2013 Technological Studies

Higher

Finalised Marking Instructions

Part One: General Marking Technological Studies Higher

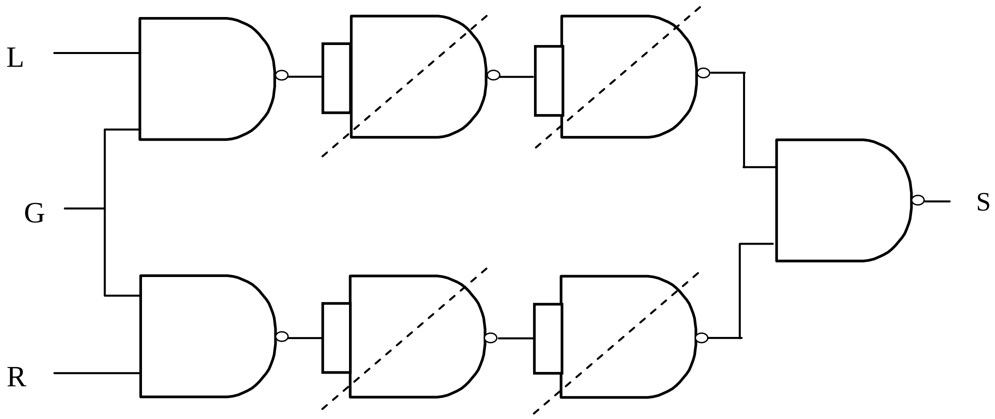
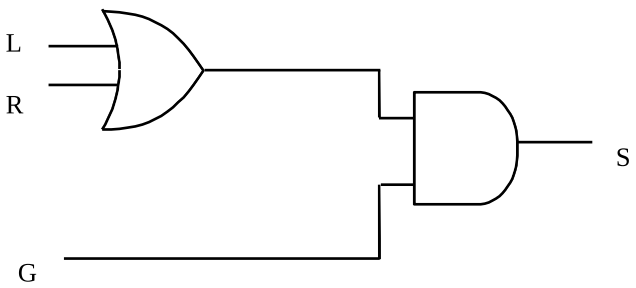
This information is provided to help you understand the general principles you must apply when marking candidate responses to questions in this Paper. These principles must be read in conjunction with the specific Marking Instructions for each question.

(a) Marks for each candidate response must always be assigned in line with these general marking principles and the specific Marking Instructions for the relevant question. If a specific candidate response does not seem to be covered by either the principles or detailed Marking Instructions, and you are uncertain how to assess it, you must seek guidance from your Team Leader/Principal Assessor.

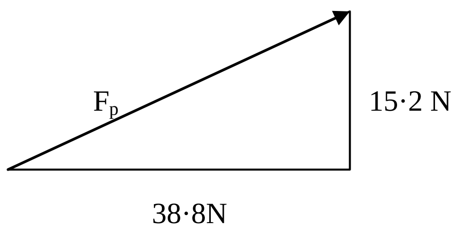
(b) Marking should always be positive ie, marks should be awarded for what is correct and not deducted for errors or omissions.

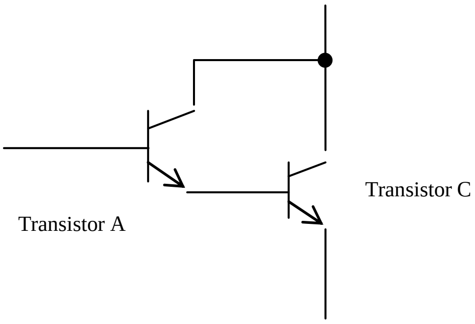
GENERAL MARKING ADVICE: Technological Studies Higher

The marking schemes are written to assist in determining the "minimal acceptable answer" rather than listing every possible correct and incorrect answer. The following notes are offered to support Markers in making judgements on candidates' evidence, and apply to marking both end of unit assessments and course assessments.

