	Modeling and System Identification – Microexam 3 Prof. Dr. Moritz Diehl, IMTEK, University Freiburg, February 6, 2017, 8:15-9:45					
Su	mame:	First Name:	Matriculation number	er:		
Su	oject:	Programme: Bachelor Mas	ster Lehramt others	Signature:		
	Please fill in your name above a	nd tick exactly ONE box for the	right answer of each question b	pelow.		
1.	Consider the discrete LTI syste abbreviations best describes this	$m y_k = \theta_1 y_{k-1} + \theta_2 \epsilon_k + \theta_3 \epsilon_k$ system?	$\epsilon_{k-1}$ with scalar output $y$ and	noise $\epsilon$ . What of the following		
	(a) ARX	(b) FIR	(c) ARMA	(d) NARX		
2.	For which type of system can a	global minimum to the estimatio	n problem be guaranteed?			
	(a) Output-Error	(b) Input-Output-Error	(c) LIP, additive noise	(d) Equation-Error		
3.	Which statement concerning the	set-up of the Kalman Filter is N	IOT typically true:			
	(a) $\square$ The larger $P$ , the small	er the innovation step.	(b) The more trustworthy	the model, the smaller P.		
	(c) The model is assumed	to be linear.	(d) Process noise effects i	increase progressively.		
4.	4. What does the expression $Q_{N+1}^{-1}\phi(N+1)(y(N+1)-\phi(N+1))$		$(\Lambda)^{\top}\hat{\theta}(N)$ stand for in the context of Recursive Least Squares?			
	(a) The innovation update.		(b) The downweighing of past information.			
	(c) The best prior guess.		(d) The expression is not correct.			
5.	5. Consider a linear system defined as $x_i = A_{i-1}x_{i-1} + w_i$ with a linear measurement equation $y_i = C_i x_i + v_i$ . If $x_i \in \mathbb{R}^n$ and $y_i \in \mathbb{R}^m$ , what is NOT true about the covariance of the process noise $W_i$ and measurement noise $V_i$ of a Kalman Filter?					
	(a) $\square W_i$ and $V_i$ are diagonal	matrices.	(b) $\square W_i$ has $n$ non-zero sir	ngular values.		
	(c) $W_i \in \mathbb{R}^{n \times n}$ , and $V_i \in$	$\mathbb{R}^{m  imes m}$ .	(d) $\square W_i$ and $V_i$ are positive	e definite.		
6.	Given the transfer function $G(jacondot g)$	$\omega$ ), what quantity does the magn	itude plot of the Bode diagram s	show on its y-axis?		
	(a) $ \ G(j\omega)\  $	(b) $\Box  G(j\omega) $	(c) $\log  G(j\omega) $	(d) $\Box \log G(j\omega)^2$		
7.	7. For scalar phase shift $\alpha$ , what is the output of the LTI system, described by the transfer function $G(j\omega)$ , that is excited with sinusoidal input $u(t) = U_0 \cdot \sin(\omega \cdot t)$ ?			on $G(j\omega)$ , that is excited with a		
	(a) $\qquad y(t) =  G(j\omega) U_0 \cdot \sin(\alpha \cdot t + \omega)$		(b) $\qquad y(t) =  G(j\omega) U_0 \cdot \sin(\omega \cdot t + \alpha)$			
	(c) $y(t) = \frac{U_0}{ G(j\omega) } \cdot \sin(\omega)$	$\cdot t + \alpha)$	(d) $\qquad y(t) =  G(j\omega) U_0 \cdot \mathrm{si}$	$\mathbf{n}(\boldsymbol{\omega}\cdot\boldsymbol{t}) + \boldsymbol{\alpha}$		
8.	Consider the case in the previo function $G(j\omega)$ for the specific	us question for an output signal frequency $\omega$ ?	with the magnitude $Y_0$ . Which	h equation describes the transfer		
	(a) $\prod \frac{U_0}{Y_0} e^{j\alpha}$	(b) $\prod \frac{U_0}{Y_0} e^{j\omega}$	(c) $\prod \frac{Y_0}{U_0} e^{j\omega}$	(d) $\prod \frac{Y_0}{U_0} e^{j\alpha}$		
9.	Regard a periodic signal with bad different frequencies are contain	ase frequency $f_{base}$ that is sampled in the discretized signal?	bled every $\Delta t = 1s$ (with $1/\Delta t$	a multiple of $f_{base}$ ). How many		
	(a) $2\Delta t/f_{base}$	(b) $\int f_{base}/2\Delta t$	(c) $\Box 2\Delta t f_{base}$	(d) $\Box 1/(2\Delta t f_{base})$		
10.	At which frequency $f$ [Hz] is th	e resonance peak of the followin	g transfer function: $G(s) = \frac{1}{s^2 + 1}$	$\frac{a^2}{2as+a^2}$ , with $a \in \mathbb{R}$ ?		
	(a) $f = \frac{a}{2\pi}$	(b) $\Box f = \frac{-ja}{2\pi}$	(c) $\Box f = \frac{ja}{2\pi}$	(d) $\Box f = \frac{j2\pi}{a}$		

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11. Which slope has the plot of the magnitude of the transfer function  $G(s) = \frac{1}{s^2 + 2s + 1}$  at high frequencies?

(a) 0 dB/decade	(b) -20 dB/decade	(c) 20 dB/decade	(d)40 dB/decade

12. A continuous function in the time domain  $u_c(t)$  is sampled with a frequency  $f_s$ , resulting in a set of discrete values  $u = [u(0), \ldots, u(N-1)]^\top$ . Applying the DFT to u yields  $U = [8, 2, 0, 8, 0, 8, 0, 2]^\top$ . Reconstruct the function  $u_c(t)$  from U. IDFT:  $u(n) = \frac{1}{N} \sum_{k=0}^{N-1} U(k) e^{j\frac{2\pi kn}{N}}$ , for  $n = 0, \ldots, N-1$ 

(a) $u_{c}(t) = 1 + \frac{1}{2}\cos(\frac{\pi f_{s}t}{8}) + 2\cos(\frac{\pi f_{s}t}{4})$	(b) $u_{c}(t) = 2 + \cos(\frac{\pi f_{s}t}{4}) + 2\cos(\frac{3\pi f_{s}t}{4})$
(c) $u_{c}(t) = 1 + \frac{1}{2}\cos(\frac{\pi f_{s}t}{4}) + 2\cos(\frac{3\pi f_{s}t}{4})$	(d) $u_{c}(t) = 2 + \cos(\frac{\pi f_{s}t}{4}) + 2\cos(\pi f_{s}t)$

- 13. You want to do multisine excitation to identify the transfer function of an unknown system. How should the multisine be designed, to prevent aliasing errors?
- 14. What is the name of the theorem that defines the above mentioned condition?
- 15. You want to do multisine excitation to identify the transfer function of an unknown system. How should the multisine be designed, to prevent leakage errors?
- 16. What is the frequency resolution of the DFT of a given periodic signal with period T, sampling frequency  $f_s$ , and the number of samples per period N?

(a) $\Box \omega = 2\pi f_s$ (b) $\Box \omega = \frac{2\pi f_s}{T}$ (c) $\Box \omega = \frac{2\pi}{N \cdot T}$ (d) $\Box \omega = \frac{2\pi f_s}{N}$	
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17. You identify an LTI system with periodic multisine excitations, where each window has length T and the total duration of your experiment is MT with a large integer M. Which procedure should you follow to identify the transfer function  $\hat{G}(j\omega_k)$  at a given frequency  $\omega_k = \frac{2\pi k}{T}$ ?

(a) $\square$ build the quotients of the $M$ windows, average the	(b) $\square$ average the $M$ windows, build the quotient of the
quotients and apply the DFT on the quotients	average and apply DFT
(c) compute the DFTs of each window, build the DFT	(d) compute the DFTs of each window, then average the
quotients and then average the quotients	DFTs and then build the quotient of the average

18. Which expression describes the Kalman filter innovation step of the covariance P?

(a) $P_{[k k]} = (P_{[k k-1]} + C_k^\top V^{-1} C_k)^{-1}$	(b) $\square P_{[k k]} = (P_{[k k-1]}^{-1} + C_k^\top V^{-1} C_k)^{-1}$
(c) $P_{[k k-1]} = (P_{[k-1 k-1]}^{-1} + C_k^{\top} V^{-1} C_k)^{-1}$	(d) $\square P_{[k k]} = P_{[k k-1]}^{-1} + C_k^{\top} V^{-1} C_k$

19. What signal-to-noise-ratio (SNR) at a certain frequency  $f_0$  of a measured signal do you want to achieve, in order to be able to estimate the amplitude of this frequency component with an accuracy of 10%?

(a) 1dB	(b) 10dB	(c) 20dB	(d) 40dB

20. Which are the appropriate matrices of the state space model of a system described by the following ODE:  $\ddot{a} = c_1\dot{a} + c_2a + \dot{s}$  $\ddot{s} = c_3\dot{a} + c_4\dot{s} + s$  and the output  $y = c_5s + c_6\dot{a}$ , with  $c_1, \ldots, c_6 \in \mathbb{R}$ . Consider the states to be  $x = [a, \dot{a}, s, \dot{s}]^\top$ .

(a) $\square A = \begin{bmatrix} 0 & 0 & 0 & 1 \\ 0 & c_3 & 1 & c_4 \\ 0 & 1 & 0 & 0 \\ c_2 & c_1 & 0 & 1 \end{bmatrix}, C = \begin{bmatrix} c_5 & 0 & 0 & c_6 \end{bmatrix}$	(b) $\square A = \begin{bmatrix} 0 & 1 & 0 & 0 \\ c_2 & c_1 & 0 & 1 \\ 0 & 0 & 0 & 1 \\ 0 & c_3 & 1 & c_4 \end{bmatrix}, C = \begin{bmatrix} c_5 & 0 & 0 & c_6 \end{bmatrix}$
(c) $\square A = \begin{bmatrix} 0 & 1 & 0 & 0 \\ c_2 & c_1 & 0 & 1 \\ 0 & 0 & 0 & 1 \\ 0 & c_3 & 1 & c_4 \end{bmatrix}, C = \begin{bmatrix} 0 & c_6 & c_5 & 0 \end{bmatrix}$	$(\mathbf{d}) \square A = \begin{bmatrix} c_2 & c_1 & 0 & 1\\ 0 & 1 & 0 & 0\\ 0 & 0 & 0 & 1\\ 0 & c_3 & 1 & c_4 \end{bmatrix}, C = \begin{bmatrix} 0 & c_6 & c_5 & 0 \end{bmatrix}$

Points on page (max. 10)

