Chapter 10

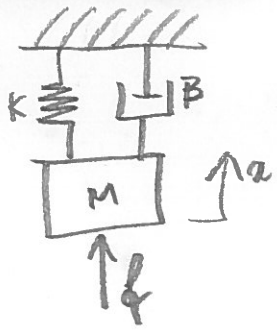
10 Os diagramas corretos podem obter-se em Matlab com o comando *bode*.

12 a) 3 s b) $-1+t+e^{-t}$ c) $-1+t$ d) 2,52 s (exige resolver uma equação não-linear, o que se consegue no Matlab)

15 As respsotas corretas podem obter-se em Matlab com o comando *step*.

18 Ver página seguinte.

(18)



$$M\ddot{x} = f - Kx - B\dot{x}$$

$$MXs^2 + BXs + KX = F$$

$$\frac{X}{F} = \frac{1}{Ms^2+Bs+K} = \frac{\frac{1}{M}}{s^2+\frac{B}{M}s+\frac{K}{M}}$$

a) ① $y_M = \frac{\frac{1}{M}}{\frac{K}{M}} F \Rightarrow \frac{8,9}{K} = 3\times10^{-2} \Leftrightarrow K = \frac{8,9}{3\times10^{-2}} = 297 \text{ N/m}$

② $M_p = e^{-\frac{\xi\pi}{\sqrt{1-\xi^2}}} \Leftrightarrow -\frac{\xi\pi}{\sqrt{1-\xi^2}} = \log M_p \Rightarrow \xi^2\pi^2 = (1-\xi^2)(\log M_p)^2 \Rightarrow \xi^2(\pi^2+(\log M_p)^2) = (\log M_p)^2$

para ser >0 $\Rightarrow \xi = \frac{-\log M_p}{\sqrt{\pi^2+(\log M_p)^2}} \Rightarrow \xi = \frac{-\log 0,097}{\sqrt{\pi^2+(\log 0,097)^2}} = 0,6$

③ $t_p = \frac{\pi}{\omega_n\sqrt{1-\xi^2}} \Rightarrow \omega_n = \frac{\pi}{t_p\sqrt{1-\xi^2}} \Rightarrow \omega_n = \frac{\pi}{1\sqrt{1-0,6^2}} = 3,93 \text{ rad/s}$

logo $\frac{K}{M} = \omega_n^2 \Rightarrow M = \frac{297}{3,93^2} = 19,2 \text{ kg}$

④ $2\xi\omega_n = \frac{B}{M} \Rightarrow B = 2\times0,6\times3,93\times19,2 = 90,5 \text{ Ns/m}$

Em resumo: $M = 19,2 \text{ kg}$; $K = 297 \text{ N/m}$; $B = 90,5 \text{ Ns/m}$

$$\frac{X(s)}{F(s)} = \frac{0,0521}{s^2+4,71s+15,5}$$

b) Mesmo $y_M \Rightarrow \frac{1}{K}$ igual

Mesmo t_s (irrelevante se é 2% ou 5%) $\Rightarrow \xi\omega_n$ igual $\Rightarrow \frac{B}{M}$ igual

Queremos $\frac{1}{M^*s^2+B^*s+K} = \frac{\frac{1}{M^*}}{s^2+\frac{B^*}{M^*}s+\frac{K}{M^*}}$ com $\frac{B^*}{M^*} = \frac{B}{M} = \frac{90,5}{19,2}$ (K não muda)

e com $\xi = \frac{-\log 0,0015}{\sqrt{\pi^2+(\log 0,0015)^2}} = 0,9$

$\frac{B^*}{M^*} = 4,714 = 2\xi\omega_n \Rightarrow \omega_n = \frac{4,714}{2\times0,9} = 2,619$

Ora $\frac{K}{M^*} = \omega_n^2 \Rightarrow \frac{297}{M^*} = 2,619^2 \Rightarrow M^* = \frac{297}{2,619^2} = 43,3 \text{ kg}$

logo $B^* = 43,3\times4,714 = 204 \text{ Ns/m}$

Em resumo $M^* = 43,3 \text{ kg}$; $K = 297 \text{ N/m}$; $B^* = 204 \text{ Ns/m}$