Question		*Mark Allocation*	*Marks*	
1.	**a**	S = (L.G) + (R.G) (brackets not necessary) — AND functions 1 each OR function 1	3	
		$S = (\overline{L}.G.R) + (L.G.\overline{R}) + (L.G.R)$ S = (L + R) . G — Each statement 1 L+R 1 .G 1 ( ) 1		**3**
	b			
		Two AND equivalents @ 1 each	2	
		OR equivalent	1	
		deleting redundant gates	1	**4**
	c	(truth table below)		**5**
		1 each fully correct column for M,N,P,Q and S		
	d			
		correct OR	1	
		correct AND	1	
		correct interconnections	1	**3**
				(15)

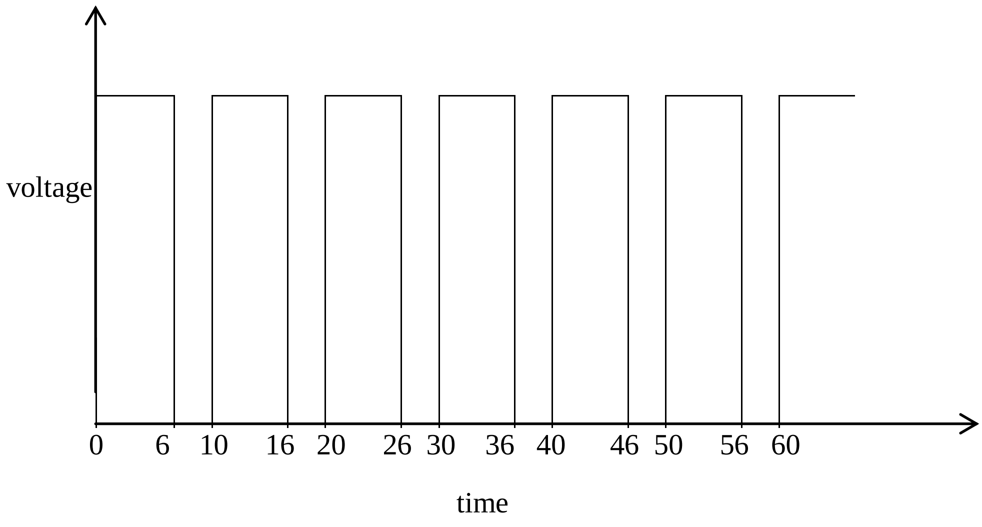
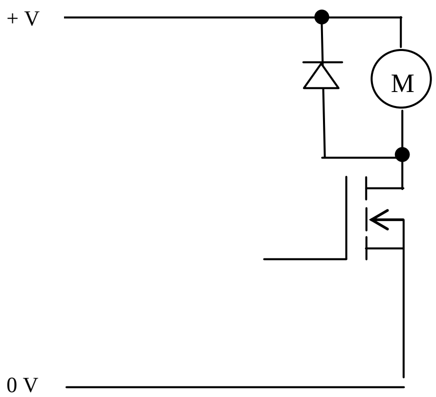
L	G	R	M	N	P	Q	S
0	0	0	1	1	0	1	0
0	0	1	1	0	1	1	0
0	1	0	1	1	0	1	0
0	1	1	1	0	1	0	1
1	0	0	0	1	1	1	0
1	0	1	0	0	1	1	0
1	1	0	0	1	1	0	1
1	1	1	0	0	1	0	1

Question		Mark Allocation		Marks	
2.	a	From Data Book, R_{LDR} at 80 lux = 1·5 kΩ (accept 1·2 – 1·5)		1	
		$V_{in} = 9 \times 1{\cdot}5/2{\cdot}7$	all substitutions	1	
		= 5V	answer	1	
		$V_{out} = 5 \times (1 + (24/36))$	all substitutions	1	
		= 8.33V	answer & unit	1	**5**
	b	85% of 16 = 13·6V	answer	1	
		$V_{in} = 13{\cdot}6 / (1 + (24/36))$	all substitutions	1	
		= 8·16V	answer	1	
		$R_{LDR} = 1{\cdot}2 \times 8{\cdot}14 / (9 – 8{\cdot}14)$	all substitutions	1	
		= 11·66 kΩ	answer	1	
		Light level = 6 – 8 lux	answer and unit	1	**6**
	c	Voltage operated: no current draw from input/high input impedance.		1	
		Low Drain-Source resistance / can provide large (Drain-Source) currents/low power consumption.		1	**2**
					(13)
3.	a	Taking moments about the pivot:			
		$\Sigma M_P = 0$ (c/w +ve)			
		(S cos 65° × 120) – (6·25 sin 50° × 500) = 0	2 for each term	4	
		S = 47·2 N	answer, including unit	1	**5**
	b	Taking horizontal components			
		$\Sigma F_H = 0$ (→ +ve)			
		$F_{p(H)}$ + 6·25 cos 50° - 47.2 sin 65° = 0	1 for each term	2	
		$F_{p(H)}$ = 38·8 N (→)	answer (unit not necessary)	1	
		Taking vertical components:			
		$\Sigma F_V = 0$ (↑+ve)			
		$F_{P(V)}$ + 6·25 sin 50° - 47·2 cos 65° = 0	1 for each term	2	
		$F_{P(V)}$ = 15·2 N (↑)	answer (unit not necessary)	1	
					
