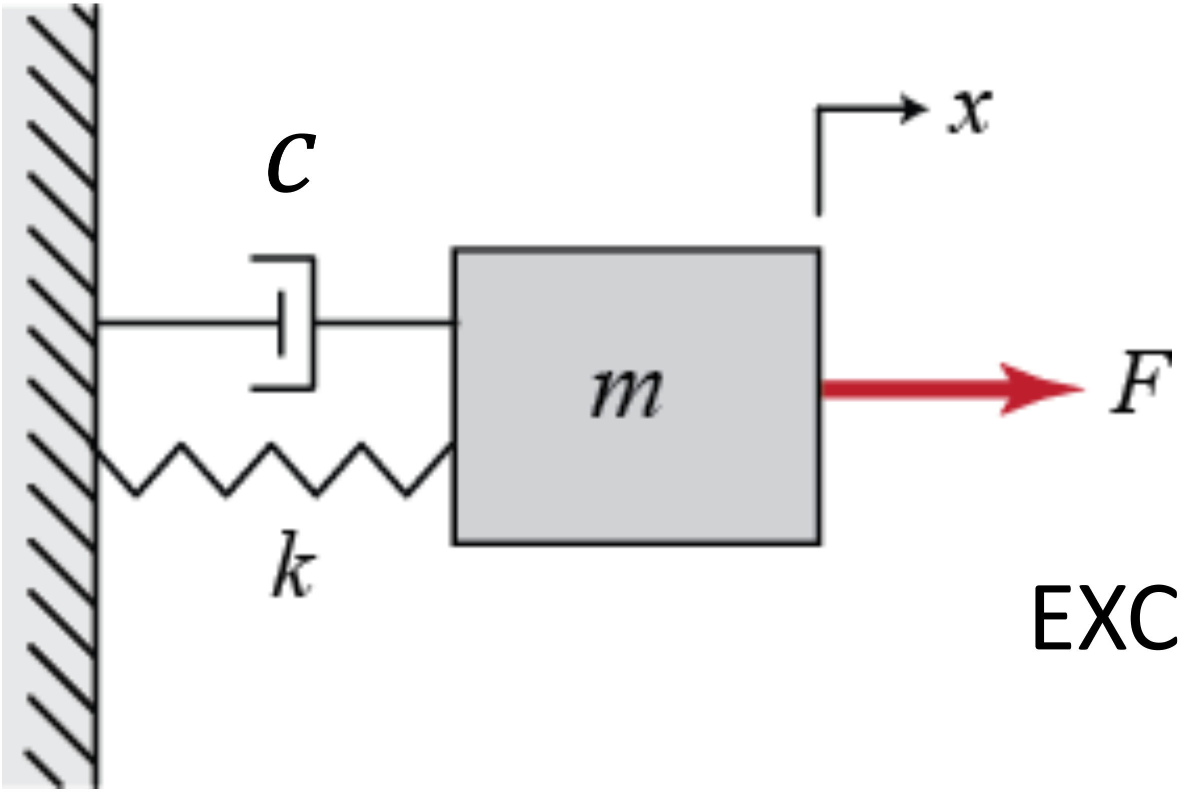
Dinâmica de Sistemas Navais e Oceânicos

PNV3314 Dinâmica de Sistemas

Aula 3



EXCITAÇÃO EXTERNA
INÉRCIA
RIGIDEZ
AMORTECIMENTO

Equação do movimento:
eq. diferencial ordinária linear de segunda ordem

$x = x(t)$

Derivadas de uma única função (x) de uma variável independente (t)

Sem produtos entre x, $\dot{x}$ e $\ddot{x}$

$\ddot{x}$(t)

$$m\ddot{x} + c\dot{x} + kx = F(t)$$

INERCIAL

AMORTECIMENTO (DISSIPAÇÃO)

RIGIDEZ (RESTAURAÇÃO)

FORÇA EXTERNA (EXCITAÇÃO)

