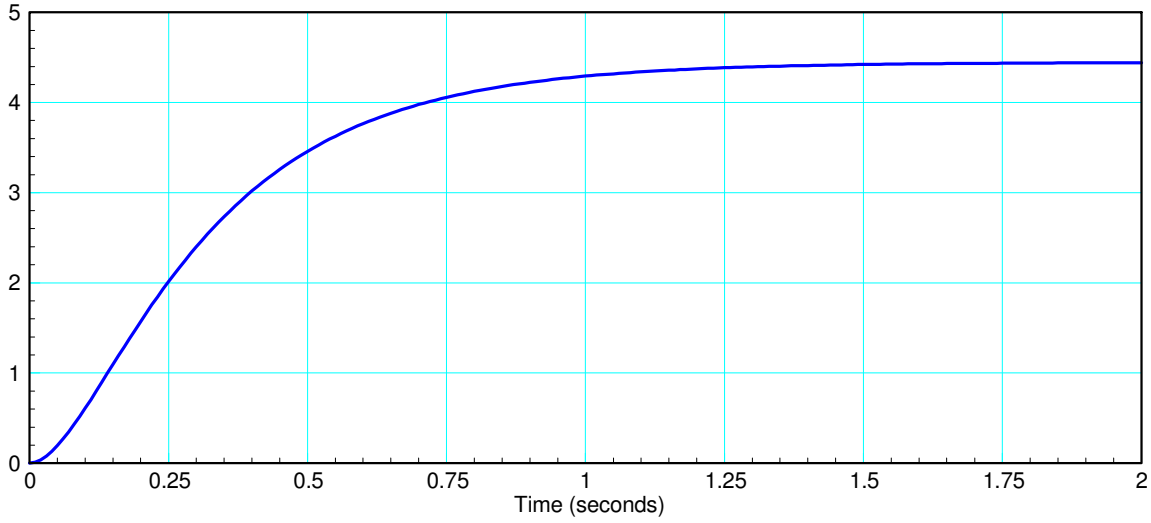
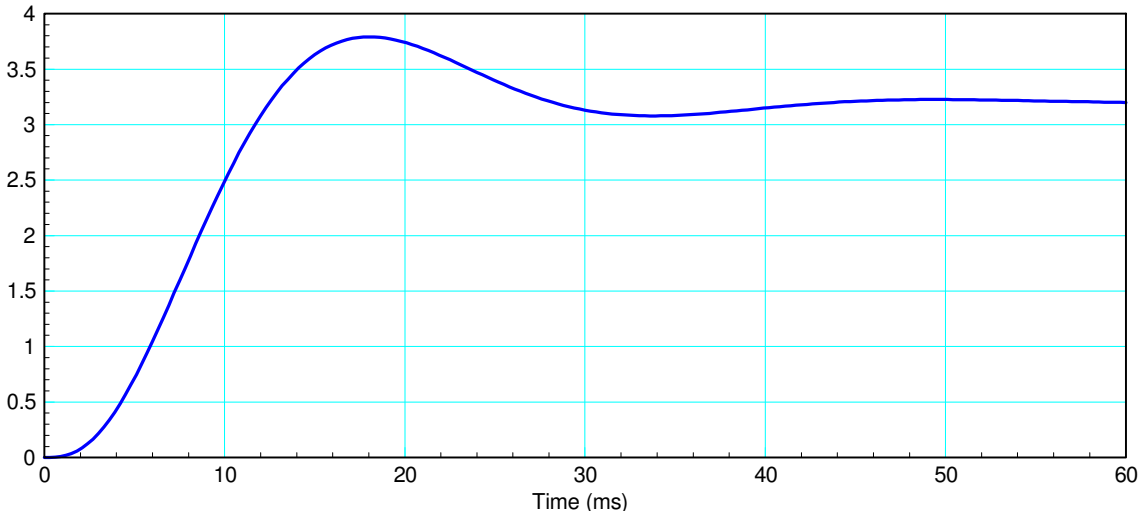
ECE 461/661 Handout #11

