



**2010 Technological Studies**

**Advanced Higher**

**Finalised Marking Instructions**

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**Section A**

**Q1**

- (a) Sub-system A :-
- 555 timer configured as an ASTABLE
  - regular clock pulses
  - RC network affects lid-fitting frequency
  - counter counts sends high signal to NAND of subsystem B on 40<sup>th</sup> bottle

- Sub-system B :-
- NAND goes low when both inputs high
  - resets counter
  - triggers 555 timer configured as an MONOSTABLE
  - actuates motor via relay

(b)  $T = 1.2 \text{ s}$

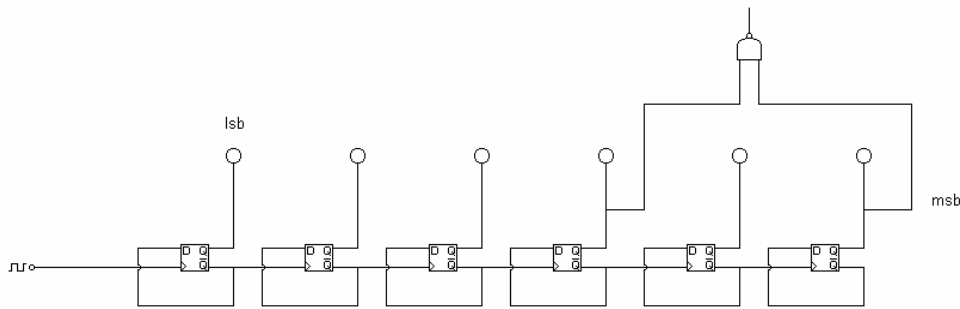
$$f = \frac{1}{T} = 0.833 \text{ Hz}$$

$$f = \frac{1.44}{(R_1 + 2R_2) \times C}$$

$$R_2 = \frac{1}{2} \left\{ \frac{1.44}{0.833 \times 100 \times 10^{-6}} - 1000 \right\}$$

$$R_2 = 8140 \text{ } \Omega = 8.14 \text{ k}\Omega$$

(c)



- 1/2 for D-types with  $\bar{Q}$  feedback
- 1/2 for clock input
- 1/2 for  $\bar{Q}$  cocking next
- 1/2 for 6 D-types
- 1/2 for signal from 4<sup>th</sup> D-type to NAND
- 1/2 for signal from 6<sup>th</sup> D-type to NAND

| <b>Marks</b> |          |
|--------------|----------|
| 1/2          | <b>4</b> |
| 1/2          |          |
| 1/2          |          |
| 1/2          |          |
| 1/2          | <b>2</b> |
| 1            |          |
| 1/2          |          |
| 3            | <b>3</b> |
| <b>(9)</b>   |          |



**Q3 (continued)**

```

(b)  softstop:      btfss      PORTB,0      }
                        goto      softstop

                        movlw     d'1'      }
                        movwf     DELAYTIME }

                        movlw     d'9'      }
                        movwf     COUNTER  }
                        call      stepper

loop:      incf      DELAYTIME,F      }
                        decfsz    COUNTER,F }
                        goto      loop

                        movlw     d'10'     }
                        movwf     COUNTER   }
                        call      stepper

loop2:     movlw     d'2'      }
                        addwf     DELAYTIME }

                        decfsz    COUNTER,F }
                        goto      loop2

                        end
    
```

| <b>Marks</b> |            |
|--------------|------------|
| 1/2          |            |
| 1/2          |            |
| 1/2          |            |
| 1/2          |            |
| 1/2          |            |
| 1/2          |            |
| 1/2          |            |
| 1/2          |            |
| <b>4</b>     |            |
|              | <b>(8)</b> |
|              |            |
|              | <b>(7)</b> |
|              |            |
|              | <b>1</b>   |
|              | <b>2</b>   |

**Q4**

See Worksheet Q4

**Q5**

- (a) Scenario 1 = sagging
- Scenario 2 = hogging
- (b) See Worksheet Q5(a)

**Q4 (continued)**

- (c) 0m BM = 0 kNm
- 10m BM =  $-(100 \times 10 \times 5)$   
 $= - 5000 \text{ kNm}$
- 20m BM =  $-(100 \times 20 \times 10) + (5000 \times 10)$   
 $= - 20000 + 50000 = + 30000 \text{ kNm}$
- 30m BM =  $-(100 \times 30 \times 15) + (5000 \times 20)$   
 $= - 45000 + 100\,000 = + 55000 \text{ kNm}$
- 40m BM =  $-(100 \times 40 \times 20) + (5000 \times 30)$   
 $= - 80000 + 150\,000 = + 70000 \text{ kNm}$
- 50m BM =  $-(100 \times 50 \times 25) + (5000 \times 40)$   
 $= - 125000 + 200\,000 = + 70000 \text{ kNm}$
- (d) See Worksheet Q5(a)
- (e) See Worksheet Q5(b)

| <b>Marks</b> |  |
|--------------|--|
| 1            |  |
| 1            |  |
| 1            |  |
| 1            |  |
| 1            |  |
| 1            | <b>6</b>   |
|              | <b>2</b>   |
|              | <b>2</b>   |
|              | <b>(13)</b>  |
| <b>Q6</b>    |  |
| (a)          | <pre> heat:      movlw      d'30'            movwf     COUNTER    }             loop:     bsf      PORTB, 7            movfw    MARK        }            call     pause      }             bcf      PORTB, 7    }            movfw    SPACE      }            call     pause      }             decfsz   COUNTER,F   }            goto    loop        }            return </pre> |
|              | ½  |
|              | ½  |
|              | ½  |
|              | ½  |
|              | ½  |
|              | ½  |
|              | <b>3</b>   |