		$F_p^2 = 15{\cdot}2^2 + 38{\cdot}8^2$		1	
		F_p= 41·7 kN (including unit)		1	
		$\text{Tan}^{-1}\,\theta = 15{\cdot}2/38{\cdot}8$		1	
		θ = 21·4° (or 68.6°) answer 1		1	
		direction shown 1		1	**11**
					(16)

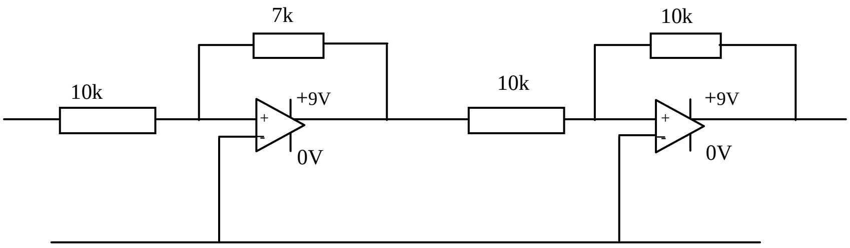
Question		Mark Allocation			Marks	
4.	**a**	(i)	I_{100} = V/R = 11·3/100 = 0·113mA	(substitution 1; answer including unit 1)		**2**
		(ii)	I_{th} = V/R = 0·7/8 = 0·0875mA	(8 kΩ from data book 1; substitution 1) (answer including unit 1)		**3**
		(iii)	I_b = 0·113 - 0·0875 = 0·0255mA	(answer including unit 1)		**1**
	b		h_{FE} = 1000/0·0255 = 39 200	(substitution 1; answer including unit 1)		**2**
	c			transistor A first	1	
				transistor C second	1	
				first emitter to second base	1	
				collectors connected	1	**4**
						(12)
5.		main:	if pin0 = 0 then delay	1 mark condition; 1 destination		
		test1:	if pin5 = 0 then main	1 mark condition; 1 destination		
			gosub wiper	1 mark for all four gosub wiper		
			goto main	1 mark for both goto main		
		delay:	if pin1 = 0 then wash	1 mark condition; 1 destination		
			pause 1500	1 mark		
			gosub wiper	(mark awarded above)		
			goto delay	1 mark		
		wash:	if pin 2 = 0 then main	1 mark condition; 1 destination		
			high 6	1 mark		
		again:	gosub wiper	(mark awarded above)		
			if pin 2 = 1 then again	1 mark condition; 1 destination		
			low 6	1 mark		
			for b0 = 1 to 5	1 mark (including *next b0* below)		
			gosub wiper	(mark awarded above)		
			next b0	(mark awarded above)		
			goto main	(mark awarded above)		
						(17)