Excitação externa: ondas

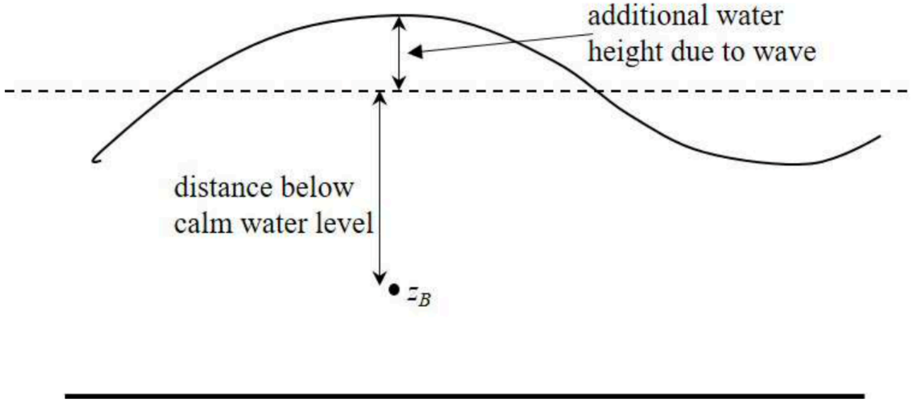


Figure 3.3: Figure showing a point z_B beneath a wave

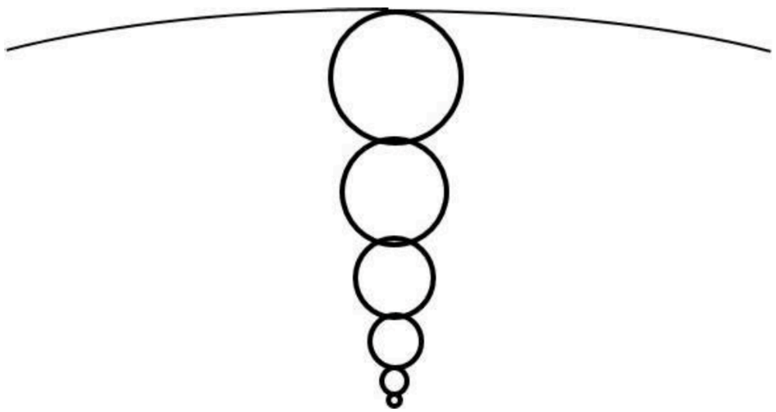


Figure 3.2: Decreasing Particle Motion as a Function of Depth

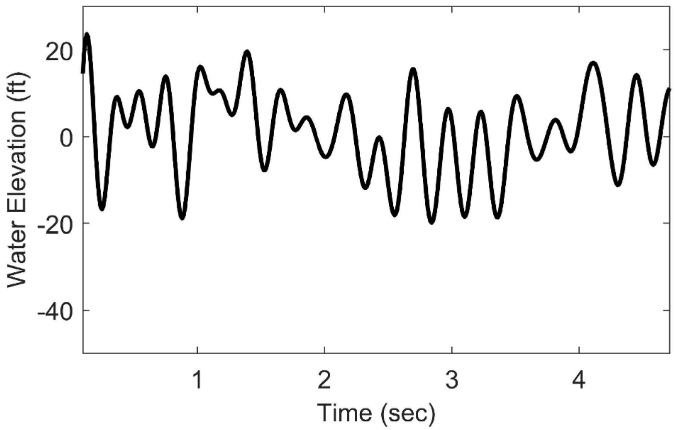