**Q6 (continued)**

```

(b)  main:      bsf      PORTB,6      }
      call     adcread   }
      subwf    DESIRED,W  }
      movwf   ERROR      }
      btfss   STATUS,C   }
      goto    neg        }

      pos:      movwf   ERROR      }
      addwf   MARK,F     }
      call   heat        }
      goto   overflow    }

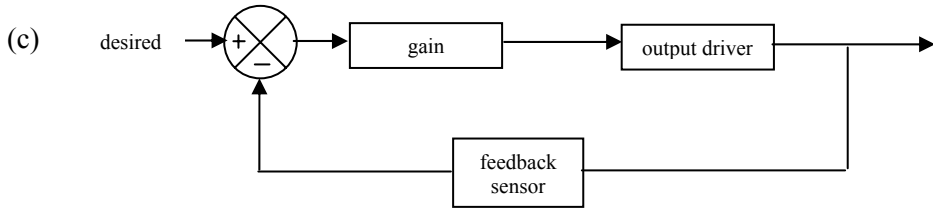
      neg:      comf    ERROR,F    }
      incf    ERROR,F    }
      movwf   ERROR      }
      subwf   MARK,F     }
      call   heat        }

      overflow: btfss   PORTB,0    }
      goto   main        }

      bcf     PORTB,6

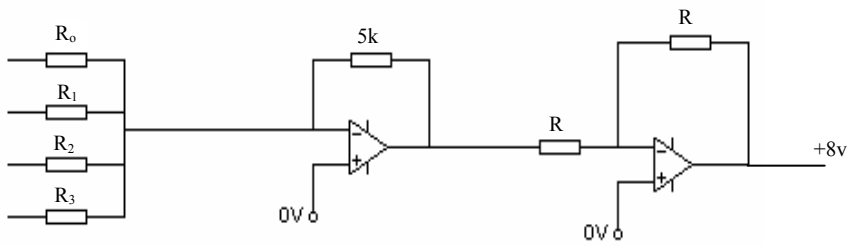
      movlw   d'150'     }
      call   wait        }
      goto   main        }
  
```

| Marks       |          |
|-------------|----------|
| 1/2         | <b>7</b> |
| 1/2         |          |
| 1/2         |          |
| 1/2         |          |
| 1/2         |          |
| 1/2         |          |
| 1/2         |          |
| 1/2         |          |
| 1/2         |          |
| 1/2         |          |
| 1/2         |          |
| 1/2         |          |
| 1/2         |          |
| 1/2         |          |
| <b>(11)</b> |          |



**Q7**

(a)



$$\frac{1}{15} \times 8 \text{ v} = 0.533 \text{ v}$$

$$0.533 = 5 \times \frac{5}{R_0}$$

$$R_0 = 5 \times \frac{5}{0.533} = 47 \text{ k}\Omega$$

$$R_1 = 23.5 \text{ k}\Omega$$

$$R_2 = 11.75 \text{ k}\Omega$$

$$R_3 = 5.875 \text{ k}\Omega$$

(b)  $1101 = 13$

$$\frac{13}{15} \times 8 = 6.933 \text{ V}$$

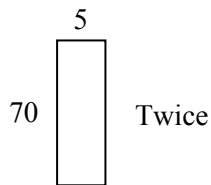
| Marks |            |
|-------|------------|
| 1 ½   |            |
| 1     |            |
| 1     |            |
| 1     |            |
| 1 ½   | <b>6</b>   |
| ½     |            |
| ½     | <b>1</b>   |
|       | <b>(7)</b> |

**Section B**

**Q8**

- (a) (i)  $R_A = R_B = \frac{1}{2} [ 5000 + 5000 + (1.6 \times 1600) ] = 6280 \text{ N}$   
 (ii)  $M = + (6280 \times 800) - (5000 \times 600) - (1.6 \times 800 \times 400)$   
 $= + 5024000 - 3000000 - 512000$   
 $= 1512000 \text{ Nmm} = 1512 \text{ Nm} = 1.512 \text{ kNm}$

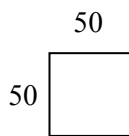
(b)



$$I = [ \frac{1}{12} (5 \times 70^3) ] \times 2$$

$$= 285833 \text{ mm}^4$$

PLUS



$$I = \frac{1}{12} (50 \times 50^3)$$

$$= 520833 \text{ mm}^4$$

$$I_{\text{tot}} = 806666 \text{ mm}^4$$

(c)

$$I_{\text{min}} = \frac{My}{\sigma}$$

$$= \frac{(1.4 \times 10^6 \times 35)}{65} = 753846 \text{ mm}^4$$

$$I_{\text{HOLE}} = 806666 - 753846 = 52820 \text{ mm}^4$$

$$52820 = \frac{\pi}{64} \times D^4$$

$$D^4 = \frac{(52820 \times 64)}{\pi}$$

$$D = 32.2 \text{ mm}$$

| Marks |          |
|-------|----------|
|       | <b>1</b> |
| 1     |          |
| 1     |          |
| 1     | <b>3</b> |
| 1     |          |
| 1     |          |
| 1     | <b>3</b> |
| 2     |          |
| 1     |          |
| 1     |          |
| 1     | <b>5</b> |



