**Summer 2023**

**AME 455: Control System Design**

**Midterm Exam**

**Date: June 16, 2023**

**Student Name:** ­­­\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Instructions:

* This exam is closed book, and closed notes. A calculator with basic functions can be used.
* Please write your name clearly above.
* This is a 120-minute exam, and your proctor will keep time.

**Problem 1 (10 points):**

1. **(1 point)** Obtain where
2. **(1 point)** Obtain where
3. **(3 points)** Based on the block diagram below and answer what kind of transfer function do the ratios belong to:
4. **(4 points)** Observe the following graph and assign the missing parameters.

**A picture containing text, diagram, line, plot

Description automatically generated**

a –

b –

c –

d –

1. **(1 point)** At , the exponential response curve , of a first-order system reaches \_\_\_\_\_ % of its final value.

**Problem 2 (10 points):**

Consider the mass-spring-dashpot system shown below. The block of mass is attached to a spring on the left side while the dashpot is attached on the right side. A force is applied to the mass , which undergoes displacement .

Answer the following questions:

1. **(2 points)** Draw the free body diagram and use Newton’s second law to determine the equation of motion.
2. **(2 points)** Derive the transfer function from the input force and the output displacement i.e.,

1. **(1 point)** What is the order of the resulting system?
2. **(5 points)** For , , , **step-input**, determine the time response ?

**Problem 3 (10 points):**

Determine the range of values of , for which the following system is stable.

**Problem 4 (10 points):**

1. **(6 points)** For the following system:
2. **(2 points)** Convert the above block diagram into a closed loop system with unity-feedback.
3. **(2 points)** Determine steady-state error due to unit-step input?
4. **(2 points)** Determine steady-state error due to unit-ramp input?
5. **(4 points)** For the following transfer function:

Determine

* 1. **(1 point)** Maximum Percent Overshoot
  2. **(1 point)** Rise Time
  3. **(1 point)** Peak Time
  4. **(1 point)** 2%Settling Time

**Use the following formulae if required:**

1. Rise time
2. Peak time
3. 2% Settling time
4. 5% Settling time
5. Maximum % overshoot