FAKULTEIT INGENIERSWESE
FACULTY OF ENGINEERING

Stelsels en Seine 414 ***Systems and Signals 414***			**Tweede Toets** **3 Junie 2013** ***Second Test*** ***3 June 2013***
Tydsduur ***Duration***	**3 h**	**Volpunte** ***Full marks***	**90**
Eksaminator: ***Examiner:***			**Mede-eksaminator(e):** ***Co-examiner(s):***
T.R. Niesler			**R. Wolhuter**

Sertifisering
Certification

Opgestel: Set: Eksaminator Examiner	Gemodereer: Moderated: Mede-eksaminator Co-examiner

Kandidaatinligting
Candidate's particulars

Van: ***Surname:***	
Voorname: ***First Names:***	
Studentenommer: ***Student number:***	
Handtekening: ***Signature:***	

Lees asseblief noukeurig die instruksies op die volgende bladsy.
Please read instructions on the next page carefully.

INSTRUKSIES

- ***Vul u naam en studentenommer in soos aangedui op die voorblad van hierdie vraestel !***
- Lees die inligting op beide hierdie vraestel en die meegaande eksamenboek. Verskaf u gegewens op beide.
- Gee u antwoorde op die beskikbare plek onderaan elke vraag *op die vraestel*. **Die meegaande eksamenboek is beskikbaar net vir rofwerk en word nie gemerk nie.**
- U mag u voorgeskrewe handboek, Proakis & Manolakis sowel as die klasnotas soos in die lesings uitgedeel raadpleeg. Normale notas/kommentaar daarin is in orde. Geen verdere notas (ook nie in 'n sakrekenaar) word toegelaat nie.
- Toon en motiveer u redenasies altyd volledig. ***Punte sal afgetrek word indien dit nie gedoen word nie***. Omskryf in woorde wat u probeer doen - dit tel in u guns indien u nie 'n berekening suksesvol deurvoer nie.
- Waar gegewens na u mening ontbreek, maak sinvolle, gemotiveerde aannames.
- Skryf met 'n pen. Sketse kan egter in potlood gemaak word.
- Plaas die voltooide vraestel in die rofwerkboek en handig beide (volledig) in.

INSTRUCTIONS

- ***Fill in your name and student number in the space provided on the cover of this question paper!***
- Read the information on this question paper and on the accompanying examination book. Provide your details on both.
- Provide your answers in the space allocated after each question *on this question paper*. **The accompanying examination book is for rough-work only and will not be marked.**
- You may consult the prescribed handbook, Proakis & Manolakis as well as the handouts given in class. Normal notes/comments in it are acceptable. All further notes (also in a calculator) are forbidden.
- Always show and motivate your reasoning fully. ***Marks will be deducted for failing to do so***. Describe what you are trying to do - this counts in your favour with unsuccessful calculations.
- If in your opinion any information is missing, make reasonable, motivated assumptions.
- Write with a pen. Sketches may be in pencil.
- Put the completed question paper inside the rough-work book and hand both (everything) in.

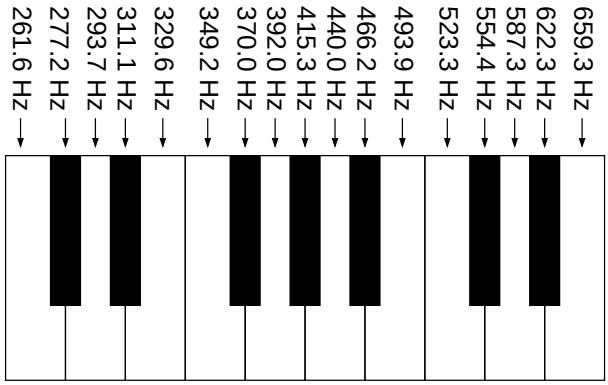
FOR MARKING PURPOSES ONLY

Question	1	2	3	4	5	6	7	8	9	10	11	12	**Tot**
Mark													
Check													

TOTAL:

