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	FOR OFFICIAL USE					
	National					
	Qualificat	ions			Marl	ĸ
	2016					
X723/76/01				Engine	ering S	cience
WEDNESDAY, 11 MAY						
9:00 AM - 11:00 AM				 *	× 7 2 3 7	7 6 0 1 *
Fill in these boxes and rea	d what is printe	d below.				
Full name of centre			Town			
Forename(s)	Surr	name			Number	of seat
Date of birth						
Day Month	Year	Scottish ca	andidate	e number		
Total marks — 90						
SECTION 1 — 20 marks						
Attempt ALL questions.						
Attempt ALL guestions.						
Show all working and units	s where appropr	iate.				
The number of significant	figures express	ed in a final	answer	should be e	equivalent t	o the least
figure than this will be acc	epted.	on. Answers	that ha	ive two mo	re figures c	or one less
Reference may be made to	the Engineering	g Science High	ner Data	a Booklet.		
Write your answers clearly	in the spaces pr	rovided in this	s bookle	et. Addition	al space for	answers is
provided at the end of the		ase uns spa	ce you i	must cicarly	activity th	e question
number you are attempting	g.					

Invigilator; if you do not, you may lose all the marks for this paper.





SECTION 1 — 20 marks Attempt ALL questions

1. The motor driver circuit shown below is used to switch a motor on and off.



(a) Calculate the resistance of the motor.Show all working and final unit.

2

MARKS DO NOT WRITE IN THIS MARGIN

When the circuit is switched on, the resistance of the MOSFET is 0.5Ω .

(b) Calculate the MOSFET drain current.Show all working and final unit.

2











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3. A logic circuit for an industrial press is shown below.



- (a) Write a Boolean expression for the logic circuit above.
- (b) Complete the truth table below for the logic circuit. Include the intermediate logic values for D and E.

А	В	С	D	E	Z
0	0	0			
0	0	1			
0	1	0			
0	1	1			
1	0	0			
1	0	1			
1	1	0			
1	1	1			

3

3

[Turn over



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4. Flat pack furniture and other items are to be stored on shelving in a home improvement store. The shelving must be designed to support both point loads and uniform distributed loads.



A simplified free body diagram of the forces expected on one shelf is shown below.



Calculate the reaction force R_B .



3



Γ			MARKS	DO NOT WRITE IN
	5.	A manufacturer uses bearings to locate motorcycle wheels.		THIS MARGIN
		Explain two functions of bearings.	2	
		Function 1	-	
			-	
		Function 2	-	
			-	
		[END OF SECTION 1]		
		[Turn over	-	







5 .	(cor	ntinued)		TH
	(a)	Describe, using appropriate terminology, the operation of the pneumatic circuit.	8	
		[Turn over		
				I

6.	(cor	ntinued)		WRITE THIS MARG
0.	(b)	Describe two modifications that would allow the pneumatics to be controlled electronically. Modification 1	2	
		Modification 2		
	A nu brid	umber of different engineers would be involved in implementation of the ge project, from design through to completion.		
	(c)	Describe two examples of specialist skills and one example of specialist knowledge that a mechanical engineer would use.	3	
		Knowledge		

6	(co)	atioud)	MARKS	DO NOT WRITE IN THIS MARGIN
0.	(d)	Describe the role of one other type of engineer who may be involved in the implementation of the bridge.	2	
		[Turn over		



7. A theatre company requires part of the scenery of their latest play to be raised and lowered by means of an electric winch. The winch has to be controlled by a microcontroller.

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An outline diagram of the scenery system is shown below.





7. (continued)

Relays are energised when either an Up switch or a Down switch has been activated and a Master switch has also been activated.

The limit switches are used to detect the upper and lower positions of the scenery.

The winch is operated by Relay A and Relay B.

When Relay A is energised the scenery should rise, when Relay B is energised it should lower.

If neither relay is energised, the winch motor should switch off.