Surmame:       First Name:       Matriculation number:         Subject:       Programme:       handroff       Master       Signature:         Please fill in your name above and lick exactly ONE box for the right answer of each question below.       1.       Consider a linear system defined as $x_1 = A_{t-1}x_{t-1} + w_t$ with a linear measurement equation $y_t = C_tx_1 + w_t$ . If $x_t \in \mathbb{R}^n$ and $y_t \in \mathbb{R}^n$ , what is NOT true about the covariance of the process noise $W_t$ and measurement noise $V_t$ of a Kalman Filter?         (a) $W_t \in \mathbb{R}^{n, x_1}$ and $V_t \in \mathbb{R}^{n, x_m}$ .       (b) $W_t$ has $n$ non-zero singular values.       (c) $(-)$ $W_t$ and $V_t$ are diagonal matrices.       (d) $W_t$ and $V_t$ are positive definite.         2. Given the transfer function $G(j\omega)$ , what quantity does the magnitude plot of the Bode diagram show on its y-axis?       (a) $\Box \log(G(j\omega)^2)$ (b) $\Box G(j\omega)^2$ 3. For which type of system can a global minimum to the estimation problem be guaranted?       (d) $\Box \log(G(j\omega)^2)$ (d) $\Box \log(G(j\omega)^2)$ 4. Which statement concerning the set-up of the Kalman Filter is NOT typically true:       (d) $\Box$ the nore trustworthy the model, the smaller $P$ .       (b) $\Box$ The model is assumed to be linear.         (e) $\Box$ the larger $P_t$ the smaller the innovation step.       (d) $\Box$ The correct.       (d) $\Box$ the correct.         5. What does the expression $Q_{x_{1-1}}^{-1} \phi(N + 1) - \phi(N + 1)^{-1} \hat{\theta}(N)$ stand for in the context of Recursive Least Squares?       (a) $\Box$ the best prior guess.       (b) $\Box$ The innovation update.       <		Modeling and System Identification – Microexam 3 Prof. Dr. Moritz Diehl, IMTEK, University Freiburg, February 6, 2017, 8:15-9:45				
Subject:       Programme:       Baschelor       Master       Lehnon       others       Signature:         Pleuse fill in your name above and tick exactly ONE box for the right answer of each question below.       1.       Consider a linear system defined as $x_i = A_{i-1}x_{i-1} + w_i$ with a linear measurement noise $V_i$ of a Kalman Filter?       (a) $W_i \in \mathbb{R}^{n \times n}$ , and $V_i \in \mathbb{R}^{m \times m}$ .       (b) $W_i$ has $n$ non-zero singular values.       (c)       (i) $W_i$ and $V_i$ are diagonal matrices.       (d) $W_i$ and $V_i$ are positive definite.         2. Given the transfer function $G(j\omega)$ , what quantity does the magnitude plot of the Bode diagram show on its y-axis?       (ii) $                                    $	Su	mame:	First Name:	Matriculation numbe	r:	
Please fill in your name above and tick exactly ONE box for the right answer of each question below. 1. Consider a linear system defined as $x_i = A_{i-1}x_{i-1} + w_i$ with a linear measurement equation $y_i = C_i x_i + v_i$ . If $x_i \in \mathbb{R}^n$ and $y_i \in \mathbb{R}^{n \times n}$ , and $V_i \in \mathbb{R}^{n \times n}$ . (b) $\square W_i$ has <i>n</i> non-zero singular values. (c) $\square W_i$ and $V_i$ are diagonal matrices. (d) $\square W_i$ and $M_i$ and	Su	bject:	Programme: Bachelor Mas	ster Lehramt others	Signature:	
<ol> <li>Consider a linear system defined as x<sub>1</sub> = A<sub>1</sub> x<sub>k-1</sub> + w<sub>k</sub> with a linear measurement equation y<sub>k</sub> = C<sub>k</sub>x<sub>k</sub> + v<sub>k</sub>. If x<sub>k</sub> ∈ ℝ<sup>n</sup> and y<sub>k</sub> ∈ ℝ<sup>n</sup>, what is NOT true about the covariance of the process noise W<sub>k</sub> and measurement noise V<sub>k</sub> of a Kalman Filter?</li> <li>(a) W<sub>k</sub> ∈ ℝ<sup>n,x<sub>n</sub></sup>, and V<sub>k</sub> ∈ ℝ<sup>n,x<sub>m</sub></sup>.</li> <li>(b) W<sub>k</sub> has n non-zero singular values.</li> <li>(c) W<sub>k</sub> and V<sub>k</sub> are diagonal matrices.</li> <li>(d) W<sub>k</sub> and V<sub>k</sub> are positive definite.</li> <li>Given the transfer function G(jω), what quantity does the magnitude plot of the Bode diagram show on its y-axis?</li> <li>(a) log[G(jω)]</li> <li>(b) [G(jω)]</li> <li>(c) [IG(jω)]</li> <li>(d) [IG(jω)]</li> <li>(e) [IG(jω)]</li> <li>(f) [IG(jω)]</li> <li>(g) [IG(jω)]</li> <li>(g) [IG(jω)]</li> <li>(h) [G(jω)]</li> <li>(h) [IG(jω)]</li> <li>(h) [III]</li> <li>(h) [IIII</li></ol>		Please fill in your name above a	and tick exactly ONE box for the	right answer of each question be	elow.	
(a) $W_i \in \mathbb{R}^{n \times n}$ , and $V_i \in \mathbb{R}^{n \times m}$ .       (b) $W_i$ has <i>n</i> non-zero singular values.         (c) $W_i$ and $V_i$ are diagonal matrices.       (d) $W_i$ and $V_i$ are positive definite.         2. Given the transfer function $G(j\omega)$ , what quantity does the magnitude plot of the Bode diagram show on its y-axis?         (a) $[\log G(j\omega))$ (b) $[G(j\omega) $ (c) $[G(j\omega) $ (d) $[\log G(j\omega)^2]$ 3. For which type of system can a global minimum to the estimation problem be guaranteed?       (a) $[(d) \ D gG(j\omega)^2]$ (a) $[Output-Firor$ (b) $Equation-Firor$ (c) $[nput-Output-Firor$ (d) $[1.1P, additive noise]$ 4. Which statement concerning the set-up of the Kalman Filter is NOT typically true:       (a) $[(d) \ D more trustworthy the model, the smaller P.       (b) [(d) \ D more trustworthy the model, the smaller P.       (b) [(d) \ D more trustworthy term concerning the set-up of the Kalman Filter is NOT typically true:         (a) [(d) \ D more trustworthy the model, the smaller P.       (b) [(d) \ D more trustworthy the model, the smaller P.       (b) [(d) \ D more trustworthy term concerning the set-up of (N + 1)^{T} \hat{\theta}(N)) stand for in the context of Recursive Least Squares?         (a) [(d) \ D more trustworthy the model, the smaller P.       (d) [(d) \ D more trustworthy term concerning the set programs.       (b) [(d) \ D more trustworthy term concerning the set programs.         (a) [(d) \ D more trustworthy the model, the smaller the innovation step.       (d) [(d) \ D more trustwore truntsmaller P.       (d) [(d$	1.	Consider a linear system defined $y_i \in \mathbb{R}^m$ , what is NOT true about	d as $x_i = A_{i-1}x_{i-1} + w_i$ with at the covariance of the process r	a linear measurement equation $y_i = C_i x_i + v_i$ . If $x_i \in \mathbb{R}^n$ and noise $W_i$ and measurement noise $V_i$ of a Kalman Filter?		
(c) $[w]_i$ and $V_i$ are diagonal matrices.       (d) $[w]_i$ and $V_i$ are positive definite.         2. Given the transfer function $G(j\omega)_i$ , what quantity does the magnitude plot of the Bode diagram show on its y-axis?         (a) $[\log[G(j\omega)]]$ (b) $[G(j\omega)]$ (c) $[  G(j\omega) ]$ (d) $[\log G(j\omega)^2]$ 3. For which type of system can a global minimum to the estimation problem be guaranteed?       (a) $[  Output-Error $ (b) $[  Equation-Error $ (c) $[  Du _U - Output-Error $ (d) $[  LP, additive noise]$ 4. Which statement concerning the set-up of the Kalman Filter is NOT typically true:       (a) $[  Du _U - Error $ (b) $[  Du _U - Error $ (d) $[  Du _U - Error $ (d) $[  LP, additive noise]$ 5. What does the expression $Q_{N+1}^{-1}\phi(N+1)(y(N+1) - \phi(N+1)^T \hat{P}(N))$ stand for in the context of Recursive Least Squares?       (b) $[  The best prior guess.       (b) [ The expression is not correct.         6. Which slope has the plot of the magnitude of the transfer function G(s) = \frac{1}{2^{-1}(2\omega+1)} at high frequencies?       (a) [  -d0   D   D   D   D   D   D   D   D   D  $		(a) $W_i \in \mathbb{R}^{n \times n}$ , and $V_i \in \mathbb{R}^{n \times n}$	$\mathbb{R}^{m  imes m}$ .	(b) $\square W_i$ has <i>n</i> non-zero singular values.		
2. Given the transfer function G(jω), what quantity does the magnitude plot of the Bode diagram show on its y-axis?         (a) □ log(G(jω))       (b) □ G(jω)        (c) □   G(jω)         (d) □ log G(jω) <sup>2</sup> 3. For which type of system can a global minimum to the estimation problem be guaranteed?       (a) □ Output-Error       (b) □ Equation-Error       (c) □ Input-Output-Error       (d) □ LIP, additive noise         4. Which statement concerning the set-up of the Kalman Filter is NOT typically true:       (a) □ The more trustworthy the model, the smaller P.       (b) □ The model is assumed to be linear.       (c) □ The larger P, the smaller the innovation step.       (d) □ Process noise effects increase progressively.         5. What does the expression $Q_{N+1}^{-1}\phi(N+1)(y(N+1) - \phi(N+1)^{\top}\hat{\theta}(N))$ stand for in the context of Recursive Least Squares?       (a) □ The best prior guess.       (b) □ The downweighing of past information.       (c) □ The innovation update.       (d) □ The expression is not correct.         6. Which slope has the plot of the magnitude of the transfer function $G(s) = \frac{1}{x^{1} + 2x + 1}$ at high frequencies?       (a) □ 40 B/decade       (c) □ -20 B/decade       (d) □ 20 B/decade         (a) $y(t) =  G(j\omega) U_0 \cdot sin(\omega \cdot t + \alpha)$ (b) □ $y(t) =  G(j\omega) U_0 \cdot sin(\omega \cdot t + \alpha)$ (c) $y(t) =  G(j\omega) U_0 \cdot sin(\omega \cdot t + \alpha)$ (d) $y(t) =  G(j\omega) U_0 \cdot sin(\omega \cdot t + \alpha)$ (a) $y(t) =  G(j\omega) U_0 \cdot sin(\omega \cdot t + \alpha)$ (b) $y(t) =  G(j\omega) U_0 \cdot sin(\omega \cdot t + \alpha)$ (d) $y(t) =  G(j\omega) U_0 \cdot sin(\omega \cdot t + \alpha)$ (c) $y(t) =  G(j\omega$		(c) $\square W_i$ and $V_i$ are diagonal	l matrices.	(d) $\square W_i$ and $V_i$ are positive	definite.	
(a) $\log[G(j\omega) $ (b) $[G(j\omega) $ (c) $[G(j\omega)  $ (d) $\log G(j\omega)^2$ 3. For which type of system can a global minimum to the estimation problem be guaranteed?       (a) $Output-Error$ (b) $[Equation-Error$ (c) $[nput-Output-Error$ (d) $[LIP, additive noise]$ 4. Which statement concerning the set-up of the Kalman Filter is NOT typically true:       (a) $[n]$ The more trustworthy the model, the smaller <i>P</i> .       (b) $[n]$ The model is assumed to be linear.       (c) $[n]$ The larger <i>P</i> , the smaller the innovation step.       (d) $[n]$ Process noise effects increase progressively.         5. What does the expression $Q_{N+1}^{-1}\phi(N+1)(y(N+1) - \phi(N+1)^{\top}\hat{\theta}(N))$ stand for in the context of Recursive Least Squares?       (a) $[n]$ The best prior guess.       (b) $[n]$ the downweighing of past information.         (c) $[n]$ The innovation update.       (d) $[n]$ the expression is not correct.       6. Which slope has the plot of the magnitude of the transfer function $G(s) = \frac{1}{x^{1}+2x+1}$ at high frequencies?         (a) $[-40  dB/decade]$ (b) $[0  dB/decade]$ (c) $[-20  dB/decade]$ (d) $[-20  dB/decade]$ 7. For scalar phase shift $\alpha$ , what is the output of the LTI system, described by the transfer function $G(j\omega)$ , that is excited with a sinusoidal input $u(t) = U_0 \cdot \sin(\omega \cdot t)$ ?       (a) $[u] =  G(j\omega) U_0 \cdot \sin(\alpha \cdot t + \alpha)$ (b) $[u] =  U_0 U_0 \cup \sin(\alpha \cdot t + \alpha)$ (c) $[u] y(t) =  G(j\omega) U_0 \cdot \sin(\alpha \cdot t + \omega)$ (d) $[u] = \frac{U_0}{V_0} e^{j\omega}$ (d) $[U_0] e^{j\omega}$ (d) $[U_0] e^{j\omega}$	2.	Given the transfer function $G(jaconstructure)$	$\omega$ ), what quantity does the magn	itude plot of the Bode diagram sl	how on its y-axis?	