**Q8 (continued)**

- (d) Wein bridge produces a sine wave  
 Frequency determined by R and C<sub>1</sub>  
 Triggers transistor (@ + 0.7V)  
 Actuates relay which discharges C<sub>2</sub> to reset integrator  
 Integrator produces -ve ramp  
**OR:** produces a sawtooth waveform

(e)  $f = \frac{1}{2\pi RC}$

$$C = \frac{1}{2\pi RF}$$

$$= \frac{1}{(2\pi \times 5000 \times 2)}$$

$$= 1.6 \times 10^{-5} \text{ F} = 16 \text{ } \mu\text{F}$$

(f)  $V_{\text{out}} = \frac{-5}{0.2} = -25 \text{ t}$

$$V_{\text{out}} = -\frac{1}{RC} \int V_i dt$$

$$-25 \text{ t} = \frac{-1}{10 \times 10^3 \times C} \int 10 dt$$

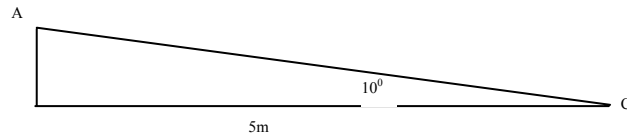
$$-25 \text{ t} = \frac{-1}{(10 \times 10^3 \times C)} \times 10t$$

$$C = \frac{10}{(10 \times 10^3 \times 25)} = 4 \times 10^{-5} \text{ F} = 40 \text{ } \mu\text{F}$$

| Marks       |          |
|-------------|----------|
| ½           | <b>3</b> |
| ½           |          |
| ½           |          |
| 1 ½         |          |
|             |          |
| ½           | <b>2</b> |
| 1           |          |
| ½           |          |
| ½           |          |
| ½           | <b>3</b> |
| 1           |          |
| <b>(20)</b> |          |

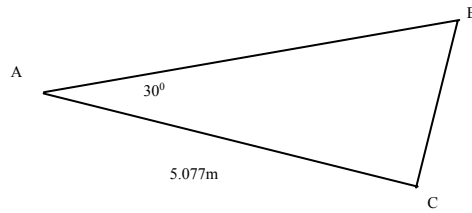
**Q9**

(a) (i)



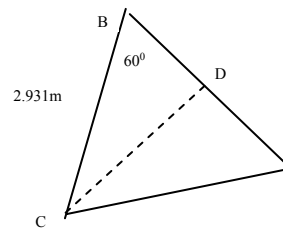
$$AC = \text{hyp} = \frac{5}{\cos 10^\circ} = 5.077 \text{ m}$$

(ii)



$$BC = \text{opp} = 5.077 \tan 30^\circ = 2.931 \text{ m}$$

(iii)