Figure 3.8: Superposition of 50 components

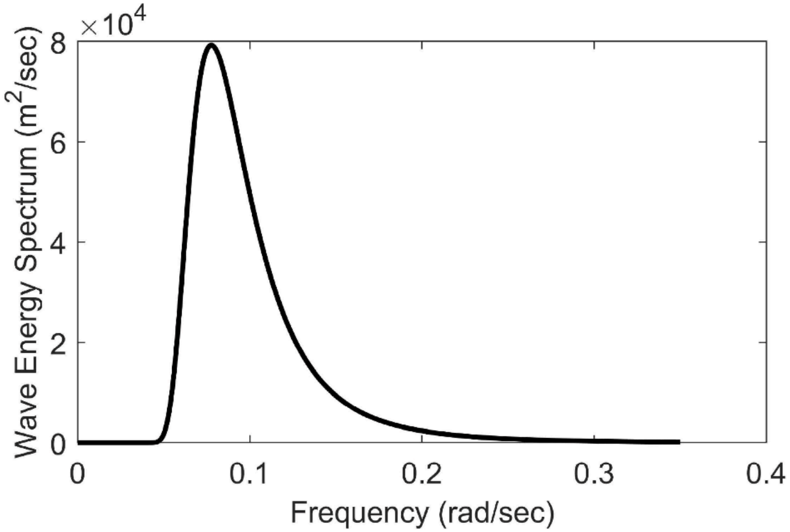


Figure 3.11: Wave Energy Spectrum as number of components approaches ∞

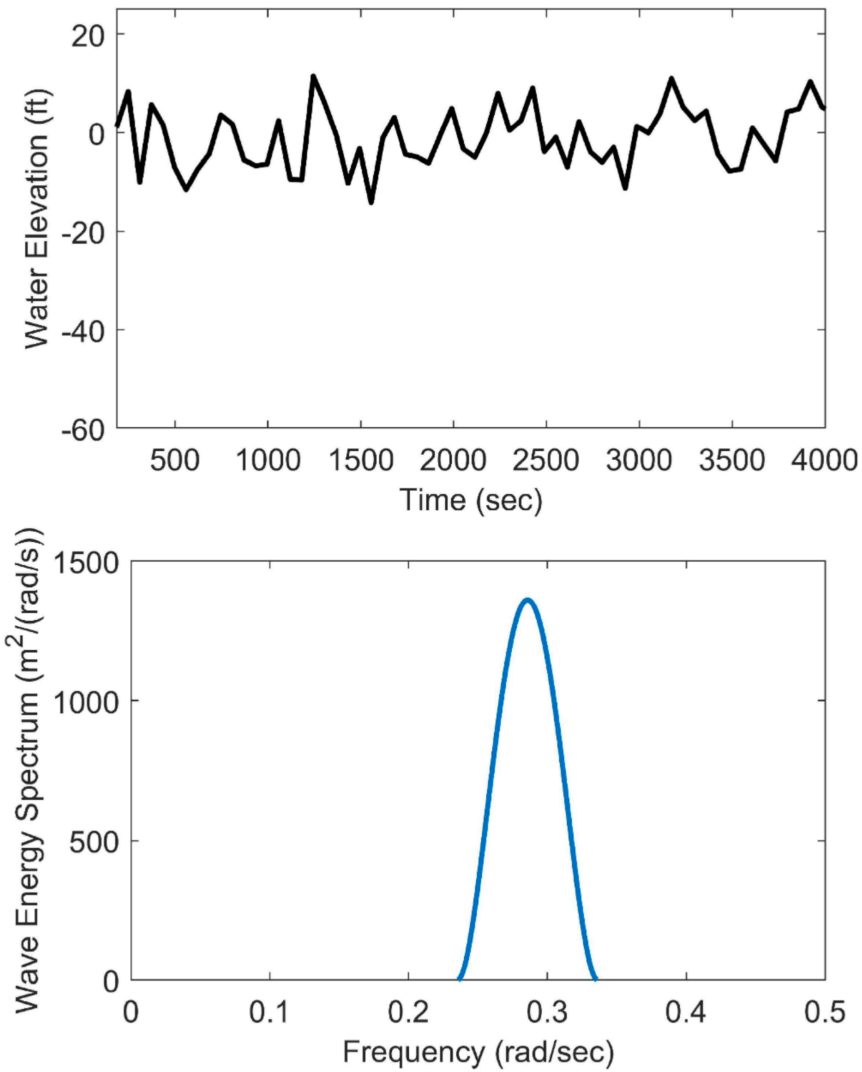


Figure 3.12: Sample Narrow-Banded Wave Energy Spectrum and Water Surface Time History

