

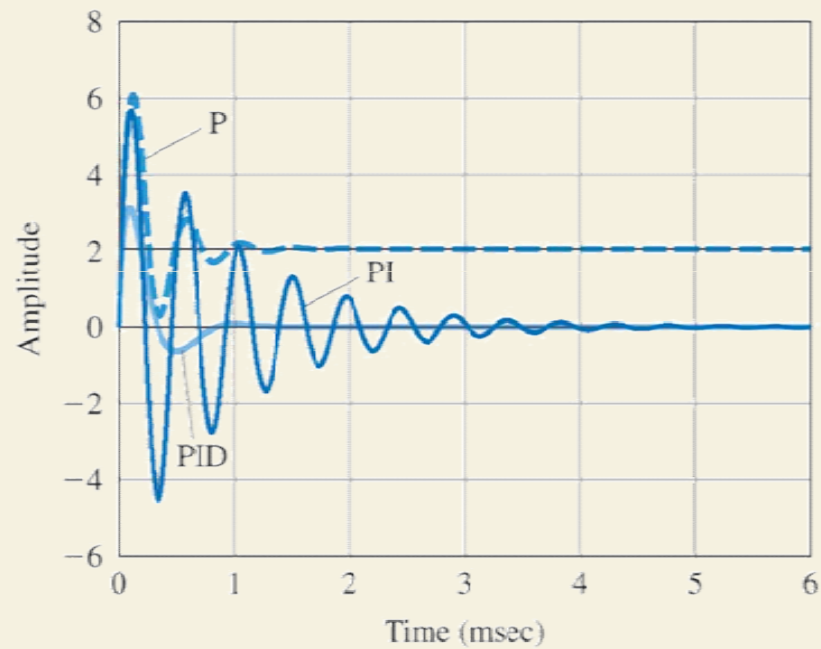


TE055

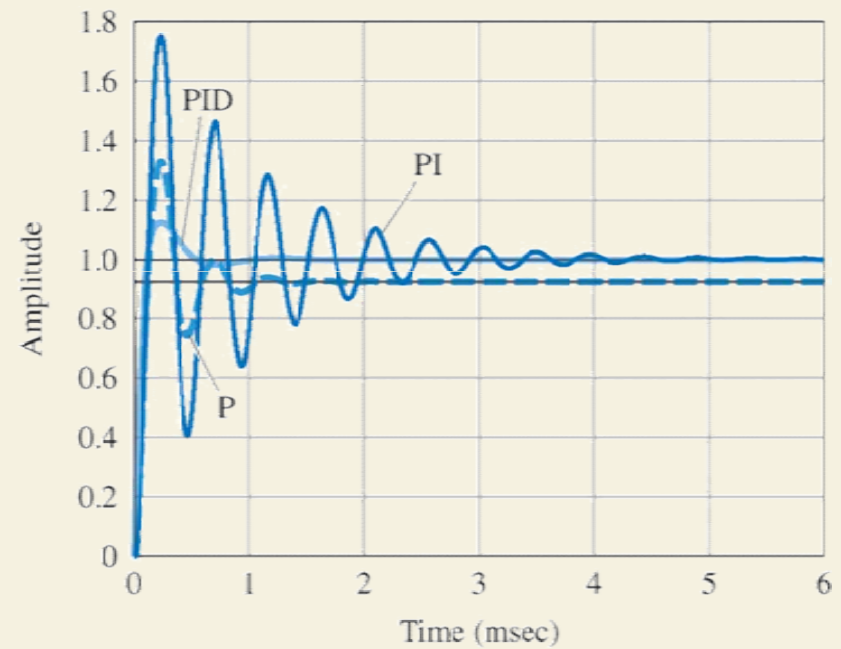
Controlador PID

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# Exemplo 4.6 (Franklin)



(a)



(b)

**Figure 4.9** Responses of P, PI, and PID control to (a) step disturbance input (b) step reference input

# Métodos de Ziegler-Nichols

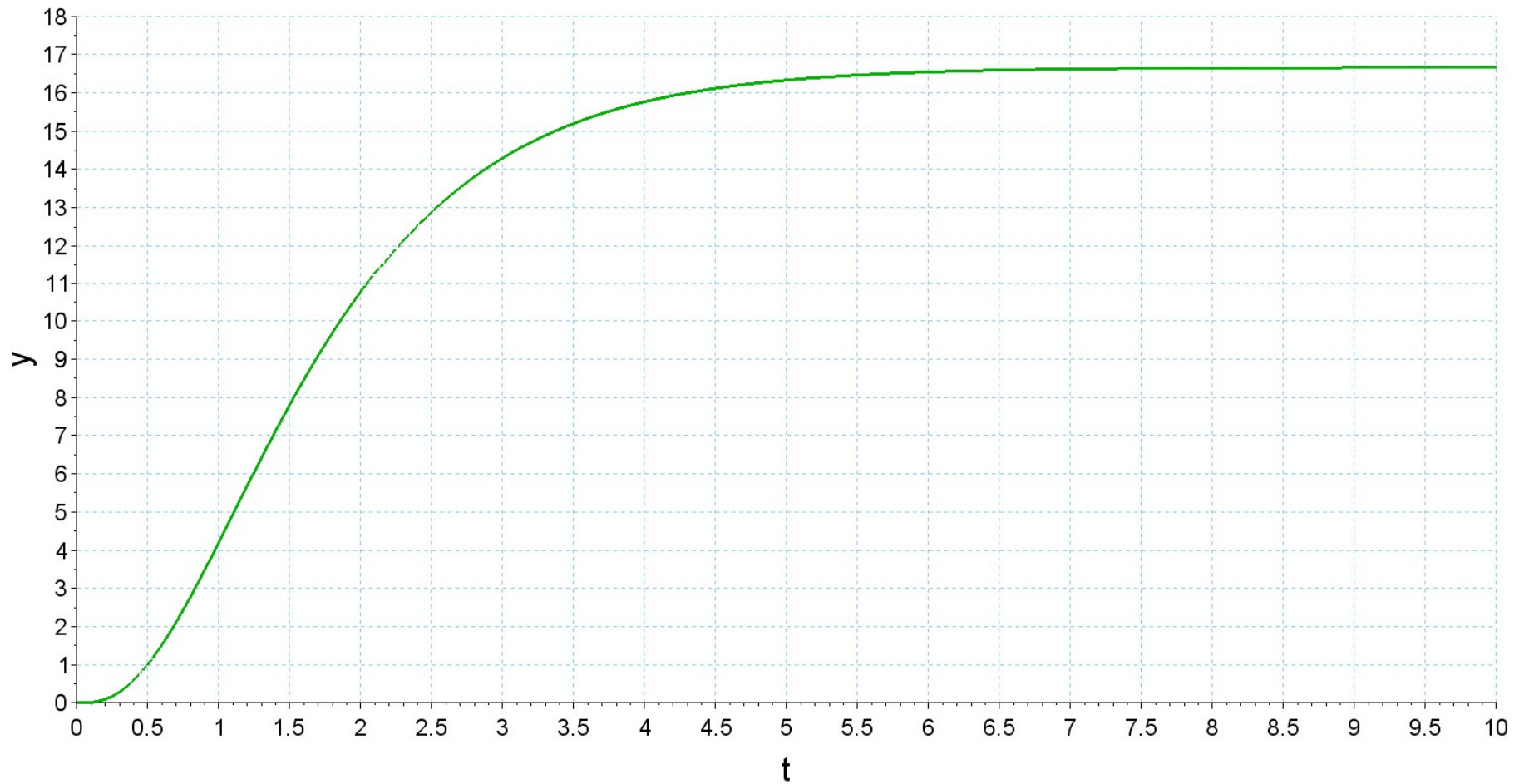
- Permitem um ajuste rápido dos parâmetros de um controlador PID;
- A solução obtida pode requerer ajustes adicionais para se atingir os parâmetros desejados para a resposta do sistema.
- O 1º método é baseado na resposta da planta em malha aberta;
- O 2º método requer que se leve o sistema em malha fechada ao limite da estabilidade.

