2014 Technological Studies

Advanced Higher

Finalised Marking Instructions

© Scottish Qualifications Authority 2014

The information in this publication may be reproduced to support SQA qualifications only on a non-commercial basis. If it is to be used for any other purposes written permission must be obtained from SQA’s NQ Assessment team.

Where the publication includes materials from sources other than SQA (secondary copyright), this material should only be reproduced for the purposes of examination or assessment. If it needs to be reproduced for any other purpose it is the centre’s responsibility to obtain the necessary copyright clearance. SQA’s NQ Assessment team may be able to direct you to the secondary sources.

These Marking Instructions have been prepared by Examination Teams for use by SQA Appointed Markers when marking External Course Assessments. This publication must not be reproduced for commercial or trade purposes.
Part One: General Marking Principles for: Technological Studies Advanced 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 Advanced 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.
Part Two: Marking Instructions for each Question

Section A

Q1

(a) (i) Wein-bridge oscillator 1 1

(ii) Sine wave 1 1

(b) \[ f = \frac{1}{2\pi RC} \]

\[ R = \frac{1}{2\pi fC} = \frac{1}{2 \times 3 \times 14 \times 1 \times 10^{-6} \times 1000} \]

3 subs 3

\[ R = 159\Omega \] Answer plus unit 1 4

(c) Output fed into a Schmitt trigger (1) which would produce a square wave (1) which is suitable as a falling edge. 2
Q2

<table>
<thead>
<tr>
<th>Function</th>
<th>Instruction</th>
<th>Description</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>main:</td>
<td>btfss PORTB,0</td>
<td>;start switch</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>goto main</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>water:</td>
<td>btfss PORTB,3</td>
<td>;float switch</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>goto ALARM</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>bsf PORTB,1</td>
<td>;poll mux for quantity dial</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>call adread</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>movwf QUANTITY</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>bsf PORTB,7</td>
<td>;heat water</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>bcf PORTB,1</td>
<td>;poll mux for temperature</td>
<td>1</td>
</tr>
<tr>
<td>HEAT:</td>
<td>call adread</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>movwf TEMPERATURE</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>movlw d'180'</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>subwf TEMPERATURE,W</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>btfss STATUS,C</td>
<td>;check temp reached 180</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>goto HEAT</td>
<td>;no, so keep heating</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>bcf PORTB,7</td>
<td>;heater off</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>rrf QUANTITY,F</td>
<td>;quantity ÷ 2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>movfw QUANTITY</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>bsf PORTB,6</td>
<td>;valve on</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>call wait</td>
<td>;time delay</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>bcf PORTB,6</td>
<td>;valve off</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>goto main</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>ALARM:</td>
<td>bsf PORTB,5</td>
<td>;bleep on</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>movlw d'10'</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>call wait</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>bcf PORTB,5</td>
<td>;bleep off</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>goto main</td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>
Q3

(a) \( \Sigma M_A = 0 + (10 \times 6) + (5 \times 12) + (1 \times 2 \times 3) - (R_B \times 12) = 0 \)
\[ + 60 + 60 + 6 - 12R_B = 0 \]
\[ R_B = + \frac{126}{12} = +10 \cdot 5 \text{kN} \uparrow \]

\( \Sigma V = 0 \uparrow + \)
\[ + R_A - (1 \times 2) - 10 - 5 + 10 \cdot 5 = 0 \]
\[ R_A = + 6 \cdot 5 \text{kN} \uparrow \]

(b) [Diagram of load distribution and reactions]

(c) [Diagram of shear force and bending moment]
Q3

(c) (cont)

\[
0m \& 12mBM = 0kNm
\]

\[
\begin{align*}
2m & \quad \text{BM} = + (6.5 \times 2) = +13kNm & 1 \\
3m & \quad \text{BM} = + (6.5 \times 3) - (1 \times 0.5) = +19.5 - 0.5 = +19kNm & 2 \\
4m & \quad \text{BM} = + (6.5 \times 4) - (2 \times 1) = +26 - 2 = +24kNm & 2 \\
6m & \quad \text{BM} = + (6.5 \times 6) - (1 \times 2 \times 3) = +39 - 6 = +33kNm & 2
\end{align*}
\]

Plotting line

Nature

<table>
<thead>
<tr>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (\text{(20)})</td>
</tr>
</tbody>
</table>
Q4