$$CD = \text{opp} = 2.931 \sin 60^\circ = 2.538 \text{ m}$$

| Marks |  |
|-------|--|
| 1     |  |
| 1     |  |
| 1     |  |

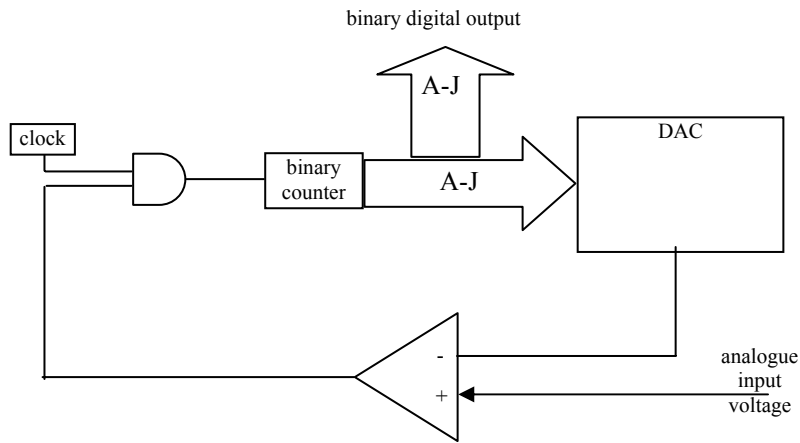


**Q9 (continued)**

|     |            |        |               | <b>Marks</b>             |             |  |        |            |   |
|-----|------------|--------|---------------|--------------------------|-------------|--|--------|------------|---|
| (c) | multiplex: | movlw  | d'4' }        |                          | 1/2         |  |        |            |   |
|     |            | movwf  | COUNTER }     |                          |             |  |        |            |   |
|     |            | movlw  | d'0' }        |                          | 1/2         |  |        |            |   |
|     |            | movwf  | PORTB }       |                          |             |  |        |            |   |
|     | loop:      | call   | adcread }     |                          | 1/2         |  |        |            |   |
|     |            | call   | storeval }    |                          |             |  |        |            |   |
|     |            | incf   | PORTB,F }     |                          | 1/2         |  |        |            |   |
|     |            | decfsz | COUNTER,F }   |                          | 1/2         |  |        |            |   |
|     |            | goto   | loop }        |                          |             |  |        |            |   |
|     |            | end    |               |                          | 1/2         |  |        |            |   |
|     | <b>3</b>   |        |               |                          |             |  |        |            |   |
| (d) | overload3: | movlw  | b'00000000' } | ;clear all outputs       | 1/2         |  |        |            |   |
|     |            | movwf  | PORTB }       |                          |             |  |        |            |   |
|     |            | movlw  | d'10' }       |                          |             | ;subtract 10 from data3 (save result into w) |        |            |   |
|     |            | subwf  | DATA3,W }     |                          |             |  |        |            |   |
|     |            |        |               |                          |             |  | 1/2    |            |   |
|     |            |        |               |                          |             |  |        | 1/2        |   |
|     |            |        |               |                          |             |  | btfsz  | STATUS,C } |   |
|     |            |        |               |                          |             |  | bsf    | PORTB,6 }  | ;data3 less than 10 so amber condition    |
|     |            |        |               |                          |             |  | return |            |   |
|     |            |        |               |                          |             |  | movlw  | d'51' }    | ;data3 greater than 10 so check for green |
|     |            |        |               |                          |             |  | subwf  | DATA3,W }  |   |
|     |            |        |               |                          |             |  |        |            | 1/2                                       |
|     |            |        |               |                          |             |  | btfsz  | STATUS,C } | ;if positive then carry flag set          |
|     |            |        |               |                          |             |  | goto   | red }      |   |
|     |            |        |               |                          |             |  | bsf    | PORTB,5 }  | ;data3 less than 51 so green condition    |
|     |            |        |               | 1/2                      |             |  |        |            |   |
|     |            | return |               | ; return to main program | 1/2         |  |        |            |   |
|     | red:       | movlw  | d'10' }       |                          | 1/2         |  |        |            |   |
|     |            | movwf  | COUNT }       |                          |             |  |        |            |   |
|     | loop:      | bsf    | PORTB,7 }     |                          | 1/2         |  |        |            |   |
|     |            | bsf    | PORTB,4 }     |                          | 1/2         |  |        |            |   |
|     |            | movlw  | d'2' }        |                          | 1/2         |  |        |            |   |
|     |            | call   | wait }        |                          |             |  |        |            |   |
|     |            | bcf    | PORTB,4 }     |                          | 1/2         |  |        |            |   |
|     |            | movlw  | d'3' }        |                          |             |  |        |            |   |
|     |            | call   | wait }        |                          |             |  |        |            |   |
|     |            | decfsz | COUNT,F }     |                          | 1/2         |  |        |            |   |
|     |            | goto   | loop }        |                          |             |  |        |            |   |
|     |            | return |               |                          | 1/2         |  |        |            |   |
|     |            |        |               |                          | <b>8</b>    |  |        |            |   |
|     |            |        |               |                          | <b>(20)</b> |  |        |            |   |

**Q10**

(a) (i)



(ii) clock - provides counting pulses

AND gate - allows clock pulses through to binary counter when comparator high

binary counter - counts clock pulse when comparator high provides binary output

DAC - converts binary back into analogue

comparator - freezes count when analogue from DAC equivalent to analogue input

(b)  $2^{10} = 1024 = -8$  Volts

$$\text{resolution} = \frac{8}{1024} = -7.8125 \text{ mV}$$

bit "E" = 16 decimal

$$V_{\text{out}} = 16 \times -7.8125 = -125\text{mV} = -0.125 \text{ V}$$

- (c) (i)
- $R_1 = 1024 \text{ k}\Omega$
  - $R_3 = 256 \text{ k}\Omega$
  - $R_4 = 128 \text{ k}\Omega$
  - $R_5 = 64 \text{ k}\Omega$
  - $R_6 = 32 \text{ k}\Omega$
  - $R_7 = 16 \text{ k}\Omega$
  - $R_8 = 8 \text{ k}\Omega$
  - $R_9 = 4 \text{ k}\Omega$
  - $R_{10} = 2 \text{ k}\Omega$

(ii)

