

12 Pages

1. Please give the information requested in the boxes below.
2. Enter your name in the space provided to the right, fold over and seal down (using the label provided) to hide your name.
3. The answers must be legibly written. The Examiners can either ignore illegible script or have it typed and the expense of typing charged to the candidate.
4. Write your answers in ink.
5. Begin each answer on a fresh page. Do all rough work in the answer book and cross it through.
6. No part of this book is to be torn out; it must be handed in complete.
7. If more books than one are used, fasten them together using the tags available from the invigilator(s).
8. **Every book must be handed in. In no circumstances may answer books, used or unused, be taken out of the examination venue.**

**Complete, fold and seal
(see note 2 below)**

SURNAME: BOVAGORA

FORENAME(S): EITANUELE

1	Student Number	160335
2	Title of Examination Paper	Digital Signal Processing
3	Module Code	17248518 ~~6042500~~
4	Date and Time of Examination	11/03/2018
5	Examination Venue	Manin Hall Gower College
6	Seat Number	1
7	Number of Answer Books handed in	1

[illegible]

(Gweler yr ochr arall am y fersiwn Cymraeg)

Template for Question 1 (Insert in Answer Booklet if used)

[illegible]

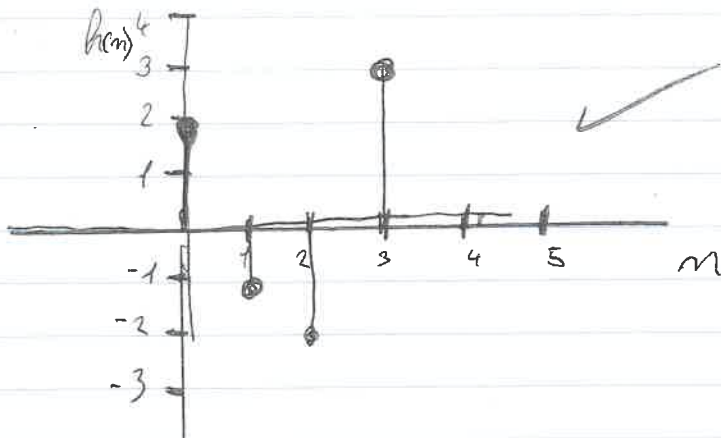
The image shows a blank grid paper template. It features a central grid of 20 columns and 20 rows. Above this central grid is a single horizontal row of 20 squares, serving as a header. To the left and right of the central grid are vertical sidebars, each consisting of 20 squares stacked vertically. The entire template is composed of small squares, suitable for graphing or data entry.

Student Name: _____

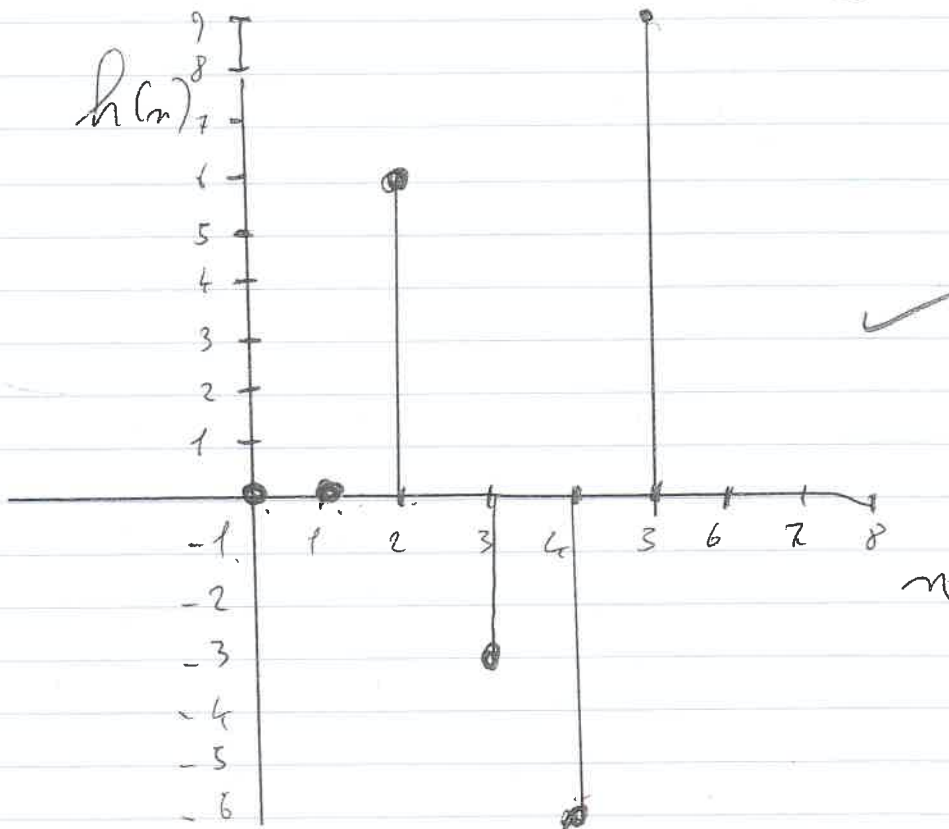
1)