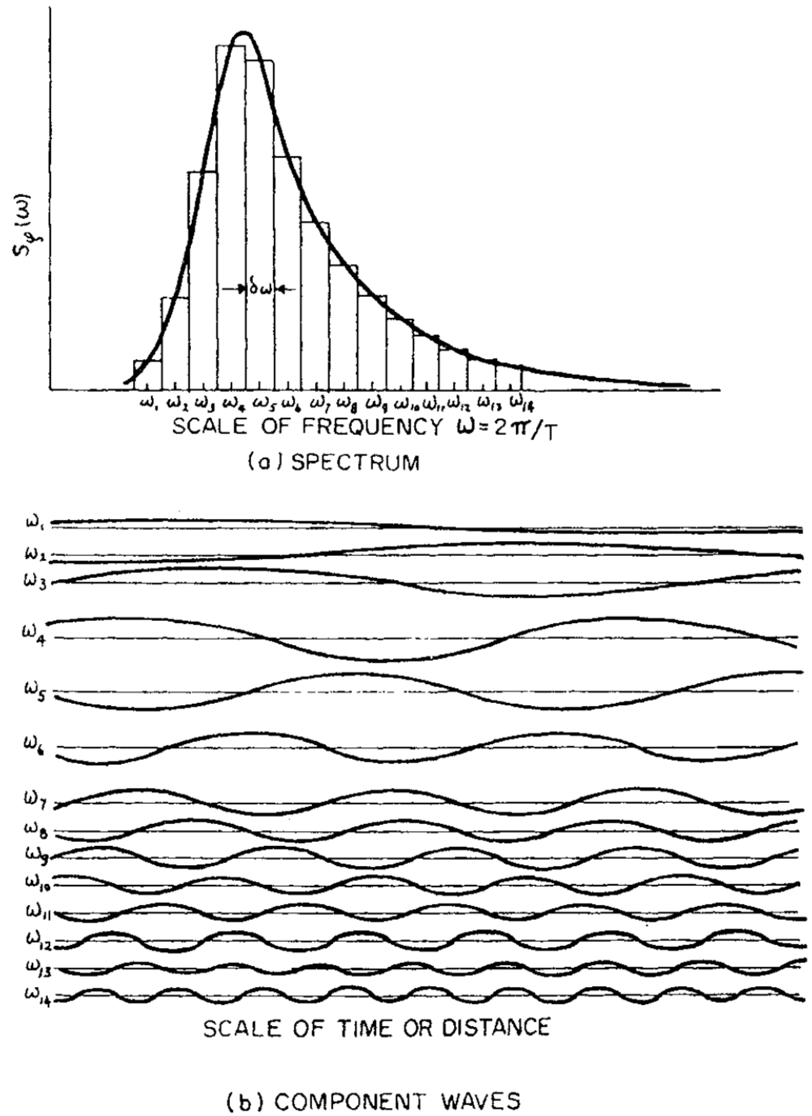


Fig. 8 Typical variance spectrum of waves, showing approximation by a finite sum of components

