2011 Technological Studies

Higher

Finalised Marking Instructions

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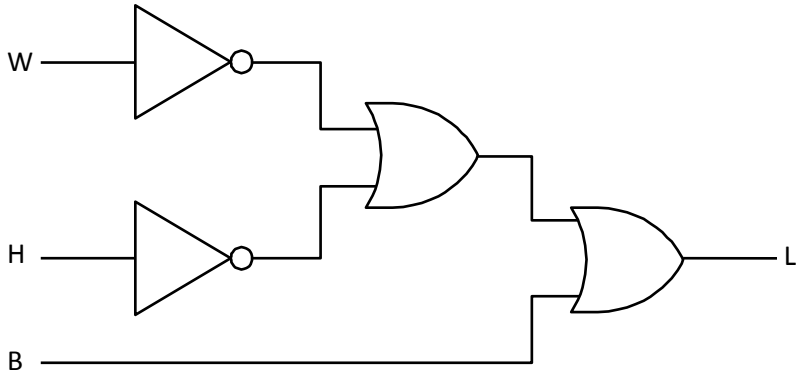
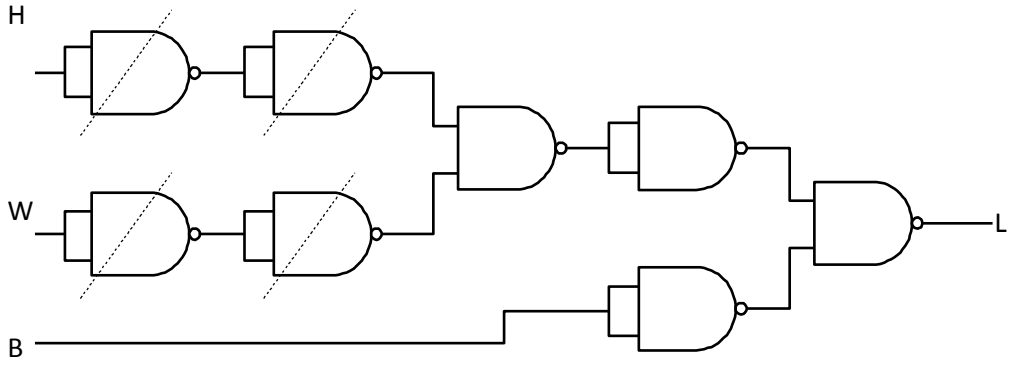
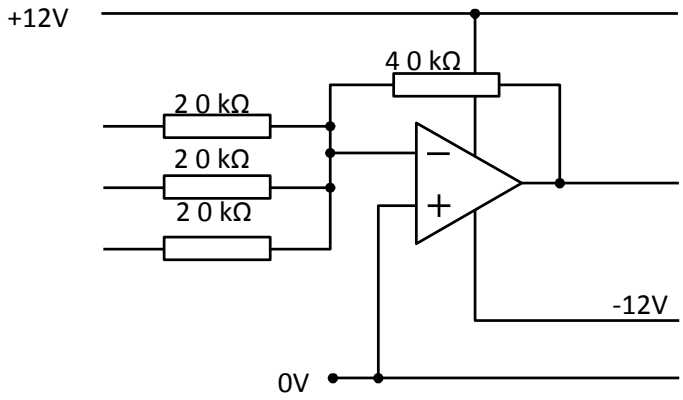
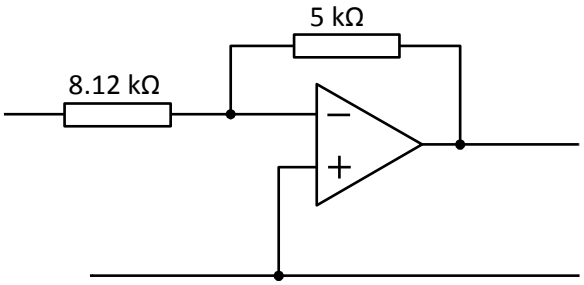
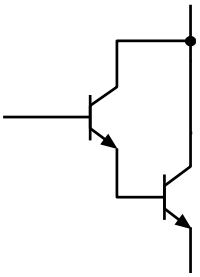
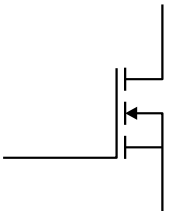
Section A

