



INTRODUCTION TO CONTROL (034040)

TUTORIAL 9

**Question 1.** The process

$$P(s) = \frac{12}{(s+2)^2(s+2.5)}$$

is controlled in closed loop (unity feedback) by a proportional controller,  $C(s) = k_p$ . Find stabilizing  $k_p$ 's using the Nyquist stability criterion.

**Question 2.** The process

$$P(s) = \frac{s^2 + 4s/3 + 4}{6s(s^2 + s/2 + 1)}$$

is controlled in closed loop (unity feedback) by a proportional controller,  $C(s) = k_p$ , for  $k_p > 0$ . Find the number of closed-loop poles in the RHP as a function of  $k_p$  using the Nyquist stability criterion.

**Question 3.** Use the Nyquist stability criterion to determine the stability of the unity-feedback closed-loop system with

1.  $L_1(s) = \frac{1}{s^2}$

2.  $L_2(s) = \frac{\sqrt{3}s + 1}{s^2(s + \sqrt{3})}$

3.  $L_3(s) = \frac{s + \sqrt{3}}{s^2(\sqrt{3}s + 1)}$

Explain the difference.