1st & 2nd Order Approximations

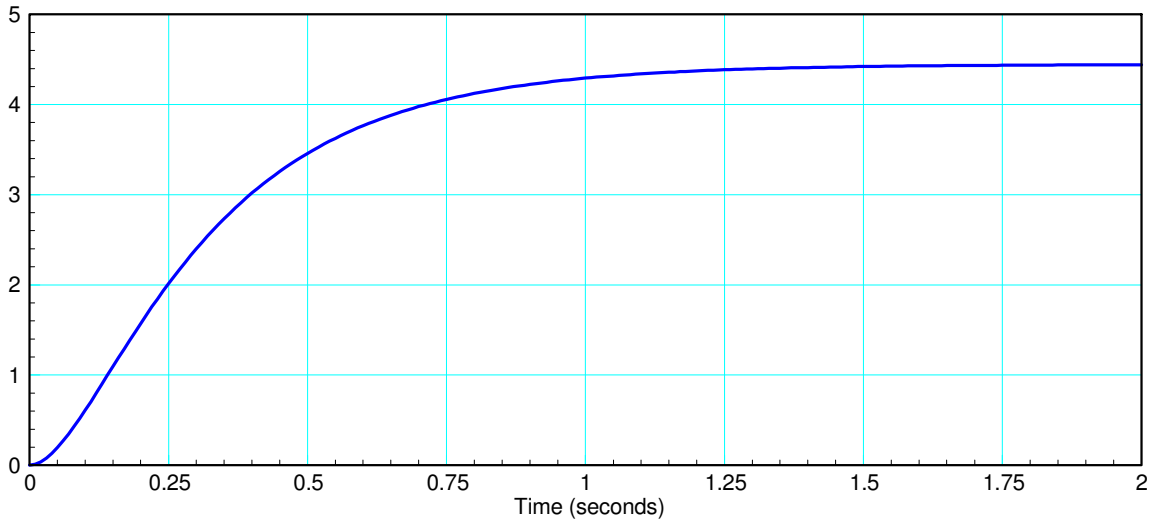
1) Determine the system with the following step response



2) Determine the system with the following step response



1) Determine the system with the following step response



This is a 1st-order system (no oscillation)

$$Y = \left(\frac{a}{s+b}\right) U$$

The DC gain is about 4.4

$$\left(\frac{a}{s+b}\right)_{s=0} = 4.4$$

$$\left(\frac{a}{b}\right) = 4.4$$

The 2% settling time is about 1.25 seconds

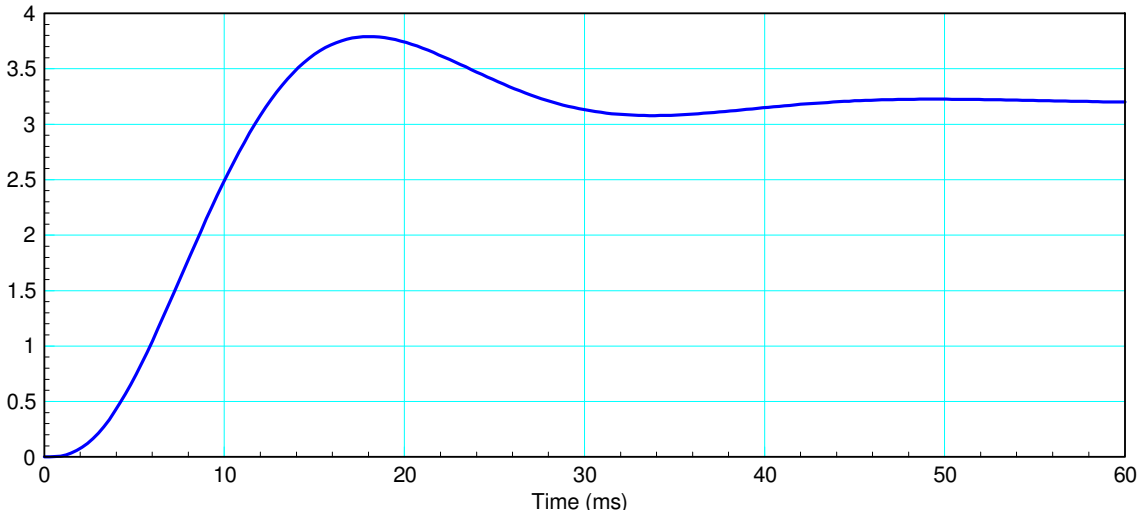
$$\frac{4}{1.25} = b$$

$$b = 3.2$$

so

$$G(s) \approx \left(\frac{14.08}{s+3.2}\right)$$

2) Determine the system with the following step response



This is a second-order system (it has oscillations). There are several ways to write this

$$G(s) = \left(\frac{a}{(s+\sigma+j\omega)(s+\sigma-j\omega)} \right)$$

The 2% settlign time is about 40ms

$$\sigma = \frac{4}{40ms} = 100$$

The period is about 33ms (min at t = 0, the next min is at t = 33ms)

$$f = \frac{1}{period} = \frac{1}{33ms} = 30.3Hz$$

$$\omega = 2\pi f = 190$$

so

$$G(s) \approx \left(\frac{k}{(s+100+j190)(s+100-j190)} \right)$$

The DC gain is 3.2

$$\left(\frac{k}{(s+100+j190)(s+100-j190)} \right)_{s=0} = 3.2$$

$$k = 148,007$$

and

$$G(s) \approx \left(\frac{148{,}007}{(s+100+j190)(s+100-j190)} \right)$$