2015 Technological Studies

Advanced Higher

Finalised Marking Instructions

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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)

(b)

(c) \(1024 = 2^{10} = 10\)
(b) PID control adds extra functions to proportional control in ideal conditions. While proportional tries to minimise the error, PI eliminates it, but PID eliminates it with a faster response time.
Q3  (a)  \( I = \frac{bd^3}{12} \)
\[
= 100 \times 100^3 / 12 \\
= 8.33 \times 10^6 \text{ mm}^4
\]
\[
y = 50 \text{ mm}
\]
\[
M = \sigma I / y \\
= 220 \times 833333.3 / 50 \\
M = 36.7 \times 10^6 \text{ Nmm}
\]
\[
M = \frac{\omega L^2}{8}
\]
\[
L = \left[ \frac{8M}{\omega} \right]^{1/2} \\
= \left[ 8 \times 36,666,666.67 / 7.65 \right]^{1/2} \\
L = 6.19 \text{ m}
\]

(b)  \( M/I = \sigma/y = E/R \)
\[
R = (E y) / \sigma \\
= (196000 \times 50) / 220 \\
R = 44.5 \text{ m}
\]

(c)  Reduced weight  

Increased strength/weight ratio  

Any one point per mark.
Q4 (a) 10 digital inputs  
Analogue input  
1 ADC  
LCD output  
Flash/EEPROM  
Internal memory  
4 outputs  
Internal clock  

Any six points 1 mark each 6

(b) Plan the program  
Write the code  
Assemble the code  
Download to PIC  
Test the program  

Any six 6

Q5 (a) Sub A = RC circuit, charges via 1K & 1M 2
Sub B = voltage divider, provides 1/3 & 2/3 reference voltages 2
Sub C = two comparators, comparing capacitor voltage with ref voltages 1
Sub D = SR bistable, set and reset by comparators 2
Sub E = DPDT relay, used to:  
- discharge capacitor when voltage > 2/3, 1
- charge up capacitor when voltage < 1/3, 1
- provide flashing switching for lamp 1

11

(b) Limited frequency range due to being a mechanical device. 1

Wear of components means it has a finite life 1

2

(13)
Q6 (a) main:

```assembly
bcf PORTB,3 ;mux measure left wheel
call adcread
movwf LEFTSPEED
bsf PORTB,3
call adcread
movwf RIGHTSPEED ;mux measure right wheel
movfw RIGHTSPEED ;subtract
subwf LEFTSPEED,W
btfsc STATUS,Z ;zero error
goto main
btfss STATUS,C ;carry bit means + error (or zero)
goto right
call brakeleft
goto main
```

right:

```assembly
call brakeright
goto main
```

(b) brakeleft:

```assembly
movwf ERROR
rlf ERROR,F
movfw ERROR
```

Double the error value (gain x2)
Use as mark value for PWM

```assembly
movwf MARK
```

2 marks

```assembly
comf MARK,W
movwf SPACE
```

Use twos complement of mark value as space value

2 marks

```assembly
bsf PORTB,7
movfw MARK
```

Apply left brake for MARK ms

```assembly
pause
```

```assembly
bcf PORTB,7
movfw SPACE
```

Release left brake for SPACE ms

```assembly
pause
```

2 marks

brakeright:

```assembly
comf ERROR,F
```

Do twos complement

```assembly
incf ERROR,F
```

Add 1 (correct negative value)

2 marks

(22)
Q7 (a) Serial-In-Parallel-Out

(b) Sub A 2-bit binary up counter plus AND gate; sends pulse to Sub C when count = 3: this enables display

Sub B 3-bit SIPO shift register; stores a 3-bit binary value

Sub C binary – 7 seg decoder; converts binary value to decimal; inputs blanked when BI low; preventing display of incomplete value

Sub D 7-seg display, displays decimal of number in SIPO; when binary-7seg decoder is enabled

Q8 (a) \[ M = F \times L = 2500 \times 210 = 525000 \text{ Nmm} \]
\[ \sigma = \frac{M y}{I} = \left[ \frac{525000 \times 25}{260000} \right] \]
\[ = 50.5 \text{ N/mm}^2 \]