# Método da resposta da planta

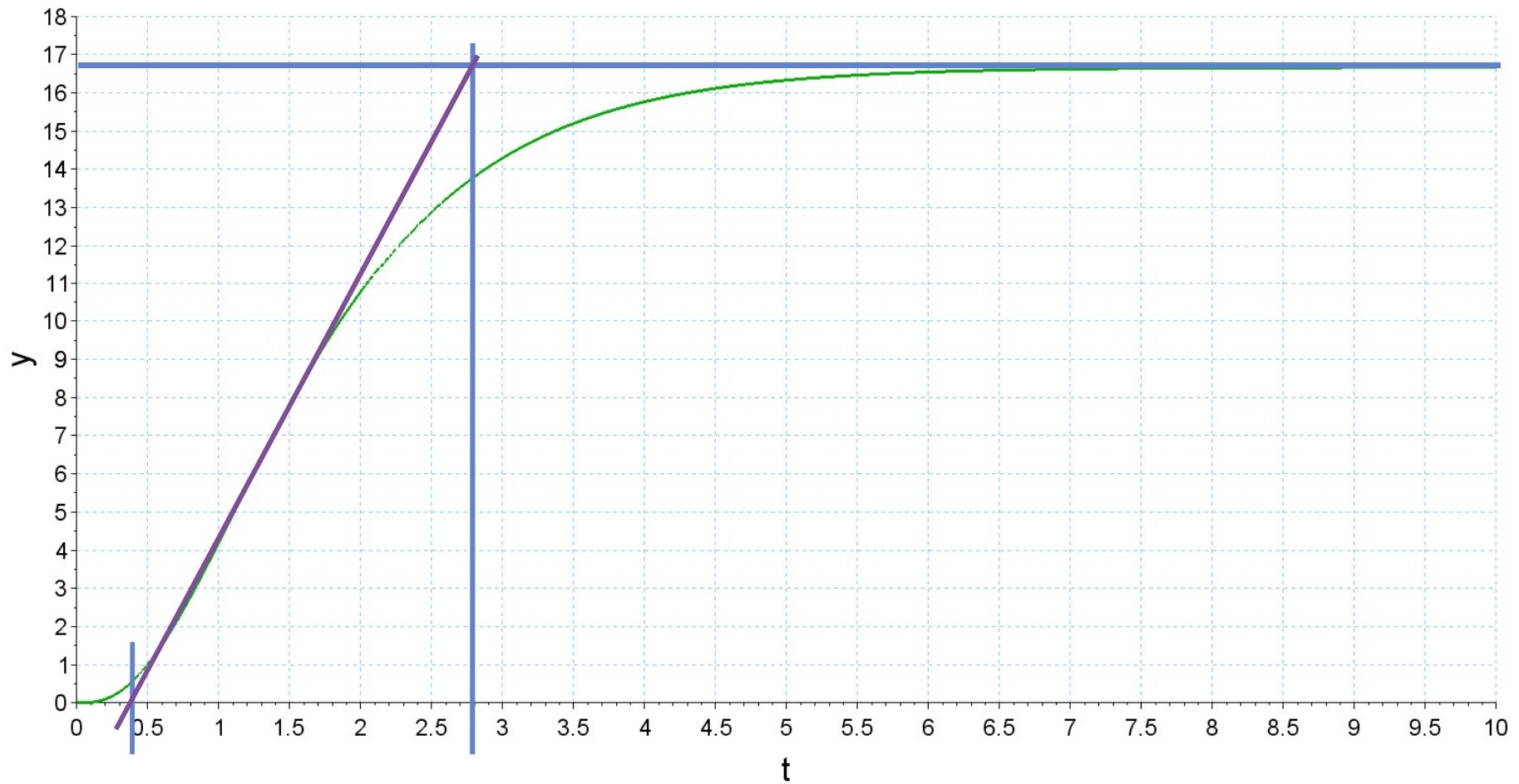
$$C(s) = k_p \left( 1 + \frac{1}{T_i s} + T_d s \right)$$

Tipo de controlador	$k_p$	$T_i$	$T_d$
P	1 / RL		
PI	0,9 / RL	L / 0,3	
PID	1,2 / RL	2L	L / 2