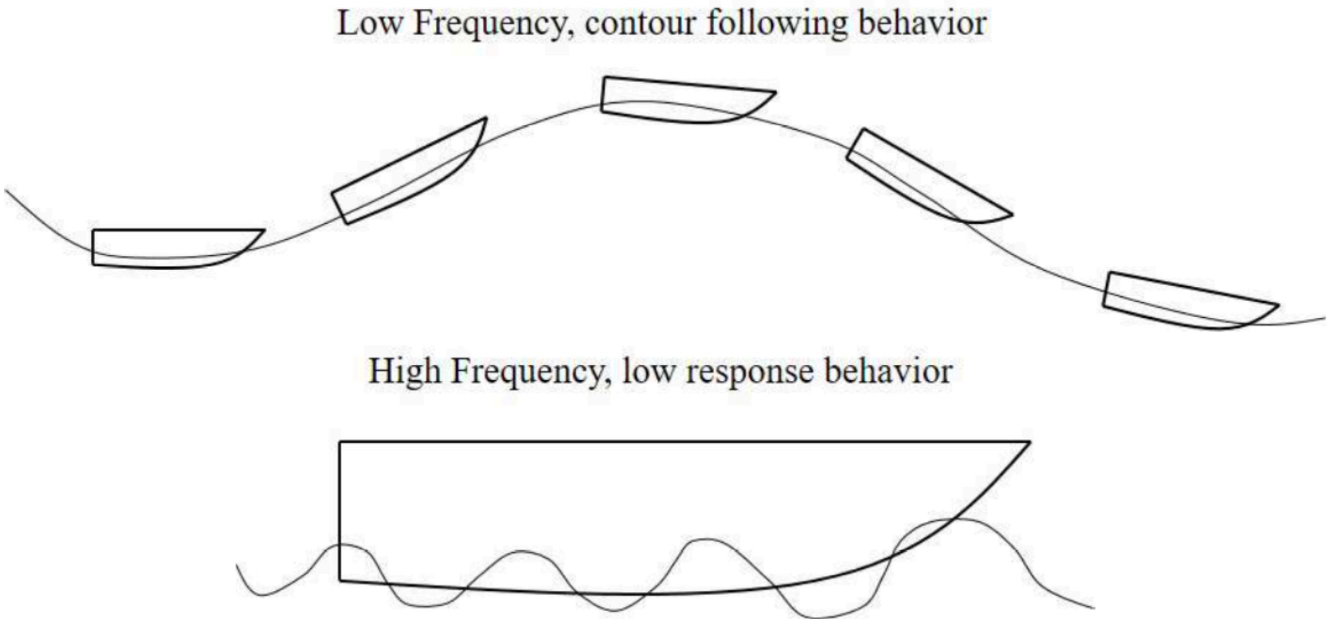


Figure 4.17: Relationship between wave amplitude and ship response

