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DESIGN & TECHNOLOGY

0445/42

Paper 4 Systems and Control

October/November 2023

MARK SCHEME

Maximum Mark: 50

Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge International will not enter into discussions about these mark schemes.

Cambridge International is publishing the mark schemes for the October/November 2023 series for most Cambridge IGCSE, Cambridge International A and AS Level components, and some Cambridge O Level components.

This document consists of **15** printed pages.

PUBLISHED**Generic Marking Principles**

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptors for a question. Each question paper and mark scheme will also comply with these marking principles.

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

GENERIC MARKING PRINCIPLE 2:

Marks awarded are always **whole marks** (not half marks, or other fractions).

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

- marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate
- marks are awarded when candidates clearly demonstrate what they know and can do
- marks are not deducted for errors
- marks are not deducted for omissions
- answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.

GENERIC MARKING PRINCIPLE 4:

Rules must be applied consistently, e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.

GENERIC MARKING PRINCIPLE 5:

Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen).

GENERIC MARKING PRINCIPLE 6:

Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind.

Section A

Question	Answer	Marks	Guidance
1(a)	Triangulation is used to: <ul style="list-style-type: none"> • Maintain 90° angles in the frame • Increase rigidity / stability 	1	Award mark for understanding shown. Allow reference to increased strength
1(b)	Benefits of offsite manufacture include: <ul style="list-style-type: none"> • Controlled conditions – weather – lighting – assembly • Speed or ease of assembly • Accuracy of dimensions • Ready access to power – machinery • Individual sections can be tested before moving to site • Less risk of damage to parts. • Easy to replace parts [2 × 1]	2	Allow other valid benefits Do not allow ‘Ease of transport’ or ‘Ease of storage’
1(c)	Drawbacks of concrete: <ul style="list-style-type: none"> • Concrete is weak in tension / bending • Time taken for the concrete to cure • The framework cannot be taken apart • Adds weight • Heavy – difficult to manoeuvre • Not so easy to join • Slow to assemble parts. 	1	Do not allow cost related drawbacks Reasons for weakness must be qualified

Question	Answer	Marks	Guidance
2	<p>Items of PPE will include:</p> <ul style="list-style-type: none"> • Hard hat • visors / face shield / goggles • Safety boots • High visibility clothing • Dust mask / respirator • Ear defenders • Gloves <p>[2 × 1]</p>	2	Allow other valid items.

Question	Answer	Marks	Guidance
3	<p>Description to include: Static load is that placed on a structure which does not move [1] Suitable example named [1]</p>	2	

Question	Answer	Marks	Guidance
4	<p>Sketch of third order lever – shovels, fishing rods, human arms and legs, springboard in a pool, tweezers, and ice tongs. [1] Correct name given to example. [1]</p>	2	

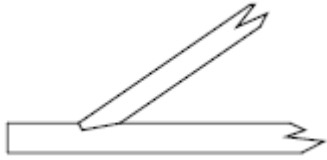
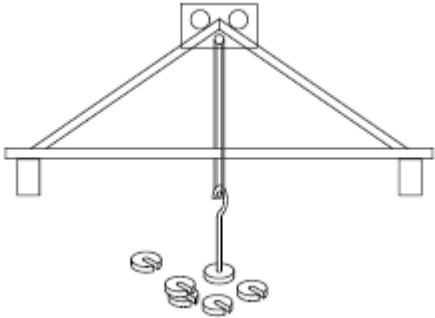
Question	Answer	Marks	Guidance
5(a)	Parallel linkage [1].	1	
5(b)	Explanation should include: <ul style="list-style-type: none"> As the bucket / container moves up it will stay parallel to the ground Any liquid contents will not spill out. Solids being lifted will not tip. Increased visibility for truck operator. 	2	Explanation with two points made, [2]. Allow 2 marks for a single fully justified point.
5(c)	Types of linkage shown could include: <ul style="list-style-type: none"> Crank and slider Crank and piston Bell crank linkage 'Z' bar linkage Clear sketch [1] notes to indicate how it works [1]	2	Allow any recognised form of linkage apart from parallel motion.

Question	Answer	Marks	Guidance
6	Reciprocating motion [1] is converted to rotary motion [1]	2	

Question	Answer	Marks	Guidance
7(a)	<p>R_1 is a fixed resistor, VR_1 is a variable resistor Tr_1 is a transistor</p> <p>[3 × 1]</p>	3	<p>Allow NPN for transistor</p> <p>Allow Rheostat for Variable</p>
7(b)	<p>M = Mega, 1 000 000 (10^6) larger than base unit. n = nano 1 / 1 000 000 000 (10^{-9}) × base unit μ = micro 1 / 1 000 000 (10^{-6}) × base unit</p> <p>[3 × 1]</p>	3	Allow marks for either the full name given or the multiple / sub-multiple value.