$$h(n) = [2, -1, -2, 3]$$

a)



$$b) \quad 3h(n-2) = [0, 0, 6, -3, -6, 9]$$



$$c) \quad y(n) = [4, -4, 1, 4, -6, 8, -3]$$

✓

6/✓

3) ~~Q6~~

1 2 3 4 5 6 7 8 9 10 11 12 13 14

a) code: 10100011010001

$$P1 = 1101000 = X$$

Error in Position 9

$$P2 = 0101101 = \checkmark$$

$$P4 = 0001001 = \checkmark$$

$$P8 = 1010001 = X$$

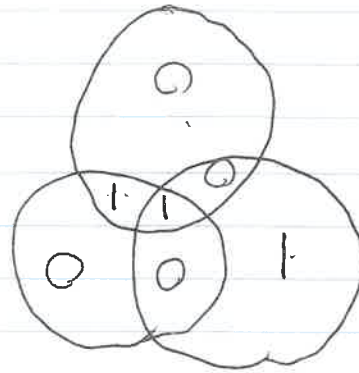
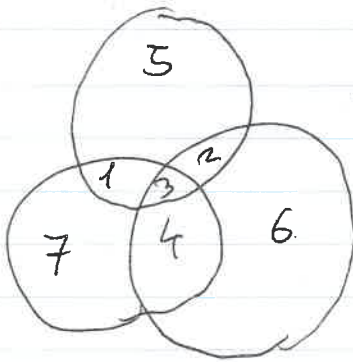
Error ✓

10100011010001

Final code: 10100011110001

6 ✓

b) Initial code = 1010



Final code = 1010010 ✓

4 ✓

4)

a)

$$x(t) = 3 \cos(2000 \pi t) + 6 \cos(14000 \pi t) - 4 \sin(4000 \pi t)$$

$$f_1 = 1000 \quad f_2 = 7000 \quad f_3 = 2000$$

$$F_N = f_{\max} \cdot 2 = 7000 \cdot 2 = 14000 \text{ Hz}$$

To avoid aliasing F_s has to be $> 14000 \text{ Hz}$

(3)

b)

$$x[n] = 3 \cos 2 \cdot \frac{1000 \pi n}{6000}$$

$$+ 6 \cos 2 \cdot \frac{7000 \pi n}{6000} -$$

$$4 \sin 2 \cdot \frac{2000 \pi n}{6000}$$

$$x[n] = 3 \cos 2 \cdot \frac{1}{6} \pi n + 6 \cos 2 \cdot \frac{7}{6} \pi n - 4 \sin 2 \cdot \frac{2}{6} \pi n$$

