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Benodigdhede vir hierdie vraestel:/Requirements for this paper:			
Multikeusekaarte:/ Multi-choice cards:	☐	Nie-programmeerbare sakrekenaar:/ Non-programmable calculator:	☒
Grafiekpapier:/ Graph paper:	☐	Skootrekenaar:/ Laptop:	☐

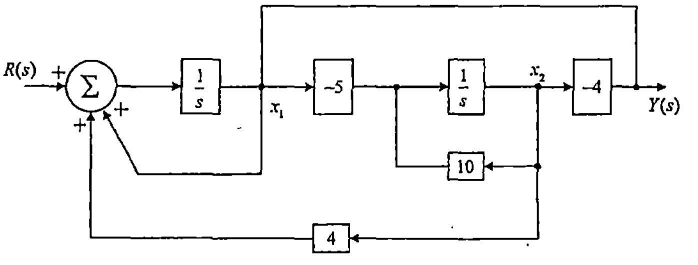
Oopboek-eksamen / Open book examination? **NEE/NO**

EKASAMEN/TOETS EXAMINATION/TEST:	**Eksamen (1e) Examination (1st)**	KWALIFIKASIERIGTING/ QUALIFICATION:	**B.Ing. / B.Eng.**
MODULEKODE/ MODULE CODE:	**EERI 418**	TYDSDUUR/ DURATION:	**3 ure/hours**
MODULEBESKRYWING/ MODULE DESCRIPTION:	**Beheerteorie II Control theory II**	MAKS/ MAX:	**100**
EKSAMINATOR(E)/ EXAMINER(S):	**PROF. K.R. UREN PROF. G. VAN SCHOOR**	DATUM/ DATE:	**09/06/2016**
		TYD/TIME	**09:00**
MODERATOR:	**DR. J. CARROLL (UJ)**		

TOTAAL / TOTAL: 105

VRAAG 1 / QUESTION 1

'n Blokdiagram van 'n stelsel word gegee in Fig. 1. Bepaal eerstens of die stelsel waarneembaar is. Ontwerp dan 'n volledige toestand skatter wat 'n krities gedempte karakteristiek sal hê. / *A block diagram of a system is given in Fig. 1. Firstly determine whether the system is observable. Design a full-state observer that will have a critically damped characteristic.*



Figuur 1/*Figure 1*

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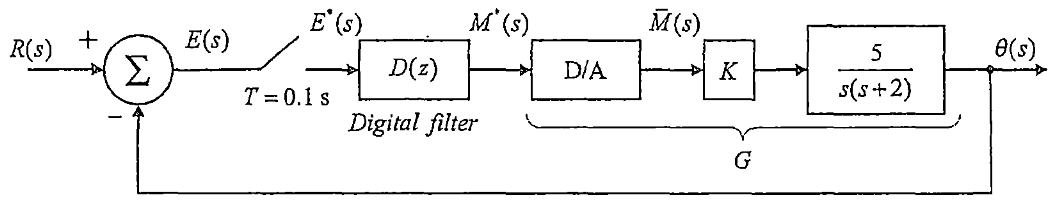
VRAAG 2 / QUESTION 2

Beskou die stelsel in Fig. 2. / *Consider the system in Fig. 2.*



Figuur 2/*Figure 2*

Die digitale filter los die volgende verskilvergelyking op: / *The digital filter solves the following difference equation:*

$$m(k+1) = e(k+1) - 0.9e(k) + 0.98m(k)$$

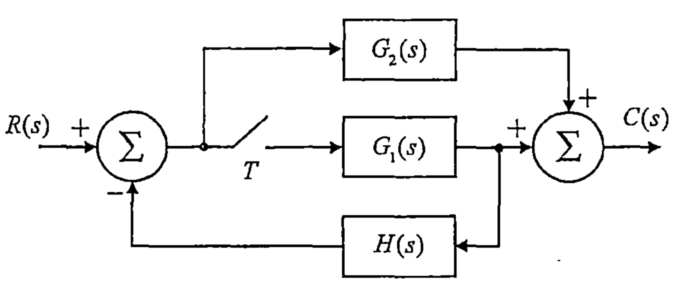
2.1 Bepaal die oordragsfunksie $\theta(z)/E(z)$ vir $K = 5$. / *Determine the transfer function $\theta(z)/E(z)$ for $K = 5$.* (7)