(b) \[ E = 70 \times 10^3 \text{ N/mm}^2 \]
\[ \delta = \frac{F L^3}{3EI} \]
\[ = \frac{2500 \times 210^3}{3 \times 70 \times 10^3 \times 260000} \]
\[ = 2.31525 \times 10^{10} / 5.46 \times 10^{10} \]
\[ = 0.424 \text{ mm} \]
Q9

(a) \[ V_a = -\frac{1}{(1 \times 10^6 \times 1 \times 10^{-6})} \times \int 6 \, dt \]
\[ = -6t \]

(b) \[ V_{out} = -\frac{1}{(1 \times 10^6 \times 1 \times 10^{-6})} \times \int 6 \, dt \]
\[ = +\frac{6}{2} t^2 \]
\[ = 3 t^2 \]

(c)

<table>
<thead>
<tr>
<th>Time</th>
<th>(V_a)</th>
<th>(V_{out})</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>0.5</td>
<td>-3</td>
<td>0.75</td>
</tr>
<tr>
<td>1.0</td>
<td>-6</td>
<td>3.00</td>
</tr>
<tr>
<td>1.5</td>
<td>-9</td>
<td>6.75</td>
</tr>
<tr>
<td>2.0</td>
<td>-12</td>
<td>12.00</td>
</tr>
<tr>
<td>2.5</td>
<td>-12</td>
<td>15.00</td>
</tr>
<tr>
<td>3.0</td>
<td>-12</td>
<td>18.00</td>
</tr>
<tr>
<td>3.5</td>
<td>-12</td>
<td>18.00</td>
</tr>
<tr>
<td>4.0</td>
<td>-12</td>
<td>18.00</td>
</tr>
</tbody>
</table>

(d)

\[ 20 \]
\[ 18 \]
\[ 16 \]
\[ 14 \]
\[ 12 \]
\[ 10 \]
\[ 8 \]
\[ 6 \]
\[ 4 \]
\[ 2 \]
\[ 0 \]
\[ 0.5 \]
\[ 1.0 \]
\[ 1.5 \]
\[ 2.0 \]
\[ 2.5 \]
\[ 3.0 \]
\[ 3.5 \]
\[ 4.0 \]

\[ \text{time (sec)} \]

\[ 0 \]
\[ -2 \]
\[ -4 \]
\[ -6 \]
\[ -8 \]
\[ -10 \]
\[ -12 \]
\[ -14 \]
\[ -16 \]
\[ -18 \]
\[ -20 \]
Q10  (a) When any LDR goes dark V across it increases 
    Causes Schmitt inverting input to go higher 
    When V− reaches 3V Schmitt saturates low 
    Triggers 555 in monostable mode 
    Pin3 goes high for a time then low 
    This clocks the 3-bit counter

(b) \[ \frac{R_p}{7} = \frac{2}{3} \]
    \[ R_p = 4 \cdot 67k\Omega \]
    \[ 10R/(10 + R) = 4.67 \]
    \[ 10R = 46.7 + 4.67R \]
    \[ R = 46.7/5.33 \]
    \[ R = 8.76k\Omega \]

(c) \[ H = (A.B.C) + (A.B.C) + (A.B.C) \]
    \[ H = C.(A + B) \]

(d) ![Diagram](image)
Q10 (e) pack:

```assembly
btfsc PORTB,2
  goto weight
btfsc PORTB,1
  goto plastic
  goto pack

weight:
  movlw d'10'
  movwf COUNT

loop:
  bsf PORTB,7
  movlw d '25'
  call pause
  bcf PORTB,7
  movlw d '25'
  call pause
  decfsz COUNT
  goto loop

return both “return”

plastic:
  movlw d '6'
  movwf COUNT

loop2:
  bsf PORTB,6
  movfw MARK
  call pause
  bcf PORTB,6
  movfw SPACE
  call pause
  rrf MARK,F
  rlf SPACE,F
  decfsz COUNT,F
  goto loop2

return
```
Q11 (a)  

\[ \sum M_a = 0 \text{ CW} + (10 \times 3250) - (20 \times 3031) - (V_B \times 6500) = 0 \]

\[ + 32500 - 60620 = +6500V_B \]

\[ V_B = -28120 / 6500 = -4.33 \text{ kN} \]

\[ \sum H = 0 \]

\[ H_B = 20 \text{kN} \rightarrow \]