<ul> <li>3. For which type of system can a global minimum to the estimation problem be guaranted? <ul> <li>(a) Output-Error</li> <li>(b) Equation-Error</li> <li>(c) Input-Output-Error</li> <li>(d) LIP, additive noise</li> </ul> </li> <li>4. Which statement concerning the set-up of the Kalman Filter is NOT typically true: <ul> <li>(a) The more trustworthy the model, the smaller P.</li> <li>(b) The model is assumed to be linear.</li> <li>(c) The larger P, the smaller the innovation step.</li> <li>(d) Process noise effects increase progressively.</li> </ul> </li> <li>5. What does the expression Q<sup>-1</sup><sub>N+1</sub>φ(N + 1)(y(N + 1) − φ(N + 1)<sup>+</sup>θ(N)) stand for in the context of Recursive Least Squares? <ul> <li>(a) The best prior guess.</li> <li>(b) The downweighing of past information.</li> <li>(c) The innovation update.</li> <li>(d) The expression is not correct.</li> </ul> </li> <li>6. Which slope has the plot of the magnitude of the transfer function G(s) = <sup>1</sup>/<sub>s<sup>2+1</sup>s+1</sub> at high frequencies? <ul> <li>(a) -40 dB/deccade</li> <li>(b) 0 dB/deccade</li> <li>(c) -20 dB/deccade</li> <li>(d) 20 dB/deccade</li> </ul> </li> <li>7. For scalar phase shift α, what is the output of the LTI system, described by the transfer function G(jω), that is excited with a sinusoidal input u(t) = U<sub>0</sub> · sin(ω · t)?</li> <li>(a) y(t) =  G(jω) U<sub>0</sub> · sin(ω · t + α)</li> <li>(b) y(t) =  G(jω) U<sub>0</sub> · sin(ω · t + α)</li> <li>(c) y(t) =  G(jω) U<sub>0</sub> · sin(α · t + ω)</li> <li>(d) y(t) =  G(jω) U<sub>0</sub> · sin(α · t + ω)</li> <li>(e) y(t) =  G(jω) U<sub>0</sub> · sin(α · t + ω)</li> <li>(f) y(t) =  G(jω) U<sub>0</sub> · sin(α · t + ω)</li> <li>(g) y(t) =  G(jω) U<sub>0</sub> · sin(α · t + ω)</li> <li>(g) y(t) =  G(jω) U<sub>0</sub> · sin(α · t + ω)</li> <li>(g) y(t) =  G(jω) L<sub>0</sub> · sin(α · t + ω)</li> <li>(g) y(t) =  G(jω) L<sub>0</sub> · sin(α · t + ω)</li> <li>(g) y(t) =  G(jω) L<sub>0</sub> · sin(α · t + ω)</li> <li>(g) y(t) =  G(jω) L<sub>0</sub> · sin(α · t + ω)</li> <li>(g) y(t) =  G(jω) L<sub>0</sub> · sin(α · t + ω)</li> <li>(g) y(t) =  G(jω) L<sub>0</sub> · sin(α · t + ω)</li> <li>(g) y(t) =  G(jω) L<sub>0</sub> · sin(α · t + ω)</li></ul>		(a) $\log  G(j\omega) $	(b) $\Box  G(j\omega) $	(c) $\square \ G(j\omega)\ $	(d) $\Box \log G(j\omega)^2$	
(a) Output-Error       (b) Equation-Error       (c) Input-Output-Error       (d) I.IP. additive noise         4. Which statement concerning the set-up of the Kalman Filter is NOT typically true:       (a) The more trustworthy the model, the smaller P.       (b) The model is assumed to be linear.         (c) The larger P, the smaller the innovation step.       (d) Process noise effects increase progressively.         5. What does the expression Q <sup>-1</sup> <sub>N+1</sub> φ(N + 1)(y(N + 1) − φ(N + 1) <sup>−</sup> θ(N)) stand for in the context of Recursive Least Squares?         (a) The best prior guess.       (b) The downweighing of past information.         (c) The innovation update.       (d) The expression is not correct.         6. Which slope has the plot of the magnitude of the transfer function G(s) = <sup>1</sup> / <sub>x<sup>2</sup>+2s+1</sub> at high frequencies?         (a) -40 dB/decade       (b) 0 dB/decade       (c) -20 dB/decade         (a) y(t) = [G(ω)]U_0 · sin(ω · t - α)       (b) y(t) = <sup>Un</sup> / <sub>[G( ω ]</sub> ] · sin(ω · t + α)         (c) y(t) =  G(jω)]U_0 · sin(α · t + ω)       (d) y(t) =  G(jω) U_0 · sin(ω · t) + α         8. Consider the case in the previous question for an output signal with the magnitude Y <sub>0</sub> . Which equation describes the transfer function f(jω) dim (ω · t) = <sup>1</sup> / <sub>U<sub>0</sub></sub> φ <sup>jω</sup> 9. Which expression describes the Kalman filter innovation step of the covariance P?       (a) Y <sub>0</sub> φ <sup>jω</sup> (a) Y <sub>0</sub> φ <sup>jω</sup> (b) U <sub>0</sub> φ <sup>jω</sup> (c) U <sub>0</sub> V <sub>0</sub> φ <sup>jω</sup> (c) D <sub>  k  =</sub> (P <sub>  k  =1</sub> + C <sup>T</sup> <sub>k</sub> V <sup>-1</sup> C <sub>k</sub> ) <sup>-1</sup> (b) D <sub>  k </sub>	3.	For which type of system can a	global minimum to the estimatio	n problem be guaranteed?		
<ul> <li>4. Which statement concerning the set-up of the Kalman Filter is NOT typically true: <ul> <li>(a) The more trustworthy the model, the smaller P.</li> <li>(b) The model is assumed to be linear.</li> <li>(c) The larger P, the smaller the innovation step.</li> <li>(d) Process noise effects increase progressively.</li> </ul> </li> <li>5. What does the expression Q<sup>-1</sup><sub>N+1</sub>φ(N + 1)(y(N + 1) - φ(N + 1)<sup>T</sup>θ(N)) stand for in the context of Recursive Least Squares? <ul> <li>(a) The best prior guess.</li> <li>(b) The downweighing of past information.</li> <li>(c) The innovation update.</li> <li>(d) The expression is not correct.</li> </ul> </li> <li>6. Which slope has the plot of the magnitude of the transfer function G(s) = z<sup>-1</sup>/zz+1 at high frequencies? <ul> <li>(a) -40 dB/decade</li> <li>(b) 0 dB/decade</li> <li>(c) -20 dB/decade</li> <li>(d) 20 dB/decade</li> </ul> </li> <li>7. For scalar phase shift α, what is the output of the LTI system, described by the transfer function G(jω), that is excited with a sinusoidal input a(t) = U<sub>0</sub> · sin(ω · t)?</li> <li>(a) y(t) =  G(jω) U<sub>0</sub> · sin(ω · t + ω)</li> <li>(b) y(t) =  G<sub>0</sub> ω) U<sub>0</sub> · sin(ω · t + ω)</li> <li>(c) y(t) =  G(jω) U<sub>0</sub> · sin(α · t + ω)</li> <li>(d) y(t) =  G(jω) U<sub>0</sub> · sin(α · t + ω)</li> <li>(e) y(t) =  G<sub>1</sub> ω   + C<sup>T</sup><sub>k</sub> V<sup>-1</sup>C<sub>k</sub>)<sup>-1</sup></li> <li>(f) y<sup>T</sup><sub>0</sub> e<sup>jω</sup></li> <li>(g) y<sup>T</sup><sub>0</sub> e</li></ul>		(a) Output-Error	(b) Equation-Error	(c) Input-Output-Error	(d) LIP, additive noise	
<ul> <li>(a) The more trustworthy the model, the smaller P.</li> <li>(b) The model is assumed to be linear.</li> <li>(c) The larger P, the smaller the innovation step.</li> <li>(d) Process noise effects increase progressively.</li> </ul> 5. What does the expression Q <sup>1</sup> <sub>N+1</sub> φ(N + 1)(y(N + 1) - φ(N + 1) <sup>T</sup> θ(N)) stand for in the context of Recursive Least Squares? <ul> <li>(a) The best prior guess.</li> <li>(b) The downweighing of past information.</li> <li>(c) The innovation update.</li> <li>(d) The expression is not correct.</li> </ul> 6. Which slope has the plot of the magnitude of the transfer function G(s) = <sup>1</sup> / <sub>s<sup>2</sup>+2s+1</sub> at high frequencies? <ul> <li>(a) -40 dB/decade</li> <li>(b) 0 dB/decade</li> <li>(c) -20 dB/decade</li> <li>(d) 20 dB/decade</li> </ul> 7. For scalar phase shift α, what is the output of the LTI system, described by the transfer function G(jω), that is excited with a sinusoidal input u(t) = U <sub>0</sub> sin(ω · t + α) <ul> <li>(b) y(t) = [G(jω)]U<sub>0</sub> · sin(ω · t + α)</li> <li>(c) y(t) =  G(jω) U<sub>0</sub> · sin(α · t + ω)</li> <li>(d) y(t) =  G(jω) U<sub>0</sub> · sin(α · t + ω)</li> <li>(d) y(t) =  G(jω) U<sub>0</sub> · sin(α · t + ω)</li> <li>(e) D 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</li></ul>	4.	Which statement concerning the	set-up of the Kalman Filter is N	OT typically true:	·	
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<ul> <li>5. What does the expression Q<sup>-1</sup><sub>N+1</sub>φ(N + 1)(y(N + 1) − φ(N + 1)<sup>T</sup>θ(N)) stand for in the context of Recursive Least Squares? <ul> <li>(a) The best prior guess.</li> <li>(b) The downweighing of past information.</li> </ul> </li> <li>(c) The innovation update.</li> <li>(d) The expression is not correct.</li> </ul> <li>6. Which slope has the plot of the magnitude of the transfer function G(s) = <sup>1</sup>/<sub>a<sup>2+2s+1</sup></sub> at high frequencies? <ul> <li>(a) -40 dB/decade</li> <li>(b) 0 dB/decade</li> <li>(c) -20 dB/decade</li> <li>(d) 20 dB/decade</li> </ul> </li> <li>7. For scalar phase shift α, what is the output of the LTI system, described by the transfer function G(jω), that is excited with a sinusoidal input u(t) = U<sub>0</sub> · sin(ω · t)?</li> <li>(a) y(t) =  G(jω) U<sub>0</sub> · sin(ω · t + α)</li> <li>(b) y(t) = <sup>U<sub>0</sub></sup>/<sub> G(jω) </sub> · sin(ω · t + α)</li> <li>(c) y(t) =  G(jω) U<sub>0</sub> · sin(α · t + ω)</li> <li>(d) y(t) =  G(jω) U<sub>0</sub> · sin(α · t + ω)</li> <li>(e) <sup>U<sub>0</sub></sup>/<sub>U<sub>0</sub></sub> e<sup>jα</sup></li> <li>(f) <sup>U<sub>0</sub></sup>/<sub>U<sub>0</sub></sub> e<sup>jω</sup></li> <li>(g) <sup>U<sub>0</sub></sup>/<sub>U<sub>0</sub></sub> e<sup>jα</sup></li> <li>(h) <sup>U<sub>1</sub></sup>/<sub>U<sub>0</sub></sub> e<sup>jω</sup></li>		(c) The larger $P$ , the smaller the innovation step.		(d) Process noise effects increase progressively.		
(a) The best prior guess.       (b) The downweighing of past information.         (c) The innovation update.       (d) The expression is not correct.         6. Which slope has the plot of the magnitude of the transfer function $G(s) = \frac{1}{s^2+2s+1}$ at high frequencies?         (a) -40 dB/decade       (b) 0 dB/decade       (c) -20 dB/decade       (d) 20 dB/decade         7. For scalar phase shift α, what is the output of the LTI system, described by the transfer function $G(j\omega)$ , that is excited with a sinusoidal input $u(t) = U_0 \cdot \sin(\omega \cdot t)$ ?       (b) $y(t) = \frac{U_0}{ G(j\omega) } \cdot \sin(\omega \cdot t + \alpha)$ (a) $y(t) =  G(j\omega) U_0 \cdot \sin(\omega \cdot t + \alpha)$ (b) $y(t) =  G(j\omega) U_0 \cdot \sin(\omega \cdot t + \alpha)$ (c) $y(t) =  G(j\omega) U_0 \cdot \sin(\alpha \cdot t + \omega)$ (d) $y(t) =  G(j\omega) U_0 \cdot \sin(\omega \cdot t) + \alpha$ 8. Consider the case in the previous question for an output signal with the magnitude $Y_0$ . Which equation describes the transfer function $G(j\omega)$ for the specific frequency $\omega$ ?         (a) $\frac{Y_0}{U_0}e^{j\alpha}$ (b) $\frac{U_0}{Y_0}e^{j\alpha}$ (c) $\frac{U_0}{Y_0}e^{j\alpha}$ (d) $\frac{Y_0}{U_0}e^{j\omega}$ 9. Which expression describes the Kalman filter innovation step of the covariance P?       (a) $P_{ k  k } = (P_{ k  k-1 } + C_k^T V^{-1}C_k)^{-1}$ (b) $P_{ k  k -1 } = (P_{ k  k-1 }^{-1} + C_k^T V^{-1}C_k)^{-1}$ (b) $P_{ k  k } = (P_{ k  k-1 } + C_k^T V^{-1}C_k)^{-1}$ (d) $P_{ k  k } = P_{ k  k-1 }^{-1} + C_k^T V^{-1}C_k$ (d) $P_{ k  k } = P_{ k  k-1 }^{-1} + C_k^T V^{-1}C_k$ 10. What signal-to-noise-ratio (SNR) at a certain frequency $f_0$ of a mea	5.	What does the expression $Q_{N+1}^{-1}\phi(N+1)(y(N+1)-\phi(N+1))$		$(1)^{\top}\hat{\theta}(N))$ stand for in the context	xt of Recursive Least Squares?	