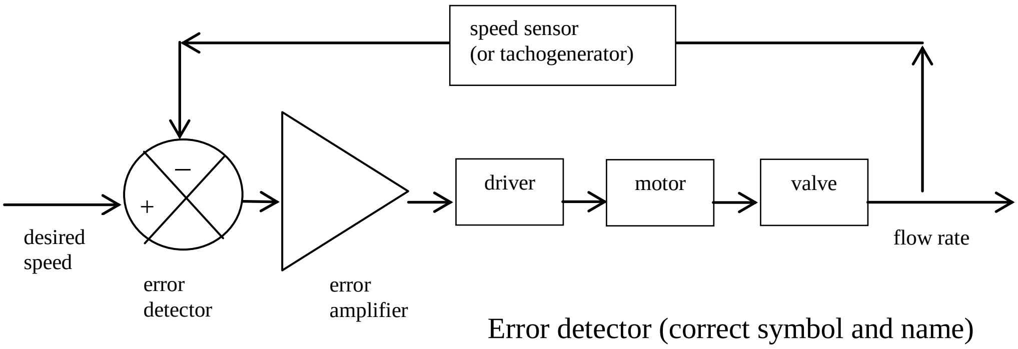
Question		Mark Allocation		Marks	
6.	**a**	(i) Area = 113mm^2	answer	1	
		$\sigma = \frac{F}{A} = \frac{717}{113}$	all substitutions	1	
		$= 6{\cdot}35\text{N/mm}^2$	answer	1	
		$\varepsilon = \frac{\Delta 1}{1} = \frac{0{\cdot}15}{2600}$	all substitutions	1	
		$= 0{\cdot}0000576$	answer	1	
		$E = \frac{6{\cdot}35}{0{\cdot}0000576}$	all substitutions	1	
		$E = 110\text{kN/mm}^2$	answer & unit	1	**7**
		(ii) Titanium Alloy	answer		**1**
	b	Safe working $\sigma = \frac{1000}{7}$	1000 from data book	1	
		$= 143\text{N/mm}^2$	answer	1	
		$F = \sigma \times A = 143 \times 113$	all substitutions	1	
		$F = 16{\cdot}2\text{kN}$	answer & unit	1	**4**
	c	Unexpected loading or Possible loading due to weather. Increased loading due to expected corrosion during lifetime. Possible impacts. Consequence of failure. Faulty material. Manufacturing defect. Or other valid reason.	Any two at 1 each		**2**
					(14)

Question		Mark Allocation	Marks	
7.	**a**	Closed loop / two state or Closed loop / on-off or Closed loop / bang-bang — 1 for each part		**2**
	b	Protects <u>transistor</u>		1
	c	Thermistor resistance increases Non-inverting input voltage increases Non-inverting input > inverting input Op-amp saturates R_v sets when op-amp saturates (<u>or</u> provides reference <u>or</u> calibrates) Base > 0·7V – transistor saturates Relay energises and element switches on — any 6 @ 1 each		**6**
	d	From Data book 800 kΩ (accept 700-800)	1	
		Voltage at inputs $= \frac{(12\times800)}{1230}$ — all substitutions	1	
		$= 7{\cdot}80\text{V}$ — answer	1	
		$R_v = \frac{(24\times4\cdot2)}{7\cdot8}$ — all substitutions	1	
		$= 12{\cdot}9\text{k}\Omega$ — answer & unit	1	**5**
	e	85% of 16V = 13·6V	1	
		$I_b = \frac{(13\cdot6-0\cdot7)}{2700}$ — all substitutions	1	
		$= 0{\cdot}0048$ — answer	1	
		$I_c = \frac{(12-0\cdot2)}{60}$ — all substitutions	1	
		$= 0{\cdot}197\text{A}$ — answer	1	
		$h_{FE} = \frac{0\cdot197}{0\cdot0048}$ — all substitutions	1	
		$= 41$ — answer, no unit	1	**7**
				(21)

Question		*Mark Allocation*	*Marks*	
8.	**a**	Pulse Width Modulation		**1**
	b			
		Square wave (1) with axes labelled with voltage and time (1) 6:4 mark:space ratio clearly indicated (1)		**3**
	c			
		Correct MOSFET symbol	1	
		MOSFET connections to motor and 0 V rail	1	
		+V connections to motor	1	
		Diode (correct way round)	1	**4**
	d	(i) 8(V)		**1**
		(ii) 0·275 (A)		**1**
		(iii) P = 8 × 0·275 — substitutions	1	
		2·2 W — answer & unit	1	**2**
				(12)

