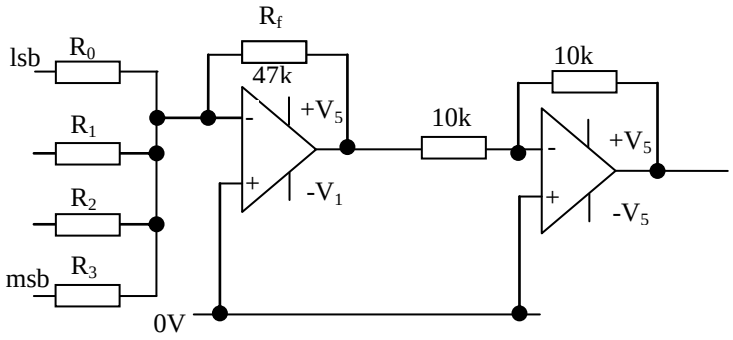
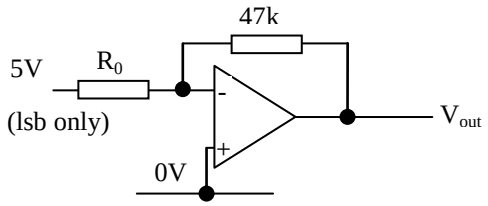
2012 Technological Studies

Advanced Higher

Finalised Marking Instructions

Section A

		Marks	
Q1			
(a)	• Clock provides regular digital pulses.	1	
	• AND gate allows pulses through to binary counter (when comparator is high)	1	
	• binary counter counts pulses in a binary form.	1	
	• Digital to Analogue Convertor (DAC) converts binary value into equivalent analogue value for comparator.	1	
	• Comparator compares analogue temp signal with signal from DAC. Output is digital which controls AND gate.	1	
	• BCD-7 seg decodes 4-bit binary into a format suitable for 7-seg display.	1	
	• 7-seg displays freezes at decimal value (0-9) equivalent to temperature signal.	1	**7**
(b)		2	
			
	$2^4 = 16 \ (0 \rightarrow 15)$	1	
	$V_{out} = \frac{1}{15} \times -6 = -0 \cdot 4\,\text{V}$ resolution	1	
	$V_{out} = \frac{-R_f}{R_o} \times V_{in}$	1	
	$-0.4 = \frac{-47}{R_o} \times 5$	1	
	$Ro = \frac{47}{0 \cdot 4} \times 5 = 587 \cdot 5 = 588\text{k}\Omega$	1	
	$R_1 = 294\text{k}\Omega$ $R_2 = 147\text{k}\Omega$ $R_3 = 73 \cdot 5\text{k}\Omega$	1	**8**
			(15)

Q2

			Marks	
(a)	$I = \frac{\pi}{64}\left(D^4 - d^4\right)$		1	
	$= \frac{\pi}{64}\left(30^4 - 27^4\right)$		1	
	$= \frac{\pi}{64}(278559)$		1	
	$= 13673{\cdot}7\ mm^4$		1	**4**
(b)	$M = \frac{FL}{4} = \frac{200 \times 1000}{4} = 50000\,Nmm$	Substitutions, answer	2	
	$\sigma = \frac{My}{I}$ $\quad y = 15mm$	Answer	1	
	$\sigma = \frac{50000 \times 15}{13673{\cdot}7} = 54{\cdot}8N/mm^2$	Substitutions, answer	2	**5**
(c)	$\delta = \frac{FL^3}{48EI}$ $\quad E = 150 \times 10^3\ N/mm^2$			
	$\delta = \frac{200 \times 1000^3}{48 \times 150 \times 10^3 \times 13673{\cdot}7}$	Substitutions, answers	2	
	$\delta = 2{\cdot}03mm$		1	**3**
				(12)

	Marks	
Q3		

	Software	Hardware
Write the assembler code	Text editor	
Convert assembler into machine code	MPASM assembler	
Burn machine code into microcontroller	Download program	Programmer
Test in target system	Test program	target