Note: the relays are never energised together. The system should run continuously.

The relevant microcontroller connections are shown in the table below.

Inputs	pins	Outputs
	7	Relay A (raise)
	6	Relay B (lower)
	5	
Upper limit switch	4	
Lower limit switch	3	
Down switch	2	
Up switch	1	
Master switch	0	

[Turn over

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7. (continu	ied)	MARKS	DO NO WRITE THIS MARG
The ele compon	ectronic engineer used a second microcontroller and interfacing ents to design a scenery anti–locking braking system.	5	
• A b • The	rake sensor produces a signal when the brake is applied. I brake actuator turns on the hydraulic braking system.		
(b) Cor bra	nplete the three missing parts for the control diagram of the scenery king system shown below.	3	
Desire brakin	d g micro- controller Brake		
An Elect scenery	tronic and Electrical engineer would be involved in the design of the system.	2	
(c) (i)	Describe two examples of specialist knowledge that an Electronic and Electrical engineer would have.	2	
	Knowledge 1	-	
	Knowledge 2	-	
(ii)	Describe two examples of specialist skills that an Electronic and Electrical engineer would use.	2	
	Skill 1	-	
	Skill 2	-	
		-	

MARKS DO NOT WRITE IN THIS MARGIN

3

4

8. A garage shutter door can be operated via a remote control (R) or a push-button (P). Neither will operate if a main switch (M) is turned off.

INPUTS	OUTPUT
R (= 1 when the remote control is operated)	Z (= 1 to operate the garage door)
M (= 1 when the main switch is on)	
P (= 1 when the push-button is operated)	

The logic diagram below shows the control of the garage shutter door.



- (a) Write a Boolean expression for the logic diagram above.
 - <u>Z</u> =
- (b) Using only two-input NAND gates, draw a logic system equivalent to the logic system shown above. Simplify if appropriate.







8. (continued)

An engineer is to design a bracket to hold the drum mechanism and shutter.

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The tensile strength of three newly developed materials A, B and C has been tested and the results are shown on the Load-Extension graph below.



(d) Describe the properties of materials A, B and C in relation to each other. 4





8. (continued)

During a tensile test, a 100 mm long cylindrical sample of material A stretched by 0.7 mm. The sample had a diameter of 15 mm and a Young's Modulus of 202 kN mm⁻².

(e) Calculate the load applied to the sample piece.

Show all working and final unit.

The drum mechanism uses a mineral based lubricant to reduce friction. The crude oil based lubricant in the mechanism is to be replaced with a vegetable based lubricant.

(f) Describe **two** environmental and **one** economic effect of this decision.

3

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4

THIS

Environmental effect 1 _____

Environmental effect 2

Economic effect _____



[Turn over

9. A sports centre is building a retractable roof over a synthetic pitch.



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The diagram below shows a sketch for the proposed retractable roof.



The roof will open and close depending on the amount of rain that is falling. Part of the input sensing circuit is shown below.







9. (b) (continued)
(iii) Sketch a suitable op-amp circuit diagram showing appropriate resistor values. 2



MARKS DO NOT WRITE IN THIS MARGIN (continued) 9. A second op-amp circuit is required to condition the signal from +4V to +2V. (c) Sketch a circuit diagram below, showing appropriate resistor values. 3 The roof motor is supplied with 230 V, 3 A. The motor provides a torque of 18.6 Nm at a speed of 300 revs min⁻¹. Two motors are positioned symmetrically to open and close the roof. 3 (d) Calculate the efficiency of the roof motor.



9. (continued)

(e) The free body diagram for a pin-jointed frame is shown below for the end support of the roof.

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8



Member BC is a 1.1 kN strut.

Calculate, using **nodal analysis**, the magnitude and nature of the force in beams AB, AC, BD.

Show all working and final units.

[END OF QUESTION PAPER]



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ADDITIONAL SPACE FOR ANSWERS



ADDITIONAL SPACE FOR ANSWERS



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