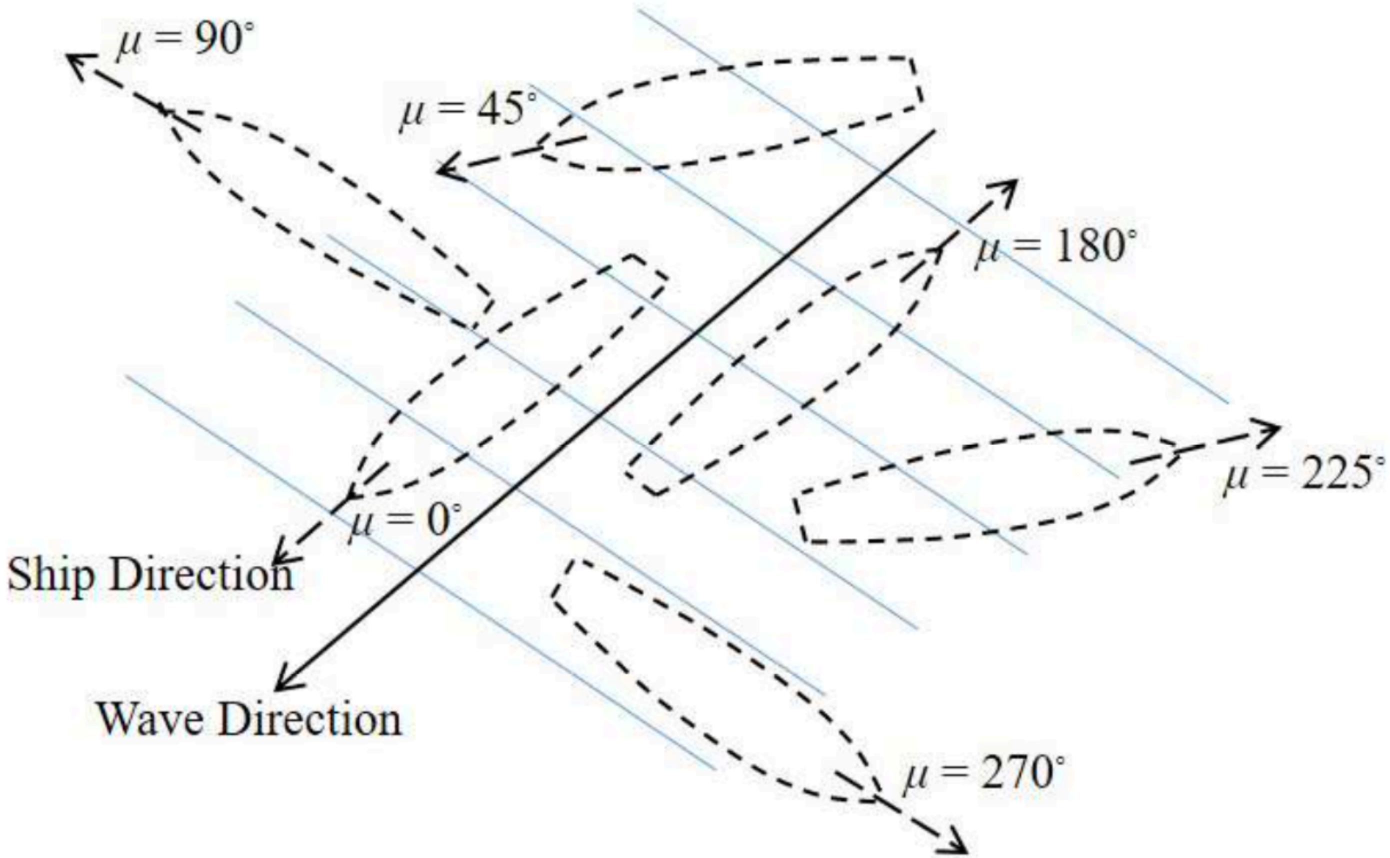
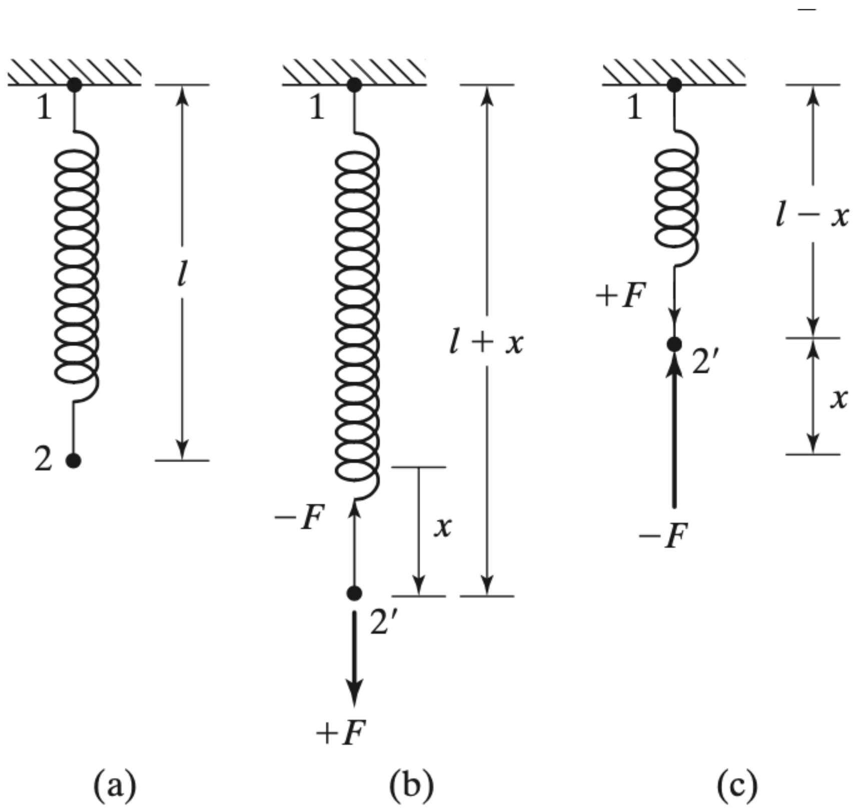