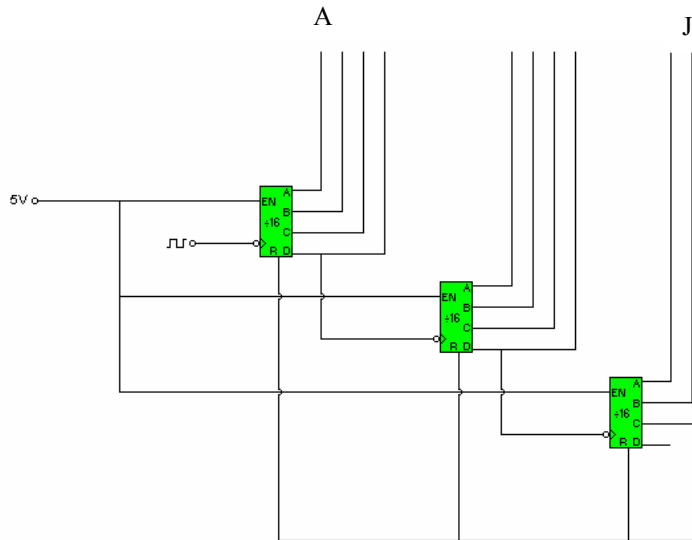
$$-7.8125 \times 10^{-3} = \frac{-R_f}{1024} \times 5$$

$$R_f = (7.8125 \times 10^{-3} \times 1024) / 5 = 1.6 \text{ k}\Omega$$

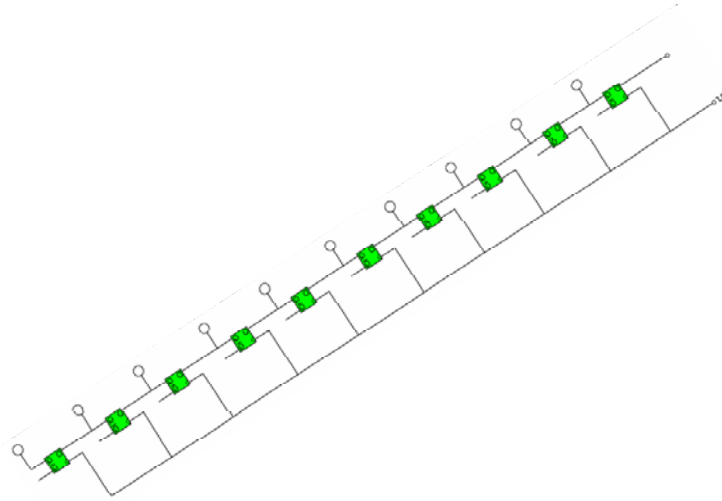
| Marks         |   |
|---------------|---|
| 1             | 1 |
| $\frac{1}{2}$ |   |
| $\frac{1}{2}$ |   |
| $\frac{1}{2}$ |   |
| $\frac{1}{2}$ |   |
| $\frac{1}{2}$ | 3 |
| $\frac{1}{2}$ |   |
| $\frac{1}{2}$ |   |
| $\frac{1}{2}$ | 2 |
| 1             |   |
| 1             | 2 |

**Q10 (continued)**

(d)



(e)



(f)

```

transfer:    movlw    d'7'
             movwf    CLOCKCOUNT

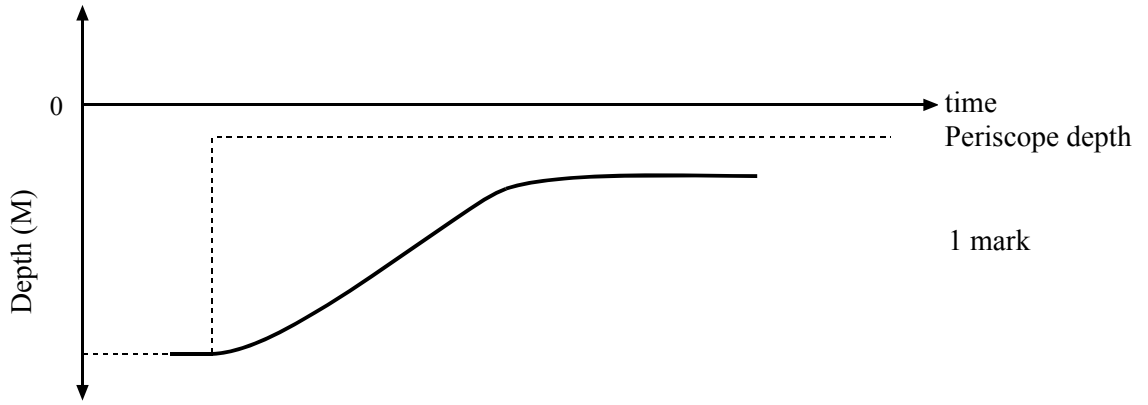
loop:       bsf      PORTA,2
             movlw   d'1'
             call    pause
             bcf      PORTA,2
             rlf      PORTB,F
             decfsz  CLOCKCOUNT,F
             goto    loop
             movfw   PORTB
             movwf   BEARING
             return
    
```