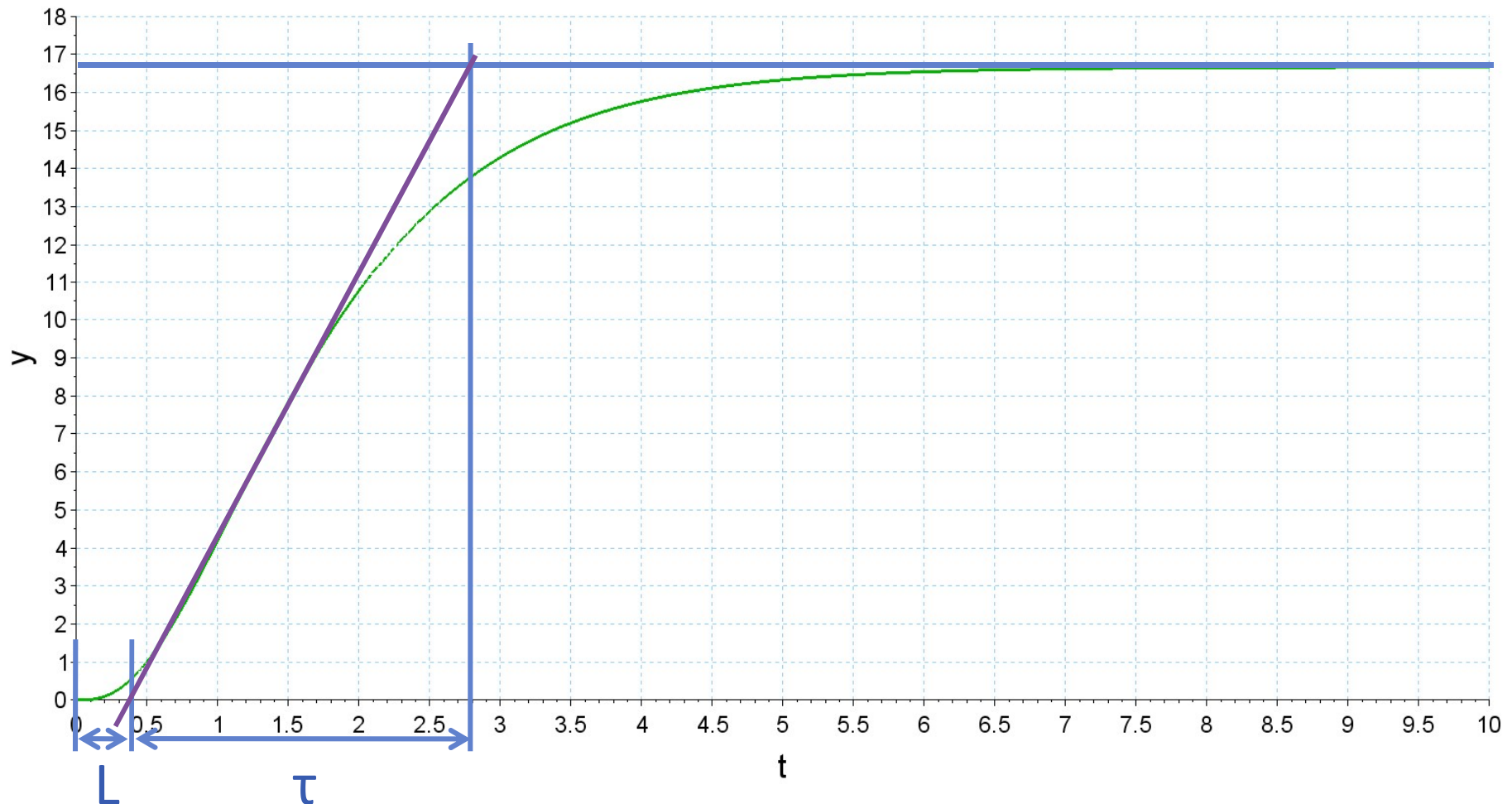
# Método da resposta da planta: exemplo 1



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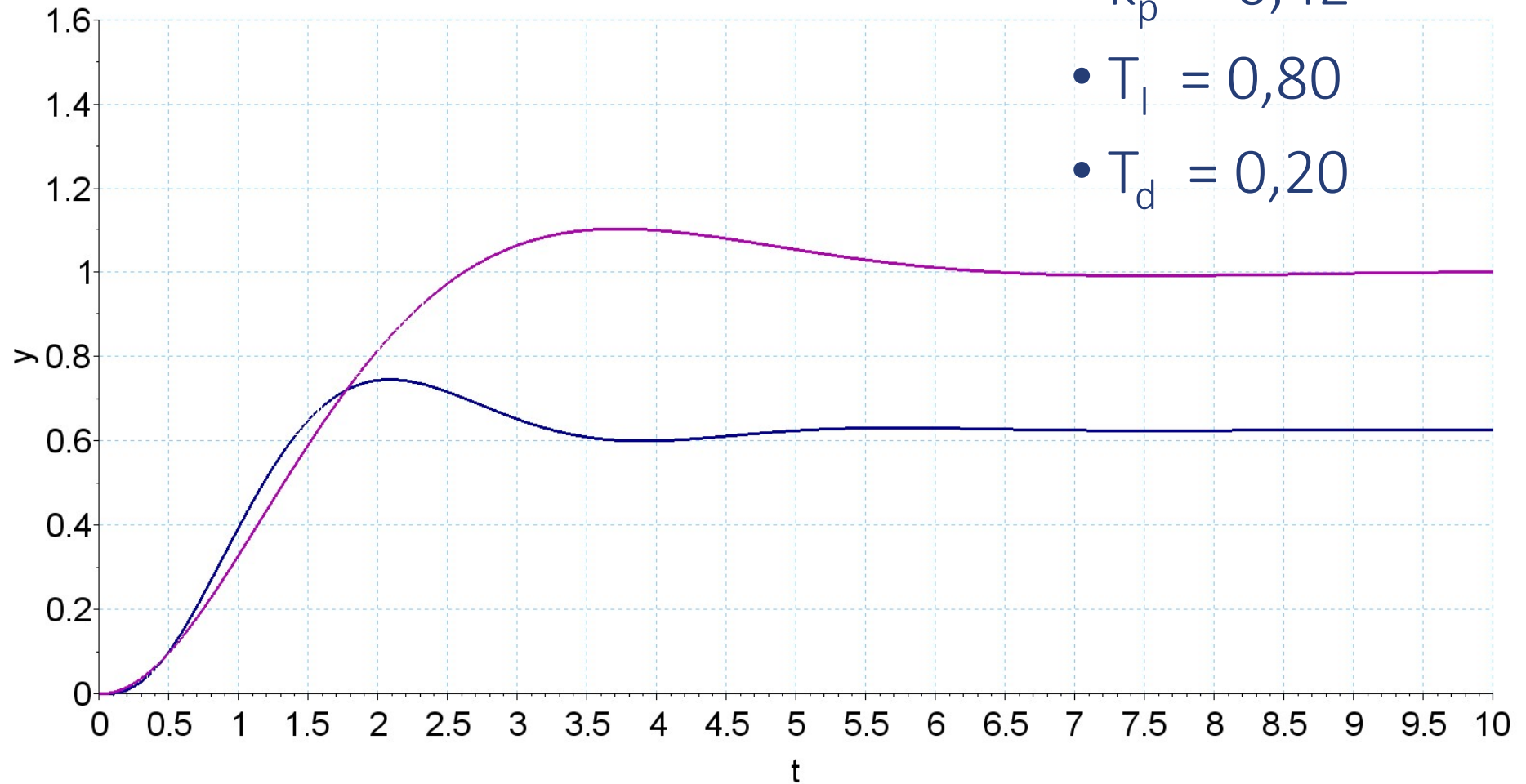
# Método da resposta da planta: exemplo 1