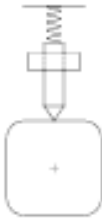
Question	Answer	Marks	Guidance
8	<p>Sketches to indicate use of a magnet to operate switch [1] Notes giving indication of contacts opening / closing when magnet is near to switch. [1]</p>	2	

Section B

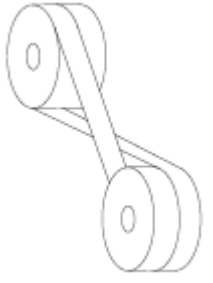
Question	Answer	Marks	Guidance
9(a)(i)	Tension	1	
9(a)(ii)	Joints X and Y are likely to slide [1], horizontally away from each other [1] Caused by shear force [1]	2	Award marks for understanding shown.
9(a)(iii)	 <p>Joints prevented from sliding [1], no extra materials used [1] notes to indicate how the method will work [1]</p>	3	Allow any mechanical method of combining the two pieces which prevents movement, reducing tension on the glued joint.
9(a)(iv)	<p>Test rig must:</p> <ul style="list-style-type: none"> • Allow weights to hang from the apex [1] • Provide support under joints X and Y for the model [1] • Allow extra weights to be easily added [1] 	3	
9(a)(v)	Static load could be roof covering, roofing timbers bearing on the truss [1] Moving load could be person walking on the roof, weather related – wind / snow / rain [1]	2	Allow birds as moving load

Question	Answer	Marks	Guidance
9(b)(i)	Advantages of the scissor lift: <ul style="list-style-type: none"> • More stable • Larger base surface area • More people can have access to work area • Can carry greater load • Less chance of joints breaking • Larger working area when lift is raised. [2 × 1]	2	Accept any valid alternative. Accept safety related advantages
9(b)(ii)	Disadvantage could relate to: <ul style="list-style-type: none"> • Difficulty of access to building with the equipment • More limited height and reach • Takes longer to manoeuvre to a different work position 	1	Accept any valid alternative
9(b)(iii)	The designer and manufacturer of the equipment will be responsible for initial safety of the equipment. Construction company will be responsible for implementing the safety precautions. 1 mark for identified person / company.	1	
9(b)(iv)	Features assessed will include: <ul style="list-style-type: none"> • Height to be reached • Extension length • Angle of lifting arm • Load to be carried • Prevention of wheeled items moving • Prevention of tipping sideways • Barriers to prevent falling. 	3	1 mark for each point included up to three. Allow 2 marks for a single point described in depth.

Question	Answer	Marks	Guidance
9(c)(i)	Clockwise moment = $(1 \times 100) + (2 \times 250 \text{ N})$, [1] = $100 + 500$ [1] = 600 Nm [1]	3	3 marks for correct answer with no working.
9(c)(ii)	$3 \times X = 600$ [1] $X = \mathbf{200 \text{ N}}$ [1]	2	
9(c)(iii)	With beam in equilibrium reaction at $R_1 = \mathbf{0}$ [1] reaction at $R_2 = \mathbf{0}$ [1]	2	Allow equal reactions 1 mark for anything other than 0.

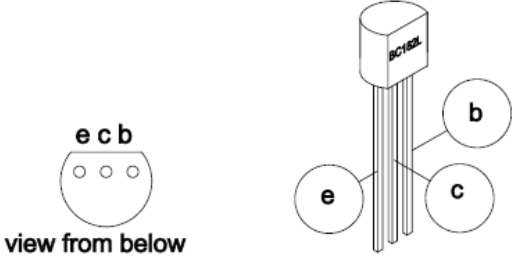
Question	Answer	Marks	Guidance
10(a)(i)	 <p>Square cam drawn [1] suitable proportions [1]</p>	2	
10(a)(ii)	The spring ensures that the follower is always touching the cam.	1	Allow mark for understanding shown.

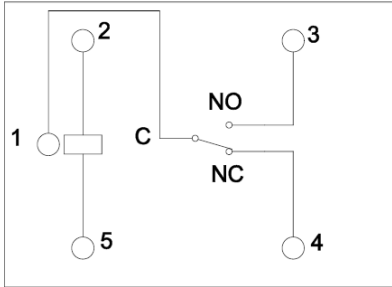
Question	Answer	Marks	Guidance
10(a)(iii)	Mechanical property of nylon: <ul style="list-style-type: none"> • Efficient bearing material • Self-lubricating • Does not corrode / durable • Ease of batch production – can be moulded Electrical property: <ul style="list-style-type: none"> • It is an insulator. [2 × 1]	2	Do not accept cost related properties
10(b)(i)	Linear motion is converted to rotary motion	2	
10(b)(ii)	Plain bearings: <ul style="list-style-type: none"> • Are a plain surface • Reduces friction • With no rolling elements • They allow rotation between two parts 	2	1 mark for each point mentioned in explanation, up to 2 marks.
10(b)(iii)	Factors will include: <ul style="list-style-type: none"> • Adjustment of the plain bearing • Any additional lubrication added to bearing surfaces • Speed with which the string is pulled • Length of string wrapped around the spindle • Diameter / mass of rotor. [2 × 1]	2	Allow other valid points.