\[ \sum M_q = 0 \text{ CW} + (F_1 \times 1299) + (4 \times 33 \times 1500) = 0 \]

\[ -1299F_1 + 6495 = 0 \]

\[ F_1 = +5 \text{ kN (tie)} \]

\[ \sum M_p = 0 \text{ CW} + (4 \times 33 \times 2250) - (20 \times 1299) + (F_3 \times 1441) = 0 \]

\[ +9742.5 - 25980 + 1441F_3 = 0 \]

\[ F_3 = +11.27 \text{kN TIE} \]

\[ \sum V = 0 \]

\[ -11.27 \sin 13.9^\circ - 4.33 + F_2 \sin 60^\circ = 0 \]

\[ -2.71 - 4.33 + 0.866F_2 = 0 \]

\[ F_2 = +8.13 \text{ kN (TIE)} \]

\[ \sin 73.9^\circ = \text{perp} / 1500 \]

\[ \text{perp} = 1500 \times \sin 73.9^\circ = 1441 \text{ mm} \]
Q11 (c)  

2.555/511 = 0.005 resolution

\[
\frac{2}{R_0} \times 5 = 0.005
\]

\[R_0 = \frac{2 \times 5}{0.005}
\]

\[R_0 = 2000 \text{ k}\Omega\]

\[R_1 = 1000 \text{ k}\Omega\]
\[R_2 = 500 \text{ k}\Omega\]
\[R_3 = 250 \text{ k}\Omega\]
\[R_4 = 125 \text{ k}\Omega\]
\[R_5 = 62.5 \text{ k}\Omega\]
\[R_6 = 31.3 \text{ k}\Omega\]
\[R_7 = 15.6 \text{ k}\Omega\]
\[R_8 = 7.8 \text{ k}\Omega\]

Q11 (d)  

<table>
<thead>
<tr>
<th>(Q_a)</th>
<th>(\bar{Q}_a)</th>
<th>(Q_b)</th>
<th>(\bar{Q}_b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>toggle</td>
<td>set</td>
<td>reset</td>
<td>toggle</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>toggle</td>
<td>set</td>
<td>reset</td>
<td>reset</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Marks

<table>
<thead>
<tr>
<th>Q11 (c)</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q11 (d)</td>
<td>8</td>
</tr>
</tbody>
</table>
Q12  (a) main:

```
movlw d '25'
movwf LOOPCOUNT
loop:
    btfsc PORTB,0
    incf PULSECOUNT,F
    movlw d '1'
call pause
decfsz LOOPCOUNT
    goto loop
movlw d '10'
subwf PULSECOUNT,W
btfss STATUS,C
    goto bleep
movfw PULSECOUNT
sublw d '13'
bfss STATUS,C
    goto bleep
bsf PORTB,7
movlw d '80'
call pause
bcf PORTB,7
```  

```
bleep:
    bsf PORTB,6
    movlw d '150'
call pause
    bcf PORTB,6
    movfw PULSECOUNT
    sublw d '23'
    btfsc STATUS,C
    goto main
    bsf PORTB,5
    movlw d '2'
call pause
    bcf PORTB,5
    goto main
```  

(b)  \( I_{\text{solid}} = BD^3/12 \)

\[ = 11 \times 20^3/12 = 7333 \]  

\[ I_{\text{hole}} = 9 \times 16^3/12 = 3072 \]  

\[ I_{xx} = 4261 \text{ mm}^4 \]
Q12 (c) \( \Sigma M = 0 \) about \( R_2 \):

\[
+(R_1 \times 250) - \left(25 \times 250 \times \frac{250}{2}\right) - (1200 \times 70) = 0
\]

\( R_1 = 3.46 \text{ kN} \)

(d) 50: \( 3461 \times 50 - 25 \times 50^2/2 = 141800 \text{ Nmm} = 142 \text{ kNmm} \)
100: \( 3461 \times 100 - 25 \times 100^2/2 = 221100 \text{ Nmm} = 221 \text{ kNmm} \)
150: \( 3461 \times 150 - 25 \times 150^2/2 = 237900 \text{ Nmm} = 238 \text{ kNmm} \)
180: \( 3461 \times 180 - 25 \times 180^2/2 = 217980 \text{ Nmm} = 218 \text{ kNmm} \)

[END OF MARKING INSTRUCTIONS]