2.2 Bepaal ook die stelseloordragsfunksie $\theta(z)/R(z)$. / *Determine the transfer function $\theta(z)/R(z)$.* (3)

2.3 Bepaal die bestendige toestand fout vir 'n eenheidshellingsinset. / *Determine the steady state error for a unit ramp input.* (6)

2.4 Bepaal die oodragsfunksie $\theta(z)/E(z)$ indien die verwerkingstyd van die digitale filter van 0.15 s ook gemodelleer moet word. / *Determine the transfer function $\theta(z)/E(z)$ when a computational delay of 0.15 s also needs to be modelled.* (6)

2.5 Bepaal vir die stelsel in Fig. 3 die uitset $C(z)$ in terme van die inset en die oordragsfunksies. / *Determine for the system in Fig. 3 the output $C(z)$ in terms of the input and the transfer functions.* (8)



Figuur 3/*Figure 3*

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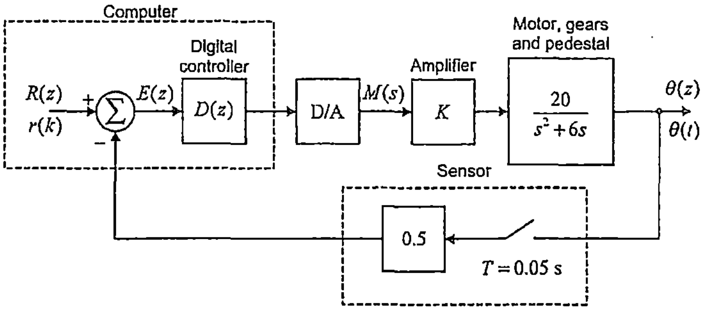
VRAAG 3 / QUESTION 3

Beskou die antenna-beheerstelsel in Fig. 4. Die eenheid van die antenna hoek $\theta(t)$ is grade en die bereik is $\pm 135°$. / *Consider the antenna control system in Fig. 4. The unit of the antenna angle $\theta(t)$ is degrees, and the range is $\pm 135°$.*



Figuur 4/*Figure 4*

3.1 Die inset sein $r(k)$ word deur die rekenaar gegenereer. Vind die verlangde waardes van $r(k)$ vir die verlangde hoek waardes $\theta(t) = \pm 30°$. / *The input signal $r(k)$ is generated in the computer. Find the required values of $r(k)$ for the desired angle values $\theta(t) = \pm 30°$.* (2)

3.2 Bepaal die oordragsfunksie van die stelsel as $K = 20$ en $D(z) = 1$. / *Determine the transfer function of the system for $K = 20$ and $D(z) = 1$.* (6)

3.3 Wat is die tipe van die stelsel? / *What is the system type?* (2)

3.4 Bepaal die demping asook die natuurlike frekwensie van die diskrete stelsel. / *Determine the damping as well as the natural frequency of the discrete system.* (5)

3.5 Spreek jou uit oor die sinvolheid van die keuse van die monstertempo. Wat is die effek van die keuse van die monstertempo op die respons van die gediskretiseerde stelsel? Maak 'n aanbeveling oor die monstertempo wat die diskretiseringsfout sal minimeer, maar nie die modelleringstyd onnodig sal verleng nie. / *Discuss the meaningfulness of the choice of the sampling rate. What is the effect of the choice of sampling rate on the response of the system? Make a recommendation on the sampling rate that would minimise the discretisation error without unnecessarily increasing the modelling time.* (5)