Question	Answer	Marks	Guidance
10(c)(i)	Advantages of the vee belt include: <ul style="list-style-type: none"> • Larger section so less likely to stretch • Vee belt will provide more grip when it is pulled into the vee of the pulley • Less likely to slip than a flat belt • Precise torque transfer between pulleys • Durable • Quieter when operating. [2 × 1]	2	Allow other valid advantages
10(c)(ii)	Flat belt will be crossed over to reverse direction 	1	
10(c)(iii)	Explanation to include: The thickness of the vee belt does not allow it to bend backwards [1] The outer surface of the vee would be next to the pulley [1]	2	Award marks for understanding shown in explanation.
10(c)(iv)	Sketches and notes to indicate: <ul style="list-style-type: none"> • Idler wheel pressed against the vee belt [1] • Method of adjusting the idler wheel [1] • Position of two pulleys is not altered [1] 	3	

Question	Answer	Marks	Guidance
10(d)(i)	Distance moved by thread in 1 revolution = 1.75 mm Distance moved by handle = $\pi \times 2 \times 250 = 1571$ [1] VR = $1571 / 1.75 = 897.6$, [1]	2	Allow rounding errors in calculation.
10(d)(ii)	Loss of efficiency will be due to: <ul style="list-style-type: none"> • Friction in the jack components • Heat • Sound 	1	Allow mark for understanding shown.
10(d)(iii)	Effort = load / VR [1] = $5000 / 897.6$ [1] = 5.57 N [1] Alternative method – (load \times pitch) / effort distance [1] = $(5000 \times .00175) / (\pi \times 2 \times 250)$ [1] = 5.57 N [1]	3	Allow ecf from (d)(i)

Question	Answer	Marks	Guidance
11(a)(i)	Emitter to 0 V connection added [1]	1	
11(a)(ii)	To amplify the current coming from the LDR and VR potential divider [1] When the current is large enough the lamp L1 will switch on [1] The current increases with light level increase. [1] [2 \times 1]	2	

Question	Answer	Marks	Guidance
11(a)(iii)	 <p>view from below</p>	2	1 leg correct, 1 mark 2 or 3 legs correct 2 marks
11(b)(i)	Parallel connection is used to ensure that if one lamp fails they do not all go out.	1	
11(b)(ii)	<p>In a single lamp using $P / V = V / R$ $21 / 12 = 12 / R$ [1] $R = (12 \times 12) / 21$ [1] $R = 6.86 \Omega$ [1]</p>	3	If the answer is correct with no working award 3 marks.
11(b)(iii)	Single Pole Double Throw	1	All words must be correct.
11(b)(iv)	<p>Benefits of a relay include:</p> <ul style="list-style-type: none"> • Isolation of two parts of a circuit • High current can flow in the output side • Can be used in latch circuits • Different voltages can be used for input and output of circuit • The switching circuit will draw much lower current. <p>[2 × 1]</p>	2	AOVR

Question	Answer	Marks	Guidance
11(b)(v)	 <p style="text-align: center;">view from below</p>	3	Both coil connections correct [1] Pin 1 to common [1] Pin 3 to NO Pin 4 to NC [1]
11(b)(vi)	Filament lamps are being replaced by LEDs because: <ul style="list-style-type: none"> • LEDs last longer • Lower cost • Smaller and lighter • Low energy consumption • More efficient 	1	AOVR
11(c)(i)	<ul style="list-style-type: none"> • If the inverting input (–) is greater than the non-inverting input (+) the output will be at 0 V [1] • If the non-inverting input (+) is greater than the inverting input (–) the output will be at supply voltage. [1] • Correct reference to ‘inverting’ and ‘non-inverting’. [1] 	3	
11(c)(ii)	Pins 1, 5, 8 will not be used in a comparator circuit. 1 mark for each pin correctly identified [3 × 1]	3	
11(d)(i)	Any device which uses a coil can produce back emf, e.g. motor.	1	
11(d)(ii)	Sketch must include a diode [1] connected in reverse bias with cathode to positive [1]	2	