Vraag 1 Die *Enterprise* benodig dringende herstelwerk en wentel tans om 'n onbekende planeet. Kirk en Spock besoek die planeetoppervlak en ontdek dat, hoewel die vriendelike bewoners uitmuntende gehoor besit, hulle hulle geen spraakorgane het nie. Hulle kan dus geen spraak voorbring nie. As plaasvervanger, gebruik hulle 'n klawerbord met 17 klawers wat opeenvolgende tone by 17 verskillende frekwensies voortbring, soos onder aangetoon. (Hulle was blykbaar geïnspireer om op hierdie wyse te improviseer nadat 'n episode van die oeroue aarduitsendingreeks 'Noot-vir-noot' hulle deur 'n rumitetyd-wurmtonnel bereik het.)

Question 1 The *Enterprise* is in urgent need of repairs and in orbit about a yet-unknown planet. Kirk and Spock beam down to the planet's surface to discover that the friendly inhabitants have excellent hearing but no vocal organs and hence cannot produce speech. Instead, they communicate using a device that uses a keyboard with 17 keys to make sequential tones at different frequencies, pictured below. (It turns out that they were inspired to improvise in this way after receiving an episode of the ancient Earth broadcast show 'Noot-vir-noot' which had passed through a wormhole in space-time).



In 'n poging om met die planeetbewoners te kommunikeer, beplan Spock om 'n aanpassing aan sy Starfleet Communicator aan te bring. Aanvaar dat hy 'n FFT en Hamming-venster gebruik om die oudiofrekwensies wat die klawerbord voorbring, te analiseer. Die Starfleet Communicator het 'n monsterfrekwensie van 40kHz. Bepaal die minimum tydsduur van elke toon, in sekondes, om betroubare dekodering te verseker. Identifiseër enige nadele verbonde aan u voorgestelde metode, en stel gepaste verbeteringe voor. Beskryf al jou stappe duidelik en meld alle aanvaardings wat jy maak. (8)

In order to communicate with the planet's inhabitants, Spock has a plan to modify his Starfleet Communicator. Assume he will use an FFT and a Hamming window to analyse the audio frequencies made by the keyboard, and that the communicator has a sampling rate of 40kHz. Determine the minimum length, in seconds, each note should have to reliably decode the message. Identify any weaknesses you see in your proposed method, and suggest remedies. Describe your working clearly, and state all assumptions that you make. (8)

Vraag 1 (vervolg) *Addisionele ruimte vir berekenings*

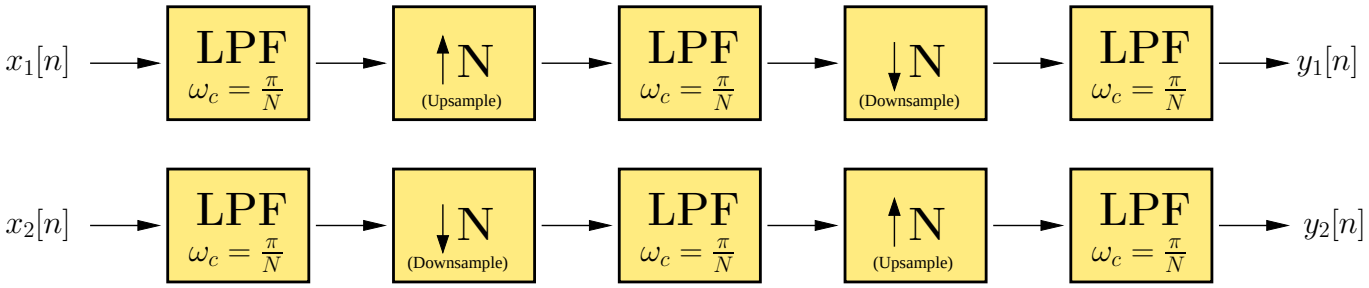
Question 1 (continued) *Addisional space for working*

Vraag 1 totaal: 8 punte.

Question 1 total: 8 marks.

Vraag 2 Beskou die volgende twee kaskade konfigurasies bestaande uit laag-deurlaat filters (LPF), afmonsterers (downsamplers) en opmonsterers (upsamplers). Die laag-deurlaat filters het almal afsny-frekwensies van π/N radiale per monster.