PID com

- $k_p = 0,42$

- $T_I = 0,80$

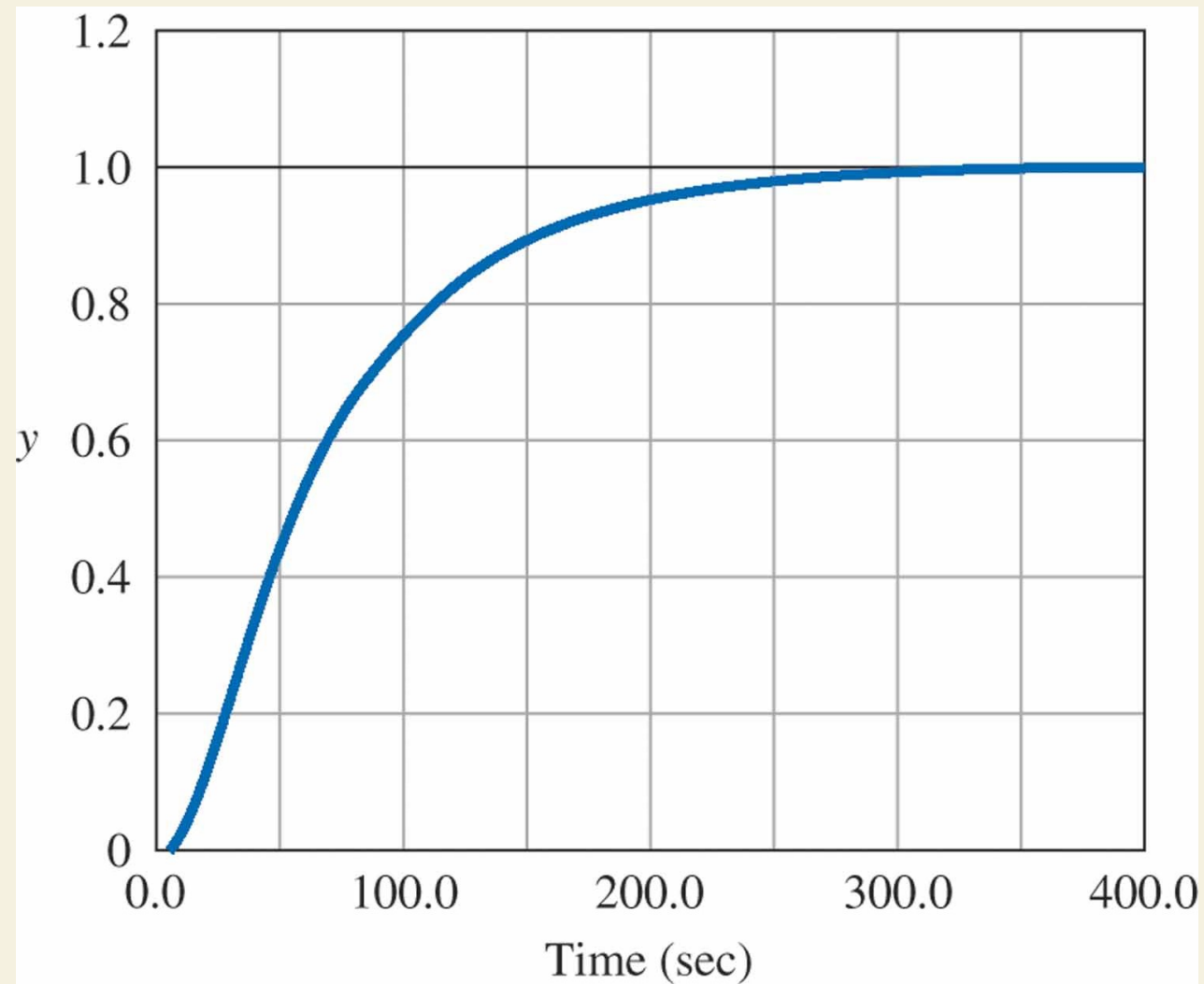
- $T_d = 0,20$





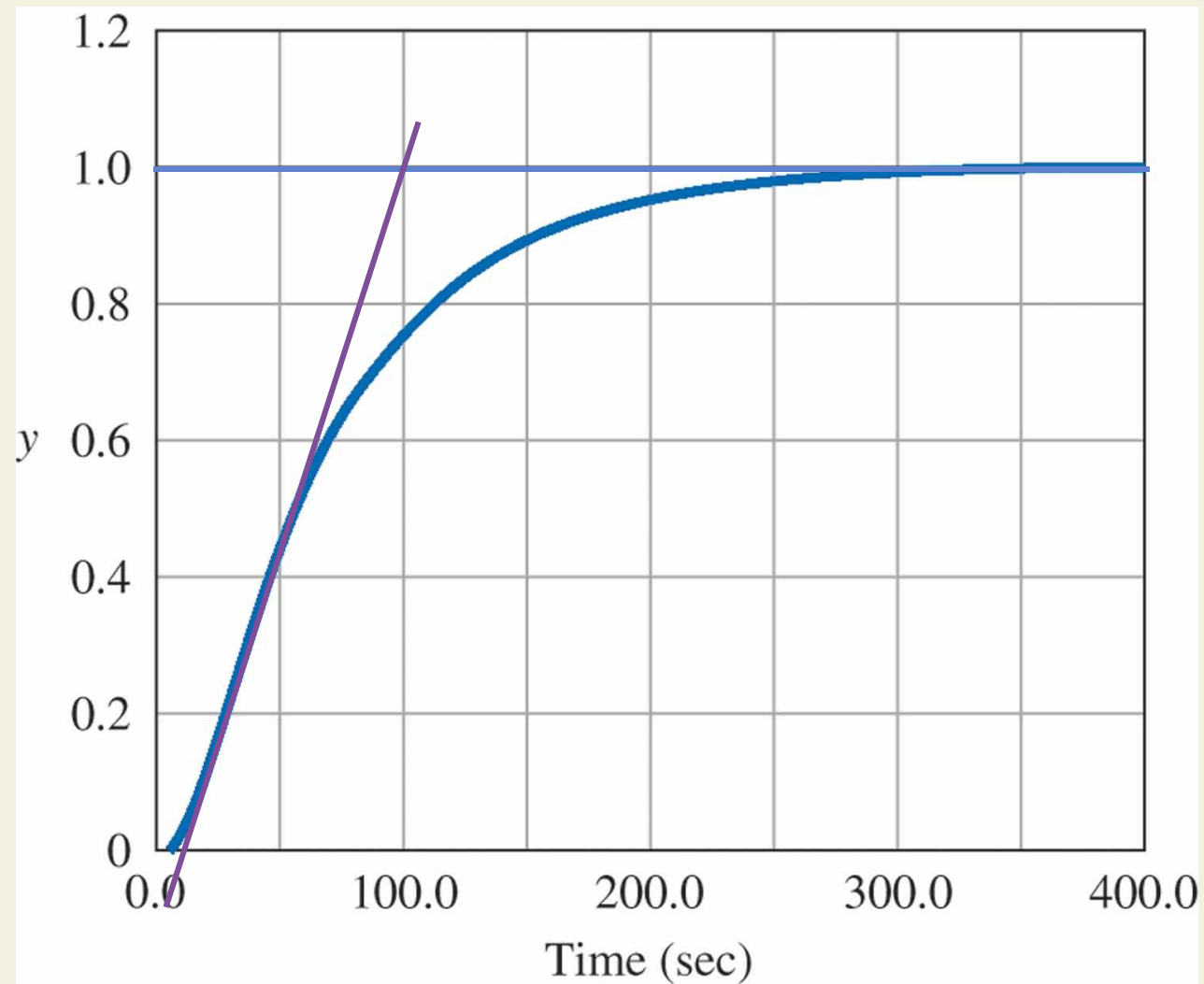
# Método da resposta da planta: exemplo 2

Figure 4.15 A measured process reaction curve



