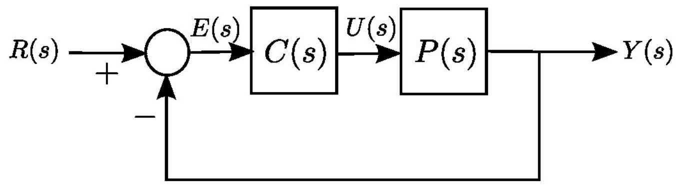
Universidad Pontificia Bolivariana
Facultad de Ingeniería Aeronáutica
Automatic Flight Control
Problem set 8
Feedback Control Systems

1. Suppose a feedback control system represented by the block diagram in figure



   (a) Determine the equivalent transfer function of the system considering as input to $R(s)$ and output to $Y(s)$.

   (b) Determine the equivalent transfer function of the system considering $R(s)$ as input and $E(s)$ as output.

2. Assuming that the reference is a step signal and using analytical and computational tools for the feedback control system from the above problem determine:

   (a) The value of the controlled variable, $y(t)$

   (b) The steady state value of the controlled variable, $y_{ss} = \lim_{t\to\infty} y(t)$

   (c) The steady state error, $e_{ss} = \lim_{t\to\infty} e(t)$

   (d) The transitory error, $e(t)$ in each case.

   (e) The maximum overshoot, M_p.

   (f) The rise time, t_r.

   (g) The settling time, t_s.

   Do the above for each of the following cases:

   (a) P control (proportional control) on first-order plant:

$$G(s) = \frac{K}{\tau s + 1},\ C(s) = K_p.$$

   (b) PI control (proportional-integral control) on first order plant:

$$G(s) = \frac{K}{\tau s + 1},\ C(s) = K_p + \frac{K_i}{s}.$$

   (c) P control (proportional control) over a second order plant with a pole at the origin (servo system):

$$G(s) = \frac{K}{s\,(\tau s + 1)},\ C(s) = K_p.$$

(d) PD control (proportional-derivative control) over a second order plant with a pole at the origin (servo system):

$$G(s) = \frac{K}{s\,(\tau s + 1)}, \; C(s) = K_p + K_d s.$$

(e) PI control (proportional-integral control) over a second order plant with a pole at the origin (servo system):

$$G(s) = \frac{K}{s\,(\tau s + 1)}, \; C(s) = K_p + \frac{K_i}{s}.$$

(f) PID control (proportional-integral-derivative control) over a second order plant with a pole at the origin (servo system):

$$G(s) = \frac{K}{s\,(\tau s + 1)}, \; C(s) = K_p + \frac{K_i}{s} + K_d s.$$

(g) P control (proportional control) over a second order plant:

$$G(s) = \frac{K w_n^2}{s^2 + 2\zeta w_n s + w_n^2}, \; C(s) = K_p.$$

(h) PD control (proportional-derivative control) over a second order plant:

$$G(s) = \frac{K w_n^2}{s^2 + 2\zeta w_n s + w_n^2}, \; C(s) = K_p + K_d s.$$

(i) PI control (proportional-integral-derivative control) over a second order plant:

$$G(s) = \frac{K w_n^2}{s^2 + 2\zeta w_n s + w_n^2}, \; C(s) = K_p + \frac{K_i}{s}.$$

(j) PID control (proportional-integral-derivative control) over a second order plant:

$$G(s) = \frac{K w_n^2}{s^2 + 2\zeta w_n s + w_n^2}, \; C(s) = K_p + \frac{K_i}{s} + K_d s.$$