$$x[n] = 3 \cos 2 \cdot \left(\frac{1}{6}\right) \pi n + 6 \cos 2 \cdot \left(\frac{6}{6} + \frac{1}{6}\right) \pi n - 4 \sin 2 \cdot \left(\frac{6}{6} - \frac{4}{6}\right) \pi n$$

$$x[n] = 3 \cos 2 \cdot \left(\frac{1}{6}\right) \pi n + 6 \cos 2 \cdot \left(\frac{1}{6}\right) \pi n + 4 \sin 2 \cdot \left(-\frac{4}{6}\right) \pi n$$

$$x[n] = 9 \cos 2 \cdot \frac{1}{6} \pi n + 4 \sin 2 \cdot \left(\frac{4}{6}\right) \pi n$$

(2)

$$c) \quad x(t) = 9 \cos 2 \cdot \frac{6000 \pi t}{6} + 4 \sin 2 \cdot \frac{24000 \pi t}{6}$$

$$= 9$$

$$x(t) = 9 \cos 2 \cdot 1000 \pi t + 4 \sin 2 \cdot 4000 \pi t$$

(2)

$$f_{\max} = F_s \cdot f \Rightarrow 6000 \cdot f$$

5)

$$H(z) = (3 + z^{-2})(1 - 4z^{-1})(2 + 2z^{-1}) \quad \checkmark$$

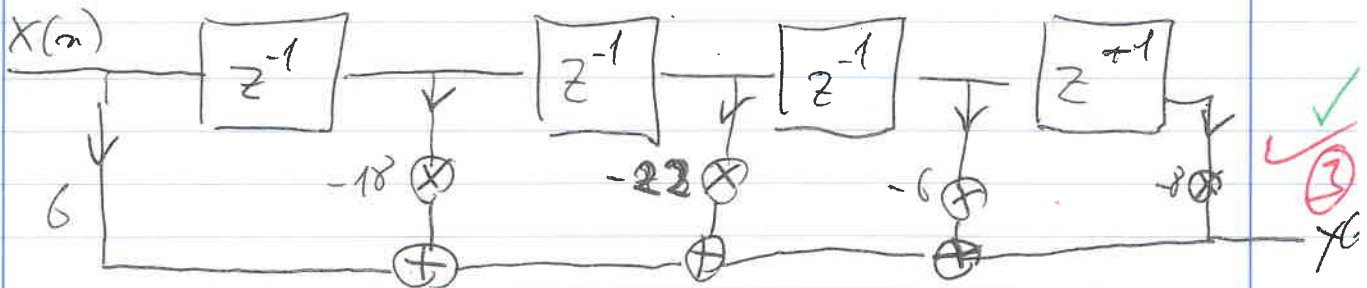
$$(3 - 12z^{-1} + z^{-2} - 4z^{-3})(2 + 2z^{-1}) \quad \checkmark$$

$$6 - 24z^{-1} + 2z^{-2} - 8z^{-3} + 6z^{-1} - 24z^{-2} + 2z^{-3} - 8z^{-4}$$

$$H(z) = 6 - 18z^{-1} + 22z^{-2} - 6z^{-3} - 8z^{-4} \quad \checkmark$$

$$H(z) = \frac{Y(z)}{X(z)} = 6 - 18z^{-1} + 22z^{-2} - 6z^{-3} - 8z^{-4}$$

$$Y(z) = 6X(z) - 18X(z)z^{-1} + 22X(z)z^{-2} - 6X(z)z^{-3} - 8X(z)z^{-4}$$



$$Y[n] = 6x[n] - 18x[n-1] + 22x[n-2] - 6x[n-3] - 8x[n-4]$$

5b.

