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DESIGN AND TECHNOLOGY **0445/41**

Paper 4 Systems and Control **October/November 2017**

MARK SCHEME

Maximum Mark: 50

Published

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

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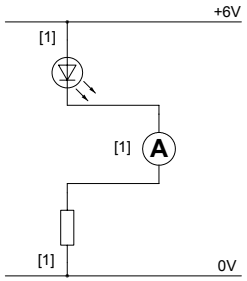
Question	Answer	Marks	Guidance
1(a)	<table><tr><th></th><th>Type</th><th>Action</th><th>Contact arrangement</th></tr><tr><td>Switch **A**</td><td>**toggle switch**</td><td>on / off</td><td>SPDT</td></tr><tr><td>Switch **B**</td><td>push switch</td><td>**PTB**</td><td>SPST</td></tr><tr><td>Switch **C**</td><td>push switch</td><td>PTM</td><td>**SPST**</td></tr></table> 1 mark for each correct.	**3**	
1(b)	Circle should be around **6**.	**1**	

Question	Answer	Marks	Guidance
2	LED Anode to +6 V, 1 mark Ammeter connected in series (could be above LED or below resistor), 1 mark Resistor connected to 0 V, 1 mark. 	**3**	Other combinations of connection are possible but LED anode has to be connected to +6V either directly or below ammeter.

Question	Answer	Marks	Guidance
3	Advantages of transistor switch could be: Fast switching No contact bounce / no moving parts Low cost Not manually operated Low failure rate Smaller than a mechanical switch 1 mark for each valid advantage	**2**	Allow other valid advantages. E.g. low current used to switch a higher current.

Question	Answer	Marks	Guidance
4(a)	**Oscillating** to **Oscillating** movement, 1 mark for each term.	**2**	
4(b)	**Second order** or **class 2** lever.	**1**	
4(c)	The gear [1] transmits motion by meshing with the holes in lever [1]	**2**	Allow marks for understanding shown.

Question	Answer	Marks	Guidance
5	Any suitable third order lever, e.g. tweezers [1]. Position of effort shown between load and fulcrum, 1 mark each for **L E F** correctly positioned, 3 · 1 mark	**4**	

Question	Answer	Marks	Guidance
6	Any natural frame structure, 1 mark	**1**	No marks for man-made structures

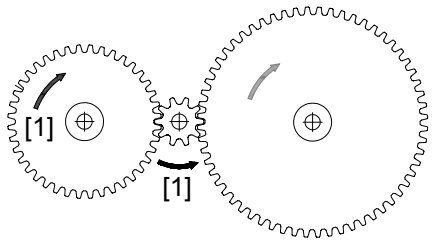
Question	Answer	Marks	Guidance
7	Any natural shell structure, 1 mark	**1**	No marks for man-made structures

Question	Answer	Marks	Guidance
8	Gusset, brace or tie used 1 mark. Correct position, e.g. tie used above joint, brace below joint, gusset either above or below joint, 1 mark. Clear sketches / notes to show fixing method / how the reinforcement would work, 1 mark.	**3**	

Question	Answer	Marks	Guidance
9	Description could relate to: clockwise moment = anticlockwise moment, opposing forces being equal or a state of balance, 1 mark Stability or no movement, 1 mark	**2**	

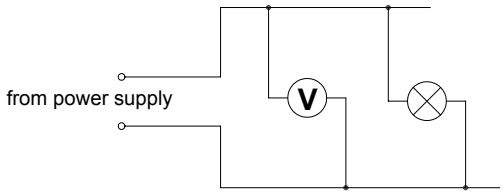
Question	Answer	Marks	Guidance
10(a)	Part .....**A**..... is a strut, which is placed there to resist **compression** Part .....**B**..... is a tie which will resist **tension** When the roof covering is added part **C** will have to resist a **bending** force.	**5**	1 mark for each term correctly placed
10(b)(i)	Elastic deformation allows the material to go back to its original shape / length [1] after the loading is removed [1]	**2**	Allow 1 mark for some understanding shown.
10(b)(ii)	Elastic limit is the maximum that a material can be stretched [1] without any permanent change to its shape / length [1].	**2**	Allow 1 mark for some understanding shown.