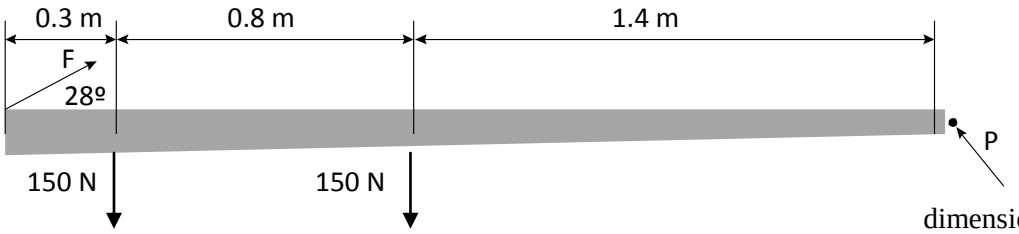
Question		*Mark Allocation*	*Marks*	
1.	**(a)**	<table><tr><td>W</td><td>H</td><td>L</td></tr><tr><td>0</td><td>0</td><td>1</td></tr><tr><td>0</td><td>1</td><td>1</td></tr><tr><td>1</td><td>0</td><td>1</td></tr><tr><td>1</td><td>1</td><td>0</td></tr></table> Correct truth table; no half marks		**1**
	(b)	NAND no half marks		**1**
	(c)	$L = \overline{W} + \overline{\mathbf{H}} + \mathbf{B}$ 3@ ½ for each correct input; ½ for OR		**2**
		Alternative answer – $\overline{L} = W \,.\, \mathbf{H} \,.\, \overline{\mathbf{B}}$ 3 @ ½ for each correct input; ½ for AND		
	(d)	 ½ mark for each NOT gate and its input connections ½ mark for each OR gate and its input connections	1 1	**2**
	(e)	 NOT equivalents and correct input connections ½ for each OR equivalent and correct input connections cancellation of redundant gates	½ 1 ½	**2** **(8)**

