape of commands e.g parallelogram, rectangle or oval, diamond.





4c	See below:  	**8**	**Level 3 [6-8 marks]** The candidate demonstrates a good level of detail in terms of how an alternative method other than pneumatics or hydraulics could be used to control the paddle in order to move boxes from one conveyor to another. All bullet points are covered. Sketches, if used, will be clear and supported with relevant notes. **Level 2 [3-5 marks]** The candidate demonstrates a sound level of detail in terms of how an alternative method other than pneumatics or hydraulics could be used to control the paddle in order to move boxes from one conveyor to another. At least two of the bullet points are covered. Sketches, if used, will for the most part be clear and supported with notes most of which are relevant. **Level 1 [1-2 marks]** The candidate demonstrates a limited level of detail in terms of how an alternative method other than pneumatics or hydraulics could be used to control the paddle in order to move boxes from one conveyor to another. At least one of the bullet points are covered. Sketches, if used, will be unclear with only basic notes to accompany them. **0 marks** No response or no response worthy of credit.

4d	tan 30* = 0.6 m / x (1) x = 0.6 m/tan 30* x = 0.6/0.577350269 x = 1.03923 m (1) y = x + 1 m (1) y = 2.03923* m tan 30* = t / 2.03923* (1) t = 2.03923* tan 30* t = 1.17735* t = 1.18* m (1)	**5**	One mark for applying correct trigonometry formula to work out x. One mark for calculating x. One mark for adding 1m to x. One mark for applying correct trigonometry formula to work out t. One mark for calculating t in m to 2 decimal places. If correct answer is given without working out shown award full marks. Where an incorrect answer is given working out should be used to credit appropriate marks. *Allow error carried forward (ECF) where correct working out is shown. This is if students have miscalculated X or not added 1m.

5a*	**Indicative Content:** Relative advantages to the manufacturer and the consumer of manufacturing products in smaller factories located in inner cities compared to much larger factories in rural areas may include: • Transport of goods and materials cheaper as retail stores closer to factory in a city. • Consumers (stakeholders) have the potential to have more say in the product if factory is located in a city as its easier to bring stakeholders in for evaluation and testing of final products. • Smaller factories mean less energy used and potentially less pollution. • Having factories more centrally located mean quicker delivery times to outlets. • Because of less space in factories the use of JIT manufacturing will mean a more efficient method of producing products. • Smaller factories can be targeted to produce specific, specialised parts or components rather than an entire product. • Any other valid suggestion.	**8** **For MB3 to be awarded advantages to both key stakeholder groups need to be considered.** **If candidates do not provide an analytical/ evaluative response then only L1 can be awarded.**	**Level 3 [6-8 marks]** The candidate has a clear understanding of the advantages to the manufacturer and the consumer of manufacturing products in smaller factories located in inner cities compared to much larger factories in rural areas. The explanation of advantages is clear and well-developed and a clear attempt has been made to consider the advantages to both key stakeholder groups. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated with the use of examples.* **Level 2 [3-5 marks]** The candidate has a reasonable understanding of the advantages to the manufacturer and/or the consumer of manufacturing products in smaller factories located in inner cities compared to much larger factories in rural areas. The explanation of advantages is sufficient although one or two opportunities are missed in considering the advantages in relation to one of the key stakeholder groups. *There is a line of reasoning presented with some structure. The information presented is for the most part relevant and supported by some evidence.* **Level 1 [1-2 marks]** The candidate has a basic knowledge of manufacturing products in smaller factories located in inner cities compared to much larger factories in rural areas. Any reference to this

			issue is descriptive in nature and has little appreciation of the two key stakeholder groups involved. The response contains no analysis or evaluation. *The information has some relevance and is presented with limited structure or detail. The information is supported by limited evidence.* **0 marks** No answer or answer not worthy of credit.
5b	Possible advantages may include: • Less storage space is needed (1) as you only order the parts to arrive when they are needed to be used (1). • It eliminates any waste as components are only ordered as they are needed (1) which means that there will be no unnecessary parts that need to be stored or thrown out (1). • Any other valid suggestion. Possible disadvantages may include: • If a part is delayed the entire production process will be delayed (1) resulting in late delivery to clients (1). • Because parts are bought in as and when they are needed they are more expensive (1). This is because the advantage of buying in bulk quantities is lost (1). • Any other valid suggestion.	**4**	Up to two marks for explaining an advantage of using a just-in-time system to produce engineered products such as electric cars. Up to two marks for explaining a disadvantage of using a just-in time system to produce engineered products such as electric cars. Mix and match approach to be taken in relation to bullet points.

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