(a) [Diagram of a system with labeled components: Clock, 4-bit counter, Logic array, Drivers, Conveyor drill]

(b) [Diagram with labeled components and JK flip-flops: 5V, A, B, C, D, Set to 5 Signal, Signal to conveyor]

(c) [Detailed circuit diagram with JK flip-flops and marked connections: 4 falling edge JKS, 5V → JK connections (x4), 1st Q → clk, 2nd & 3rd Q → clk, Q outputs (x4), 4 RESETS linked together]

Marks

<table>
<thead>
<tr>
<th></th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>5</td>
</tr>
<tr>
<td>(b)</td>
<td>6</td>
</tr>
<tr>
<td>(c)</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>18</td>
</tr>
</tbody>
</table>
Q5

(a) Neutral Axis

(b) \[
\begin{align*}
I &= \frac{bd^3}{12} = \frac{50 \times 200^3}{12} = 33.3 \times 10^6 \text{ mm}^4 \\
\end{align*}
\]

(c) \[
\begin{align*}
\frac{M}{I} &= \frac{\sigma}{y} & \sigma &= \frac{My}{I} \\
\sigma &= \frac{40 \times 10^6 \times 100}{33.3 \times 10^6} \\
\sigma &= 120 \text{ N/mm}^2
\end{align*}
\]

Marks

<table>
<thead>
<tr>
<th>Q5</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Neutral Axis</td>
<td></td>
</tr>
<tr>
<td>(b)</td>
<td>2</td>
</tr>
<tr>
<td>(c)</td>
<td>4</td>
</tr>
</tbody>
</table>

(7)
### Q6

<table>
<thead>
<tr>
<th>(a)</th>
<th>Binary coded decimal to decimal decoder (1) converts binary to decimal (1)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Binary coded decimal to 7-segment display (1) decoder converts binary to</td>
</tr>
<tr>
<td></td>
<td>segment signals. (1)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(b)</th>
<th>When OR gate is high, Counter is enabled</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Counter counts up on each rising edge</td>
</tr>
<tr>
<td></td>
<td>BCD to D decodes binary to decimal</td>
</tr>
<tr>
<td></td>
<td>When BCD to D reaches 3 counter A disabled, buzzer sounds</td>
</tr>
<tr>
<td></td>
<td>When BCD to D reaches 3 AND enabled</td>
</tr>
<tr>
<td></td>
<td>When clock goes high → low 2nd 4-bit counter B counts up.</td>
</tr>
<tr>
<td></td>
<td>The 4-bit output is decoded to drive 7-segment display.</td>
</tr>
<tr>
<td></td>
<td>7-segment display shows a digit equivalent to count</td>
</tr>
<tr>
<td></td>
<td>when count reaches 8:</td>
</tr>
<tr>
<td></td>
<td>signal is sent to OR</td>
</tr>
<tr>
<td></td>
<td>and counter A is re-enabled</td>
</tr>
<tr>
<td></td>
<td>Decoder continues to 5 and resets counter B to 0.</td>
</tr>
<tr>
<td></td>
<td>Counter A resets at 10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
</tr>
<tr>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Any 11 points@1</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(15)</th>
</tr>
</thead>
</table>
Q7

(a)(i) gain (k) too low

(a)(ii) gain (k) too high

(b)(i) Removes offset

(b)(ii) Removes hunting / reduces settling time

(c) ideal PID response

(d) \[ A = \left(\frac{60^\circ}{90^\circ} \times 0.75\right) + 0.75 = 1.25 \] substitutions 1

Position A pulse-time (mark) = 1.25ms answer 1

\[ B = \left(\frac{30^\circ}{90^\circ} \times 0.75\right) + 1.50 = 1.75 \]

Position B pulse-time (mark) = 1.75ms 1 3

(e) \[ 1.75 - 1.25 = 0.5 \text{ ms} \]

\[ 0.5 \div 0.01 = 50 \text{ steps} \] 1 2
<table>
<thead>
<tr>
<th>Q7 (cont)</th>
<th>Assembler Code</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>(f) drive:</td>
<td>movlw d’125’</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>movwf MARK</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>movlw d’50’</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>movwf COUNTER</td>
<td>1</td>
</tr>
<tr>
<td>loop:</td>
<td>bsf PORTB,4</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>movfw MARK</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>call short</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>bcf PORTB,4</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>movlw d’20’</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>call pause</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>incf MARK,F</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>decfsz COUNTER,F</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>goto loop</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>movlw d’50’</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>movwf COUNTER</td>
<td>1</td>
</tr>
<tr>
<td>loop2</td>
<td>bsf PORTB,4</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>movfw MARK</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>call short</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>bcf PORTB,4</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>movlw d’20’</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>call pause</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>decf MARK,F</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>decfz COUNTER,F</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>goto loop2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>return</td>
<td>1</td>
</tr>
</tbody>
</table>