Question 2 Consider the following two cascade configurations of low pass filters (LPF), upsamples and downsamplers. The low pass filters all have cutoff frequencies of π/N radians per sample.



Is hiedie twee konfigurasies ekwivalent, d.w.s. is $y_1[n] = y_2[n]$ as $x_1[n] = x_2[n]$?. Motiveer u anwoord duidelik en deur gebruik van sketse. (8)

Are these two configurations equivalent, i.e. will $y_1[n] = y_2[n]$ when $x_1[n] = x_2[n]$? Motivate your answer clearly and by using sketches. (8)

Vervolg ... Continued ...

Vraag 2 (vervolg) *Addisionele ruimte vir berekenings.*

Question 2 (continued) *Additional space for working.*

Vraag 2 totaal: 8 punte.

Question 2 total: 8 marks.

Vraag 3 Beskou die volgende twee diskrete-tyd seine $x[n]$ en $y[n]$:

Question 3 Consider the following two discrete-time signals $x[n]$ and $y[n]$:

$$\begin{aligned} x[n] &= 0.2\cos(0.2\pi n) \\ y[n] &= 0.2\sin(0.2\pi n) \end{aligned}$$

Bepaal 'n geslote-vorm uitdrukking vir die 10-punt sirkulêre convolusie van $x[n]$ en $y[n]$. Wys en motiveer u bewerkings duidelik. *Wenk: gebruik die DFT.* (8)

Determine a closed-form expression for the 10-point circular convolution of $x[n]$ and $y[n]$. Show and motivate your working clearly. *Hint: use the DFT.* (8)

Vraag 3 (vervolg) *Addisionele ruimte vir berekenings.*

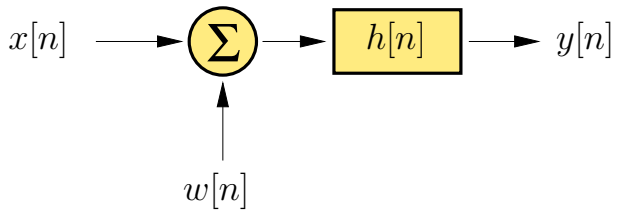
Question 3 (continued) *Additional space for working.*

Vraag 3 totaal: 8 punte.

Question 3 total: 8 marks.

Vraag 4 Beskou 'n lineêre stelsel met 'n impulsweergawe $h[n]$ wat baie stadig met tyd verander. Aanvaar dat die stelsel aanhoudend intreedata $x[n]$ verwerk, en dat dit nie aflyn geneem kan word nie. Beskryf hoe die konfigurasie onder gebruik kan word om aanlyn $h[n]$ af te skat.

Question 4 Consider a linear system with an impulse response $h[n]$ that varies very slowly over time. Assume that the system is processing input data $x[n]$ continuously, and cannot be taken offline. Describe how the configuraton shown below can be used to achieve online estimation of $h[n]$.



Aanvaar dat die drywing van $w[n]$ weglaatbaar is in vergelyking met die drywing van $x[n]$. Dui al die aanames wat u maak duidelik aan, en motiveer u oplossing algebraïes (d.w.s. deur middel van vergelykings). Motiveer alle stappe van u algebraïese oplossing duidelik. (8)

You may assume that the power of $w[n]$ is negligible in comparison to the power of $x[n]$. Clealy state all the assumptions you are making, and motivate your approach algebraically (i.e. using equations). Motivate all steps of your algebraic development clearly. (8)

Vervolg ... Continued ...

Vraag 4 (vervolg) *Addisionele ruimte vir berekenings.*

Question 4 (continued) *Additional space for working.*

Vraag 4 totaal: 8 punte.

Question 4 total: 8 marks.