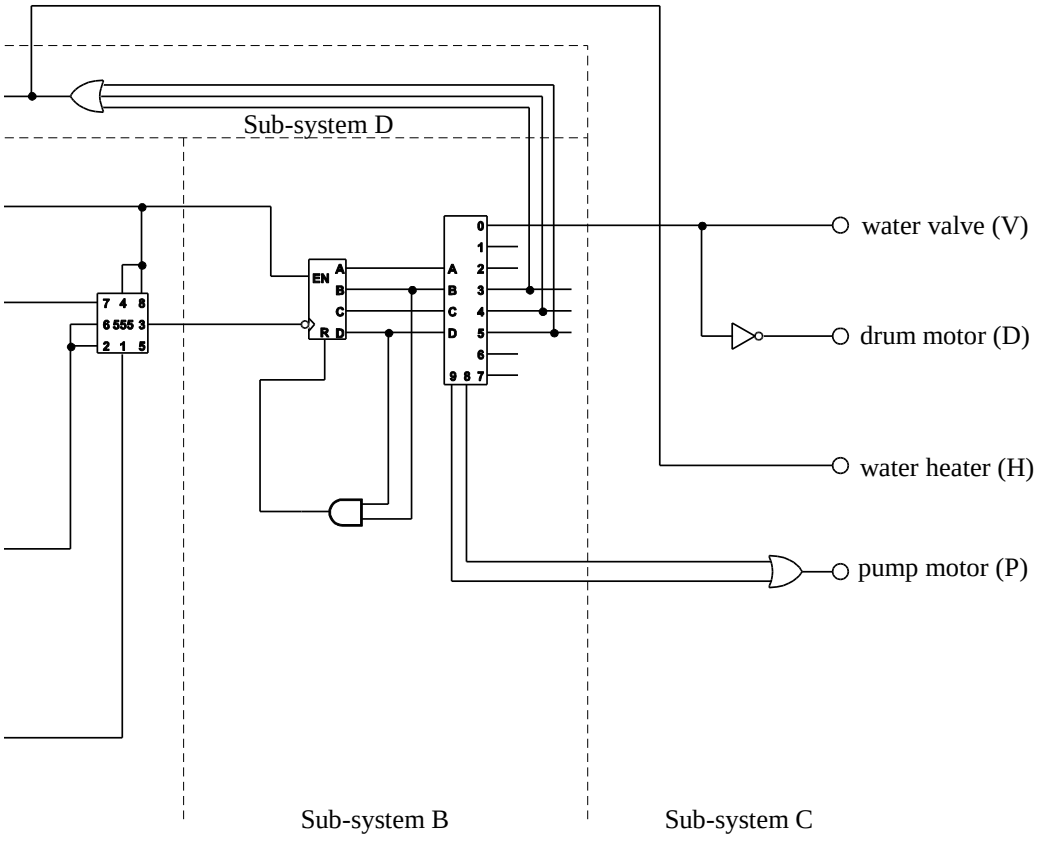
Any 4 points from each column

	8
	(8)