| | | 13 |
| | | (26) |
Q8

(a) obstruction:

```assembly
movlw d '8'
subwf DATA,W
btfsc STATUS,C
bsf PORTB,6
movlw d '26'
call wait
bcf PORTB,6
```

```
finish:
return
```

(b) main:

```assembly
main:
call navdata
```

```assembly
loop:
bsf PORTB,3
bsf PORTB,7
movlw d '10'
call pause
call obstruction
decfsz FORWARDTIME
```

```assembly
goto loop (incl. goto main below)
```

```assembly
movlw d '1'
subwf TURN
btfsc STATUS,Z
goto main
clrf TURNTIME
```

```assembly
ACW:
bsf PORTB,4
movlw d '8'
call pause
```

```assembly
bcf PORTB,4
movfw d '19'
call pause
```

```assembly
incf TURNTIME
movfw TURNTIME
subwf TURNSTOP
```

```assembly
btfss STATUS,Z
goto ACW
bcf PORTB,7
```

```assembly
goto main (incl. goto loop above)
```

<table>
<thead>
<tr>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>20</td>
</tr>
</tbody>
</table>
Q8

(c)  
\[ I_D = \frac{BD^3 - bd^2}{12} \]
\[ = \frac{40 \times 150^3 - 38 \times 146^3}{12} \]
\[ = 11250000 - 9855097 \]
\[ = 1394903 \]

\[ I = \frac{\pi D^4}{64} \]
\[ = \frac{\pi \times (2 \times 36)^4}{64} \div 2 \]
\[ I_D = 659584 \]
\[ I_{\text{total}} = 1394903 + 659584 \]
\[ I_{\text{total}} = 2054487 \text{mm}^4 \]

(d)  
yield stress aluminium  = 30 N/mm\(^2\)

\[ \sigma = \frac{my}{I} \]
\[ m = \frac{\sigma I}{y} \]
\[ = \frac{30 \times 2054487}{75} \]
\[ = 821795 \]

\[ m = \frac{FL}{4} \quad F = \frac{4m}{L} \]
\[ = \frac{4 \times 821795}{850} \]
\[ = 3.87 \text{kN} \]
Q9

(a) \(2^8 = 0 \rightarrow 255\)

\[
\frac{4\cdot 606}{235} = 0.0196 \text{ volt increments}
\]

\[
V_{\text{out}} = -\frac{R_1}{R_0} \times V_i
\]

\[
0.0196 = -\frac{10.192}{R_0} \times 5
\]

\(R_0 = 2600\,\Omega\)

\(R_1 = 1300\,\Omega\)

\(R_2 = 650\,\Omega\)

\(R_3 = 325\,\Omega\)

\(R_4 = 162.5\,\Omega\)

\(R_5 = 81.3\,\Omega\)

\(R_6 = 40.6\,\Omega\)

\(R_7 = 20.3\,\Omega\)
Q9
(a) (cont)

[Diagram of electrical circuit with annotations and components labeled. Diagram includes resistors, capacitors, and operational amplifiers.]

bilge pump motor

Marks
10
Q9

(b) (i) Voltage controlled Oscillator

(ii) SubA = RC circuit, charging time prop to $V_{in}$
SubB = voltm divider, provides 1 Volt ref
SubC = comparator compares 1 Volt ref with Cap volt $V_{cap} > 1$ volt then +ve output
SubD = npn trans responds to +ve, switches on DPDT relay briefly, disch cap + switches on output
SubE = lamp and buzz, frequency of outputs prop to current drawn by pump motor

(iii) $V_{in}$ must be greater than 1 volt, limited frequency of relay, mech life of relay

(c) main:  
bsf PORTB,4  
movlw d’5’  
call wait  
bcf PORTB,4  
loop:  
call adcread  
sblw d’140’  
btfs STATUS,Z (1 for status Z, 1 for clear) 
goto wet  
btfss STATUS,C (1 for status C, 1 for set) 
goto wet (1 for both goto wet)  
bcf PORTB,4  
call delay  
goto main  
wet:  
bsf PORTB,4  
goto loop