Question		Mark Allocation	Marks	
9.	**a**	Force on each bolt = $\dfrac{820\times10^3}{28}$ — all substitutions	1	
		$= 29\cdot3\text{kN}$ — answer	1	
		Working stress = $\dfrac{430}{4\cdot5}$ — 430 from Data book	1	
		$= 95\cdot6$ — all substitutions	1	
		Stress due to load = 95.6 – 10 = 85.6 N/mm^2 — answer	1	
		Area = $\dfrac{29\cdot3\times10^3}{85.6}$		
		$= 342\text{mm}^2$ — answer	1	
		Diameter = $\sqrt{\dfrac{342\times4}{3\cdot14}}$		
		= 20.9mm — answer & unit	1	**7**
	b	$E = 196\times10^3$ — from data book	1	
		$\varepsilon = \dfrac{95.6}{196\times10^3}$ — all substitutions	1	
		$= 0\cdot000488$ — answer	1	
		$\Delta l = 0\cdot000488\times60$ — all substitutions	1	
		$= 0\cdot0293\text{mm}$ — answer & unit	1	**5**

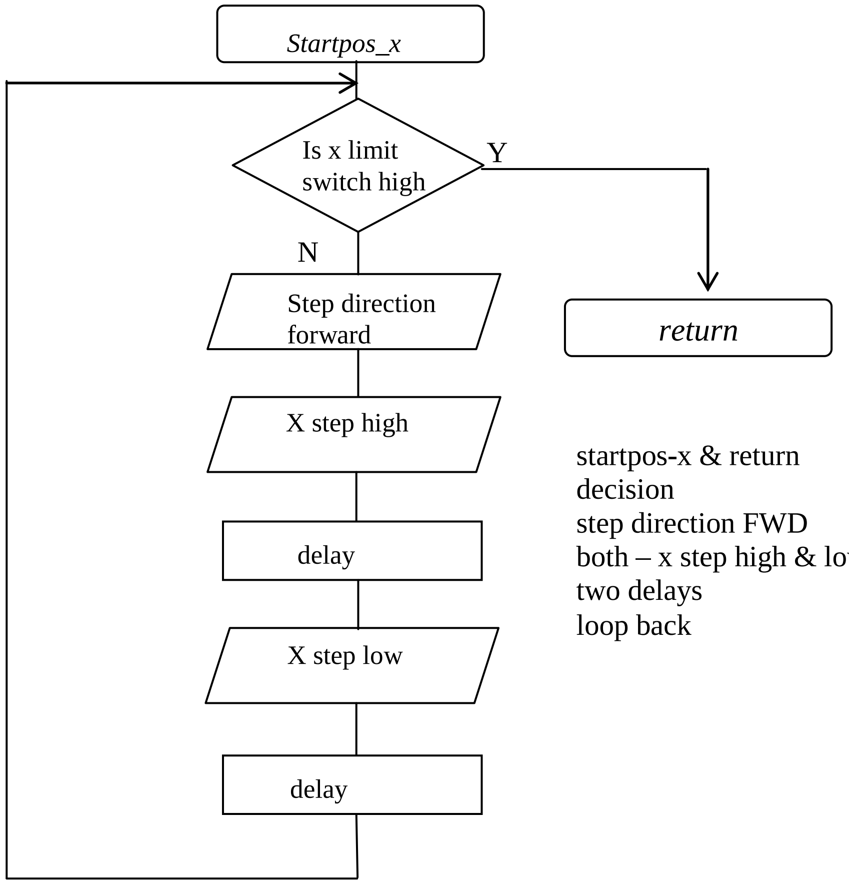
Question		Mark Allocation	Marks	
9.	**c**	**(cont)**		
		Signal from flow sensor increases :		
		V_{in} increases: inverting input > non-inverting input		
		op-amp output goes negative		
		V_{out} <-0.7V PNP transistor switches on		
		motor closes valve		
		V_{in} reduces		
		V_{out} drops *or* PNP transistor switches off *or* motor stops		
		6 points @ 1 each Adjust scheme if sequence starts from V_{in} decreases		**6**
	d			
		$V_{out} = -4 - 0{\cdot}7$ $= -4{\cdot}7V$ — For +4V and NPN: $V_{out} = 4 + 0{\cdot}7$	all substitutions	1	
		$= -4{\cdot}7V$ — For +4V and NPN: $= 4{\cdot}7V$	answer	1	
		Gain $= \frac{200}{10} = 20$ — For +4V and NPN: Gain $= \frac{200}{10} = 20$	answer	1	
		Error $= \frac{-4.7}{20}$ — For +4V and NPN: Error $= \frac{4{\cdot}7}{20}$	all substitutions	1	
		$= -0{\cdot}235V$ — For +4V and NPN: $= +0{\cdot}235V$	answer	1	
		$V_{in} = +1.47 - (-0{\cdot}235)$ — For +4V and NPN: $V_{in} = +1.47 - 0{\cdot}235$	all substitutions	1	
		$= +1{\cdot}705V$ — For +4V and NPN: $V_{in} = +1.24V$	answer	1	**7**
	e			
		Two op-amps @ 1 each	2	
		Gain of 0·7	1	
		7 & 10 ratio in kΩ range	1	
		10 & 10 ratio in kΩ range	1	**5**
	f	recorddata: page = 0	1	
		for b0 = 1 to 240 — both commands to total 480	1	
		address = b0 — for both address = b0 commands	1	
		gosub adcread — for both gosub adcread commands	1	
		gosub eewrite — for both gosub eewrite commands	1	
		pause 5000 — for both pause commands	1	
		next b0	1	
		page = 1	1	
		for b0 = 1 to 240 — (incl. b0 below)	1	
		address = b0 — (mark awarded above)		
		gosub acread — (mark awarded above)		
		gosub eewrite — (mark awarded above)		
		pause 5000 — (mark awarded above)		
		next b0 — (mark awarded above)		
		return — + label	1	**10**
				(40)