3.6 Bepaal die z-transform in geslote vorm van die volgende sein: / *Determine the z-transform in closed form of the following signal:*

$$E(s) = \frac{(e^s - 1)^2}{e^{2s}s(s+1)}, \quad T = 0.5 \text{ s}$$

(5)

Addisionele inligting / *additional information:*

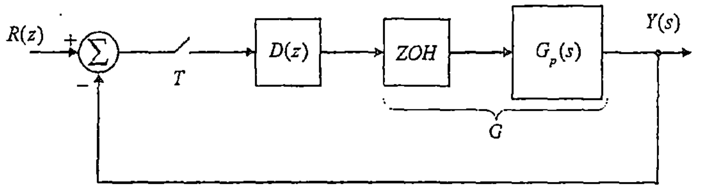
$$\zeta = \frac{-\ln r}{\sqrt{\ln^2 r + \theta^2}}$$

$$\omega_n = \frac{1}{T}\sqrt{\ln^2 r + \theta^2}$$

$$\tau = \frac{1}{\zeta \omega_n}$$

[25]

VRAAG 4 / QUESTION 4



Figuur 5/*Figure 5*

Die stelsel in Fig. 5 het die volgende oordragsfunksie: / *The system in Fig. 5 has the following transfer function:*

$$G_p = \frac{5K}{s(s+2)}$$

Vir $K = 1$, is die diskrete oordragsfunksie van die stelsel soos volg: / *For $K = 1$, the discrete transfer function of the system is as follows:*

$$G(z) = \frac{K(0.00605z + 0.00585)}{z^2 - 1.905z + 0.905}, \quad T = 0.05 \text{ s}$$

4.1 Verstel K na 10 om die bestendige toestand foutvereiste te bevredig./ *Adjust K to 10 to satisfy the steady state error requirement.*
Ontwerp 'n PID beheerder $D(z)$ in die bodediagramvlak wat 'n fasegrens van 60° tot gevolg sal hê. / *Design a PID controller $D(z)$ in the bode diagram plane that will give a phase margin of 60°.*
Fig. 6 toon die bodediagram van $G(j\omega)$ vir $K = 1$./ *Fig. 6 shows the bode diagram of $G(j\omega)$ for $K = 1$.* (10)

4.2 Die stelsel moet bedryf word by die punt van kritiese demping. Teken die benaderde wortellokus van die stelsel en bepaal die wins van die stelsel vir krities gedempte pole. /
The system must be operated at the point of critical damping. Draw the approximate root locus of the system and determine the gain of the system for crytically damped poles.
Ontwerp 'n fase-voorloopkompensator wat krities gedempte poolposisies behou, maar die tydkonstante van die stelsel met 'n faktor 3 verklein, maw die stelsel reageer 3 keer vinniger. /
Design a phase lead compensator that will retain crytically damped pole positions, but reduce the time constant of the system by a factor of 3, ie the system reacts 3 times faster. (15)

[25]