Vraag 5 'n Lineêre-fase kousale filter met oordragsfunksie $H(z)$ vertraag 'n sinusvormige intreesein met frekwensie $f_\omega = 0.05$ siklusse/monster met $\pi/2$ radiale. Met hoeveel monsters sal die stelsel 'n arbitrêre sein vertraag? Wys en motiveer u bewerkings duidelik. (3)

Question 5 A linear-phase causal filter with transfer function $H(z)$ delays an input sinusoid with a frequency $f_\omega = 0.05$ cycles/sample by $\pi/2$ radians. How long (in terms of samples) is the delay introduced by the system to an arbitrary signal? Show and motivate your working clearly.(3)

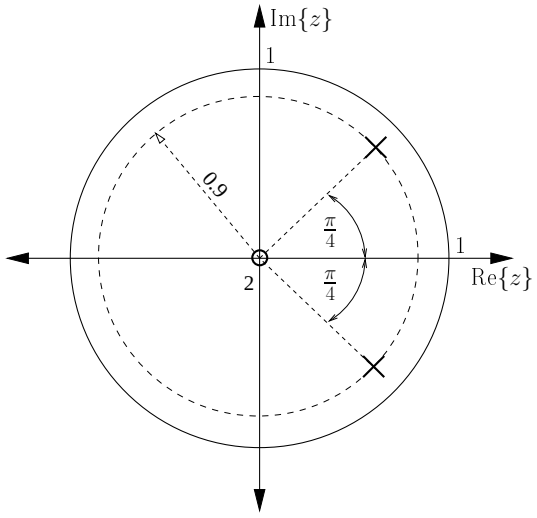
Vraag 5 totaal: 3 punte.

Question 5 total: 3 marks.

Vraag 6 Maak rowwe sketse van die amplitude van die frekwensieweergawes van die LTI stelsels met die volgende pool-zero patrone:

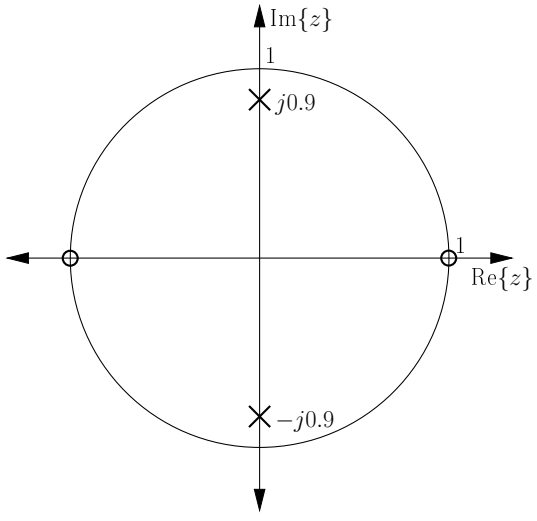
Question 6 Make rough sketches of the magnitude of the frequency responses of the LTI systems with the following pole-zero patterns:

a) (3)



(3)

b) (3)

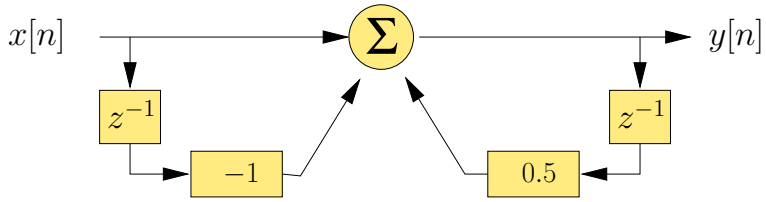


(3)

Vraag 6 totaal: 6 punte.

Question 6 total: 6 marks.

Vraag 7 beskou die volgende LTI stelsel:



Bepaal 'n geslote vorm uitdrukking vir die frekwensieweergawe $H(e^{j\omega})$ van die stelsel, en skets dan die amplitude $|H(e^{j\omega})|$ oor die interval $0 \leq \omega \leq 2\pi$. Dui berekende amplitudes aan by $\omega = 0$, $\omega = \frac{\pi}{4}$, $\omega = \frac{\pi}{2}$, $\omega = \frac{3\pi}{4}$ en $\omega = \pi$. *Daar is meer spasie vir u berekeninge op die volgende bladsy.* (12)

Question 7 Consider the following LTI system:

Determine a closed-form expression for the frequency response $H(e^{j\omega})$ of this system and then sketch the magnitude $|H(e^{j\omega})|$ over the range $0 \leq \omega \leq 2\pi$. Indicate calculated amplitudes at $\omega = 0, \omega = \frac{\pi}{4}, \omega = \frac{\pi}{2}, \omega = \frac{3\pi}{4}$ and $\omega = \pi$. *There is more space for your calculations on the following page.* (12)

Vraag 7 (vervolg) *Addisionele ruimte vir berekenings*

Question 7 (continued) *Addisional space for working*

Vraag 7 totaal: 12 punte.

Question 7 total: 12 marks.

Vraag 8 Beskou die laagdeurlaat filter (LPF) wat deur die volgende oordragsfunksie beskryf word:

$$H(z) = \frac{1-a}{2} \cdot \frac{1+z^{-1}}{1-az^{-1}}$$

Bepaal die waarde(s) van die koëffisiënt a sodat die filter 'n -3dB afsnyfrekwensie by $\omega = \pi/4$ radiale per monster toon. Toon en motiveer u berekeninge. (12)

Question 8 Consider the low pass filter (LPF) described by the following transfer function:

Determine the value(s) of the coefficient a such that the filter has a -3dB cutoff frequency of $\omega = \pi/4$ radians per sample. Show and motivate your calculations. (12)

Vervolg ... Continued ...

Vraag 8 (vervolg) *Addisionele ruimte vir berekenings.*

Question 8 (continued) *Additional space for working.*

Vraag 8 totaal: 12 punte.

Question 8 total: 12 marks.

Vraag 9 Beskou die vogende oordragsfunksie van 'n kontinue-tyd stelsel met resonante pole by $\Omega = 10$rad/sekonde.

$$H(s) = \frac{1}{s^2 + 2s + 101}$$

Gebruik hierdie filter as prototipe om met die bilineêre transform 'n diskrete-tyd resonator te ontwerp met resonante frekwensie $\omega_c = 0.5$ rad/monster. Gee 'n direkte-vorm I blokdiagram vir die resulterende filter. Wys en motiveer u bewerkings duidelik. (9)

Question 9 Consider the following transfer function of a continuous-time system with resonant poles at $\Omega = 10$rad/second.

With this filter as a prototype, use the bilinear transform to design a discrete-time resonator with resonant frequency $\omega_c = 0.5$ rad/sample. Express the resulting filter as a direct-form I block diagram. Show and motivate your working clearly. (9)

Vervolg ... Continued ...

Vraag 9 (vervolg) *Addisionele ruimte vir berekenings.*

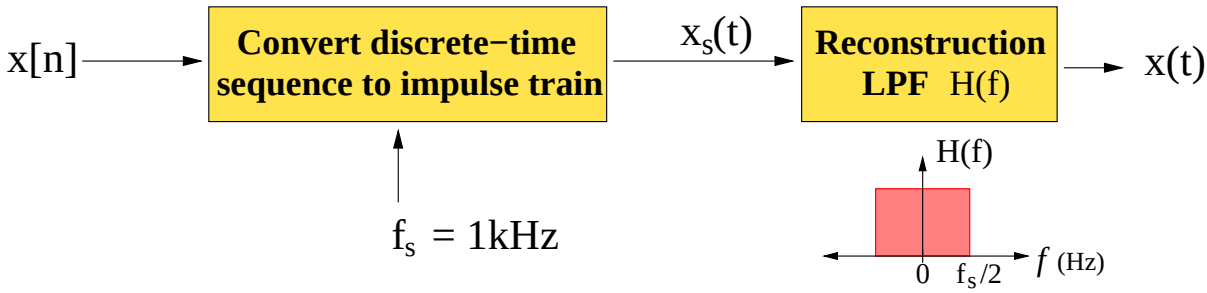
Question 9 (continued) *Additional space for working.*

Vraag 9 totaal: 9 punte.

Question 9 total: 9 marks.

Vraag 10 Die volgende figuur illustreer 'n ideale diskrete-tyd na kontinue-tyd rekonstruksie proses.