Q4

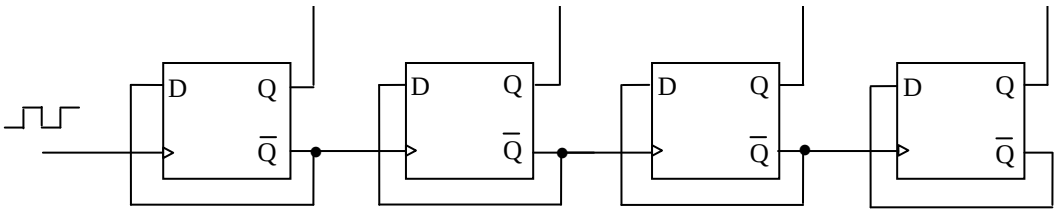
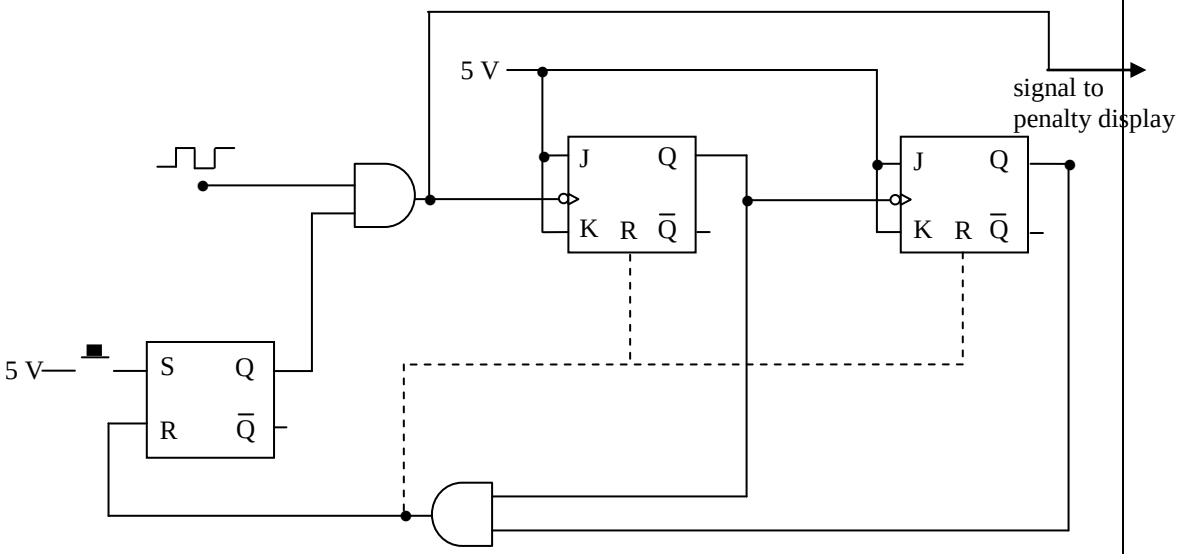
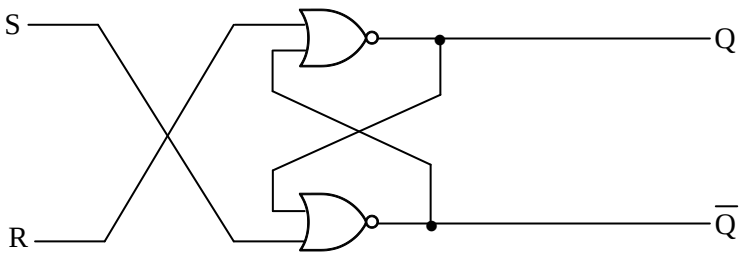
			Marks	
(a)	H = 3 + 4 + 5			**2**
(b)	See Worksheet Q4 below			**6**
(c)	• 555 is an astable to provide regular digital clock pulses whose frequency is determined by R_1 & R_2 & C • relay is operated by OR gate which switches between 10MΩ & 1MΩ resistors • changing frequency of astable by a factor of 10	Sub-system A	3	
	• OR is only high during C_3 or C_4 or C_5	Sub-system D	1	
	• Therefore water heater is on 10 times longer than duration of these clock pulses • 4-bit binary counter counts astable pulses and resets on 10 via AND gate • BCD – Decimal decoder decodes binary value of count into a decimal output	Sub-system B	3	
	• logic array interprets decimal outputs for washing machine outputs	Sub-system C	1	**8**
				(16)

Worksheet Q4



Q5

						Marks	
(a)	calibrate:	call	adcread	; value in DATA		1	
		movfw	DATA			1	
		movwf	ANGLE	; move into ANGLE		1	
		rlf	ANGLE, F	; double		1	
		movlw	d‘15’	; 15 in W		1	
		subwf	ANGLE, F	; W from file		1	
		bsf	PORTB, 7				
		movlw	d‘5’			1	
		call	wait				
		bcf	PORTB, 7	; bleep	(with bsf PORTB,7 above)	1	
		return					**8**
(b)	main:	movlw	d‘50’				
		movwf	COUNTER			1	
	loop:	btfsc	PORTB, 1			1	
		goto	calib			1	
		movlw	d‘1’			1	
		call	wait				
		decfsz	COUNTER, F			1	
		goto	loop			1	
		goto	check			1	
	calib:	call	calibrate			1	
	check:	call	adcread	; value in DATA		1	
		movfw	ANGLE	; alarm value in W		1	
		subwf	DATA	; DATA – W		1	
		btfss	STATUS, C	; test for +ve answer		1	
		goto	check	; no, so check again		1	
				; yes, +ve ∴ alarm			
		bsf	PORTB, 7	; DATA > ANGLE		1	
		movlw	d‘50’			1	
		call	pause				
		bcf	PORTB, 7			1	
		movlw	d‘250’			1	
		call	pause				
		goto	main			1	**18**
							(26)