# Método da resposta da planta: exemplo 2

Figure 4.15 A measured process reaction curve



$$\tau \approx 1/90$$

$$L \approx 13s$$

# Método da resposta da planta: exemplo 2

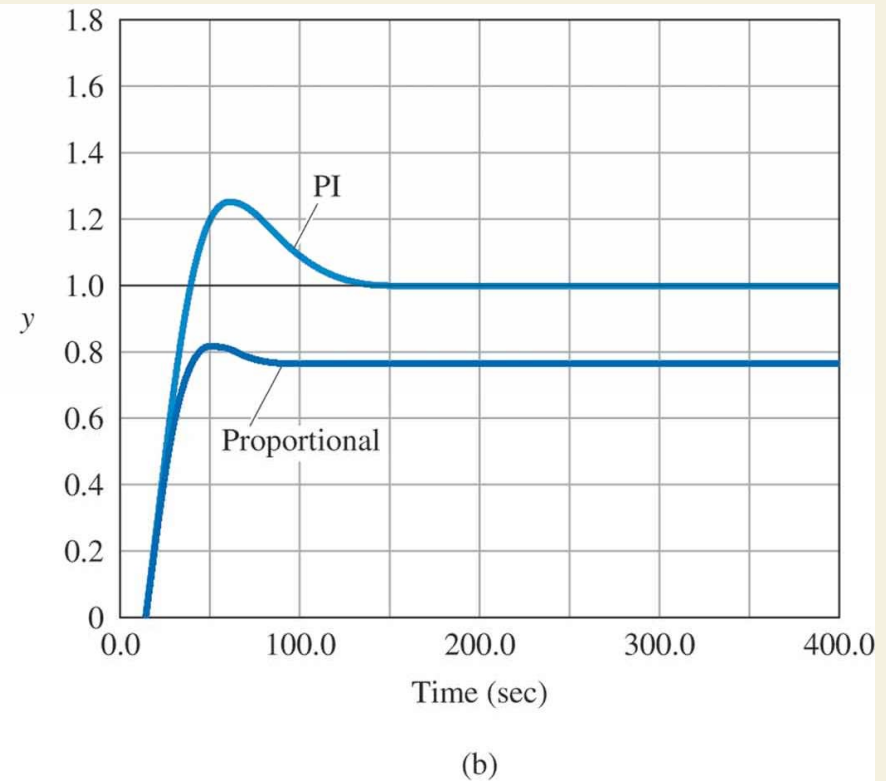
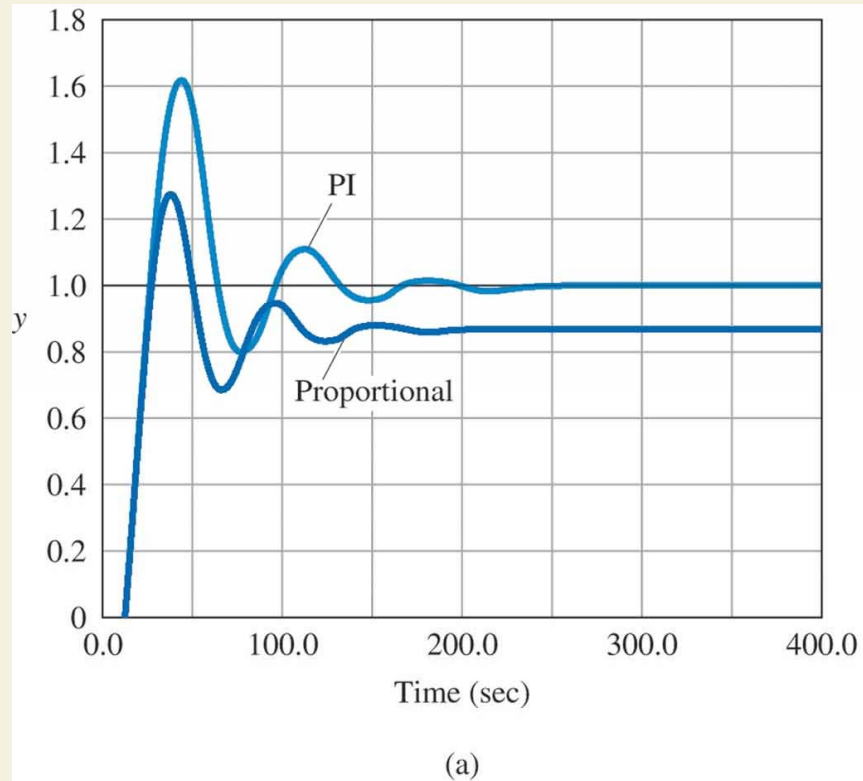
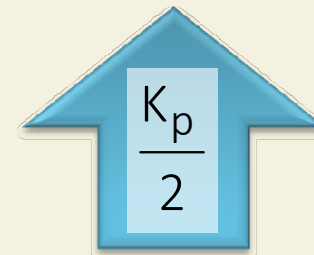