(c) ☐ The innovation update.       (d) ☐ The expression is not correct.         6. Which slope has the plot of the magnitude of the transfer function G(s) = 1/(s+2s+1) at high frequencies?         (a)40 dB/decade       (b) _ 0 dB/decade       (c)20 dB/decade       (d) _ 20 dB/decade         7. For scalar phase shift α, what is the output of the LTI system, described by the transfer function G(jω), that is excited with a sinusoidal input u(t) = U <sub>0</sub> · sin(ω · t)?         (a) _ y(t) =  G(jω) U <sub>0</sub> · sin(ω · t + α)       (b) _ y(t) = U <sub>0</sub> /(G(jω)) · sin(ω · t + α)         (c) _ y(t) =  G(jω) U <sub>0</sub> · sin(α · t + ω)       (d) _ y(t) =  G(jω) U <sub>0</sub> · sin(ω · t) + α         8. Consider the case in the previous question for an output signal with the magnitude Y <sub>0</sub> . Which equation describes the transfer function G(jω) for the specific frequency ω?       (d) _ Y <sub>0</sub> / <sub>0</sub> e <sup>jα</sup> (a) _ Y <sub>0</sub> / <sub>0</sub> e <sup>jα</sup> (b) _ U <sub>0</sub> / <sub>0</sub> e <sup>jω</sup> (c) _ U <sub>0</sub> / <sub>0</sub> e <sup>jω</sup> (d) _ Y <sub>0</sub> / <sub>0</sub> e <sup>jω</sup> 9. Which expression describes the Kalman filter innovation step of the covariance P?       (a) _ P <sub> k k </sub> = (P <sub> k k-1 </sub> + C <sub>k</sub> <sup>T</sup> V <sup>-1</sup> C <sub>k</sub> ) <sup>-1</sup> (c) _ P <sub> k k </sub> = (P <sub> k k-1 </sub> + C <sub>k</sub> <sup>T</sup> V <sup>-1</sup> C <sub>k</sub> ) <sup>-1</sup> (d) _ P <sub> k k-1 </sub> = (P <sub> k k-1 </sub> + C <sub>k</sub> <sup>T</sup> V <sup>-1</sup> C <sub>k</sub> ) <sup>-1</sup> (e) _ P <sub> k k </sub> = (P <sub> k k-1 </sub> + C <sub>k</sub> <sup>T</sup> V <sup>-1</sup> C <sub>k</sub> ) <sup>-1</sup> (d) _ P <sub> k k =1</sub> + C <sub>k</sub> <sup>T</sup> V <sup>-1</sup> C <sub>k</sub> ) <sup>-1</sup>		(a) The best prior guess.		(b) The downweighing of	past information.	
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(a)40 dB/decade       (b) _ 0 dB/decade       (c)20 dB/decade       (d) _ 20 dB/decade         7. For scalar phase shift α, what is the output of the LTI system, described by the transfer function G(jω), that is excited with a sinusoidal input u(t) = U_0 · sin(ω · t)?         (a) _ y(t) =  G(jω) U_0 · sin(ω · t + α)       (b) _ y(t) = U_0 / Sin(ω · t + α)         (c) _ y(t) =  G(jω) U_0 · sin(α · t + ω)       (d) _ y(t) =  G(jω) U_0 · sin(ω · t) + α         8. Consider the case in the previous question for an output signal with the magnitude Y <sub>0</sub> . Which equation describes the transfer function G(jω) for the specific frequency ω?       (d) _ U_0 e^{jα}       (d) _ U_0 e^{jα}         9. Which expression describes the Kalman filter innovation step of the covariance P?       (a) _ P_{[k k]} = (P_{[k k-1]} + C_k^T V^{-1}C_k)^{-1}       (b) _ P_{[k k-1]} = (P_{[k k-1]} + C_k^T V^{-1}C_k)^{-1}         (c) _ P_{[k k]} = (P_{[k k-1]} + C_k^T V^{-1}C_k)^{-1}       (d) _ P_{[k k]} = P_{[k k-1]}^{-1} + C_k^T V^{-1}C_k)^{-1}         (d) _ P_{[k k]} = (P_{[k k-1]} + C_k^T V^{-1}C_k)^{-1}       (d) _ P_{[k k]} = P_{[k k-1]}^{-1} + C_k^T V^{-1}C_k)^{-1}         (e) _ P_{[k k]} = (P_{[k k-1]} + C_k^T V^{-1}C_k)^{-1}       (d) _ P_{[k k]} = P_{[k k-1]}^{-1} + C_k^T V^{-1}C_k)^{-1}         (f) _ Q dB       (g) _ 1 dB       (g) _ 1 dB       (g) _ 2 0 dB	6.	Which slope has the plot of the	magnitude of the transfer function	on $G(s) = \frac{1}{s^2 + 2s + 1}$ at high frequ	encies?	
<ul> <li>7. For scalar phase shift α, what is the output of the LTI system, described by the transfer function G(jω), that is excited with a sinusoidal input u(t) = U<sub>0</sub> · sin(ω · t)?</li> <li>(a) y(t) =  G(jω) U<sub>0</sub> · sin(ω · t + α)</li> <li>(b) y(t) = U<sub>0</sub>/ G(jω)  · sin(ω · t + α)</li> <li>(c) y(t) =  G(jω) U<sub>0</sub> · sin(α · t + ω)</li> <li>(d) y(t) =  G(jω) U<sub>0</sub> · sin(ω · t) + α</li> <li>8. Consider the case in the previous question for an output signal with the magnitude Y<sub>0</sub>. Which equation describes the transfer function G(jω) for the specific frequency ω?</li> <li>(a) Y<sub>0</sub>/<sub>0</sub> e<sup>jα</sup></li> <li>(b) U<sub>0</sub>/Y<sub>0</sub>/Y<sub>0</sub> e<sup>jω</sup></li> <li>(c) U<sub>0</sub>/Y<sub>0</sub> e<sup>jα</sup></li> <li>(d) Y<sub>0</sub>/U<sub>0</sub> e<sup>jω</sup></li> <li>(e) U<sub>0</sub>/Y<sub>0</sub>/Y<sub>0</sub> e<sup>jω</sup></li> <li>(f) U<sub>0</sub>/Y<sub>0</sub>/Y<sub>0</sub> e<sup>jω</sup></li> <li>(g) U<sub>0</sub>/Y<sub>0</sub> e<sup>jω</sup></li> <li>(g) U<sub>0</sub>/Y<sub>0</sub>/Y<sub>0</sub> e<sup>jω</sup></li> <li>(h) U<sub>0</sub>/Y<sub>0</sub>/Y<sub>0</sub>/Y<sub>0</sub>/Y<sub>0</sub></li> <li>(h) U<sub>0</sub>/Y<sub>0</sub>/Y<sub>0</sub>/Y<sub>0</sub></li> <li>(h) U<sub>0</sub>/Y<sub>0</sub>/Y<sub>0</sub>/Y<sub>0</sub></li> <li>(h) U<sub>0</sub>/Y<sub>0</sub>/Y<sub>0</sub>/Y<sub>0</sub></li> <li>(h) U<sub>0</sub>/Y<sub>0</sub>/Y<sub>0</sub>/Y<sub>0</sub></li> <li>(h) U<sub>0</sub>/Y<sub>0</sub>/Y<sub>0</sub>/Y<sub>0</sub></li> <li>(h) U<sub>0</sub>/Y<sub>0</sub>/Y<sub>0</sub></li> <li>(h) U<sub></sub></li></ul>		(a) -40 dB/decade	(b) 0 dB/decade	(c) -20 dB/decade	(d) 20 dB/decade	
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(c) $y(t) =  G(j\omega) U_0 \cdot \sin(\alpha \cdot t + \omega)$ (d) $y(t) =  G(j\omega) U_0 \cdot \sin(\omega \cdot t) + \alpha$ 8. Consider the case in the previous question for an output signal with the magnitude $Y_0$ . Which equation describes the transfer function $G(j\omega)$ for the specific frequency $\omega$ ?         (a) $Y_0 e^{j\alpha}$ (b) $Y_0 e^{j\omega}$ (c) $Y_0 e^{j\alpha}$ (d) $Y_0 e^{j\omega}$ 9. Which expression describes the Kalman filter innovation step of the covariance P?       (a) $P_{[k k]} = (P_{[k k-1]}^{-1} + C_k^T V^{-1} C_k)^{-1}$ (b) $P_{[k k-1]} = (P_{[k k-1]}^{-1} + C_k^T V^{-1} C_k)^{-1}$ (c) $P_{[k k]} = (P_{[k k-1]} + C_k^T V^{-1} C_k)^{-1}$ (d) $P_{[k k]} = P_{[k k-1]}^{-1} + C_k^T V^{-1} C_k)^{-1}$ 10. What signal-to-noise-ratio (SNR) at a certain frequency $f_0$ of a measured signal do you want to achieve, in order to be able to estimate the amplitude of this frequency component with an accuracy of 10%?       (d) $20dB$		(a) $\qquad y(t) =  G(j\omega) U_0 \cdot \sin \theta$	$(\omega \cdot t + \alpha)$	(b) $\qquad y(t) = \frac{U_0}{ G(j\omega) } \cdot \sin(\omega)$	$\cdot t + \alpha)$	
<ul> <li>8. Consider the case in the previous question for an output signal with the magnitude Y<sub>0</sub>. Which equation describes the transfer function G(jω) for the specific frequency ω?</li> <li>(a) Y<sub>0</sub>/U<sub>0</sub>e<sup>jα</sup> (b) U<sub>0</sub>/U<sub>0</sub>e<sup>jω</sup> (c) U<sub>0</sub>/U<sub>0</sub>e<sup>jα</sup> (d) Y<sub>0</sub>/U<sub>0</sub>e<sup>jω</sup></li> <li>9. Which expression describes the Kalman filter innovation step of the covariance P?</li> <li>(a) P<sub>[k k]</sub> = (P<sup>-1</sup><sub>[k k-1]</sub> + C<sup>T</sup><sub>k</sub>V<sup>-1</sup>C<sub>k</sub>)<sup>-1</sup> (b) P<sub>[k k-1]</sub> = (P<sup>-1</sup><sub>[k-1 k-1]</sub> + C<sup>T</sup><sub>k</sub>V<sup>-1</sup>C<sub>k</sub>)<sup>-1</sup></li> <li>(c) P<sub>[k k]</sub> = (P<sub>[k k-1]</sub> + C<sup>T</sup><sub>k</sub>V<sup>-1</sup>C<sub>k</sub>)<sup>-1</sup> (d) P<sub>[k k]</sub> = P<sup>-1</sup><sub>[k k-1]</sub> + C<sup>T</sup><sub>k</sub>V<sup>-1</sup>C<sub>k</sub></li> <li>10. What signal-to-noise-ratio (SNR) at a certain frequency f<sub>0</sub> of a measured signal do you want to achieve, in order to be able to estimate the amplitude of this frequency component with an accuracy of 10%?</li> <li>(a) 40dB (b) 1dB (c) 10dB (d) 20dB</li> </ul>		(c) $\qquad y(t) =  G(j\omega) U_0 \cdot \sin(\alpha \cdot t + \omega)$		(d) $\qquad y(t) =  G(j\omega) U_0 \cdot \sin(\omega \cdot t) + \alpha$		
(a) $\begin{array}{c} Y_0 e^{j\alpha} \\ U_0 e^{j\alpha} \\ U_0$	8.	Consider the case in the previor function $G(j\omega)$ for the specific	us question for an output signal frequency $\omega$ ?	with the magnitude $Y_0$ . Which	equation describes the transfer	
<ul> <li>9. Which expression describes the Kalman filter innovation step of the covariance P? <ul> <li>(a) □ P<sub>[k k]</sub> = (P<sup>-1</sup><sub>[k k-1]</sub> + C<sup>T</sup><sub>k</sub>V<sup>-1</sup>C<sub>k</sub>)<sup>-1</sup></li> <li>(b) □ P<sub>[k k-1]</sub> = (P<sup>-1</sup><sub>[k-1 k-1]</sub> + C<sup>T</sup><sub>k</sub>V<sup>-1</sup>C<sub>k</sub>)<sup>-1</sup></li> <li>(c) □ P<sub>[k k]</sub> = (P<sub>[k k-1]</sub> + C<sup>T</sup><sub>k</sub>V<sup>-1</sup>C<sub>k</sub>)<sup>-1</sup></li> <li>(d) □ P<sub>[k k]</sub> = P<sup>-1</sup><sub>[k k-1]</sub> + C<sup>T</sup><sub>k</sub>V<sup>-1</sup>C<sub>k</sub></li> </ul> </li> <li>10. What signal-to-noise-ratio (SNR) at a certain frequency f<sub>0</sub> of a measured signal do you want to achieve, in order to be able to estimate the amplitude of this frequency component with an accuracy of 10%? <ul> <li>(a) □ 40dB</li> <li>(b) □ 1dB</li> <li>(c) □ 10dB</li> <li>(d) □ 20dB</li> </ul> </li> </ul>		(a) $\prod \frac{Y_0}{U_0} e^{j\alpha}$	(b) $\prod \frac{U_0}{Y_0} e^{j\omega}$	(c) $\prod \frac{U_0}{Y_0} e^{j\alpha}$	(d) $\prod \frac{Y_0}{U_0} e^{j\omega}$	
(a) $\Box P_{[k k]} = (P_{[k k-1]}^{-1} + C_k^{\top} V^{-1} C_k)^{-1}$ (b) $\Box P_{[k k-1]} = (P_{[k-1 k-1]}^{-1} + C_k^{\top} V^{-1} C_k)^{-1}$ (c) $\Box P_{[k k]} = (P_{[k k-1]} + C_k^{\top} V^{-1} C_k)^{-1}$ (d) $\Box P_{[k k]} = P_{[k k-1]}^{-1} + C_k^{\top} V^{-1} C_k$ 10. What signal-to-noise-ratio (SNR) at a certain frequency $f_0$ of a measured signal do you want to achieve, in order to be able to estimate the amplitude of this frequency component with an accuracy of 10%?(a) $\Box 40dB$ (b) $\Box 1dB$ (c) $\Box 10dB$ (d) $\Box 20dB$	9.	Which expression describes the	Kalman filter innovation step of	the covariance P?	<u> </u>	
(c) $\square P_{[k k]} = (P_{[k k-1]} + C_k^\top V^{-1} C_k)^{-1}$ (d) $\square P_{[k k]} = P_{[k k-1]}^{-1} + C_k^\top V^{-1} C_k$ 10. What signal-to-noise-ratio (SNR) at a certain frequency $f_0$ of a measured signal do you want to achieve, in order to be able to estimate the amplitude of this frequency component with an accuracy of 10%?(a) $\square 40dB$ (b) $\square 1dB$ (c) $\square 10dB$ (d) $\square 20dB$		(a) $P_{[k k]} = (P_{[k k-1]}^{-1} + C_k^{\top})$	$V^{-1}C_k)^{-1}$	(b) $P_{[k k-1]} = (P_{[k-1 k-1]}^{-1})$	$+ C_k^\top V^{-1} C_k)^{-1}$	
10. What signal-to-noise-ratio (SNR) at a certain frequency f <sub>0</sub> of a measured signal do you want to achieve, in order to be able to estimate the amplitude of this frequency component with an accuracy of 10%?         (a) 40dB       (b) 1dB       (c) 10dB       (d) 20dB		(c) $P_{[k k]} = (P_{[k k-1]} + C_k^{\top})$	$V^{-1}C_k)^{-1}$	(d) $P_{[k k]} = P_{[k k-1]}^{-1} + C_k^{\top}$	$V^{-1}C_k$	
(a) $40dB$ (b) $1dB$ (c) $10dB$ (d) $20dB$	10.	What signal-to-noise-ratio (SNF estimate the amplitude of this from the section of the section o	R) at a certain frequency $f_0$ of a equency component with an accurate	measured signal do you want to uracy of 10%?	o achieve, in order to be able to	
		(a) 40dB	(b) 1dB	(c) 10dB	(d) 20dB	