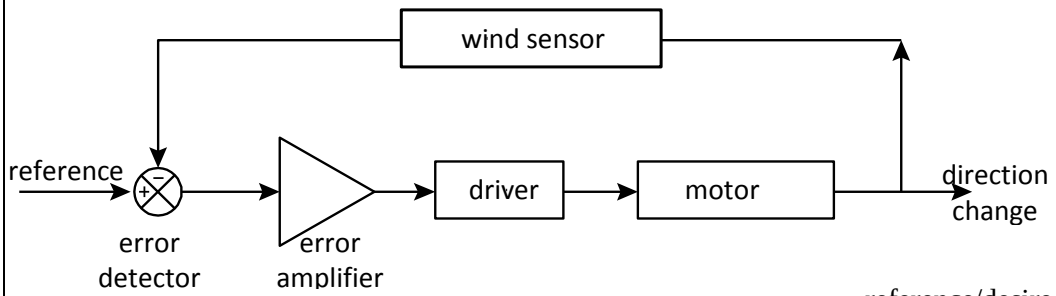
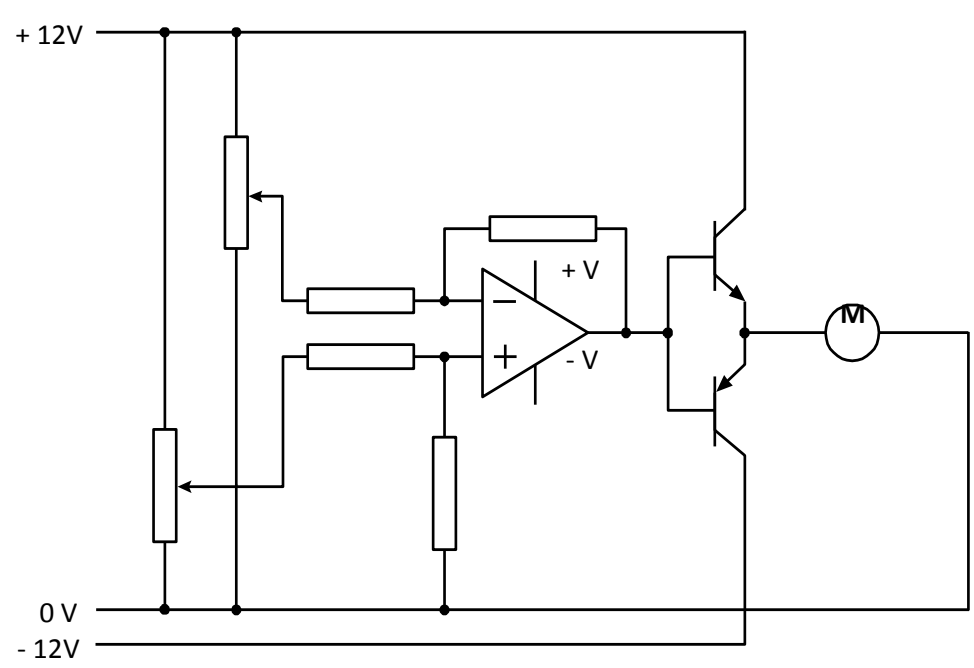
Question		*Mark Allocation*	*Marks*	
2.	**(a)**	Thermistor resistance @ 16ºC = 80 kΩ (accept 78 – 82 kΩ) (from Data Booklet)	½	
		R/80 = 4.8/1.2 formula, stated or implicit	½	
		R = 80 × 4.8/1.2 calculation	½	
		= 320 kΩ answer including unit	½	**2**
	(b)			
		correct summing amplifier configuration	½	
		correct supply connections and resistors in correct places	½	**1**
	(c)	Thermistor resistance @ 10ºC = 100 kΩ (from Data Booklet)	½	
		V/6 = 100/420		
		V = 6 × 100/420		
		= 1.43 V answer (unit not req)	½	
		V_{out} = -Rf (Va/Ra + Va/Rb + Vb/Rc) formula, stated or implicit	½	
		= -40 (1.43/20 + 1.43/20 + 1.2/20) substitution of values ½ for **two** 1.43, ½ for 1.2	1	
		= -8.12 V correct answer including unit	½	**3**
	(d)	Gain = 5/8.12 = 0.62	½	
		Inverting amplifier diagram	½	
		R_f = 5 kΩ, R_i = 8.12 kΩ (or other suitable pair – in the kΩ range)	½	
		Resistors values correct way round.	½	
				
				2
				(8)

Question		*Mark Allocation*		*Marks*	
3.	**(a)**	$\Sigma Fv = 0$			
		$R_V = 400\cos10 - 200\cos50$	2 components @ ½ each	1	
		$= 265$ N	answer (unit not required)	½	
		$\Sigma F_H = 0$			
		$R_H = 200\cos40 - 400\cos80$	2components @ ½ each	1	
		$= 84$ N	answer (unit not required)	½	
		$R = \sqrt{(265^2 + 84^2)}$	substitution	½	
		$= 278$ N	answer including unit	½	
		$\theta = \tan^{-1}(265/84)$	substitution	½	
		$= 72.4^o$	answer including unit	½	**5**
	(b)	$A = 314$ mm^2	answer (unit not required)	½	
		$\sigma = F/A$			
		$= 400/314$			
		$= 1.27$ N/mm^2	answer (unit not required)	½	
		$E = 0.9 \times 10^3$ N/mm^2	from Data Booklet	½	
		$\varepsilon = \sigma/E$			
		$\varepsilon = 1.27/0.9 \times 10^3$			
		$= 0.00141$	answer no unit	½	
		$\Delta l = \varepsilon \times l$			
		$\Delta l = 0.00141 \times 20 \times 10^3$	substitution	½	
		$\Delta l = 28.2$mm	answer including unit	½	**3**
					(8)

