Final Duration: **90** minutes **Spring 2023**

- It is advisable to take knowledge of the entire text before answering any question.

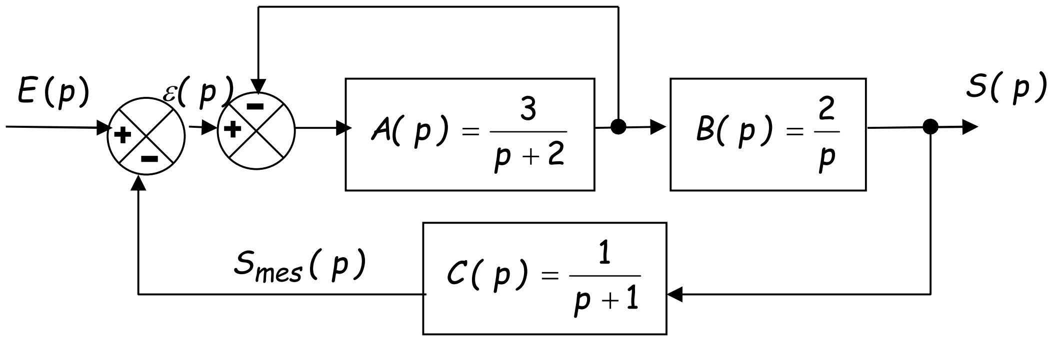
- Applicants must respect the used notation and specify in each case the question number.

- Most attention will be given to the clarity of writing, presentation, the diagram and the presence of measurement unit

Results will be put in frames - ***Exercises are independent.***

Documentation: An A4 double face is authorized, Calculator authorized, phone forbidden

Exercise 1 (6pts): Consider the Regulation loop below where a sensor *C(p)* is needed to measure the signal.



1) Calculate the OLTF G(p) of this system.
2) Simplify this structure and determine the CLTF H(p).

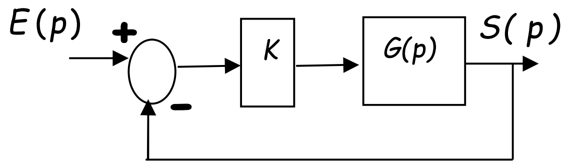
Exercise 2 (4pts): Consider this system defined by its OLTF G(p): $G(p) = \frac{1000}{p(p+5)(p+20)}$,

1) Calculate the phase margin of this system.
2) Conclude about this system stability.

Exercise 3 (10pts):

Consider this system having a control gain K and

$$G(p) = \frac{1}{(1+p)^3}$$



1) Determine, using the Nyquist criterion, the stability conditions of this system.
2) Determine, using the Routh-Hurwitz criterion, the stability conditions of this system. Compare with 1)
3) We want to have a 45° phase margin, calculate for this:
   a. The value of K
   b. The position error when the input is a unitary step.

We would like now to control this system using a PID controller. The PID parameters should be determined by Ziegler Nichols closed loop method.

4) Give the limit value K_{max} of the proportional gain rending this system at the limit of the stability.
5) In this case, determine the period of the generated sinus function.
6) Determine the PID parameters (No need to draw the PID schematic).

Annexes