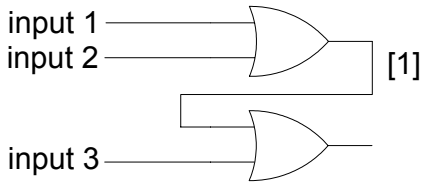
Question	Answer	Marks	Guidance
10(b)(iii)	Plastic deformation is permanent deformation of the material [1] without any fracture occurring [1].	**2**	Allow 1 mark for some understanding shown.
10(c)(i)	**3** / **three** cables is the minimum, 1 mark.	**1**	
10(c)(ii)	Functional method [1] Adjustment possible [1] Clear understandable sketch / notes [1].	**3**	
10(c)(iii)	**Shear** force, 1 mark.	**1**	
10(c)(iv)	$(0.9 \cdot \mathbf{X}) + (0.45 \cdot 25) = 2.55 \cdot 125$, 1 mark $0.9\mathbf{X} + 11.25 = 318.75$, 1 mark $X = (318.75 - 11.25) / 0.9$, 1 mark **X = 341.66 N**, 1 mark	**4**	Award 4 marks for correct answer with no working.
10(d)	Static loads are those that do not change [1] made up of construction materials used in the building of the bridge [1] Dynamic loads are changing values [1] made up of vehicles, pedestrians, animals or the loading caused by changing weather conditions. [1]	**4**	For changing weather conditions allow: High winds, snow, heavy rain, earthquake. For static loads allow any item described as stationary.
10(e)	Reasons for using aluminium honeycomb could include: Low weight / high strength Resistance to twisting / torsion Moisture and corrosion resistance High thermal conductivity	**1**	Do not allow marks for ‘strong’ with no justification

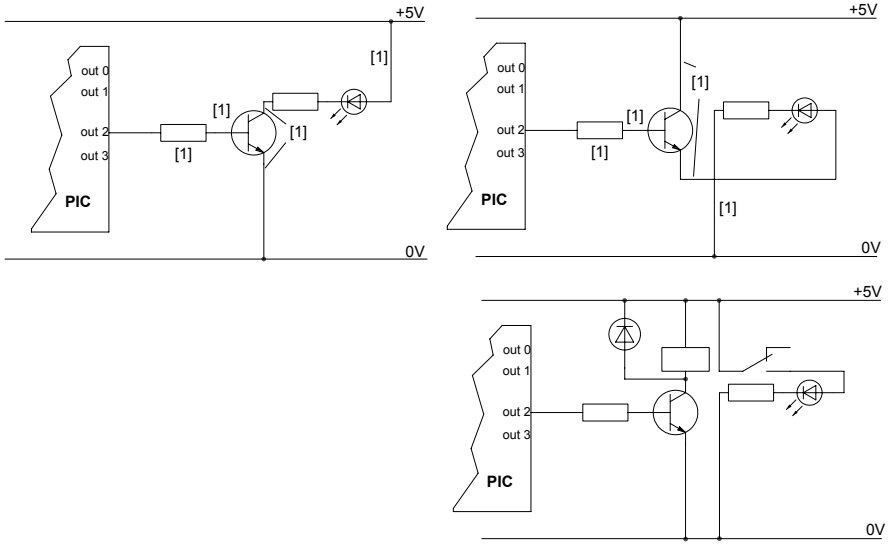
Question	Answer	Marks	Guidance
11(a)	<table><tr><th>Power Source</th><th>Safety Device</th></tr><tr><td>mains electricity</td><td>residual current device RCD</td></tr><tr><td>natural gas</td><td>solenoid valve</td></tr><tr><td>low voltage electricity</td><td>fuse</td></tr><tr><td>compressed air</td><td>regulator</td></tr></table>	**3**	1 mark for each correct.
11(b)(i)	The driven pulley will turn anti-clockwise, 1 mark, The speed of the driven pulley will be slower than the driver, 1 mark.	**2**	
11(b)(ii)	 1 mark for each arrow correct, 2 · 1 marks.	**2**	Arrows may be in different positions on the drawing.
11(b)(iii)	Benefits of a belt drive could include: Pulley position is not so critical Belt can slip to save damage if a shaft is jammed Lower initial cost and replacement belt cost than gears Can be quieter in operation than gears No lubrication required. 2 · 1 marks for valid benefits	**2**	Allow other valid benefits