Question			Mark Allocation		Marks	
4.	**(a)**		$R = V/I = (12 - 0.7)/(3 \times 10^{-3})$ $= 3.77\ k\Omega$	substitution answer including unit	½ ½	**1**
	(b)		$Ic = P/V$ $= 20/12$ $= 1.67\ A$	answer, unit not required	½	
			$Ic_{max} = 1.67 \times 5 = 8.35A$	answer, unit not required	½	
			$h_{FE} = I_c/I_b$ $= 8{\cdot}35/(3 \times 10^{-3})$ $= 2780$	substitution answer, **no** unit	½ ½	**2**
	(c)	**(i)**		two npn transistors connections	½ ½	**1**
		(ii)	$R = V/I = 12 - 1.4/3 \times 10^{-3}$ $= 3.53$ **kΩ**	substitution answer including unit	½ ½	**1**
	(d)			symbol no half marks		**1**
	(e)		Draws negligible or no current from the logic circuit. No 'base' resistor required. Can provide high output current. Has high switching speed. Low power consumption.	any 2 @ ½		**1** **(7)**

Question		*Mark Allocation*	*Marks*	
5.	**(a)**	• Tests if window is open.	½	
		• If open, motor off and returns, if not motor ON.	½	
		• Test every 1ms if window is open.	½	
		• Repeats 500 times and stops motor.	½	**2**
	(b)	main: pause 60000 — ½ (mark for label 'main' awarded below) gosub adcread — ½ if data < 40 then closew — ½ condition; ½ destination low 5 — ½ if data > 44 then openw — ½ condition; ½ destination low 4 — ½ goto main — mark below closew: gosub close — ½ if pin1 = 0 then main — ½ for 'if' statement, 'then main' awarded below high 5 — ½ goto main — (mark awarded below) openw: gosub open — ½ if pin 0 =0 then main — ½ for 'if' statement, ½ for both 'then main' high 4 — ½ goto main — ½ (including two 'goto main' above + label 'main')		**8** **(10)**

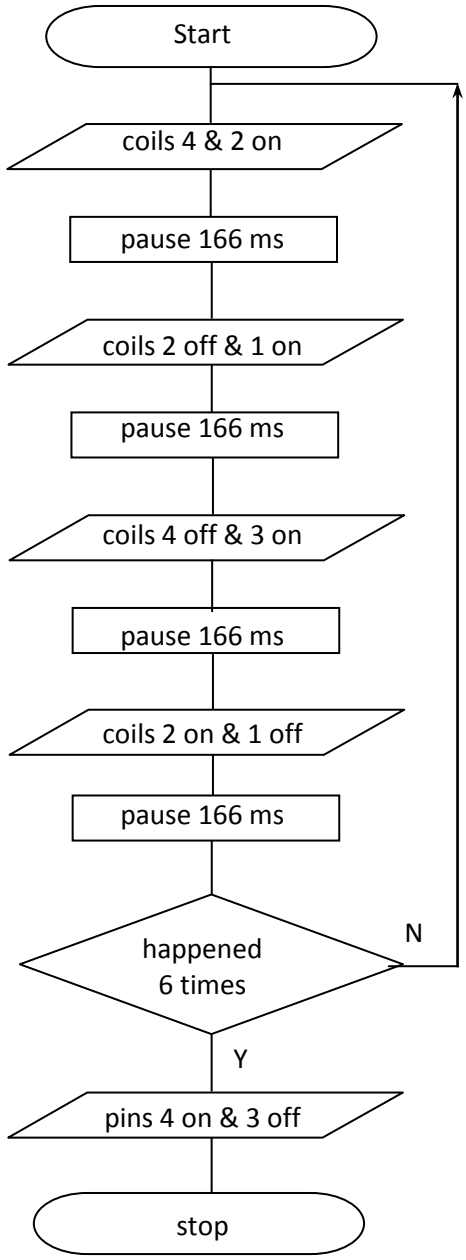
Question		*Mark Allocation*		*Marks*	
6.	**(a)**				
			dimensions	½	
			two 150N forces and labelled	½	
			force F with angle	½	
			reaction at pivot with label (could be components)	½	**2**
	(b)	$\Sigma M_P = 0$			
		$(F_V \times 2.5) = (150 \times 2.2) + (150 \times 1.4)$	3 moments @ ½ each	1½	
		$Fv = 216$ N	answer (unit not required)	½	
		$F = 216/\sin 28$	substitution	½	
		$= 460$ N	answer, including unit	½	**3**
	(c)	$\Sigma Fv = 0$			
		$P_V = 150 + 150 - 216$	substitution	½	
		$P_V = 84$N	answer (unit not required)	½	
		$\Sigma F_H = 0$			
		$P_H = 460\cos 28$	substitution	½	
		$P_H = 406$ N	answer (unit not required)	½	
		$P = \sqrt{(84^2 + 406^2)}$			
		$= 415$ N	answer including unit	½	
		$\tan\theta = 84/406$			
		$\theta = 11.7º$ OR $78.3º$	answer (diagram not necessary)	½	**3**
					(8)