 ~~$y(n) = 2y(n-1) + 3y(n-2) + 2x(n-2) + 4x(n-2) + 2x(n-1) + x(n)$~~

$$a) \quad y(n) = 2y(n-1) + 3y(n-2) + 2x(n-2) + 4x(n-2) + 2x(n-1) + x(n)$$

$$y(n) = 2y(n-1) + 3y(n-2) + 2x(n-2) + 4x(n-2) + 2x(n-1) + x(n) \quad (2) \checkmark$$

$$b) \quad y(z) = 2y(z)z^{-1} + 3y(z)z^{-2} + 2x(z)z^{-2} + 4x(z)z^{-2} + 2x(z)z^{-1} + x(z)$$

Correct Method.

(2) ✓

$$-y(z) - 2y(z)z^{-1} - 3y(z)z^{-2} = 6x(z)z^{-2} + 2x(z)z^{-1} + x(z)$$

$$y(z)(-1 - 2z^{-1} - 3z^{-2}) = x(z)(6z^{-2} + 2z^{-1} + 1)$$

$$\frac{y(z)}{x(z)} = \frac{6z^{-2} + 2z^{-1} + 1}{-1 - 2z^{-1} - 3z^{-2}}$$

2)

$$\begin{aligned}
 f_p &= 10 \text{ kHz} \\
 \Delta f &= 300 \text{ Hz} \\
 A_p &= 0,1 \text{ dB} \\
 A_s &= 50 \text{ dB} \\
 f_s &= 40 \text{ kHz}
 \end{aligned}$$

$$\begin{aligned}
 F_p &= 0,25 \text{ Hz} \\
 \Delta F &= 0,0075 \text{ Hz} \\
 \delta_p &= 0,01157 \\
 \delta_s &= 0,00316 \\
 \omega_c &= 1,59
 \end{aligned}$$

$$\delta_s = \log^{-1} \left[\frac{-A_s}{20} \right] = \log^{-1} \left[\frac{-50}{20} \right] = 3,16227 \times 10^{-3}$$

$$\delta_p = \log^{-1} \left[\frac{A_p}{20} \right] - 1 = \log^{-1} \left[\frac{0,1}{20} \right] - 1 = 0,01157$$

$$\Delta F = \frac{\Delta f}{f_s} = \frac{300}{40 \times 10^3} = 0,0075 \text{ Hz (normalised)}$$

$$F_p = \frac{f_p}{f_s} = \frac{10 \cdot 10^3}{40 \cdot 10^3} = 0,25 \text{ Hz}$$

From Table 4.3 we chose the narrowest δ_s and the suitable dB:

Hamming window

$$\Delta F = \frac{3,3}{N} \Rightarrow N = \frac{3,3}{0,0075} = 440 \text{ (number of taps)}$$

Also remember N (number of taps) has to be a odd number so

$$440 + 1 = 440 + 1 = 441$$

$$h(n) = w(n) \cdot h_D(n) =$$

$$h_D(n) = \frac{\sin(n\omega_c)}{n\pi} = \frac{2F_c \sin(n\omega_c)}{n\omega_c}$$

$$\Omega_c = 2\pi (F_p + 0,5 \cdot \Delta F) \quad \checkmark$$

① ✓

$$\Omega_c = 2\pi (0,25 + 0,5 \cdot 0,0075) = 1,59 \quad \checkmark$$

① ✓

$$h_0(6) = \frac{\sin(6 \cdot 1,59)}{6 \cdot \pi} = -0,00609$$

$$W(m) = 0,54 - 0,46 \cos \left[\frac{2\pi m}{N-1} \right] \quad \checkmark$$

① ✓

$$W(6) = 0,54 - 0,46 \cos \left[\frac{2 \cdot \pi \cdot 6}{\cancel{440}} \right] = 0,081687 \quad \checkmark$$

③ ✓

$$h(oi) = W(m) \cdot h_{D(m)} \quad \checkmark$$

① ✓

$$h(6) = (-0,00609) \cdot (0,081687) = -0,00049747$$

$$= -4,9747 \times 10^{-4}$$