Two labels ½ mark

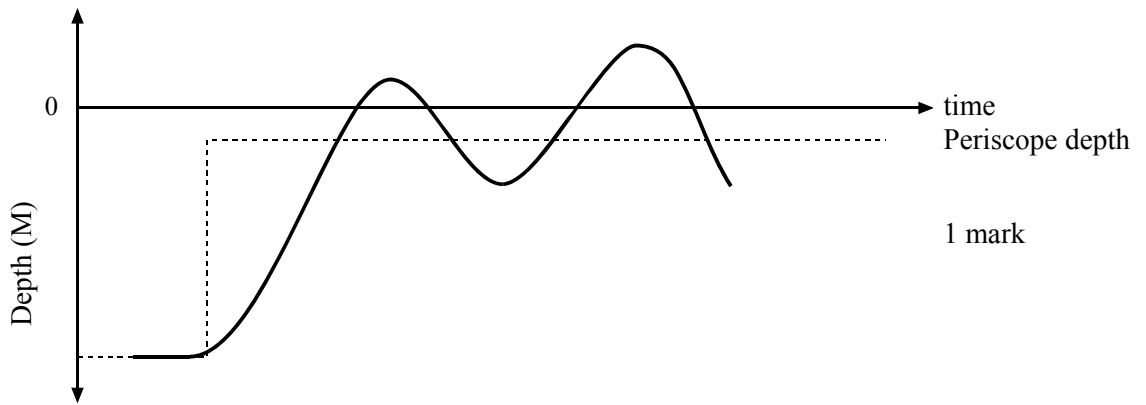
| Marks                                     |   |
|---|---|
| 2   |   |
| 2   |   |
| ½<br>½                                    |   |
| ½<br>½<br>½<br>½<br>1<br>½<br>½<br>½<br>½ |   |
| ½   | 7 |
| <b>(20)</b>                               |   |

**Worksheet Q2**

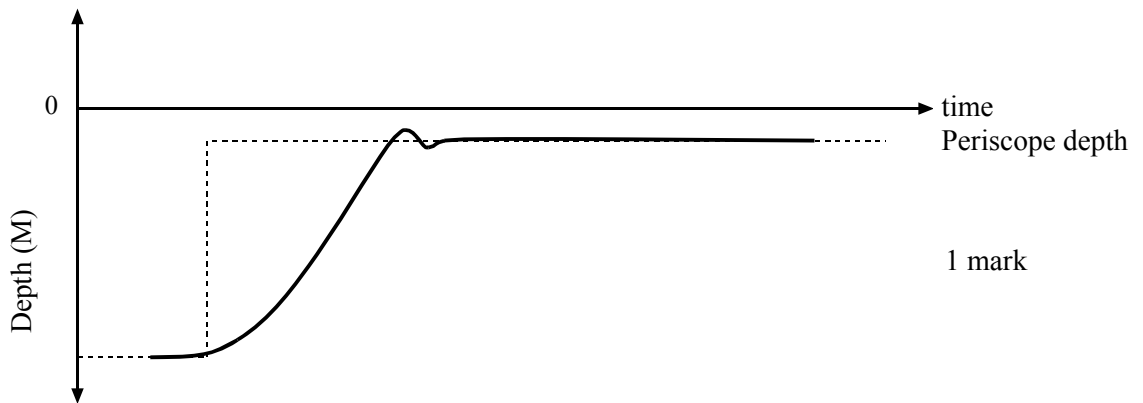
(i)



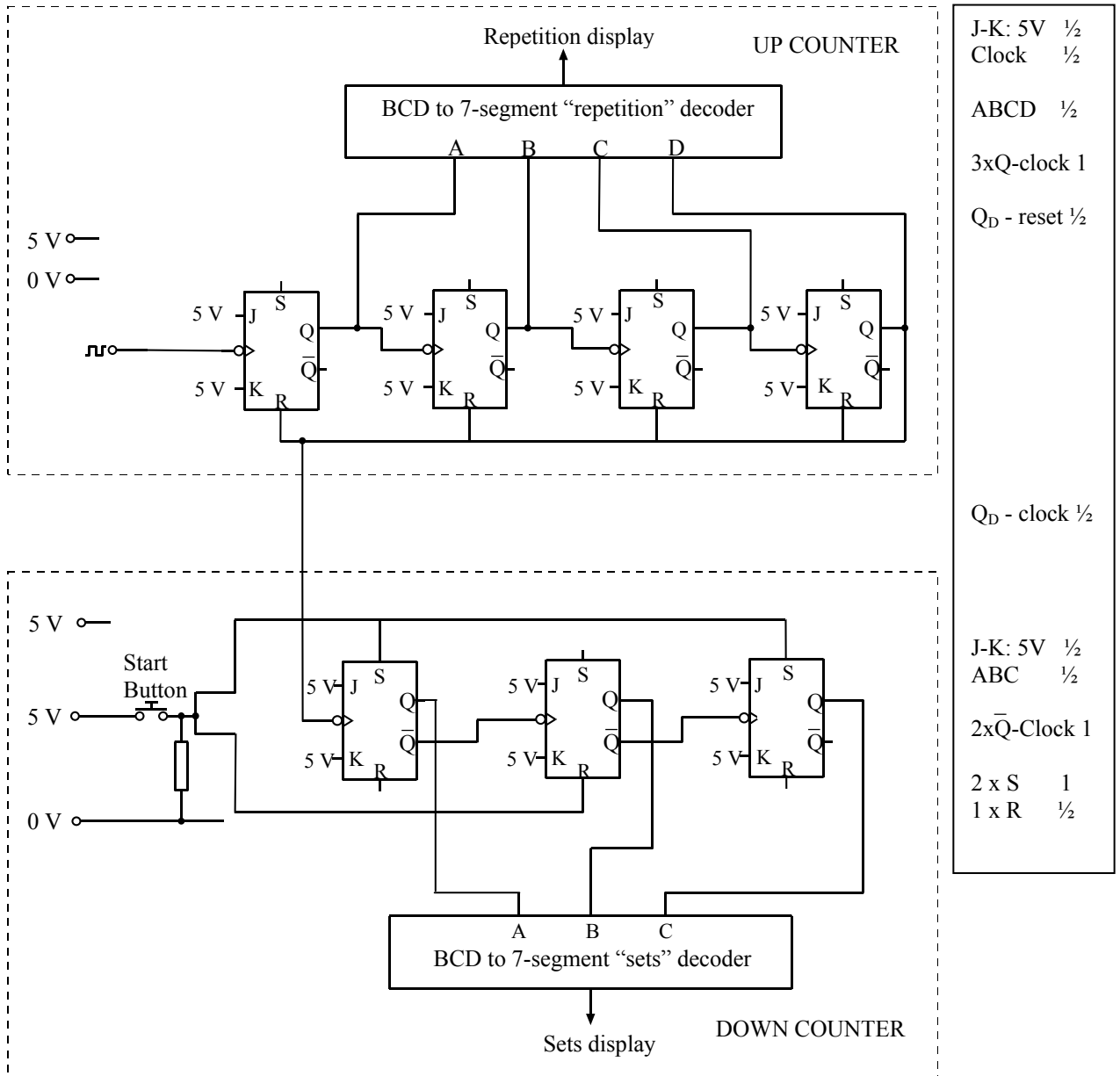
(ii)