Points	on	page	(max.	10)
			(	

11. Which are the appropriate matrices of the state space model of a system described by the following ODE:  $\ddot{a} = c_1\dot{a} + c_2a + \dot{s}$  $\ddot{s} = c_3\dot{a} + c_4\dot{s} + s$  and the output  $y = c_5s + c_6\dot{a}$ , with  $c_1, \ldots, c_6 \in \mathbb{R}$ . Consider the states to be  $x = [a, \dot{a}, s, \dot{s}]^{\top}$ .

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$(a) \square A = \begin{bmatrix} c_2 & c_1 & 0 & 1\\ 0 & 1 & 0 & 0\\ 0 & 0 & 0 & 1\\ 0 & c_3 & 1 & c_4 \end{bmatrix}, C = \begin{bmatrix} 0 & c_6 & c_5 & 0 \end{bmatrix}$	(b) $\square A = \begin{bmatrix} 0 & 1 & 0 & 0 \\ c_2 & c_1 & 0 & 1 \\ 0 & 0 & 0 & 1 \\ 0 & c_3 & 1 & c_4 \end{bmatrix}, C = \begin{bmatrix} c_5 & 0 & 0 & c_6 \end{bmatrix}$
$(c) \square A = \begin{bmatrix} 0 & 1 & 0 & 0 \\ c_2 & c_1 & 0 & 1 \\ 0 & 0 & 0 & 1 \\ 0 & c_3 & 1 & c_4 \end{bmatrix}, C = \begin{bmatrix} 0 & c_6 & c_5 & 0 \end{bmatrix}$	$(\mathbf{d}) \square A = \begin{bmatrix} 0 & 0 & 0 & 1 \\ 0 & c_3 & 1 & c_4 \\ 0 & 1 & 0 & 0 \\ c_2 & c_1 & 0 & 1 \end{bmatrix}, C = \begin{bmatrix} c_5 & 0 & 0 & c_6 \end{bmatrix}$

- 12. You want to do multisine excitation to identify the transfer function of an unknown system. How should the multisine be designed, to prevent leakage errors?
- 13. What is the frequency resolution of the DFT of a given periodic signal with period T, sampling frequency  $f_s$ , and the number of samples per period N?

(a) $\Box \omega = \frac{2\pi}{N \cdot T}$ (b) $\Box \omega = 2\pi f_s$ (c) $\Box \omega = \frac{2\pi f_s}{T}$ (d) $\Box \omega = \frac{2\pi f_s}{N}$	
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14. Regard a periodic signal with base frequency  $f_{base}$  that is sampled every  $\Delta t = 1s$  (with  $1/\Delta t$  a multiple of  $f_{base}$ ). How many different frequencies are contained in the discretized signal?