Question	Answer	Marks	Guidance
11(b)(iv)	Explanation should include: Frictional losses Energy lost in generation of heat and sound Poorly fitting parts Materials that cause losses e.g. belts that stretch or slip on initial start-up. 3 · 1 marks for each point in explanation.	**3**	Clear explanation with at least two points included, one point being well explained[3] Explanation with up to three points mentioned but no links to consequence of the cause of energy loss , [2] Award two marks for one point well explained. Single point mentioned, [1]
11(c)(i)	**Bevel gear**, 1 mark	**1**	
11(c)(ii)	Reasons will include: It can change the direction of the drive through 90° Positive drive with no chance of slipping Suited to large difference in 1number of teeth on the two gears. 2 · 1 marks.	**2**	Allow other valid reasons e.g. increased speed of driven gear.
11(c)(iii)	**12:56** or **6:28** or **3:14** or **1:4.67** Correct numbers 1 mark, correct way around, 1 mark.	**2**	
11(c)(iv)	Speed of chuck = **(56 / 12)** · **60**, 1 mark = **280 rpm**, 1 mark	**2**	2 marks for correct answer with no working.

Question	Answer	Marks	Guidance
11(c)(v)	Problems with plain bearings include: Shorter working life than other types of bearing Replacement may not be possible Not as precise a fit in many cases Lubrication will be required; other types can be sealed for life. More friction / heat is generated 1 mark for valid answer.	**1**	
11(c)(vi)	The ball bearing absorbs the thrust from the end of the shaft, [1] when the drill bit is pressed onto the work. [1] Friction at the end of the shaft is reduced [1].	**2**	Explanation with two points included [2] Explanation with a single point included [1] Allow 2 marks for one point fully explained.
11(d)	Mechanical advantage of the first lever is 800 / 75 = **10.66** Mechanical advantage of the second lever is 40 / 220 = **0.18** Combined advantage is 10.66 · 0.18 = **1.94**	**3**	3 marks for correct answer with no working.

Question	Answer	Marks	Guidance
12(a)(i)	1 mark for both voltmeter connections correct.  	**1**	
12(a)(ii)	Current calculation 1 mark for 9.5 / 60 = **0.16 A** or **158 mA**, 1 mark	**2**	.

Question	Answer	Marks	Guidance
12(a)(iii)	Power calculation P = 9.5 · 0.158, 1 mark =**1.5 W**, 1 mark.	**2**	Allow ecf on value of current
12(b)(i)	Reasons for tinning will include: Prevent oxide formation on the copper track / pads Make soldering easier / solder adheres better to a tinned surface Better chance of a successful joint. 2 · 1 marks	**2**	
12(b)(ii)	Stages could include: Putting notch next to pin 1 on board Aligning all pins with holes Checking that no pins are folded under the holder Bending pins on track side to keep IC holder in place Application of soldering iron to both pin and pad 3 · 1 marks for valid stages	**3**	
12(b)(iii)	Notes and sketches to show board inverted and supported under resistor [1] Joint heated with soldering iron[1] Pressure applied to push resistor down[1].	**3**	Allow use of desoldering tool rather than soldering iron.
12(c)(i)	Output of one gate to an input of the other, 1 mark  	**1**	Other arrangements are possible but all must have an output connected to an input.
12(c)(ii)	Labels correct for 3 inputs, 1 mark.	**1**	

Question	Answer	Marks	Guidance
12(d)(i)	<table><tr><th colspan="2">Sequence of lights on</th><th colspan="4">Logic level of outputs</th></tr><tr><th>set 1</th><th>set 2</th><th>out 0</th><th>out 1</th><th>out 2</th><th>out 3</th></tr><tr><td>red</td><td>green</td><td>0</td><td>1</td><td>1</td><td>0</td></tr><tr><td>red</td><td>red</td><td>1</td><td>0</td><td>1</td><td>0</td></tr><tr><td>green</td><td>red</td><td>1</td><td>0</td><td>0</td><td>1</td></tr><tr><td>red</td><td>red</td><td>1</td><td>0</td><td>1</td><td>0</td></tr></table> 1 mark for each correct row, 3 · 1 marks.	**3**	
12(d)(ii)		**4**	Connections must be all correct for 4 marks. Allow marks for using a relay, 4 marks from Current limiting resistor Relay coil connected correctly diode connected in reverse bias Transistor connections correct LED connected correctly through relay contacts.

Question	Answer	Marks	Guidance
12(d)(iii)	Explanation could include: Ease of changing delays Ease of changing sequence during development Higher number of usable inputs and outputs Sequence can easily be changed after manufacture Low cost of PIC compared to discrete components Circuit will be less complicated / fewer components Additional features can be built in. 3 · 1 marks for each point used. Allow 2 marks for one point well explained.	**3**	Allow other valid points in explanation