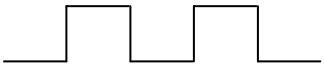
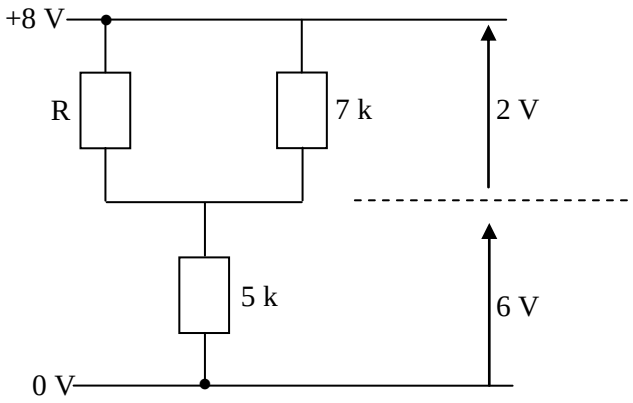
		Marks
Q6	(a)	
		**3**
	(b)	
		**9**
	(c)	
		**3**
		(15)

Q7

					Marks	
(a)	main:	call	adcread	; value in DATA	1	
		movfw	DATA	; value now in W	1	
		sublw	d‘128’	; 128 – W (128 – value)	1	
		movwf	ERROR	; error now in W	1	
		btfsc	STATUS, Z	; check for zero error	1	
		goto	main	; yes so loop back	1	
		btfss	STATUS, C	; no, check for neg error	1	
		goto	jumpneg		1	
		call	sluiceup		1	
		goto	main			
	jumpneg:	call	sluicedown		1	
		goto	main			**10**
(b)	sluiceup:	movlw	b‘1100 0000’		1	
		movwf	PORTB		1	
		movlw	d‘100’		1	
		call	wait			
		movlw	b‘01100000’			
		movwf	PORTB		1	
		movlw	d‘100’			
		call	wait			
		movlw	b‘00110000’			
		movwf	PORTB			
		movlw	d‘100’			
		call	wait		1	
		movlw	b‘10010000’			
		movlw	d‘100’			
		call	wait			
		return			1	**6**
						(16)

Q8

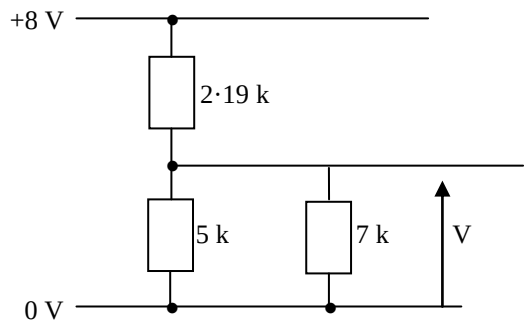
		Marks	
(a)	$\Sigma M_B = 0$		
	$+(R_A \times 4) - (6 \times 1) - (3 \times 4 \times 2) = 0$	1	
	$+4R_A = 6 + 24 = 30$	1	
	$R_A = +7 \cdot 5 KN \uparrow$	1	**3**
(b)	$M = +\left(R_a \times x\right) - \left(\omega x \times \frac{x}{2}\right)$	1	
	$= +7 \cdot 5x - \frac{3}{2}x^2$	1	
	$M = -1 \cdot 5x^2 + 7 \cdot 5x$	1	**3**
(c)	$\frac{dM}{dx} = -3x + 7 \cdot 5 \quad = 0$	2	
	$x = \frac{7 \cdot 5}{3} = 2 \cdot 5 m$ from LHS	1	**3**
(d)	$M = -1 \cdot 5x^2 + 7 \cdot 5x \qquad x = 2 \cdot 5m$		
	$= -\left(1 \cdot 5 \times 2 \cdot 5^2\right) + \left(7 \cdot 5 \times 2 \cdot 5\right)$	2	
	$= -9 \cdot 375 + 18 \cdot 75$		
	$= +9 \cdot 375 kNm$	1	**3**
			(12)