(a) $2\Delta t f_{base}$ (b) $f_{base}/2\Delta t$ (c) $1/(2\Delta t f_{base})$ (d) $2\Delta t/f_{base}$	
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- 15. You want to do multisine excitation to identify the transfer function of an unknown system. How should the multisine be designed, to prevent aliasing errors?
- 16. What is the name of the theorem that defines the above mentioned condition?
- 17. Consider the discrete LTI system  $y_k = \theta_1 y_{k-1} + \theta_2 \epsilon_k + \theta_3 \epsilon_{k-1}$  with scalar output y and noise  $\epsilon$ . What of the following abbreviations best describes this system?

(a) ARMA	(b) FIR	(c) ARX	(d) NARX
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18. A continuous function in the time domain  $u_c(t)$  is sampled with a frequency  $f_s$ , resulting in a set of discrete values  $u = [u(0), \ldots, u(N-1)]^\top$ . Applying the DFT to u yields  $U = [8, 2, 0, 8, 0, 8, 0, 2]^\top$ . Reconstruct the function  $u_c(t)$  from U.  $IDFT: u(n) = \frac{1}{N} \sum_{k=0}^{N-1} U(k) e^{j\frac{2\pi kn}{N}}$ , for  $n = 0, \ldots, N-1$ 

(a) $u_{c}(t) = 1 + \frac{1}{2}\cos(\frac{\pi f_{s}t}{4}) + 2\cos(\frac{3\pi f_{s}t}{4})$	(b) $u_{c}(t) = 2 + \cos(\frac{\pi f_{s}t}{4}) + 2\cos(\pi f_{s}t)$
(c) $u_{c}(t) = 1 + \frac{1}{2}\cos(\frac{\pi f_{s}t}{8}) + 2\cos(\frac{\pi f_{s}t}{4})$	(d) $u_{c}(t) = 2 + \cos(\frac{\pi f_{s}t}{4}) + 2\cos(\frac{3\pi f_{s}t}{4})$

19. You identify an LTI system with periodic multisine excitations, where each window has length T and the total duration of your experiment is MT with a large integer M. Which procedure should you follow to identify the transfer function  $\hat{G}(j\omega_k)$  at a given frequency  $\omega_k = \frac{2\pi k}{T}$ ?

	(a) compute the DFTs of e	each window, then average the	(b) $\square$ build the quotients of the $M$ windows, average the	
	DFTs and then build the quotie	ent of the average	quotients and apply the DFT on the quotients	
	(c) compute the DFTs of	each window, build the DFT	(d) $\square$ average the $M$ windows, build the quotient of the	
	quotients and then average the quotients		average and apply DFT	
20.	At which frequency $f$ [Hz] is th	e resonance peak of the followin	g transfer function: $G(s) = \frac{1}{s^2 + 2}$	$\frac{a^2}{2as+a^2}$ , with $a \in \mathbb{R}$ ?
	(a) $f = \frac{-ja}{2\pi}$	(b) $\prod f = \frac{ja}{2\pi}$	(c) $\int f = \frac{j2\pi}{a}$	(d) $\Box f = \frac{a}{2\pi}$

Points on page (max. 10)

## Modeling and System Identification – Microexam 3

Prof. Dr. Moritz Diehl, IMTEK, University Freiburg, February 6, 2017, 8:15-9:45

Surname:	First Name:	Matriculation number:	
Subject:	Programme:	Bachelor Master Lehramt others	Signature:

Please fill in your name above and tick exactly ONE box for the right answer of each question below.

1. For scalar phase shift  $\alpha$ , what is the output of the LTI system, described by the transfer function  $G(j\omega)$ , that is excited with a sinusoidal input  $u(t) = U_0 \cdot \sin(\omega \cdot t)$ ?

(a) $\Box y(t) =  G(j\omega) U_0 \cdot \sin(\alpha \cdot t + \omega)$	(b) $\qquad y(t) =  G(j\omega) U_0 \cdot \sin(\omega \cdot t + \alpha)$
(c) $\qquad y(t) = \frac{U_0}{ G(j\omega) } \cdot \sin(\omega \cdot t + \alpha)$	(d) $\qquad y(t) =  G(j\omega) U_0 \cdot \sin(\omega \cdot t) + \alpha$

2. Consider the case in the previous question for an output signal with the magnitude  $Y_0$ . Which equation describes the transfer function  $G(j\omega)$  for the specific frequency  $\omega$ ?

(a) $\Box \frac{U_0}{Y_0} e^{j\alpha}$ (b) $\Box \frac{U_0}{Y_0} e^{j\omega}$	(c) $\prod \frac{Y_0}{U_0} e^{j\alpha}$	(d) $\prod \frac{Y_0}{U_0} e^{j\omega}$
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- 3. You want to do multisine excitation to identify the transfer function of an unknown system. How should the multisine be designed, to prevent leakage errors?
- 4. At which frequency f [Hz] is the resonance peak of the following transfer function:  $G(s) = \frac{a^2}{s^2 + 2as + a^2}$ , with  $a \in \mathbb{R}$ ? ...

(a) $\prod f = \frac{j2\pi}{a}$	(b) $\prod f = \frac{-ja}{2\pi}$	(c) $\prod f = \frac{a}{2\pi}$	(d) $\prod f = \frac{ja}{2\pi}$

- 5. You want to do multisine excitation to identify the transfer function of an unknown system. How should the multisine be designed, to prevent aliasing errors?
- 6. What is the name of the theorem that defines the above mentioned condition?
- 7. Consider the discrete LTI system  $y_k = \theta_1 y_{k-1} + \theta_2 \epsilon_k + \theta_3 \epsilon_{k-1}$  with scalar output y and noise  $\epsilon$ . What of the following abbreviations best describes this system?

	(a) ARX	(b) NARX	(c) FIR	(d) ARMA
8.	Regard a periodic signal with ba different frequencies are contain	ase frequency $f_{base}$ that is sampled in the discretized signal?	led every $\Delta t = 1s$ (with $1/\Delta t$ :	a multiple of $f_{base}$ ). How many
	(a) $1/(2\Delta t f_{base})$	(b) $\Box 2\Delta t f_{base}$	(c) $\Box 2\Delta t/f_{base}$	(d) $\int f_{base}/2\Delta t$
9.	Which slope has the plot of the	magnitude of the transfer function	on $G(s) = \frac{1}{s^2 + 2s + 1}$ at high frequ	encies?
	(a) -40 dB/decade	(b) 0 dB/decade	(c)20 dB/decade	(d) 20 dB/decade
10.	0. What signal-to-noise-ratio (SNR) at a certain frequency $f_0$ of a measured signal do you want to achieve, in order to be able to estimate the amplitude of this frequency component with an accuracy of 10%?			
	(a) 1dB	(b) 40dB	(c) 20dB	(d) 10dB

11. For which type of system can a global minimum to the estimation problem be guaranteed?

(a) Output-Error	(b) Input-Output-Error	(c) Equation-Error	(d) LIP, additive noise
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12. You identify an LTI system with periodic multisine excitations, where each window has length T and the total duration of your experiment is MT with a large integer M. Which procedure should you follow to identify the transfer function  $\hat{G}(j\omega_k)$  at a given frequency  $\omega_k = \frac{2\pi k}{T}$ ?

(a) $\square$ average the $M$ windows, build the quotient of the	(b) $\square$ build the quotients of the $M$ windows, average the	
average and apply DFT	quotients and apply the DFT on the quotients	
(c) compute the DFTs of each window, build the DFT	(d) compute the DFTs of each window, then average the	
quotients and then average the quotients	DFTs and then build the quotient of the average	
A continuous function in the time domain $u_c(t)$ is sampled with $u = [u(0), \ldots, u(N-1)]^{\top}$ . Applying the DFT to $u$ yields $U = IDFT$ : $u(n) = \frac{1}{N} \sum_{k=0}^{N-1} U(k) e^{j\frac{2\pi kn}{N}}$ , for $n = 0, \ldots, N-1$	a frequency $f_s$ , resulting in a set of discrete values = $[8, 2, 0, 8, 0, 8, 0, 2]^{\top}$ . Reconstruct the function $u_c(t)$ from U.	
(a) $u_{c}(t) = 2 + \cos(\frac{\pi f_{s}t}{4}) + 2\cos(\frac{3\pi f_{s}t}{4})$	(b) $\qquad u_{c}(t) = 1 + \frac{1}{2}\cos(\frac{\pi f_{s}t}{8}) + 2\cos(\frac{\pi f_{s}t}{4})$	
(c) $u_c(t) = 2 + \cos(\frac{\pi f_s t}{4}) + 2\cos(\pi f_s t)$	(d) $\qquad u_{c}(t) = 1 + \frac{1}{2}\cos(\frac{\pi f_{s}t}{4}) + 2\cos(\frac{3\pi f_{s}t}{4})$	

14. Consider a linear system defined as  $x_i = A_{i-1}x_{i-1} + w_i$  with a linear measurement equation  $y_i = C_i x_i + v_i$ . If  $x_i \in \mathbb{R}^n$  and  $y_i \in \mathbb{R}^m$ , what is NOT true about the covariance of the process noise  $W_i$  and measurement noise  $V_i$  of a Kalman Filter?

	(a) $\square W_i \in \mathbb{R}^{n \times n}$ , and $V_i \in \mathbb{R}^{m \times m}$ .		(b) $W_i$ and $V_i$ are diagonal matrices.	
	(c) $W_i$ and $V_i$ are positive definite.		(d) $\square W_i$ has <i>n</i> non-zero singular values.	
15.	Given the transfer function $G(jaconstructure)$	$\omega$ ), what quantity does the magn	itude plot of the Bode diagram sl	how on its y-axis?
	(a) $\square \ G(j\omega)\ $	(b) $\log  G(j\omega) $	(c) $\Box \log G(j\omega)^2$	(d) $\Box  G(j\omega) $
16.	What is the frequency resolution samples per period $N$ ?	n of the DFT of a given periodic	signal with period $T$ , sampling t	frequency $f_s$ , and the number of
	(a) $\Box \omega = \frac{2\pi f_s}{T}$	(b) $\Box \omega = \frac{2\pi f_s}{N}$	(c) $\Box \omega = 2\pi f_s$	(d) $\Box \omega = \frac{2\pi}{N \cdot T}$

17. Which statement concerning the set-up of the Kalman Filter is NOT typically true:

13.

	(a) The model is assumed to be linear.	(b) The more trustworthy the model, the smaller $P$ .
	(c) The larger $P$ , the smaller the innovation step.	(d) Process noise effects increase progressively.
18.	What does the expression $Q_{N+1}^{-1}\phi(N+1)(y(N+1)-\phi(N+1))$	$(1)^{\top}\hat{\theta}(N)$ stand for in the context of Recursive Least Squares?

(a) The expression is not correct.	(b) The downweighing of past information.	
(c) The best prior guess.	(d) The innovation update.	

19. Which expression describes the Kalman filter innovation step of the covariance P?

(a) $P_{[k k]} = (P_{[k k-1]} + C_k^\top V^{-1} C_k)^{-1}$	(b) $\square P_{[k k]} = P_{[k k-1]}^{-1} + C_k^{\top} V^{-1} C_k$
(c) $P_{[k k-1]} = (P_{[k-1 k-1]}^{-1} + C_k^{\top} V^{-1} C_k)^{-1}$	(d) $\square P_{[k k]} = (P_{[k k-1]}^{-1} + C_k^\top V^{-1} C_k)^{-1}$

20. Which are the appropriate matrices of the state space model of a system described by the following ODE:  $\ddot{a} = c_1\dot{a} + c_2a + \dot{s}$  $\ddot{s} = c_3\dot{a} + c_4\dot{s} + s$  and the output  $y = c_5s + c_6\dot{a}$ , with  $c_1, \ldots, c_6 \in \mathbb{R}$ . Consider the states to be  $x = [a, \dot{a}, s, \dot{s}]^{\top}$ .