Question		Mark Allocation	Marks	
10.	**a**			
		Error detector (correct symbol and name)	1	
		Error amplified (correct symbol and name)	1	
		driver	1	
		Motor and/or valve	1	
		Speed sensor or tachogenerator	1	
		Desired speed and movement of valve labels	1	**6**
	b	When the turbine is turning at the desired speed, $V_{out} = 0$		
		$0 = R_f \times (3 - V_{tach}) /1000$		
		$(3 - V_{tach}) = 0$ or $V_{out} = 0$ (must be stated)	1	
		$V_{tach} = 3$ V	1	
		Desired speed = 3 × 1000 = 3000 r/min (including units)	1	
		(N.B Must "show" for full marks)		**3**
	c	1% below 3000 r/min = 99% of 3000 r/min = 2970 r/min answer	1	
		$V_{tach} = 2{\cdot}97$ V answer	1	
		$12 = R_f \times (3 - 2{\cdot}97) / 1000$ all substitutions	1	
		$R_f = \dfrac{12 \times 1000}{0 \cdot 030}$		
		$R_f = 400\text{k}\Omega$ answer including unit	1	**4**
	d	Resistor ladder creates two references voltages for the op. amps	1	
		If speed is too low, V_{tach} is below both references; op. amp 1 saturates high and op. amp 2 saturates low	1	
		Transistor 1 is on, "too slow" warning light is on; Transistor 2 is off, "too fast" warning is off	1	
		If speed not too low or too high, V_{tach} is between the two references; Both op. amps saturate low Both transistors are off, both warnings are off	1	
		If speed is too high, V_{tach} is above both references, Op. amp 1 saturates low and op. amp 2 saturates high	1	
		Transistor 1 is off, "too slow" warning light is off; Transistor 2 is on, "too fast" warning is on	1	**6**