Question 10 The following figure illustrates an ideal discrete-time to continuous-time reconstruction process.



Rekonstruksie vind plaas teen 'n monstertempo van $f_s = 1$kHz, en die rekonstruksie laagdeurlaatfilter (LPF) kan as ideaal beskou word, met 'n plat deurlaatband, zero fase-weergawe en 'n afsnyfrekwensie van $f_c = 500$Hz. Die volgende eindige-tyd sein word nou aangelê:

Reconstruction occurs at a sampling frequency $f_s = 1$kHz, and the reconstruction low-pass filter (LPF) is ideal, having a flat pasband, zero phase response and a cutoff frequency of $f_c = 500$Hz. The following limited-time signal is now applied:

$$x[n] = \{ \underset{\uparrow}{1} \quad 3 \quad 2 \}$$

Bepaal die amplitude van die resulterende kontinue-tyd sein $x(t)$ by $t = 0.0018$ sekondes, waar aangeneem word dat $t = nT$ met T die monsterperiode. Wys en motiveer u bewerkings duidelik. (8)

Determine the amplitude of the resulting continuous-time signal $x(t)$ at $t = 0.0018$ seconds, assuming $t = nT$ where T is the samping period. Show and motivate your working clearly. (8)

Vervolg ...

Continued ...

Vraag 10 (vervolg) *Addisionele ruimte vir berekenings.*

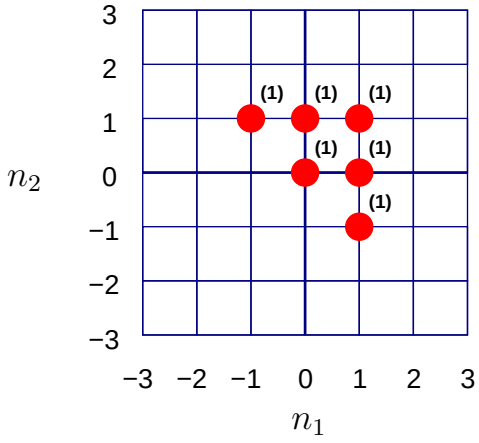
Question 10 (continued) *Additional space for working.*

Vraag 10 totaal: 8 punte.

Question 10 total: 8 marks.

Vraag 11 Die volgende figuur toon twee twee-dimensionlele diskrete seine $x_1[n_1, n_2]$ en $x_2[n_1, n_2]$.

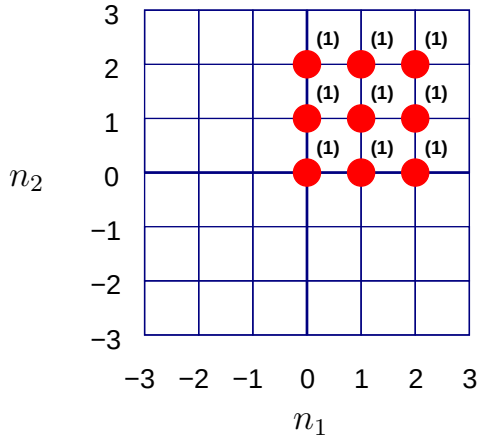
$x_1[n_1, n_2]$



Bepaal en skets die diskrete konvolusie $x_1[n_1, n_2] * x_2[n_1, n_2]$ van hierdie twee seine. Wys en motiveer u bewerkings duidelik. (8)

Question 11 The following figure shows two two-dimensional discrete signals $x_1[n_1, n_2]$ and $x_2[n_1, n_2]$.

$x_2[n_1, n_2]$



Determine and sketch the discrete convolution $x_1[n_1, n_2] * x_2[n_1, n_2]$ of these two signals. Show and motivate your working clearly. (8)

Vervolg ...

Continued ...

Vraag 11 (vervolg) *Addisionele ruimte vir berekenings.*

Question 11 (continued) *Additional space for working.*

Vraag 11 totaal: 8 punte.

Question 11 total: 8 marks.

Vraestel totaal: 90 **Question-paper total: 90**