Figure 4.16 Closed-loop step responses



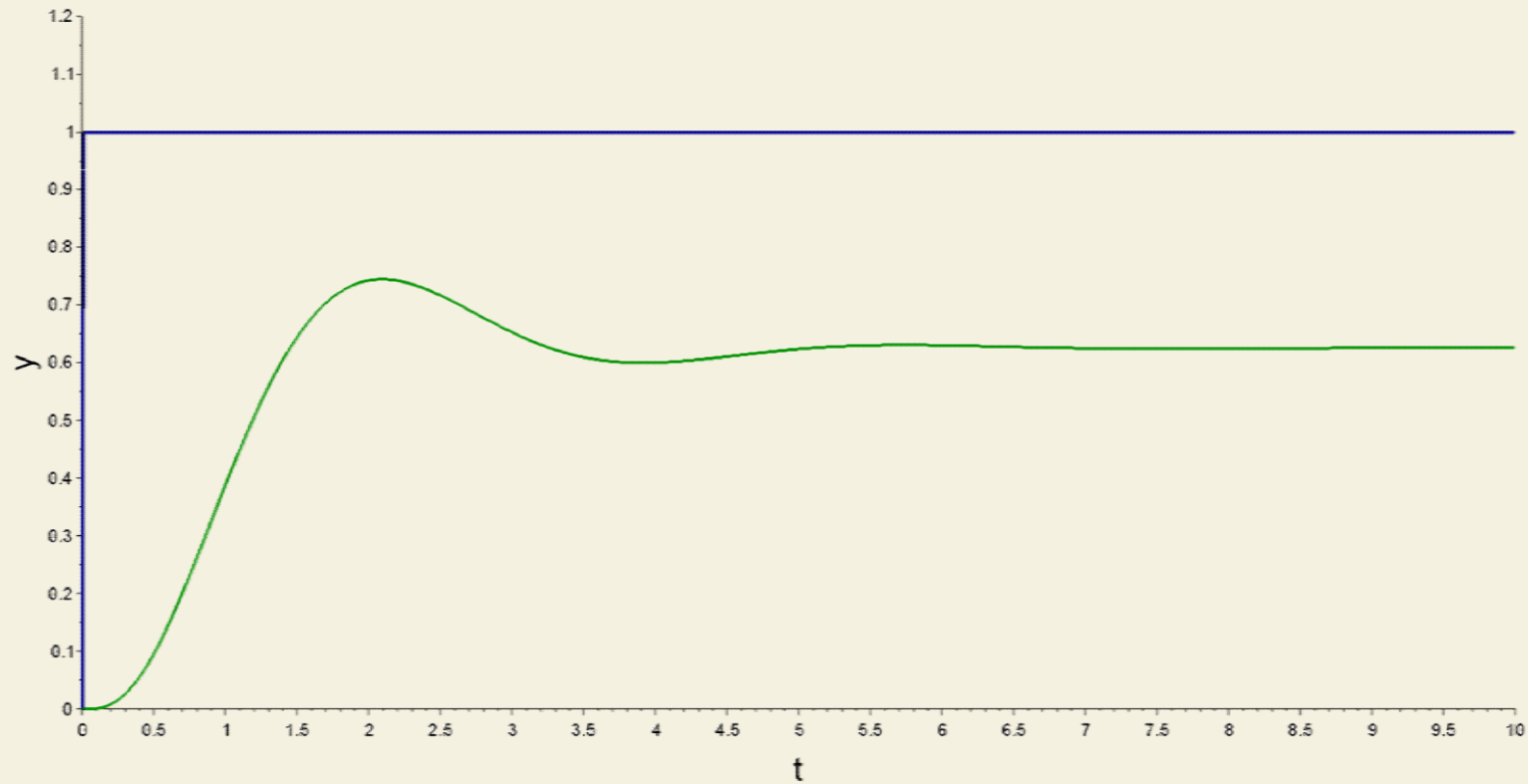
# Método do ponto crítico

$$C(s) = k_p \left( 1 + \frac{1}{T_i s} + T_d s \right)$$

Tipo de controlador	$k_p$	$T_i$	$T_d$
P	$0,5 K_c$		
PI	$0,45 K_c$	$T_c / 1,2$	
PID	$0,6 K_c$	$0,5 T_c$	$0,125 T_c$