Question			Mark Allocation		Marks
7.	**(a)**		closed loop (½) proportional (½)		**1**
	(b)				
			reference/desired	½	
			error detector (label not required)	½	
			error amplifier (label not required)	½	
			driver (transistor) & motor	½	
			output	½	
			wind sensor/pot/vane	½	**3**
	(c)		Difference	1	**1**
	(d)	**(i)**			
			each component below must have correct connections –		
			difference amp with four resistors	½	
			npn transistor in correct position	½	
			pnp transistor in correct position	½	
			motor and 0V	½	
			potential divider to inverting input (could be 2 resistors, one must be variable)	½	
			potential divider to non-inverting input (could be 2 resistors, one must be variable)	½	**3**

Question			*Mark Allocation*	*Marks*	
7. cont	**(c)**	**(ii)**	Key statements required – signal from pot. connected to wind vane changes as wind direction changes signal from pot. gives direction of turbine head error between non-inverting and inverting inputs created op-amp output increases (+ or -); error amplified a transistor switches on and motor runs/turbine head turns error reduces transistor switches off motor stops/turbine head stops 6 points @ ½		**3** **(11)**

Question			*Mark Allocation*		*Marks*	
8.	**(a)**		force = 400/sin 30 =800N ½	answer (unit not required)	½	
			rod length = 2500/cos 30 = 2890 mm	answer (unit not required)	½	
			$E = 190 \times 10^3$ N/mm^2	from Data Booklet	½	
			$\varepsilon = \Delta l/l = 3/2890 = 0.00104$	answer (unit not required)	½	
			$\sigma = E \times \varepsilon \quad = 190 \times 10^3 \times 0.00104$	substitution	½	
			$= 198$N/mm^2	answer (unit not required)	½	
			$A = F/\sigma$ $= 800/198$ $= 4.04$ mm^2	answer (unit not required)	½	
			$d^2 = 4.04 \times 4/\pi$ $d = 2.27$ mm	answer, including unit	½	**4**
	(b)		No corrosion Low chance of injury Easy/cheap repair Other valid reason	any two @ ½		**1**
	(c)	**(i)**	80/3.2 = 25 (no unit)	no ½ marks		**1**

Question		*Mark Allocation*	*Marks*
8. cont	**(c)**	(ii)	**3**



½ for start box and end box

½ for all 4 outputs in loop

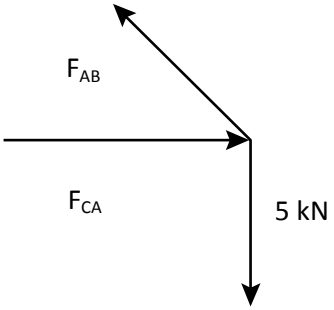
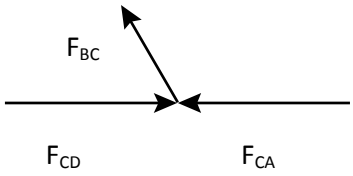
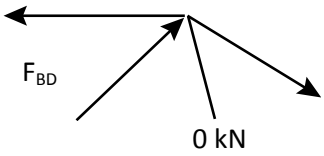
½ for pause boxes
½ for correct pause – accept 160, 166 or 167

½ for '6 times' decision box and backwards arrow, or similar structure – eg 'count = 0', count = count + 1, 'is count =6'

