**Academic Year 2021-2022**

**Exam 1 – Part I - Maximum duration: 3 hours**

**Problem 1 [3.75 points]**

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| Consider the following mechatronic circuit consisting of an RL series electrical network. The inductance has a ferromagnetic core that allows it to support a mass [kg] placed in a position (the positive axis of the position is considered to be upwards) and regulate its position by varying . The values of the parameters (in their appropriate units) are .  The equations of the system are: |  |

1. If the input voltage marking the operating point is , indicate the value of the electromagnet constant so that the equilibrium position (operating point) of the mass is **[0.25 points]**
2. Obtain a linear internal representation in state variables where the variables have physical meaning and, once obtained, substitute the values of the parameters and the result of the previous exercise and analyse their stability. **[1 point]**
3. Obtain the transfer function of the linearised system and analyse its stability. **[1 point]**
4. If the mass is placed at in the position (and therefore ), calculate the free evolution of the linearised system, disregarding the dynamics of the RL circuit (using only the two state variables position and its derivative). **[0.5 points]**
5. If at time a step of amplitude 0.1 is introduced into the input voltage, and again disregarding the dynamics of the RL circuit, calculate how the response calculated in the previous section is modified. **[0.5 points]**
6. Draw a Simulink diagram that allows you to simulate and compare the non-linear and linear systems (both in internal description and state space) for the simulation scenarios described above. **[0.5 points]**

**Problem 2 [1.25 points]**

For the transfer function:

1. Obtain the Bode diagram for this system. Indicate the approximate gain and frequencies of interest on the diagram. **[0.75 points]**
2. Obtain the Nyquist diagram for the system. **[0.5 points]**