# Método do ponto crítico – exemplo 1

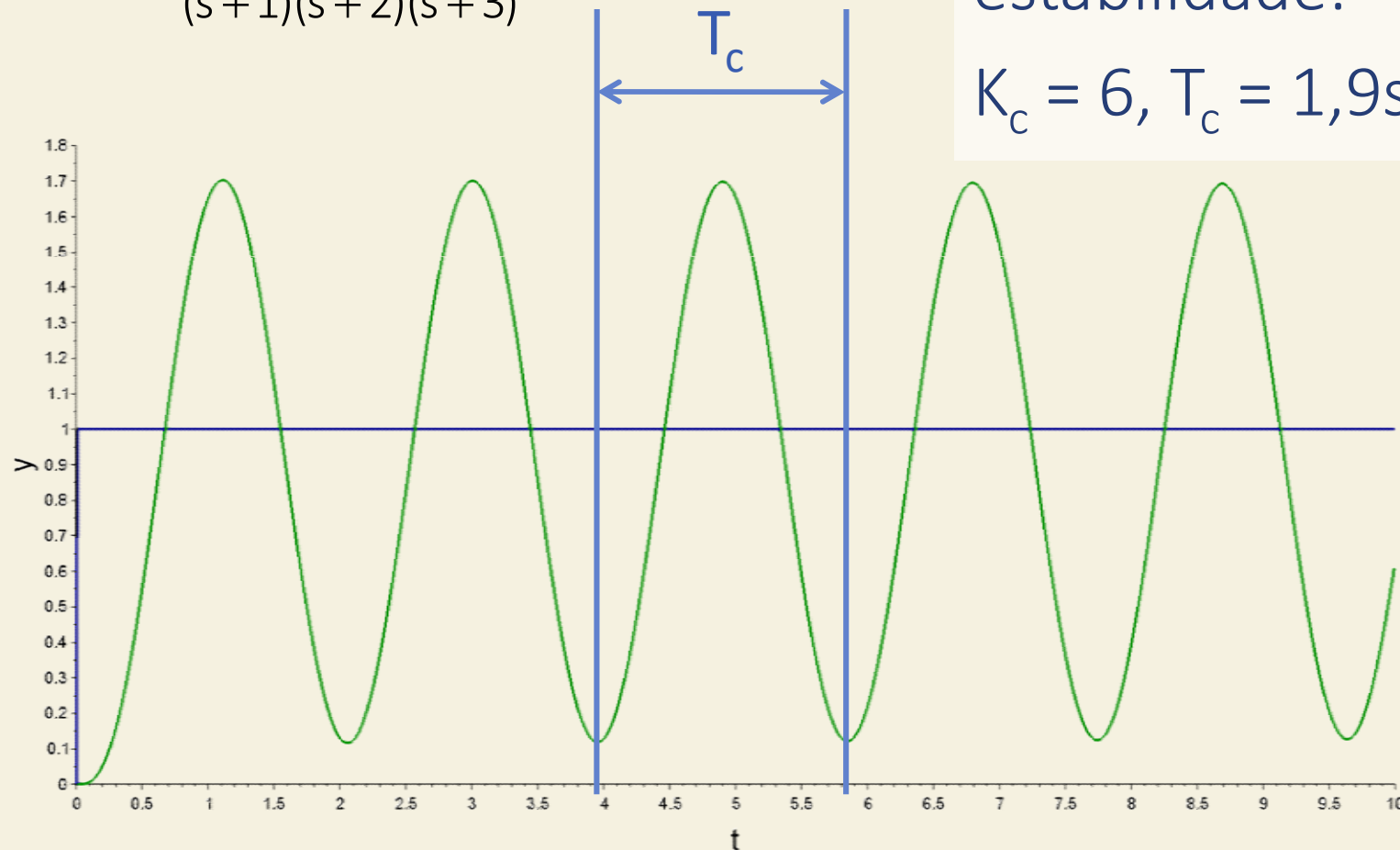
$$G(s) = \frac{10}{(s+1)(s+2)(s+3)}$$



# Método do ponto crítico – exemplo 1

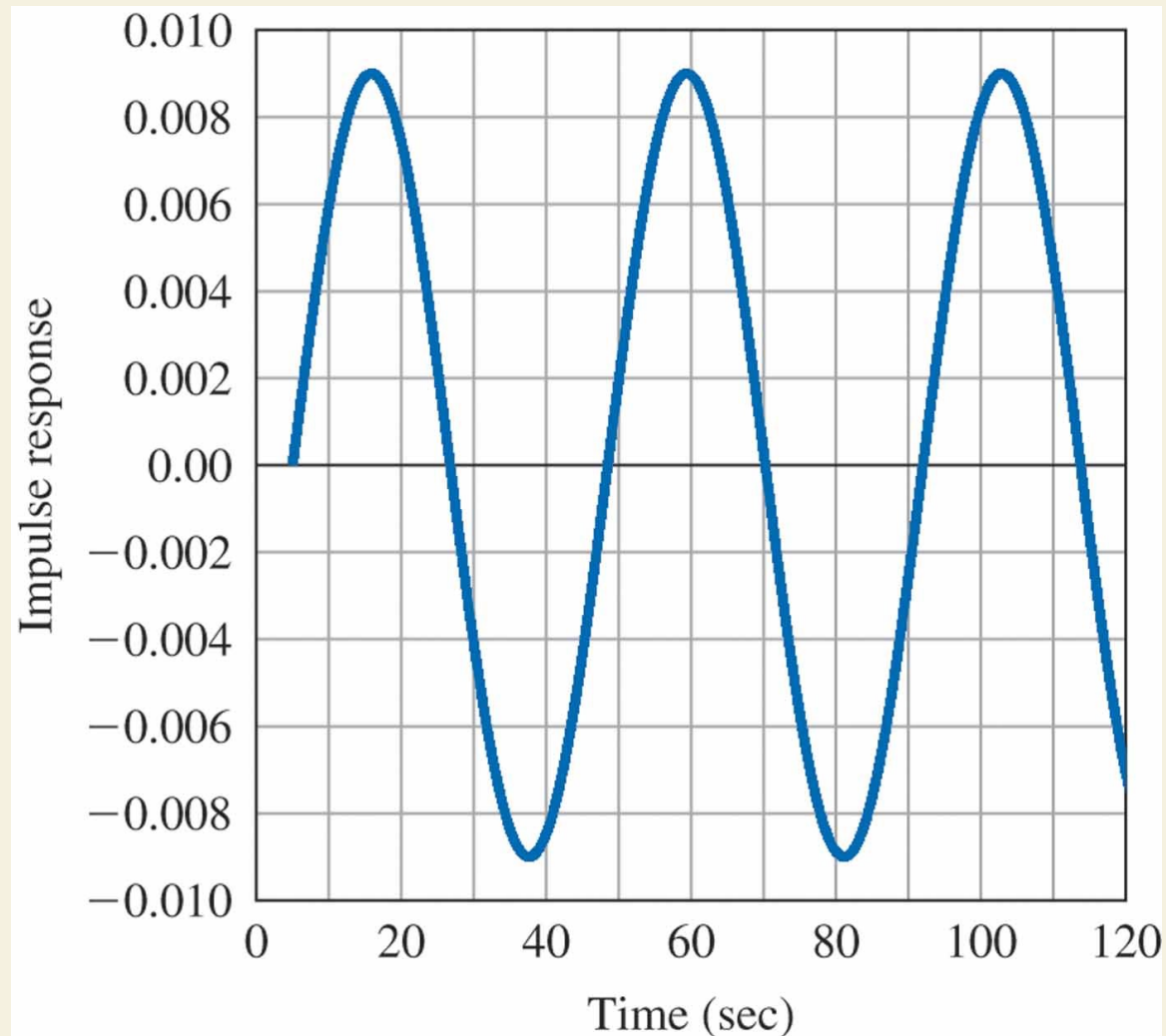
$$G(s) = \frac{10}{(s+1)(s+2)(s+3)}$$

Limite da  
estabilidade:  
 $K_c = 6, T_c = 1,9s$