		Marks	
Q9			
(a)	Wein Bridge		**1**
(b)	$f = \frac{1}{2\pi RC}$ $\quad 50 = \frac{1}{2 \times \pi \times R \times 4{\cdot}7 \times 10^{-6}}$	1	
	$R = \frac{1}{2 \times \pi \times 50 \times 4{\cdot}7 \times 10^{-6}}$	1	
	$R = 677\,\Omega$	1	**3**
(c)	A&B are Schmitt Triggers to convert the sine waves to digital square waves	1	
	C = 4 bit binary counters		
	1^{st} stage counts to 10 & resets	1	
	2^{nd} stage counts to 5		
	$\therefore$ counts to 50		
	counts are only enabled via AND gates when NOR gate is high	1	
	$\therefore$ first circuit to count to 50 disables further counting	1	
	If both circuits reach 50 at same time = freq correct indicator	1	
	If top circuit first to 50 = freq too low indicator	1	
	If bottom circuit first to 50 = freq too high indicator	1	
			7
(d)	(i) 		**1**
	(ii) 	1	
	$\frac{R_P}{5} = \frac{2}{6}$ $\quad R_P = \frac{5 \times 2}{6} = 1{\cdot}667\text{k}\Omega$	1	
	$1{\cdot}667 = \frac{R \times 7}{R + 7}$	1	
	$1{\cdot}667(R + 7) = 7R$ $1{\cdot}667R + 11{\cdot}669 = 7R$ $5{\cdot}333R = 11{\cdot}669$	1	
	$R = 2{\cdot}19\text{k}\Omega$	1	**5**

	Marks	

Q9 (d) (continued)

(iii)



$$R_P = \frac{5\times 7}{5+7} = \frac{35}{12} = 2\cdot 92k\Omega$$ 1

$$V = \frac{2\cdot 92}{5\cdot 11}\times 8$$

$$V = 4\cdot 57V$$ 1

(Switch on threshold)

2

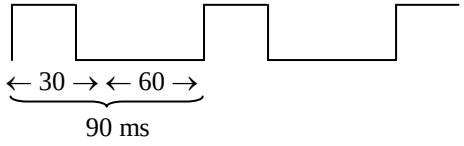
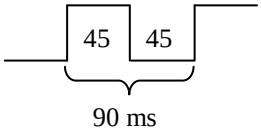
(e)

```
main:   clrf    COUNT          } 1
        clrf    EDGE           }

loop:   btfsc   PORTB, 1         1
        goto    jump             1
        clrf    EDGE             1
        goto    loop             1

jump:   movlw   d'1'             1
        xorwf   EDGE, W          1
        btfsc   STATUS, Z      } 1
        goto    loop           }
        incf    COUNT, F       } 1
        incf    EDGE, F        }
        btfss   PORTB, 0       } 1
        goto    loop           }
        movlw   d'50'            1
        subwf   COUNT            1
        btfss   STATUS, Z      } 1
        goto    jump2          }
        bsf     PORTB, 5         1

delay:  movlw   d'100'         } 1
        call    wait           }
        bcf     PORTB, 7       }
        bcf     PORTB, 6       } 1
        bcf     PORTB, 5       }
        goto    main             1

jump2:  btfss   STATUS, C      } 1
        goto    jump3          }
        bsf     PORTB, 6         1
        goto    delay            1

jump3:  bsf     PORTB, 7       } 1
        goto    delay          }
```