Question		Mark Allocation	Marks	
10.	**e**	**(cont)** V_{tach} @ 3000 r/min = 3V; 5% of 3V = 0·15V Two reference voltages = 3 – 0·15 = <u>2·85 V</u> and 3 + 0·15 = <u>3·15 V</u>	1 2	
		$R_1 = \frac{2 \cdot 85}{12} \times 12 = 2 \cdot 85$	1	
		$R_1 + R_2 = \frac{3 \cdot 15}{12} \times 12 = 3 \cdot 15$	1	
		$R_2 = 3 \cdot 15 - R_1 = 3 \cdot 15 - 2 \cdot 85$ all substitutions $= 0 \cdot 3 k\Omega$ answer & unit $R_3 = 12 - 3 \cdot 15$ all substitutions $= 8 \cdot 85 k\Omega$ answer & unit	1 1 1 1	**9**
		<u>Analysing Node A:</u> <u>Vertically</u> F_{AB} cos 70 = 2 F_{AB} = 5·85 kN STRUT (answer and unit 1, nature 1)	 1 2	
		<u>Horizontally</u> $F_{AD} = F_{AB}$ cos 20 F_{AD} = 5·49 kN TIE (answer and unit 1, nature 1)	 1 2	
		<u>Analysing Node D:</u> $F_{CD} = F_{BD}$	 1	
		<u>Horizontally</u> F_{CD} cos 40 + F_{BD} cos40 = F_{AD} $F_{CD} = F_{BD}$ = 5·49/(2 cos 40) $F_{CD} = F_{BD}$ = 3·58kN TIE (answer and unit 1, nature 1)	 2 1 2	
				12 **(40)**

Question		Mark Allocation	Marks	
11.	**a**	(i) Pulses per full rev. = $\frac{360}{7 \cdot 5} = 48$ answer	1	
		Number of turns/second = $\frac{25}{4 \cdot 8} = 5 \cdot 21$ revolutions answer	1	
		No. of steps per second = $5 \cdot 21 \times 48 = 250$ answer	1	
		Time per step = $\frac{1000}{250} = 4$ms answer	1	**4**

(ii)



startpos-x & return	1
decision	1
step direction FWD	1
both – x step high & low	1
two delays	1
loop back	1
	6

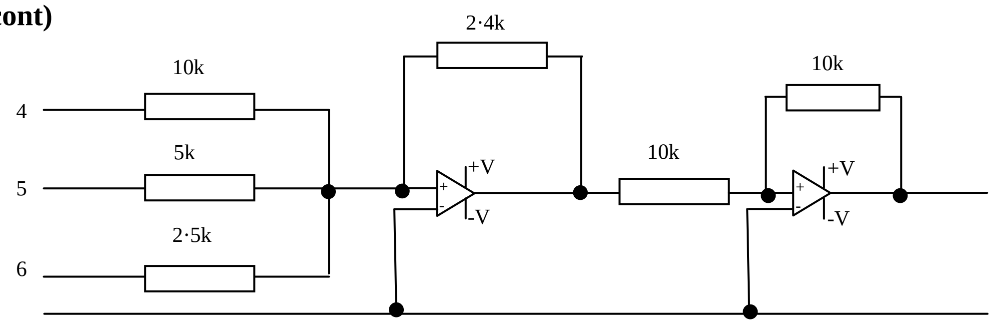
b (i)

S	P	D	R
O	O	O	1
O	O	1	1
O	1	O	1
O	1	1	1
1	O	O	O
1	O	1	1
1	1	O	O
1	1	1	1

Each correct line for R=0 **2**
All other correct lines **1** **3**

(ii) P (1 mark) / since R is low whether P is high or low (1mark) **2**

Question		Mark Allocation			Marks	
11.	**c**	**(cont)**				



				Summing amp	1	
				Ratio 1·2/5 = 0·24	1	
				Correct 2·4k & 10k	1	
				Correct 5k & 2·5k	2	
				Inverting Amp	1	
				Two res. in kΩ range	1	**7**
	d	Voltage = $8{\cdot}4 \times \frac{100}{85}$		substitution	1	
			= 9·88V	answer & unit	1	**2**
	e	speed:	count = 0		1	
			if b7 = 0 then output1	condition 1 destination 1	2	
		loop:	if b7 < 20 then output2	condition 1 destination 1	2	
			b7 = b7 – 20		1	
			count = count + 1	both count = count + 1	1	
			if b7 > 0 then error_check	condition 1 destination 1	2	
			goto output1	both goto output1		
		output2:	count = count +1	mark awarded above	1	
		output1:	gosub setpins			
			return			
					2	
		error_check:	if count > 7 then alarm	condition 1 destination 1	1	
			goto loop		1	
		alarm:	high 7		1	
			count = 0		1	
			goto output1	mark awarded above		
						16
						(40)

[END OF MARKING INSTRUCTIONS]