# Método do ponto crítico – exemplo 2

Figure 4.17 Ultimate period of heat exchanger



Limite da  
estabilidade:

$$K_c = 15,3$$

$$T_c = 42 \text{ s}$$

# Método do ponto crítico – exemplo 2

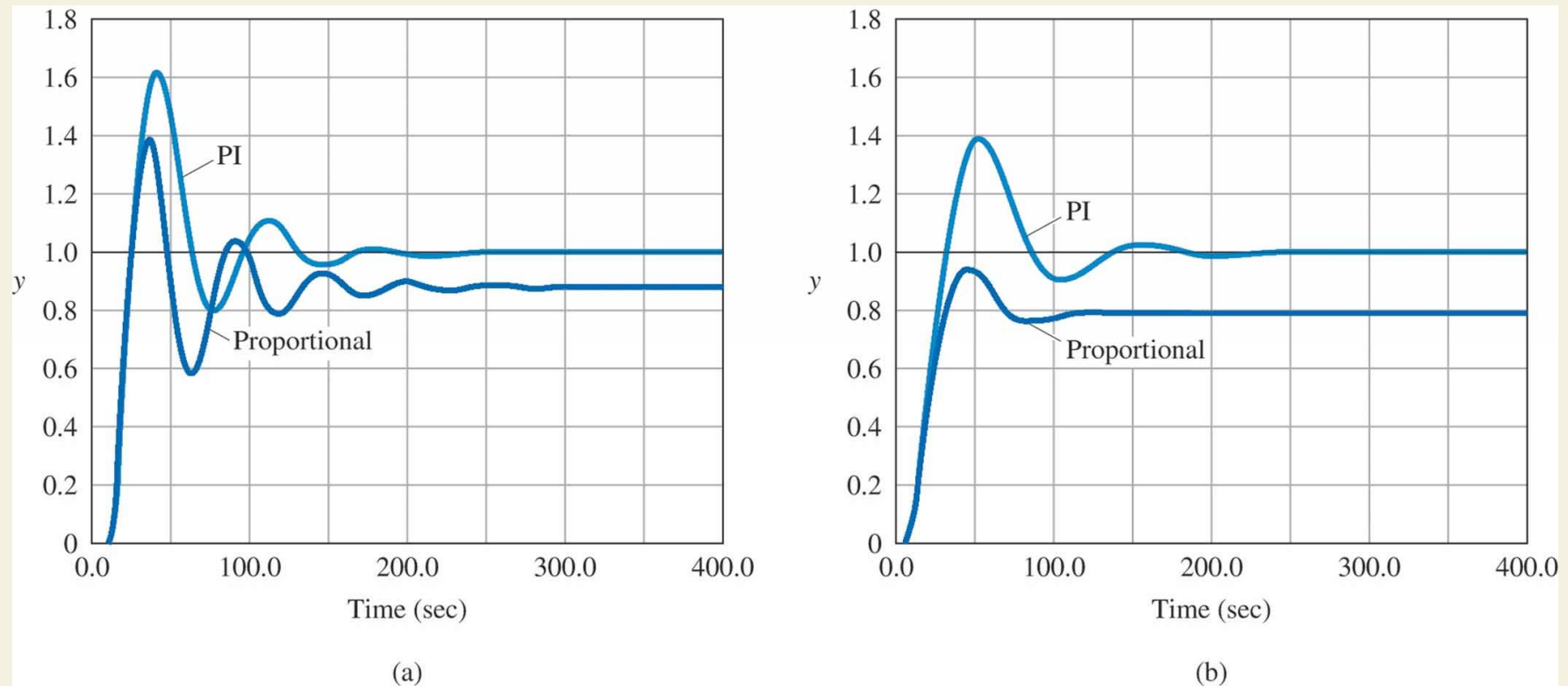


Figure 4.18 Closed-loop step response