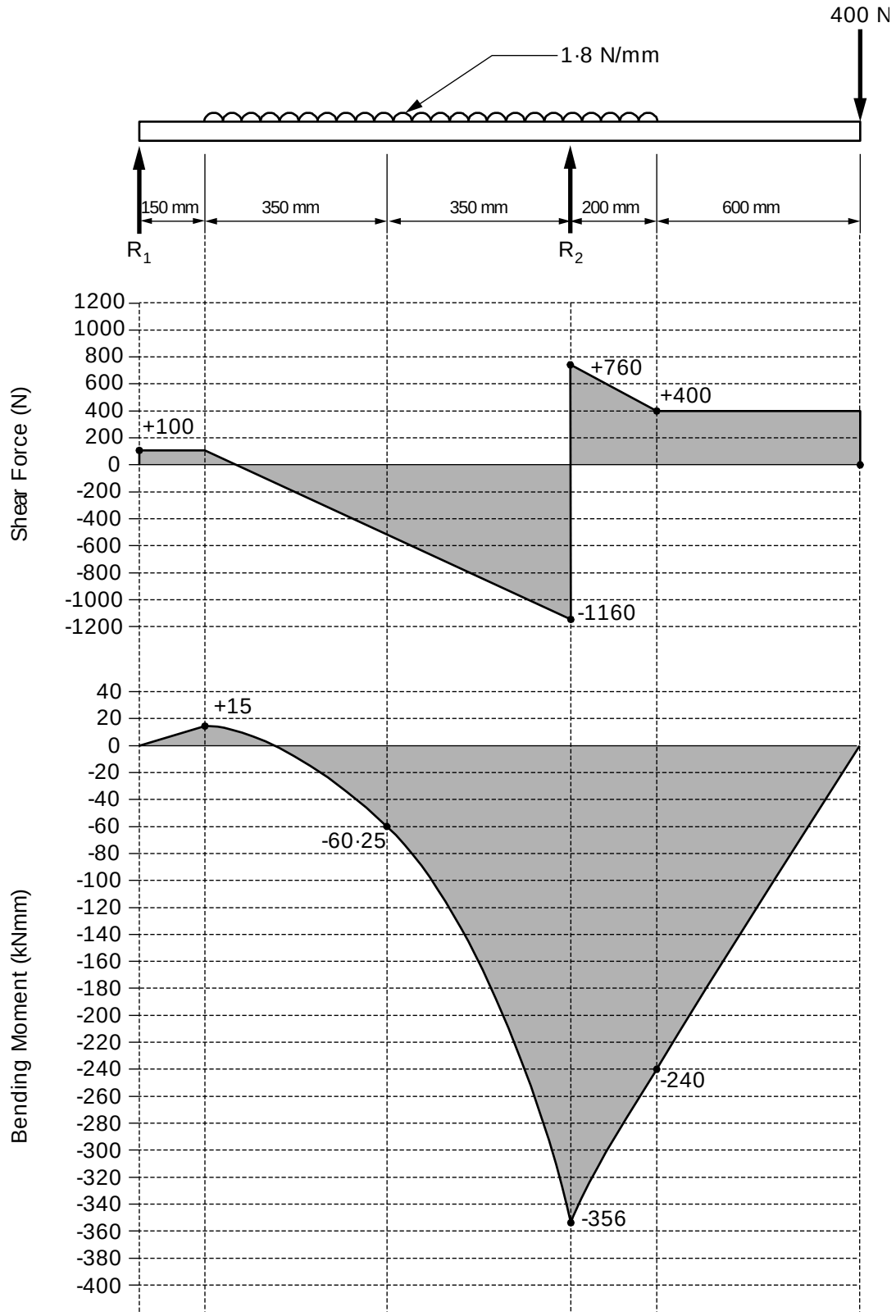
21

(40)

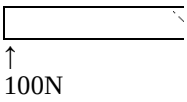
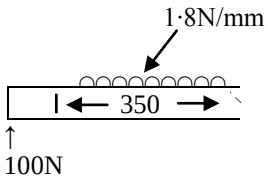
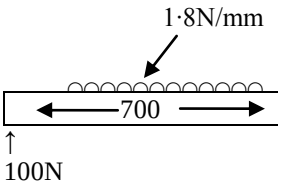
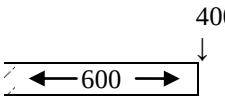
Q10