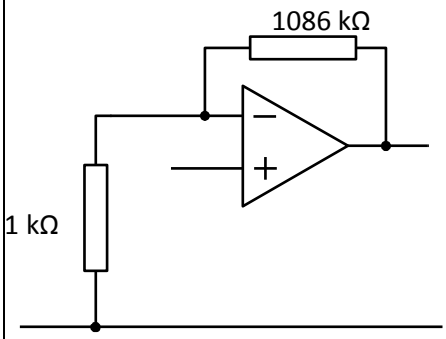
½ for 25th step

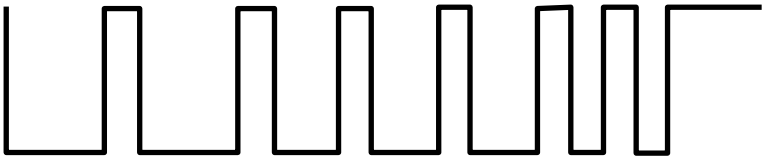
any pause here – no penalty

Question			Mark Allocation		Marks	
8.	**(d)**		Switch released – $V_1/6 = 2.4/4.6$ substitution $V_1 = 6 \times 2.4/4.6 = 3.13$ V answer (unit not required) Switch pressed – $R = (R_1 \times R_2)/(R_1 + R_2)$ $= (2.4 \times 1.6)/4 = 0.96$ kΩ answer (unit not required) $V_1/6 = 0.96/3.16$ $V_1 = 6 \times 0.96/3.16 = 1.82$ V answer (unit not required)	½ ½ ½ ½	**2**
	(e)		Switch released – inverting input is **high** LDR dark and non-inverting input **lower** than inverting input and motor **off**. Switch pressed – inverting input **drops** motor switches **on** ticket feeds until LDR **lighter** and non-inverting input **drops** motor **off** ½ mark each point		**4**
	(f)		LDR @ 10 Lux = 9.5 kΩ (accept 9.0 – 9.6 kΩ) (from Data Booklet) recognising and using 3.13V $R/9.5 = 2.87/3.13$ substitution $R = 9.5 \times 2.87/3.13 = 8.71$ kΩ answer including unit	½ ½ ½ ½	**2**
	(g)		Ib = 1000/15 substitution = 66.7mA answer (unit not required) 85% of 9V = 7.65V answer (unit not required) Rb = (V – 0.7)/I $= (7.65 – 0.7)\ 66.7 \times 10^{-3}$ two substitutions @ ½ = 104Ω answer, including unit	½ ½ ½ 1 ½	**3** **(20)**

Question		*Mark Allocation*	*Marks*	
9.	**(a)**			
		$\Sigma F_V = 0$		
		$F_{AB} = 5/\sin 25$ substitution	½	
		$F_{AB} = 11.8$ kN (tension) magnitude with unit (½) & nature (½)	1	
		$\Sigma F_H = 0$		
		$F_{CA} = 11.8\cos 25$ substitution	½	
		$F_{CA} = 10.7$ kN (compression) magnitude with unit (½) & nature (½)	1	
		<u>Analysing Node C</u>		
				
		$F_{BC} = 0$ (redundant member)		
		$\Sigma F_H = 0$		
		$F_{CD} = F_{CA}$	½	
		$F_{CD} = 10.7$ kN (compression) magnitude with unit (½) & nature (½)	1	
		<u>Analysing Node B</u>		
				
		$\Sigma F_V = 0$		
		$F_{BD} = 5/\cos 55$ substitution	½	
		$F_{BD} = 8.72$ kN (compression) magnitude with unit (½) & nature (½)	1	**6**
	(b)	UTS $= 430$ N/mm^2 from Data Book	½	
		SWS $= 430/9 = 47.8$ N/mm^2 answer (unit not required)	½	
		A = total area – inner area		
		$= (3{\cdot}14 \times 80^2/4) - (3{\cdot}14 \times 72^2/4)$ substitution	½	
		$= 5024 - 4069$		
		$= 955$mm^2 answer (unit not required)	½	
		$F = \sigma \times A$		
		$= 47.8 \times 955$ substitution	½	
		$= 45.6$ kN answer including unit	½	**3**
	(c)	As the strain in the member EG rises –		
		the input voltage to the non-inverting input **rises**	½	
		as input rises V_{out} **increases**	½	
		lower comparator **goes high** first	½	
		as V_{out} increases **upper** comparator **goes high**	½	
		lower comparator will switch **on transistor and bulb**	½	
		upper comparator will switch **on buzzer**	½	**3**