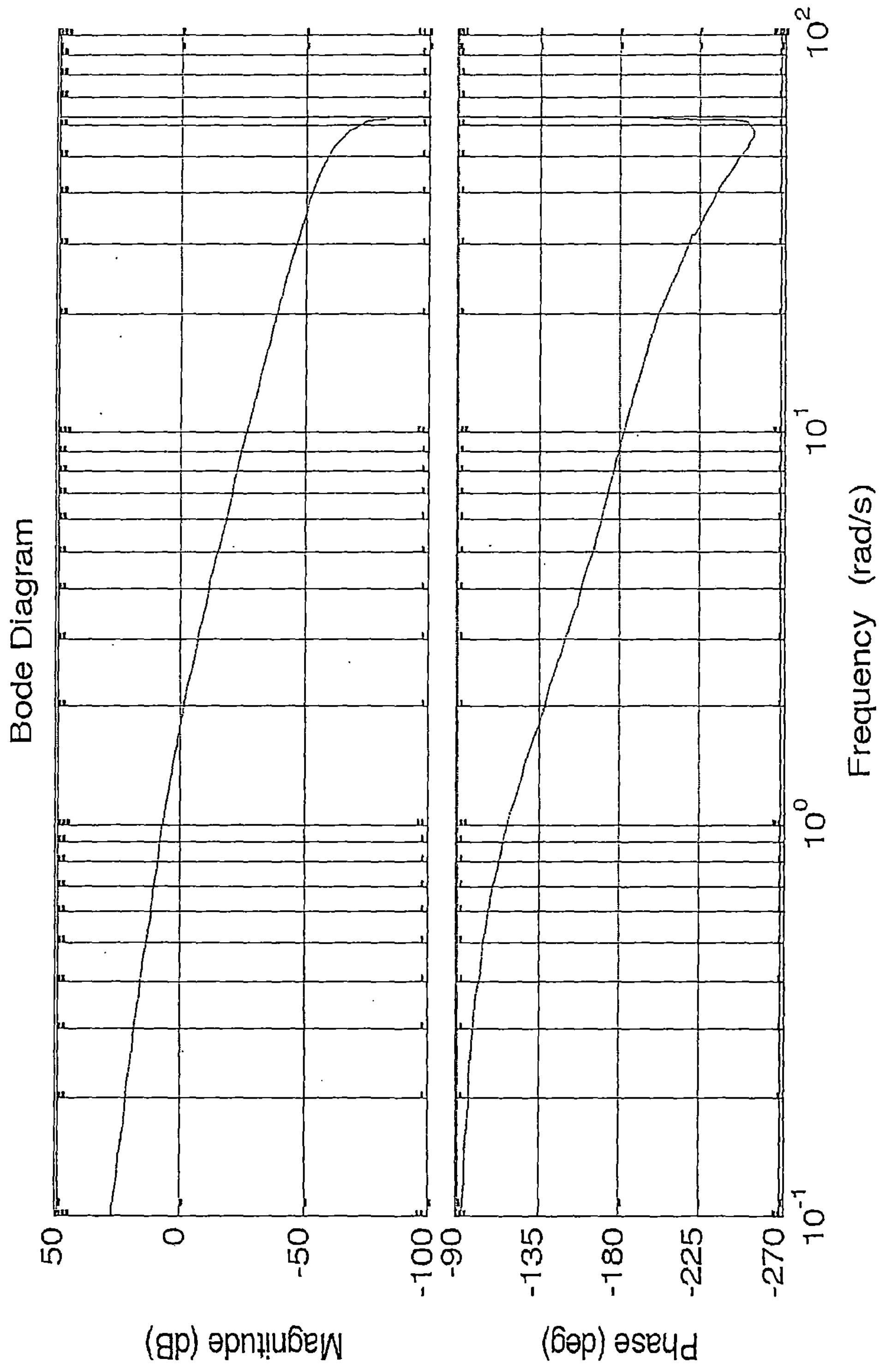
Addisionele inligting / *Additional information:*

$$D(w) = a_0\left[\frac{1+w/(a_0/a_1)}{1+w/(1/b_1)}\right], \quad a_1 = \frac{1-a_0|G(j\omega_{w1})|\cos\theta}{\omega_{w1}|G(j\omega_{w1})|\sin\theta}, \quad b_1 = \frac{\cos\theta - a_0|G(j\omega_{w1})|}{\omega_{w1}\sin\theta}$$

$$K_d = a_0\left[\frac{\omega_{wp}(\omega_{w0}+2/T)}{\omega_{w0}(\omega_{wp}+2/T)}\right], \quad z_0 = \left[\frac{2/T-\omega_{w0}}{2/T+\omega_{w0}}\right], \quad z_p = \left[\frac{2/T-\omega_{wp}}{2/T+\omega_{wp}}\right]$$

$$K_P = \frac{\cos\theta}{|G(j\omega_{w1})|}$$

$$K_D\omega_{w1} - \frac{K_I}{\omega_{w1}} = \frac{\sin\theta}{|G(j\omega_{w1})|}$$