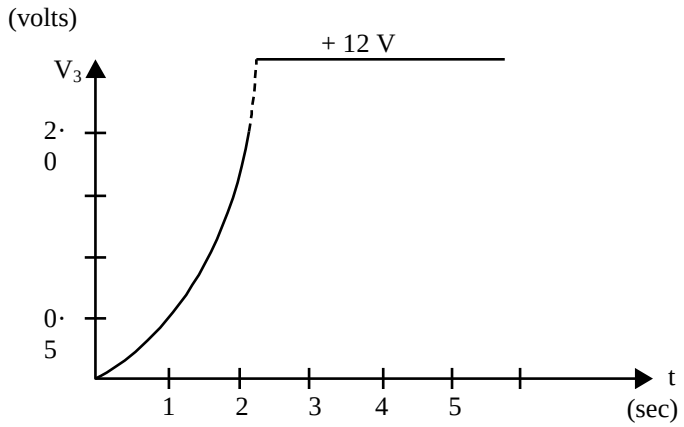
					Marks	
(a)	(i)		30 : 60		1	
			$\frac{12\cdot6}{0\cdot09}=140\,\text{cycles}$		1	**2**
	(ii)		$\frac{16\cdot2}{0\cdot09}=180\,\text{cycles}$			**1**
(b)	main:	clrf	SOLO		1	
	loop:	btfss	PORTB,0		1	
		goto	loop	(with 2nd "gotoloop" below)	1	
		incf	SOLO, F		1	
		movlw	d'200'		1	
		call	pause			
		btfsc	PORTB,0		1	
		incf	SOLO, F		1	
		clrw			1	
		xorwf	SOLO, W		1	
		btfsc	STATUS, Z		1	
		goto	loop			
		movlw	d '1'		1	
		xorwf	SOLO, W		1	
		btfss	STATUS, Z		1	
		goto	jump		1	
		call	mode 1		1	
	jump:	call	mode 2		1	
		goto	main		1	**17**
(c)	$\Sigma M_{RI} = 0$ $+(1\cdot8\times900\times600)+(400\times1650)-(R_2\times850)=0$ $+972{,}000+660{,}000=850R_2$				1	
	$R_2 = +1920\text{N}\uparrow$				1	
	$\Sigma F_V = 0$ $+ R_1 - (1\cdot8\times900) - 400 + 1920 = 0$				1	
	$+ R_1 - 1620 - 400 + 1920 = 0$ $R_1 = 100\text{ N}\uparrow$				1	**4**
(d)	See Worksheet Q10			4 Shear-Force values at 1 each		**4**

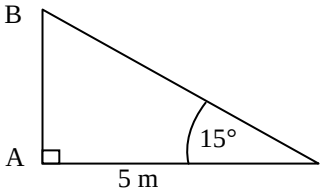
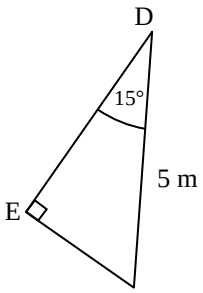
Worksheet Q10

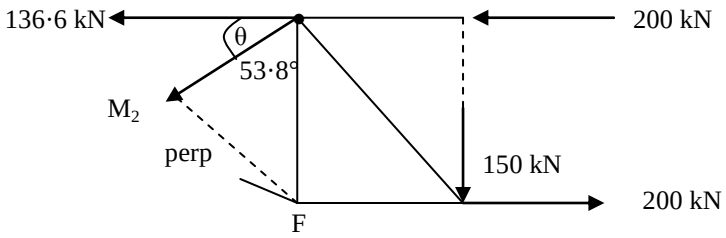


Distance from LHE (mm)	0	150	500	850	1050	1650
Bending Moment (kNmm)	0	15	-60·25	-356	-240	0