Question		*Mark Allocation*		*Marks*	
9.cont	**(d)**	Voltage at comparator inverting input = 5V	answer (unit not required)	½	
		Diff. Amp. error = $5/(450 \times 10^3/100)$			
		= 0.0011V	answer (unit not required)	½	
		Diff. Amp. inverting input voltage = 6V		½	
		Diff. Amp. non-inverting input voltage = 6V + 0.0011 = 6.0011V	answer	½	
		Active gauge resistance –			
		R/120 = 6.0011/5.9989	substitution	½	
		R = 120 × 6.0011/5.9989 = 120.044 Ω	answer including unit	½	**3**
	(e)	$E = 196 \times 10^3$ N/mm^2	from Data Booklet	½	
		strain for lamp to light = $1 \times 10^{-4} \times 0.044/0.02$			
		= 0.00022	answer	½	
		$E = \sigma/\varepsilon$			
		$\sigma = E \times \varepsilon = 196 \times 10^3 \times 0.00022$	substitution	½	
		= 43.1 N/mm^2	answer including unit	½	**2**
	(f)	ADCREAD takes reading from strain gauge, reading compared to three values		½	
		if < than or = 200 then no warning		½	
		if > than 200 then light on		½	
		if > than 220 then buzzer and light on		½	
		if > than 240 then motor, buzzer and light on		½	
		motor stays on until platform reaches ground		½	**3**
					(20)

Question		*Mark Allocation*	*Marks*	
10.	**(a)**	Gain = $5/4.6 \times 10^{-3} = 1087$ answer no unit	½	
		For non-inverting amplifier, gain = $1 + R_f / R_i = 1087$		
		$R_f / R_i = 1086$ answer	½	
		$R_f = 1086$ kΩ, $R_i = 1$ kΩ (or other suitable pair, higher <u>in the kΩ range</u>)	½	
		 Correct non inverting amplifier circuit with resistor values in correct places	½	**2**
	(b)	Output voltage = $1.48 \times 10^{-3} \times 1087 = 1.61$V answer (unit not required)	½	
		ADC output = $255 \times 1.61/5$ substitution	½	
		= 82 answer	½	
		Binary value – 0101 0010 answer	½	**2**
	(c)	First reading **stored** into variable DATA	½	
		DATA **moved** to variable FIRST	½	
		Second reading **stored** in DATA, DATA **compared** to FIRST,	½	
		If DATA **larger** value then DATA value used if not **larger** FIRST value **moved** into DATA	½	**2**
	(d)	reverse: low 3 *or low mpx*		
		gosub adcread		
		first = data ½		
		high 3 *or high mpx* ½ (both pin3 commands)		
		gosub adcread ½ (both *gosub adcread*)		
		if first > data then equal ½ condition; ½ dest		
		goto compare ½		
		equal: data = first ½		
		compare: if data < 66 then finish ½ whole line		
		if data < 122 then seventy_five ½		
		if data < 189 then fifty ½		
		if data < 255 then twenty_five ½		
		b6 = 0 ½		
		label: gosub warning ½		
		finish: return ½ incl 3goto finish/return		
		seventy_five: b6 = 75 ½		
		gosub warning or *goto label*		
		goto finish or *return* mark above		
		fifty: b6 = 50 ½		
		gosub warning or *goto label*		
		goto finish or *return* mark above		
		twenty_five: b6 = 25 ½		
		gosub warning or *goto label* ½ all 4 gosub warning		**9**
		goto finish or *return* mark above		

Question		*Mark Allocation*	*Marks*	
10.cont	**(e)**			
		both 75ms off times in correct sequence	½	
		three 50ms off times in correct sequence	½	
		two 25ms off times in correct sequence	½	
		all 25ms on times	½	**2**
	(f)	$I_b = (5 – 0.7)/1000$ substitution	½	
		$= 4{\cdot}3$mA answer (unit not required)	½	
		$I_c = (12 – 0{\cdot}22)/56$ substitution	½	
		$= 210$mA answer (unit not required)	½	
		$h_{FE} = I_c/I_b = 210/4.3$ substitution	½	
		$= 48.8$ answer, **no** units	½	**3**
				(20)

[END OF MARKING INSTRUCTIONS]