Figuur 6/*Figure 6*

VRAAG 5 / QUESTION 5

Sê of die volgende stellings **WAAR** of **VALS** is. **EEN** punt sal afgetrek word vir elke verkeerde antwoord. Moet dus nie raai nie; los liewer oop as jy nie weet nie. / *State whether the following statements are* **TRUE** *or* **FALSE**, *keeping in mind that* **ONE** *mark will be deducted for each wrong answer. Therefore do not guess; rather leave blank if you do not know the answer.*

5.1 Die ster-transform van $e(t) = e^{a(t-2T)u(t-2T)}$ in geslote vorm is $E^*(s) = \frac{e^{-2Ts}}{1-e^{(a-s)T}}$. / *The star transform of* $e(t) = e^{a(t-2T)u(t-2T)}$ *in closed form is* $E^*(s) = \frac{e^{-2Ts}}{1-e^{(a-s)T}}$. (1)

5.2 $E^*(s)$ het die volgende twee belangrike eienskappe in die s-vlak: / $E^*(s)$ *has the following two important properties in the s-plain:*

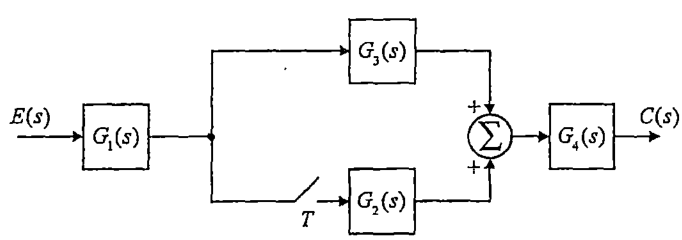
- $E^*(s)$ is liniêr. / $E^*(s)$ *is linear.*
- As $E(s)$ 'n pool by $s = s_1$ het, dan sal $E^*(s)$ pole hê by $s = s_1 + jm\omega_s$ met $m = 0, \pm1, \pm2, \ldots$ / *If* $E(s)$ *has a pole at* $s = s_1$, *then* $E^*(s)$ *will have poles at* $s = s_1 + jm\omega_s$ *with* $m = 0, \pm1, \pm2, \ldots$

(1)

5.3 Die pool in die nul-orde houbaan se oordragsfunksie van $G(z) = \mathcal{Z}\left[\frac{1-e^{-Ts}}{s}G_p(s)\right]$ transformeer na a pool by $z = 1$ in die z-vlak. / *The pole of the zero-order hold transfer function in the transfer function* $G(z) = \mathcal{Z}\left[\frac{1-e^{-Ts}}{s}G_p(s)\right]$ *transforms to a pole at* $z = 1$ *in the z-plane.* (1)

5.4 $C(z)$ kan uitgedruk word as 'n funksie van die inset vir die stelsel gegee in Fig. 7 as volg / $C(z)$ *can be expressed as a function of the input for the system in Fig. 7 as follows:*

$$C(z) = G_1G_3G_4E(z) + \overline{G_2G_4}(z)\overline{G_1E(z)}$$



Figuur 7/*Figure 7*

(1)

5.5 'n Diskrete-tyd stelsel met $T = 0.5$ s en karakteristieke vergelyking gegee deur / *A discrete time system with* $T = 0.5$ *s and a characteristic equation given by*

$$(z-0.9)(z-0.8)(z^2-1.9z+1) = 0,$$

is marginaal stabiel. / *is marginally stable.* (1)

[5]

VRAAG 6 / QUESTION 6

Bespreek wasige logiese stelsels aan die hand van hul oorsprong, struktuur, funksionaliteit en opleiding. Klassifiseer ook die gebruik daarvan in terme van toepassings. /
Discuss fuzzy logic systems in terms of their origin, structure, functionality and training. Classify their use in terms of applications. [10]