**Academic Year 2025-2026**

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

**Problem 1 [0.5 points]** [Estimated maximum completion time: 5 minutes]

Calculate the transfer function of the block diagram in the figure. Calculate for which values of and the LTI system it models is asymptotically stable.

**Diagrama

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**Problem 2 [0.75 points]** [Estimated maximum completion time: 10 minutes]

The response of an LTI system to a unit impulse, starting from zero initial conditions, is shown in the following figure:

**Gráfico, Gráfico de líneas

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Determine the transfer function of the system and, once obtained, calculate the free response that the system would have based on the following initial conditions: The free response is very simple and does not require any complicated inverse transforms. If you arrive at an expression that seems complicated, try to simplify it, and if it cannot be simplified, it is best not to waste time on it and move on to the next exercise.

**Problem 3 [2.5 points]** [Estimated maximum completion time: 45 minutes]

The following equation represents the dynamic model of a spring with damping and restoring force, as occurs in some real elastic materials:

where is the force applied (manipulable input) and the position of the mass relative to equilibrium. Parameters: is the mass (kg), is the damping coefficient (Ns/m), is the linear spring constant (N/m) and is the quadratic restoring force coefficient (N/ m3). The parameter values are as follows: . The parameter b is determined in a later section.

1. Obtain a linear model around the operating point given by , both in transfer function and state space form, at the possible equilibria of the system. **[1 point]**
2. Analyse the local stability and transient behaviour of the linearised system as a function of parameter in the range ( at the stable equilibrium of the system. **[0.5 points]**
3. For a value of parameter that yields a critically damped response, calculate the expression for when a unit impulse is introduced at the input at time s, assuming initial conditions and . **[0.5 points]**
4. Draw the Simulink diagram of the non-linear model and compare it with its transfer function for the conditions in question 3. **[0.5 points]**

**Problem 4 [0.5 points]** [Estimated maximum completion time: 10 minutes]

Draw the Bode diagram (use the semi-logarithmic sheet on the following page) of the system represented by , indicating the characteristic points of low frequency, high frequency, and some intermediate frequency on both the magnitude and phase axes and on the frequency axes.

**Problem 5 [0.75 points]** [Estimated maximum completion time: 15 minutes]

Calculate the transfer function and Nyquist plot of a minimum phase system whose Bode plot is shown in the figure below.**Gráfico

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Imagen que contiene biombo, edificio, jaula

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