		Marks	
Q10	(continued)		
(e)	Omm M = O Nmm	1	
	150mm  $M = +(100\times 150) = +15,000\,\text{Nmm}$	2	
	500mm  $M = +(100\times 500) - \left(1{\cdot}8 \times 350 \times \frac{350}{2}\right)$ $M = +50,000 - 110,250$ $M = -60,250\,\text{Nmm}$	2	
	850mm  $M = +(100\times 850) - \left(1{\cdot}8 \times 700 \times \frac{700}{2}\right)$ $M = +85,000 - 441,000$ $M = -356,000\,\text{Nmm}$	2	
	1050mm  $M = -(400\times 600) = -240,000\,\text{Nmm}$	2	
	1650mm $M = 0\,\text{Nmm}$	1	
	Plot of B-M diagram: points (1) shape (1)	2	**12**
			(40)

			Marks	
Q11				
(a)	(i)	$V_2 = -t$		**1**
	(ii)	$V_3 = -\frac{1}{RC}\int V_2 \, dt$	1	
		$= -\frac{1}{1\times10^{6}\times1\times10^{-6}}\int(-t)\,dt$	1	
		$= +\frac{1}{1}\times\frac{t^2}{2}$	1	
			1	
		$V_3 = +\frac{1}{2}t^2$	1	**5**
	(iii)			**5**
	(iv)	$V_2 = -\frac{1}{RC}\int V_1 \, dt$	1	
		$-t = \frac{1}{560\times10^{3}\times4\cdot7\times10^{-6}}\int V_1 \, dt$	1	
		$-t = -\frac{1}{2\cdot632}\times\frac{V_1 \, t^1}{1}$	1	
		$1 = \frac{V_1}{2\cdot632}$	1	
		$V_1 = 2\cdot63\,V$	1	**5**

			Marks	
Q11	(continued)			
(b)	(i)	Voltage Controlled Oscillator		**1**
	(ii)	V_{ref} is provided by voltage divider	1	
		V_1 charges up capacitor via input resistor	1	
		The comparator switches on relay (via transistor) when capacitor voltage $> V_{ref}$.	1	
		Relay briefly switches on buzzer and discharges capacitor.	1	
		Cycle repeats.	1	
		Magnitude of V_1 affects frequency of buzzing.	1	
		The greater the acceleration, the greater the frequency.	1	**7**
(c)		 $\tan 15^\circ = \frac{AB}{5}$	1	
		$AB = 5\tan 15^\circ = 1{\cdot}34\text{m}$		
		BC = 5 - 1·34 = 3·66 m	1	
		 $\cos 15^\circ = \frac{DE}{5}$		
		$DE = 5\cos 15^\circ = 4{\cdot}83\text{m}$	1	**3**

	Marks	
Q11 (continued)		
(d) $\Sigma M_D = 0 +$ (↷)		
$+(M_3 \times 4 \cdot 83) + (150 \times 5) - (200 \times 5) = 0$	1	
$+14 \cdot 83\, M_3 + 750 - 1000 = 0$	1	
$M_3 = \dfrac{250}{4 \cdot 83} = 51 \cdot 8\text{kN}$ (TIE)	2	
$\Sigma M_B = 0 +$ (↶)		
$-(M_1 \times 3 \cdot 66) + (150 \times 10) - (200 \times 3 \cdot 66) - (200 \times 1 \cdot 34) = 0$	1	
$-3 \cdot 66\, M_1 + 1500 - 732 - 268 = 0$	1	
$M_1 = \dfrac{500}{3 \cdot 66} = +137\text{kN}$ (TIE)	2	
		
$\Sigma F_V = 0$ (↑ +)		
$+M_3 \cos 75 - M_2 \cos 53 \cdot 8 - 150 = 0$	1	
$M_2 \cos 53 \cdot 8 = M_3 \cos 75 - 150$	1	
$M_2 = \dfrac{51 \cdot 8 \cos 75 - 150}{\cos 53 \cdot 8}$	1	
$M_2 = \dfrac{13 \cdot 4 - 150}{\cos 53 \cdot 8} = -233$ kN (STRUT)	2	**13**
		(40)

[END OF MARKING INSTRUCTIONS]