$(\mathbf{a}) \square A = \begin{bmatrix} c_2 & c_1 & 0 & 1\\ 0 & 1 & 0 & 0\\ 0 & 0 & 0 & 1\\ 0 & c_3 & 1 & c_4 \end{bmatrix}, C = \begin{bmatrix} 0 & c_6 & c_5 & 0 \end{bmatrix}$	(b) $\square A = \begin{bmatrix} 0 & 0 & 0 & 1 \\ 0 & c_3 & 1 & c_4 \\ 0 & 1 & 0 & 0 \\ c_2 & c_1 & 0 & 1 \end{bmatrix}, C = \begin{bmatrix} c_5 & 0 & 0 & c_6 \end{bmatrix}$
$(c) \square A = \begin{bmatrix} 0 & 1 & 0 & 0 \\ c_2 & c_1 & 0 & 1 \\ 0 & 0 & 0 & 1 \\ 0 & c_3 & 1 & c_4 \end{bmatrix}, C = \begin{bmatrix} c_5 & 0 & 0 & c_6 \end{bmatrix}$	$(\mathbf{d}) \square A = \begin{bmatrix} 0 & 1 & 0 & 0 \\ c_2 & c_1 & 0 & 1 \\ 0 & 0 & 0 & 1 \\ 0 & c_3 & 1 & c_4 \end{bmatrix}, C = \begin{bmatrix} 0 & c_6 & c_5 & 0 \end{bmatrix}$

Points on page (max. 9)

Points on page (max. 0)

	Modeling and System Identification – Microexam 3 Prof. Dr. Moritz Diehl, IMTEK, University Freiburg, February 6, 2017, 8:15-9:45				
Su	rname:	First Name:	Matriculation number	er:	
Su	bject:	Programme: Bachelor Mas	ster Lehramt others	Signature:	
	Please fill in your name above a	and tick exactly ONE box for the	right answer of each question b	elow.	
1.	Which expression describes the	Kalman filter innovation step of	the covariance P?		
	(a) $P_{[k k]} = (P_{[k k-1]} + C_k^\top)$	$V^{-1}C_k)^{-1}$	(b) $P_{[k k]} = (P_{[k k-1]}^{-1} + C_k)$	$\sum_{k}^{\top} V^{-1} C_k)^{-1}$	
	(c) $P_{[k k-1]} = (P_{[k-1 k-1]}^{-1} \cdot P_{[k-1 k-1]})$	$+ C_k^\top V^{-1} C_k)^{-1}$	(d) $P_{[k k]} = P_{[k k-1]}^{-1} + C_k^{\top}$	$V^{-1}C_k$	
2.	What signal-to-noise-ratio (SNI estimate the amplitude of this from the structure of the st	R) at a certain frequency $f_0$ of a equency component with an accurate to a set of the	measured signal do you want t aracy of 10%?	o achieve, in order to be able to	
	(a) 20dB	(b) 1dB	(c) 40dB	(d) 10dB	
3.	Which are the appropriate matrix $\ddot{s} = c_3 \dot{a} + c_4 \dot{s} + s$ and the output	ces of the state space model of a ut $y = c_5 s + c_6 \dot{a}$ , with $c_1, \ldots, c_6$	a system described by the follo $f_5 \in \mathbb{R}$ . Consider the states to be	wing ODE: $\ddot{a} = c_1 \dot{a} + c_2 a + \dot{s}$ $x = [a, \dot{a}, s, \dot{s}]^\top$ .	
	$(a) \square A = \begin{bmatrix} 0 & 1 & 0 & 0 \\ c_2 & c_1 & 0 & 1 \\ 0 & 0 & 0 & 1 \\ 0 & c_3 & 1 & c_4 \end{bmatrix}$	$,C = \begin{bmatrix} 0 & c_6 & c_5 & 0 \end{bmatrix}$	(b) $\square A = \begin{bmatrix} c_2 & c_1 & 0 & 1 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & c_3 & 1 & c_4 \end{bmatrix}$	$,C = \begin{bmatrix} 0 & c_6 & c_5 & 0 \end{bmatrix}$	
	$ (c) \square A = \begin{bmatrix} 0 & 1 & 0 & 0 \\ c_2 & c_1 & 0 & 1 \\ 0 & 0 & 0 & 1 \\ 0 & c_3 & 1 & c_4 \end{bmatrix} $	$,C = \begin{bmatrix} c_5 & 0 & 0 & c_6 \end{bmatrix}$	(d) $\square A = \begin{bmatrix} 0 & 0 & 0 & 1 \\ 0 & c_3 & 1 & c_4 \\ 0 & 1 & 0 & 0 \\ c_2 & c_1 & 0 & 1 \end{bmatrix}$	$,C=egin{bmatrix} c_5 & 0 & 0 & c_6\end{bmatrix}$	
4.	For which type of system can a	global minimum to the estimatio	n problem be guaranteed?		
	(a) LIP, additive noise	(b) Output-Error	(c) Equation-Error	(d) Input-Output-Error	
5.	Which statement concerning the	e set-up of the Kalman Filter is N	OT typically true:		
	(a) Process noise effects increase progressively.		(b) $\Box$ The more trustworthy the model, the smaller $P$ .		
	(c) The larger $P$ , the small	ler the innovation step.	(d) The model is assumed	l to be linear.	
6. What does the expression $Q_{N+1}^{-1}\phi(N+1)(y(N+1)-\phi(N+1))$		$(1)^{\top}\hat{\theta}(N))$ stand for in the context of Recursive Least Squares?			
(a) The best prior guess.		(b) The downweighing of past information.			
	(c) The expression is not c	correct.	(d) The innovation update	2.	
7.	Consider the discrete LTI syste abbreviations best describes this	$\sup_{k \in \mathbb{N}} y_k = \theta_1 y_{k-1} + \theta_2 \epsilon_k + \theta_3 \epsilon_k$ system?	$\varepsilon_{k-1}$ with scalar output $y$ and $z$	noise $\epsilon$ . What of the following	
	(a) NARX	(b) ARX	(c) FIR	(d) ARMA	
8.	Regard a periodic signal with be different frequencies are contain	ase frequency $f_{base}$ that is sampled in the discretized signal?	led every $\Delta t = 1s$ (with $1/\Delta t$	a multiple of $f_{base}$ ). How many	
	(a) $2\Delta t/f_{base}$	(b) $\Box 2\Delta t f_{base}$	(c) $\Box 1/(2\Delta t f_{base})$	(d) $\int f_{base}/2\Delta t$	
9.	What is the frequency resolution samples per period $N$ ?	n of the DFT of a given periodic	signal with period T, sampling	frequency $f_s$ , and the number of	
	(a) $\Box \omega = 2\pi f_s$	(b) $\omega = \frac{2\pi f_s}{N}$	(c) $\omega = \frac{2\pi f_s}{T}$	(d) $\Box \omega = \frac{2\pi}{N.T}$	

10. You identify an LTI system with periodic multisine excitations, where each window has length T and the total duration of your experiment is MT with a large integer M. Which procedure should you follow to identify the transfer function  $\hat{G}(j\omega_k)$  at a given frequency  $\omega_k = \frac{2\pi k}{T}$ ?

(a) $\square$ build the quotients of the $M$ windows, average the	(b) compute the DFTs of each window, build the DFT	
quotients and apply the DFT on the quotients	quotients and then average the quotients	
(c) $\square$ average the $M$ windows, build the quotient of the	(d) compute the DFTs of each window, then average the	
average and apply DFT	DFTs and then build the quotient of the average	

- 11. You want to do multisine excitation to identify the transfer function of an unknown system. How should the multisine be designed, to prevent leakage errors?
- 12. For scalar phase shift  $\alpha$ , what is the output of the LTI system, described by the transfer function  $G(j\omega)$ , that is excited with a sinusoidal input  $u(t) = U_0 \cdot \sin(\omega \cdot t)$ ?

(a) $\qquad y(t) =  G(j\omega) U_0 \cdot \sin(\alpha \cdot t + \omega)$	(b) $\qquad y(t) =  G(j\omega) U_0 \cdot \sin(\omega \cdot t + \alpha)$
(c) $\[ y(t) =  G(j\omega) U_0 \cdot \sin(\omega \cdot t) + \alpha \]$	(d) $\qquad y(t) = \frac{U_0}{ G(j\omega) } \cdot \sin(\omega \cdot t + \alpha)$

13. Consider the case in the previous question for an output signal with the magnitude  $Y_0$ . Which equation describes the transfer function  $G(j\omega)$  for the specific frequency  $\omega$ ?

(a) $\prod \frac{Y_0}{U_0} e^{j\omega}$	(b) $\prod \frac{U_0}{Y_0} e^{j\alpha}$	(c) $\prod \frac{U_0}{Y_0} e^{j\omega}$	(d) $\prod \frac{Y_0}{U_0} e^{j\alpha}$
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14. A continuous function in the time domain  $u_c(t)$  is sampled with a frequency  $f_s$ , resulting in a set of discrete values  $u = [u(0), \dots, u(N-1)]^{\top}$ . Applying the DFT to u yields  $U = [8, 2, 0, 8, 0, 8, 0, 2]^{\top}$ . Reconstruct the function  $u_c(t)$  from U. IDFT:  $u(n) = \frac{1}{N} \sum_{k=0}^{N-1} U(k) e^{j\frac{2\pi kn}{N}}$ , for  $n = 0, \dots, N-1$ 

(a) $u_{c}(t) = 2 + \cos(\frac{\pi f_{s}t}{4}) + 2\cos(\pi f_{s}t)$	(b) $\qquad u_{c}(t) = 1 + \frac{1}{2}\cos(\frac{\pi f_{s}t}{4}) + 2\cos(\frac{3\pi f_{s}t}{4})$
(c) $u_{c}(t) = 1 + \frac{1}{2}\cos(\frac{\pi f_{s}t}{8}) + 2\cos(\frac{\pi f_{s}t}{4})$	(d) $u_{c}(t) = 2 + \cos(\frac{\pi f_{s}t}{4}) + 2\cos(\frac{3\pi f_{s}t}{4})$
	-

15. At which frequency f [Hz] is the resonance peak of the following transfer function:  $G(s) = \frac{a^2}{s^2 + 2as + a^2}$ , with  $a \in \mathbb{R}$ ?...

(a) $f = \frac{ja}{2\pi}$ (b) $f = \frac{-ja}{2\pi}$ (c) $f = \frac{a}{2\pi}$ (d) $f = \frac{j2\pi}{a}$
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- 16. You want to do multisine excitation to identify the transfer function of an unknown system. How should the multisine be designed, to prevent aliasing errors?
- 17. What is the name of the theorem that defines the above mentioned condition?
- 18. Consider a linear system defined as  $x_i = A_{i-1}x_{i-1} + w_i$  with a linear measurement equation  $y_i = C_i x_i + v_i$ . If  $x_i \in \mathbb{R}^n$  and  $y_i \in \mathbb{R}^m$ , what is NOT true about the covariance of the process noise  $W_i$  and measurement noise  $V_i$  of a Kalman Filter?