(iii)



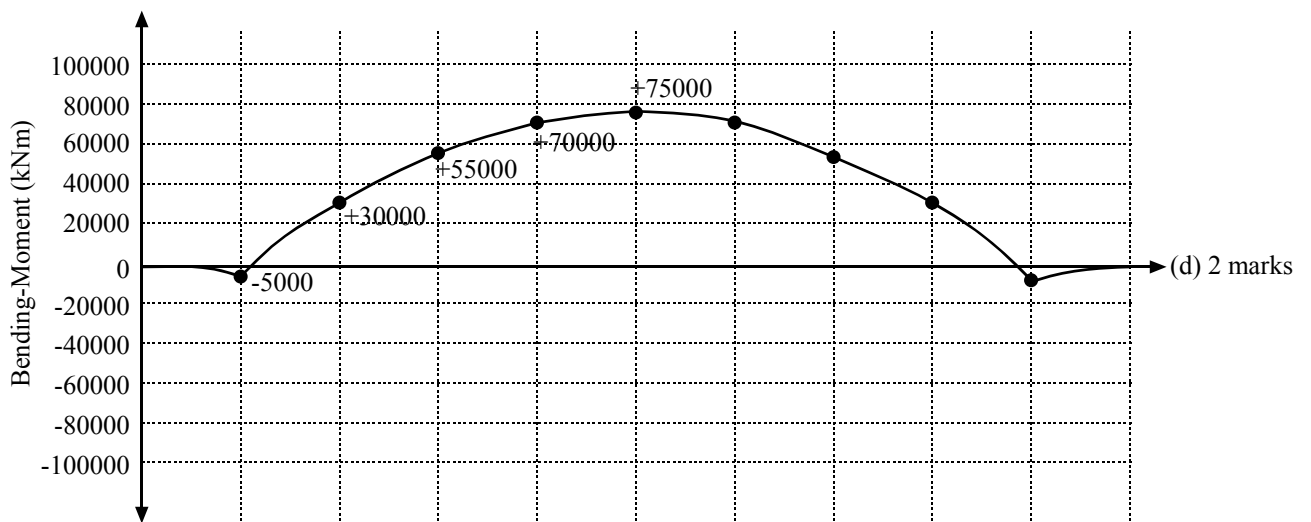
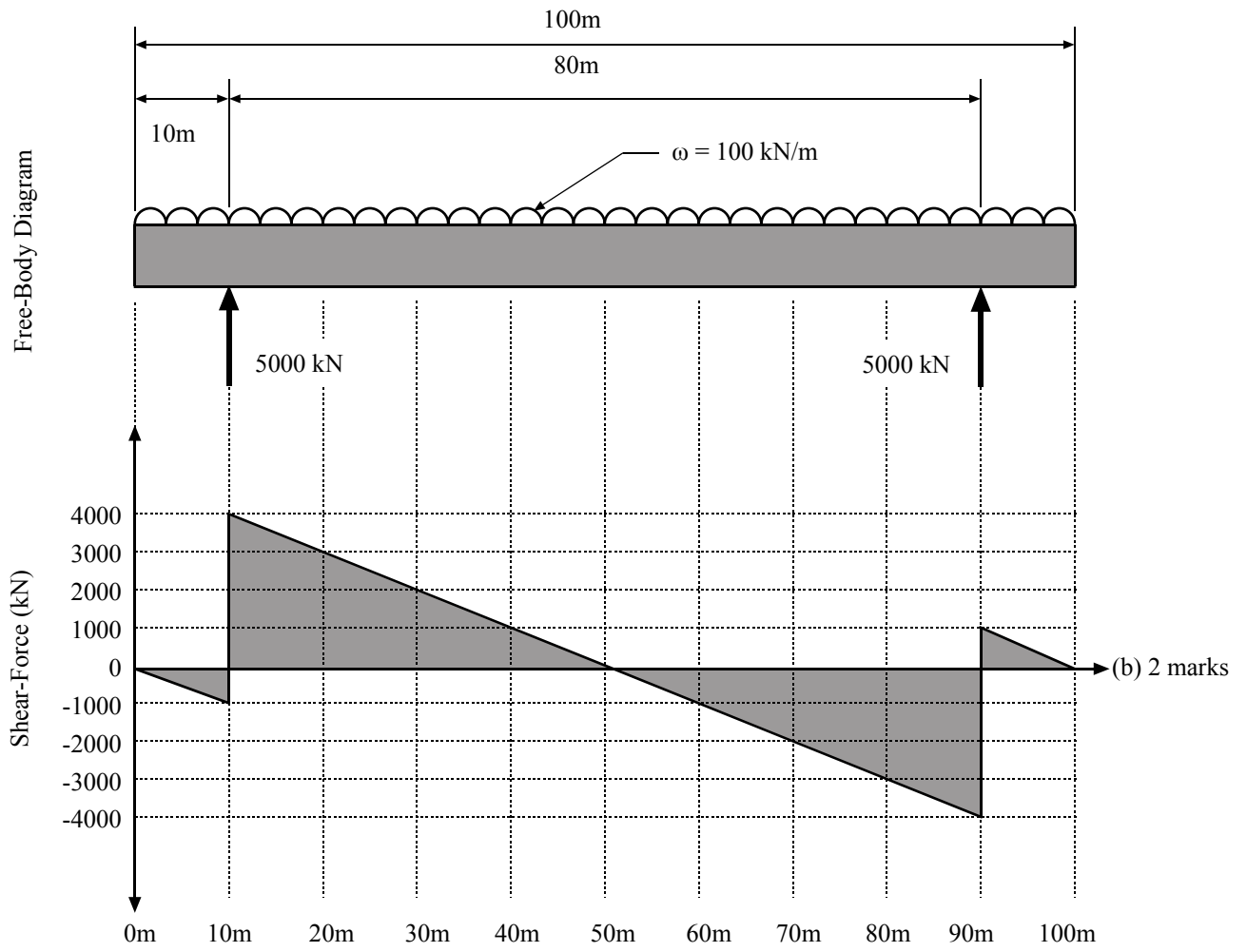
Worksheet Q4