Marks

2

2

2

2

2

2

2

10

2

1

1

1

1

1

1

1

1

1

1

1

16

(40)
Q10

(a)  

\[ \sum M_{Q} = 0 \]
\[ (R_B \times 1) + (7.5 \times 1) = 0 \]
\[ R_B = +7.5\text{kN} \]  

(i)  

\[ \sum M_{Q} = 0 \]
\[ - (R_B \times 1) + (7.5 \times 1) = 0 \]
\[ R_B = +7.5\text{kN} \]

(ii)  

\[ \sum M_{Q} = 0 \]
\[ + (4.09 \times \text{perp}) + (F \times 1) - (7.5 \times 2) = 0 \]
\[ + (4.09 \times 1.224) + F - 15 = 0 \]
\[ F = 10\text{kN} \]

\[ \text{perp} = 1.414 \cos 30^\circ = 1.224\text{m} \]
Q10

(b)

\[ \sum M_P = 0 + \]

\[ - (M_3 \times 1) + (2.5 \times 1) = 0 \]

\[ M_3 = + 2.5\text{kN} \text{ (TIE)} \]

\[ \sum M_Q = 0 + \]

\[ + (2.5 \times 2) + (M_1 \times \text{perp}) = 0 \]

\[ M_1 = \frac{-5}{1.224} = -4.08 \]

\[ M_1 = 4.08\text{kN} \text{ (STRUT)} \]

\[ \sum M_R = 0 + \]

\[ + (M_1 \times \text{perp}_2) + (M_2 \times 1.414) = 0 \]

\[ + (-4.08 \times 0.707) + (M_2 \times 1.414) = 0 \]

\[ M_2 = \frac{+4.08 \times 0.707}{1.414} \]

\[ M_2 = +2.04 \]

\[ M_2 = 2.04\text{kN} \text{ (TIE)} \]

\[ \text{OR} \]

\[ \sum F_x = 0 (+ve) : \]

\[ + M_1 \cos 15 + M_2 \cos 45 + M_3 = 0 \]

\[ - 4.08 \cos 15 + M_2 \cos 45 + 2.5 = 0 \]

\[ M_2 \cos 45 = 1.44 \]

\[ M_2 = 2.04\text{kN} \text{ (TIE)} \].
Q10

(c) \[ V_{\text{out}} = -0.32 \frac{t}{2} \]
\[ V_{\text{out}} = -0.16t \]

(d) \[ V_{\text{out}} = -\frac{1}{RC} \int V_{\text{in}} \, dt \]
\[ -0.16t = -\frac{1}{2.7 \times 10^6 \times 6.8 \times 10^{-6}} \int V_{\text{in}} \, dt \]
substitutions 2
\[ -0.16t = -\frac{1}{18.36} \times \frac{V_{\text{in}} \times t}{1} \]
integration 1
\[ V_{\text{in}} = 0.16 \times 18.36 \]
\[ = 2.94 \text{ volts} \]

(e) \[ V_{\text{out}} = -0.16t \]
\[ -12 = -0.16t \]
substitutions 1
\[ t = \frac{12}{0.16} \]
\[ t = 75 \text{ seconds} \]
answer 1
Q10

(f) When $V_{in} = 1.5V$: lower threshold, .

\[ \therefore \text{output already low.} \]

\[ \text{Correct state 1} \]

\[ R_p = \frac{6.8 \times 4.7}{6.8 + 4.7} = \frac{31.96}{11.5} = 2.78k\Omega \]

substitutions & answer 2

\[ \frac{R_1}{R_p} = \frac{3.5}{1.5} \]

substitution 1

\[ R_1 = \frac{3.5}{1.5} \times 2.78 \]

1

\[ R_1 = 6.49k\Omega \]

1 6

(g) Switch-off voltage:

\[ \text{Output already high} \]

\[ R_p = \frac{6.49 \times 4.7}{6.49 + 4.7} = 2.73k\Omega \]

substitution 1

\[ V_2 = \frac{6.8}{6.8 + 2.725} \times 5 = 3.57 \text{ volts} \]

1

\[ V_2 = 3.57 \text{ volts} \]

1 4

[END OF MARKING INSTRUCTIONS]