(a) $\square W_i \in \mathbb{R}^{n \times n}$ , and $V_i \in \mathbb{R}^{m \times m}$ .	(b) $\square W_i$ and $V_i$ are positive definite.		
(c) $\square W_i$ has <i>n</i> non-zero singular values.	(d) $\square W_i$ and $V_i$ are diagonal matrices.		

19. Given the transfer function  $G(j\omega)$ , what quantity does the magnitude plot of the Bode diagram show on its y-axis?

(a) $ \ G(j\omega)\  $	(b) $\Box \log G(j\omega)^2$	(c) $\log  G(j\omega) $	(d) $\Box  G(j\omega) $
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## 20. Which slope has the plot of the magnitude of the transfer function $G(s) = \frac{1}{s^2 + 2s + 1}$ at high frequencies?

(a) -40 dB/decade	(b) 20 dB/decade	(c) $\Box$ 0 dB/decade	(d) -20 dB/decade
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Points on page (max. 11)

## Modeling and System Identification – Microexam 3

Prof. Dr. Moritz Diehl, IMTEK, University Freiburg, February 6, 2017, 8:15-9:45

Surname:	First Name:	Matriculation number:
Subject:	Programme:	Bachelor Master Lehramt others Signature:

Please fill in your name above and tick exactly ONE box for the right answer of each question below.

1. A continuous function in the time domain  $u_c(t)$  is sampled with a frequency  $f_s$ , resulting in a set of discrete values  $u = [u(0), \dots, u(N-1)]^{\top}$ . Applying the DFT to u yields  $U = [8, 2, 0, 8, 0, 8, 0, 2]^{\top}$ . Reconstruct the function  $u_c(t)$  from U. IDFT:  $u(n) = \frac{1}{2T} \sum_{k=1}^{N-1} U(k) e^{j\frac{2\pi kn}{N}}$ , for  $n = 0, \dots, N-1$ 

(a) $u_{c}(t) = 2 + \cos(\frac{\pi f_{s}t}{4}) + 2\cos(\frac{3\pi f_{s}t}{4})$	(b) $\qquad u_{c}(t) = 1 + \frac{1}{2}\cos(\frac{\pi f_{s}t}{4}) + 2\cos(\frac{3\pi f_{s}t}{4})$
(c) $u_{c}(t) = 2 + \cos(\frac{\pi f_{s}t}{4}) + 2\cos(\pi f_{s}t)$	(d) $u_{c}(t) = 1 + \frac{1}{2}\cos(\frac{\pi f_{s}t}{8}) + 2\cos(\frac{\pi f_{s}t}{4})$

2. You want to do multisine excitation to identify the transfer function of an unknown system. How should the multisine be designed, to prevent aliasing errors?

- 3. What is the name of the theorem that defines the above mentioned condition?
- 4. For scalar phase shift  $\alpha$ , what is the output of the LTI system, described by the transfer function  $G(j\omega)$ , that is excited with a sinusoidal input  $u(t) = U_0 \cdot \sin(\omega \cdot t)$ ?

(a) $y(t) =  G(j\omega) U_0 \cdot \sin(\omega \cdot t + \alpha)$	(b) $\qquad y(t) =  G(j\omega) U_0 \cdot \sin(\omega \cdot t) + \alpha$
(c) $\qquad y(t) =  G(j\omega) U_0 \cdot \sin(\alpha \cdot t + \omega)$	(d) $\qquad y(t) = \frac{U_0}{ G(j\omega) } \cdot \sin(\omega \cdot t + \alpha)$

5. Consider the case in the previous question for an output signal with the magnitude  $Y_0$ . Which equation describes the transfer function  $G(j\omega)$  for the specific frequency  $\omega$ ?

(a) $\prod \frac{Y_0}{U_0} e^{j\omega}$	(b) $\prod \frac{U_0}{Y_0} e^{j\alpha}$	(c) $\prod \frac{U_0}{Y_0} e^{j\omega}$	(d) $\prod \frac{Y_0}{U_0} e^{j\alpha}$
Which expression describes the Valuer filter interaction star of the expression of D2			

6. Which expression describes the Kalman filter innovation step of the covariance P?  
(a) 
$$P_{[k|k]} = (P_{[k|k]}^{-1} + C_k^{\top} V^{-1} C_k)^{-1}$$
(b)  $P_{[k|k]} = P_{[k|k]}^{-1} + C_k^{\top} V^{-1} C_k$ 

(c) 
$$P_{[k|k]} = (P_{[k|k-1]} + C_k^{\top} V^{-1} C_k)^{-1}$$
 (d)  $P_{[k|k-1]} = (P_{[k-1|k-1]}^{-1} + C_k^{\top} V^{-1} C_k)^{-1}$ 

7. What signal-to-noise-ratio (SNR) at a certain frequency  $f_0$  of a measured signal do you want to achieve, in order to be able to estimate the amplitude of this frequency component with an accuracy of 10%?

(a) 20dB	(b) 40dB	(c) 10dB	(d) 1dB
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8. Which are the appropriate matrices of the state space model of a system described by the following ODE:  $\ddot{a} = c_1\dot{a} + c_2a + \dot{s}$  $\ddot{s} = c_3\dot{a} + c_4\dot{s} + s$  and the output  $y = c_5s + c_6\dot{a}$ , with  $c_1, \ldots, c_6 \in \mathbb{R}$ . Consider the states to be  $x = [a, \dot{a}, s, \dot{s}]^\top$ .

$(\mathbf{a}) \square A = \begin{bmatrix} c_2 & c_1 & 0 & 1\\ 0 & 1 & 0 & 0\\ 0 & 0 & 0 & 1\\ 0 & c_3 & 1 & c_4 \end{bmatrix}, C = \begin{bmatrix} 0 & c_6 & c_5 & 0 \end{bmatrix}$	(b) $\square A = \begin{bmatrix} 0 & 1 & 0 & 0 \\ c_2 & c_1 & 0 & 1 \\ 0 & 0 & 0 & 1 \\ 0 & c_3 & 1 & c_4 \end{bmatrix}, C = \begin{bmatrix} c_5 & 0 & 0 & c_6 \end{bmatrix}$
$(c) \square A = \begin{bmatrix} 0 & 0 & 0 & 1 \\ 0 & c_3 & 1 & c_4 \\ 0 & 1 & 0 & 0 \\ c_2 & c_1 & 0 & 1 \end{bmatrix}, C = \begin{bmatrix} c_5 & 0 & 0 & c_6 \end{bmatrix}$	$(\mathbf{d}) \square A = \begin{bmatrix} 0 & 1 & 0 & 0 \\ c_2 & c_1 & 0 & 1 \\ 0 & 0 & 0 & 1 \\ 0 & c_3 & 1 & c_4 \end{bmatrix}, C = \begin{bmatrix} 0 & c_6 & c_5 & 0 \end{bmatrix}$

9. You want to do multisine excitation to identify the transfer function of an unknown system. How should the multisine be designed, to prevent leakage errors?

10. What is the frequency resolution of the DFT of a given periodic signal with period T, sampling frequency  $f_s$ , and the number of samples per period N?

	(a) $\Box \omega = \frac{2\pi f_s}{T}$	(b) $\Box \omega = 2\pi f_s$	(c) $\Box \omega = \frac{2\pi}{N \cdot T}$	(d) $\Box \omega = \frac{2\pi f_s}{N}$	
11.	. Consider the discrete LTI system $y_k = \theta_1 y_{k-1} + \theta_2 \epsilon_k + \theta_3 \epsilon_{k-1}$ with scalar output y and noise $\epsilon$ . What of the following abbreviations best describes this system?				
	(a) ARMA	(b) ARX	(c) NARX	(d) FIR	
12.	2. Consider a linear system defined as $x_i = A_{i-1}x_{i-1} + w_i$ with a linear measurement equation $y_i = C_i x_i + v_i$ . If $x_i \in \mathbb{R}^n$ and $y_i \in \mathbb{R}^m$ , what is NOT true about the covariance of the process noise $W_i$ and measurement noise $V_i$ of a Kalman Filter?				
	(a) $\square W_i$ has $n$ non-zero sing	gular values.	(b) $\square W_i$ and $V_i$ are positive definite.		
	(c) $W_i \in \mathbb{R}^{n \times n}$ , and $V_i \in$	$\mathbb{R}^{m \times m}$ .	(d) $W_i$ and $V_i$ are diagonal matrices.		
13.	Given the transfer function $G(jaconstructure)$	$\omega$ ), what quantity does the magn	itude plot of the Bode diagram sl	now on its y-axis?	
	(a) $\log  G(j\omega) $	(b) $\square \ G(j\omega)\ $	(c) $\Box \log G(j\omega)^2$	(d) $\Box  G(j\omega) $	
14.	Regard a periodic signal with ba different frequencies are contain	ase frequency $f_{base}$ that is sampled in the discretized signal?	led every $\Delta t = 1s$ (with $1/\Delta t$ :	a multiple of $f_{base}$ ). How many	
	(a) $\int f_{base}/2\Delta t$	(b) $\Box 1/(2\Delta t f_{base})$	(c) $\Box 2\Delta t/f_{base}$	(d) $\Box 2\Delta t f_{base}$	
15.	For which type of system can a g	global minimum to the estimatio	n problem be guaranteed?	·	
	(a) Input-Output-Error	(b) Output-Error	(c) Equation-Error	(d) LIP, additive noise	
16.	6. Which statement concerning the set-up of the Kalman Filter is NOT typically true:			·	
	(a) Process noise effects increase progressively.		(b) The more trustworthy	the model, the smaller P.	
	(c) The model is assumed	The model is assumed to be linear.		(d) The larger $P$ , the smaller the innovation step.	
17.	What does the expression $Q_{N+1}^{-1}\phi(N+1)(y(N+1)-\phi(N+1))$		$(1)^{\top}\hat{\theta}(N)$ stand for in the context of Recursive Least Squares?		
	(a) The best prior guess.		(b) The expression is not correct.		
	(c) The innovation update.		(d) The downweighing of	past information.	
18.	At which frequency $f$ [Hz] is the	e resonance peak of the followin	g transfer function: $G(s) = \frac{1}{s^2 + 1}$	$\frac{a^2}{2as+a^2}$ , with $a \in \mathbb{R}$ ?	
	(a) $\prod f = \frac{j2\pi}{a}$	(b) $\prod f = \frac{a}{2\pi}$	(c) $\prod f = \frac{ja}{2\pi}$	(d) $\prod f = \frac{-ja}{2\pi}$	
19.	9. You identify an LTI system with periodic multisine excitations, where each window has length T and the total duration of your experiment is $MT$ with a large integer M. Which procedure should you follow to identify the transfer function $\hat{G}(j\omega_k)$ at a given frequency $\omega_k = \frac{2\pi k}{T}$ ?				
	(a) $\square$ average the $M$ windows, build the quotient of the		(b) compute the DFTs of each window, build the DFT		
	average and apply DFT		quotients and then average the quotients		
	(c) compute the DFTs of e	each window, then average the	(d) $\square$ build the quotients of the $M$ windows, average the		
	DFTs and then build the quotient of the average		quotients and apply the DFT on the quotients		

20. Which slope has the plot of the magnitude of the transfer function  $G(s) = \frac{1}{s^2+2s+1}$  at high frequencies?

(a) -20 dB/decade (b) -40 dB/decade	(c) $\Box$ 0 dB/decade	(d) 20 dB/decade
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Points on page (max. 0)