Name and group: ____________________

This exam is closed books. Write your name on every page. Write clearly and legibly. Explain your work in words.

P1 (1p). Circle the right answer: (**T**rue OR **F**alse OR **I D**on't **K**now) *(0.2p correct answer, -0.1p wrong answer, 0p IDK)*

[**T F IDK**] The order of a system is equal to the number of poles.

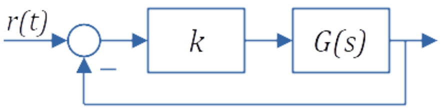
[**T F IDK**] A system has the poles $-10, -1+i, -1-i.$ The pole located at -10 is dominant.

[**T F IDK**] A first-order system is unstable if the poles are complex conjugate.

[**T F IDK**] A second-order system with the damping factor $\zeta > 1$ is overdamped.

[**T F IDK**] A second-order system with no zeros and the poles -1 and -10 is underdamped.

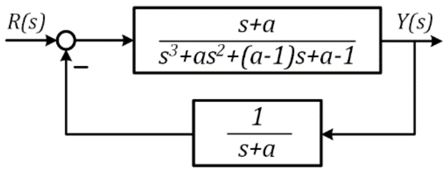
P2. (2p) Consider the closed-loop system in the figure, where:



$$G(s) = \frac{s+4}{(s+1)^2}$$

a) *(1p)* Sketch the root locus for $k \in [0, \infty)$ (*including the asymptote, the breakaway/breakin points*).
b) *(0.5p)* Find the values for k so that the closed-loop poles are equal.
c) *(0.5p)* Find the values for k so that the closed-loop system is underdamped. Use the previous result and the root locus to identify these values and describe how it shows that the system is underdamped.

P3. (1p) For the system shown in the figure:
a) *(0.5p)* Determine the range of values of the parameter a so that the closed-loop system is stable.
b) *(0.5p)* Choose a value for a so that the closed-loop system is stable and determine the steady-state error for a ramp input: $r(t) = 2t,\ t \geq 0.$



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P1 (1p). Circle the right answer: (**T**rue OR **F**alse OR **I D**on't **K**now) *(0.2p correct answer, -0.1p wrong answer, 0p IDK)*

[**T F IDK**] The transfer function is the ratio of the Laplace transform of the output signal to the Laplace transform of the input signal, with all initial conditions equal to zero.

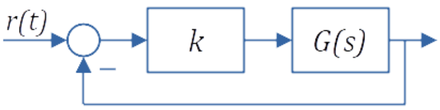
[**T F IDK**] The roots of the characteristic equation are the poles of the closed-loop system

[**T F IDK**] A system is stable if and only if all the poles have negative real parts.

[**T F IDK**] A second-order system with the damping factor $0 < \zeta < 1$ is underdamped.

[**T F IDK**] A system has the poles $-1, -10 + i, -10 - i$. The pole located at -1 is dominant.

P2. (2p) Consider the closed-loop system in the figure, where:



$$G(s) = \frac{1}{(s+4)(s-2)}$$

a) *(1p)* Sketch the root locus for $k \in [0, \infty)$ (*including the asymptotes, the breakaway/breakin points and the intersection with the imaginary axis*).
b) *(0.5p)* Find the values for k so that the closed-loop poles are equal.
c) *(0.5p)* Find the values for k so that the closed-loop system is overdamped. Use the root locus to identify these values and describe how it shows that the system is overdamped.

P3. (1p) For the system shown in the figure:
a) *(0.5p)* Determine the range of values of the parameter a so that the closed-loop system is stable.
b) *(0.5p)* Choose a value for a so that the closed-loop system is stable and determine the steady-state error for a step input: $r(t) = 2,\ t \geq 0$.