Period of Examinations
Summer Semester 2020 – 15th July
Exam

Module:Modelling and Simulation, Prof. Brandt

Examination

Points: 60

Duration of examination: 120 Minutes (+ 120 Minutes for technical issues)

Please write legibly!

Date: ____________________

Name: ____________________

Register No.: ____________________

Course of Study: ____________________

Please consider the exam rules, which are summarized in the exam section in Moodle. There you find a summary containing your different options to upload your solutions or to withdraw from the exam.

Before you turn in your solution please sign the declaration in lieu of oath:

I, ____________________________________ [full name, matriculation number], hereby confirm in lieu of an oath that I am the person who was admitted to this examination. Further, I confirm that the submitted work is my own and was prepared without the use of any unauthorised aid or materials.

____

Signature

You can print the declaration and then sign and scan it. Alternatively, you can also sign it digitally or transcribe it by hand and then sign and scan it.

Please make sure that all documents that you upload contain your name and matriculation number.

Good luck!

Problem	Possible Points	Result
1	8+8+2=18	
2	4	
3	2	
4	3	
5	2+6	
6	2	
7	3	
Sum	**40**	

Register No.:____________________

1.) In the following prey-predator system the amount of prey is modelled by x_1 and the amount of predator by x_2. The coefficients $\alpha, \beta, \gamma, \delta$ are known constants with positive values (>0). In the model it is assumed that only the two modelled species interact and that there is an infinite food resource for the prey. However, the only food resource for the predators is assumed to be the prey.

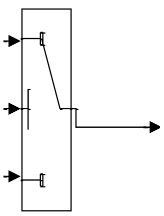
$$\dot{x}_1 = \alpha x_1 - \beta x_1 x_2$$

$$\dot{x}_2 = -\gamma x_2 + \delta x_1 x_2$$

a.) Draw the block-diagram for simulation with Simulink and indicate where the initial conditions have to be set. **(8 points)**

b.) Linearize the prey-predator system above about $\mathbf{x} = \begin{bmatrix} \frac{\gamma}{\delta} \\ \frac{\alpha}{\beta} \end{bmatrix}$. **(8 points)** c.) Decide whether the operating point $\mathbf{x} = \begin{bmatrix} \frac{\gamma}{\delta} \\ \frac{\alpha}{\beta} \end{bmatrix}$ is an equilibrium of the system or not. Justify your decision. **(2 points)**

2.) A model that contains a discontinuity handles it by a switch. The switch has three inputs and one output. Explain how it works. **(4 points)**



Switch

Register No.:____________________

3.) A vibration problem is described by the following equation:

$$\ddot{x} + d \cdot sign(\ddot{x}) \cdot \dot{x}^2 + {\omega_0}^2 \cdot x = \sin(\omega \cdot t)$$

The parameters ω, ${\omega_0}^2$ and d are known. Is the problem linear or non-linear? How many integrators are necessary in Simulink in order to model the vibration problem? **(2 points)** Non-linear

3 integerators are needed

4.) Transform the following ODE into a system of first order differential equations (ODEs). **(3 points)**

$$\ddot{x} + d \cdot \tan(x) \cdot \dot{x}^2 + {\omega_0}^2 \cdot x = \sin(\omega \cdot t)$$

$X_1 = x$

$X_2 = \dot{X} = \dot{X}_1$

$\dot{X}_1 = \dot{X}$

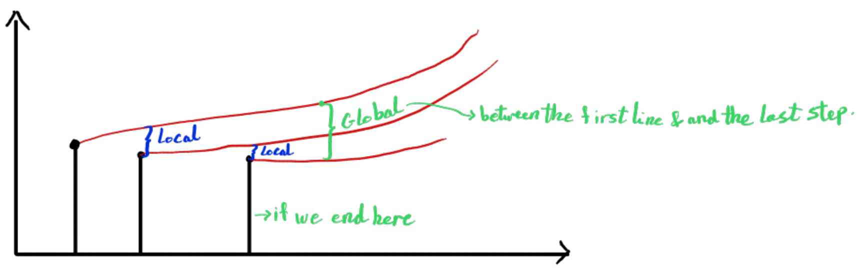
$\dot{X}_2 = \ddot{X} = -d \cdot \tan(X_1) \cdot X_2^2 - W_0^2 \cdot X_1 + \sin(w \cdot t)$

Q in the exam!

→ from one step to the other

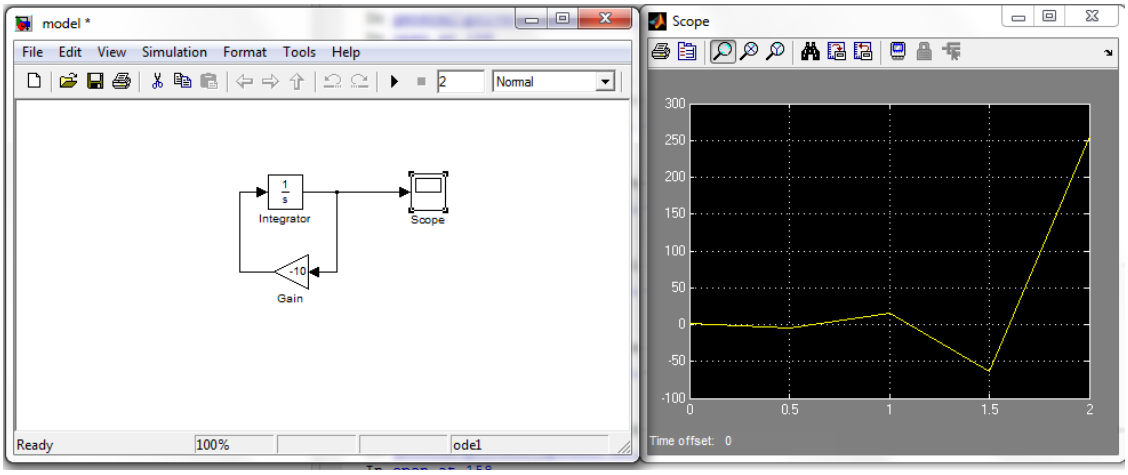
Local discolisation arrow

Global // // } Q: explain the term?



Register No.:____________________

5.) The following simulation result is given.



a.) Why is the displayed signal oscillating? **(2 points)**

we have numerical unstability

b.) Apply the explicit Euler Method (ode1) to the model. (Hint: 1st write down the *ode*, which is modelled in the above Simulink block diagram (gain=-10).) Calculate *five* steps of integration and compare the result to the signal displayed above. Explain your result. Depending on the last digit of your matriculation number use the following step-size *h*: **(6 points)**

Last digit of matriculation number	*h*=
-0	1.0
-1	0.1
-2	0.2
-3	0.3
-4	0.4
-5	0.5
-6	0.6
-7	0.7
-8	0.8
-0	0.9

6.) Find all linear ODEs and give the order of all ODEs! **(2 points)**

$\dddot{y} = \ddot{y} + 3 + y^0$	
$\sin(y) + y^1 = \dot{y}$	
$3(\dot{y} + 4\ddot{y}) = 9a^2 * \dot{y}$; with $a = 100$	
$y * y = \ddot{y}$	

7.) Explain the term global discretization error. **(3 points)**