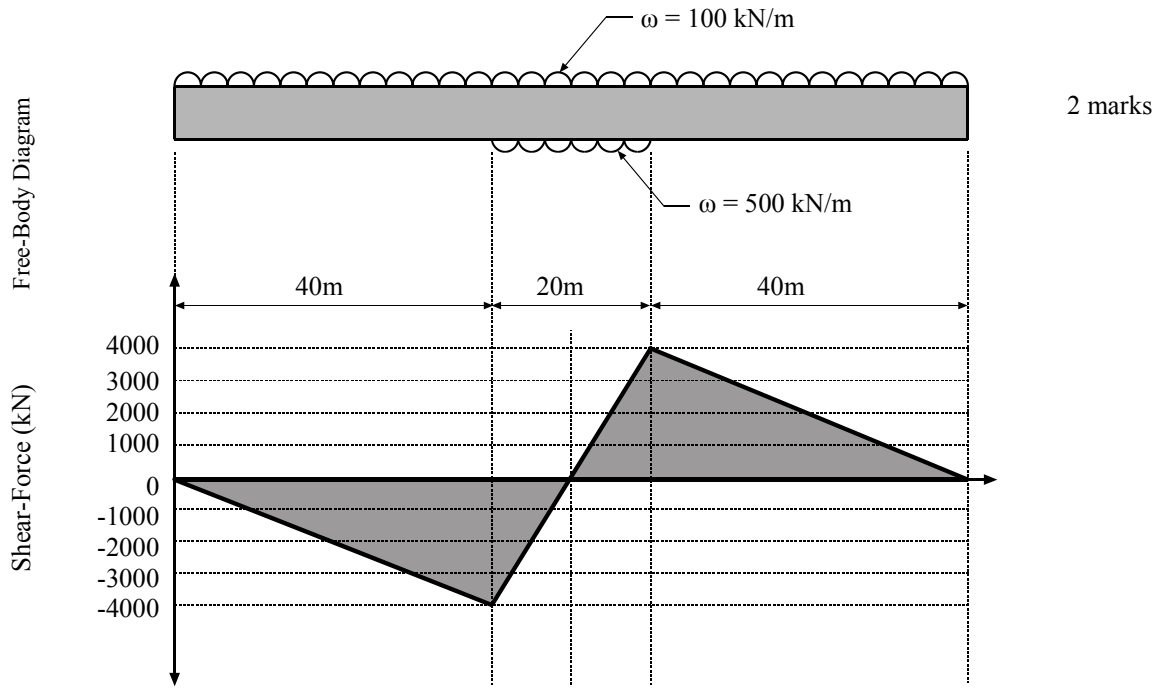
7 marks



Worksheet Q5(a)



Worksheet Q5(b)



[END OF MARKING INSTRUCTIONS]