Figure 4.15: Relative ship and wave heading angle, μ

Rigidez

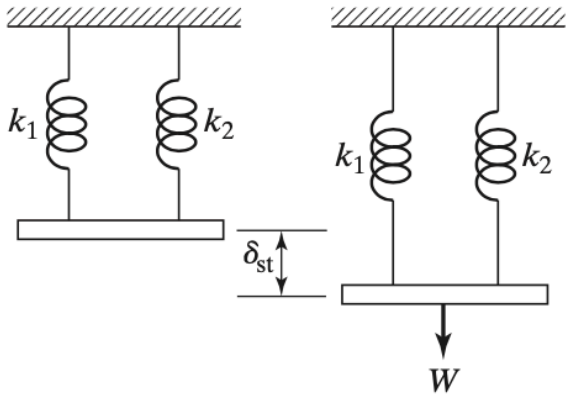
- Mola simples

$$F = kx$$



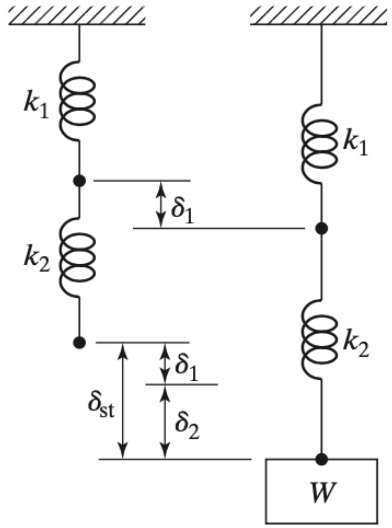
Rigidez

Molas em paralelo



$$k_{eq} = k_1 + k_2 + \cdots + k_n$$

Molas em série



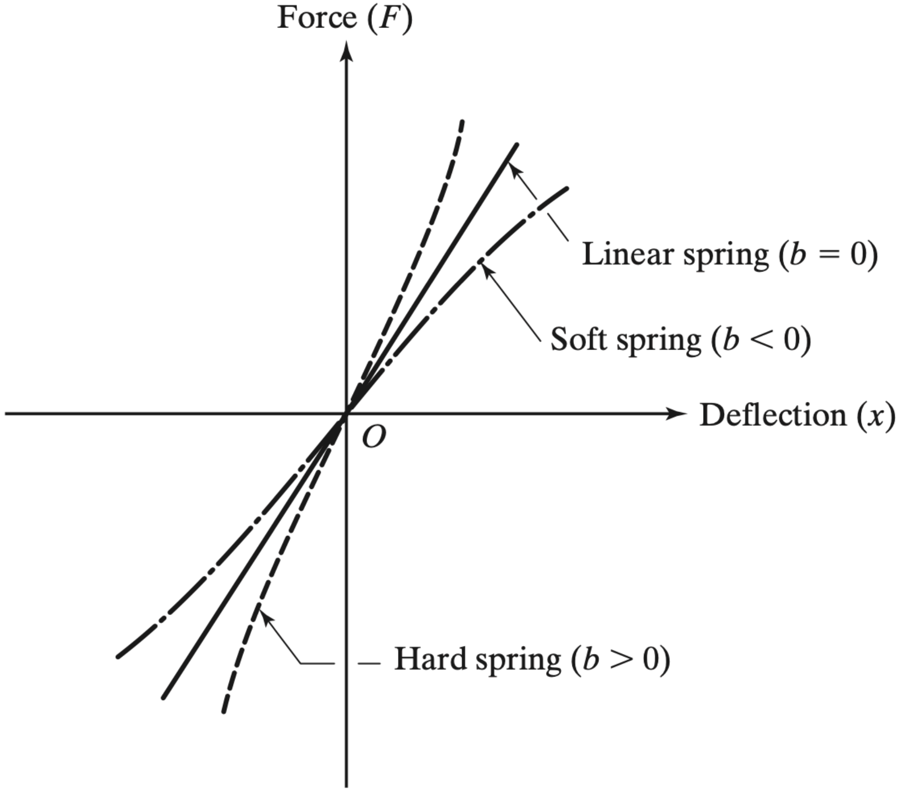
$$\frac{1}{k_{eq}} = \frac{1}{k_1} + \frac{1}{k_2} + \cdots + \frac{1}{k_n}$$

Rigidez

- Mola não linear

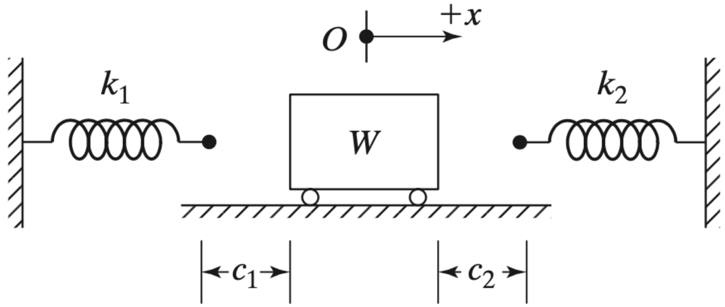
$$F = ax + bx^3$$

$$a > 0$$

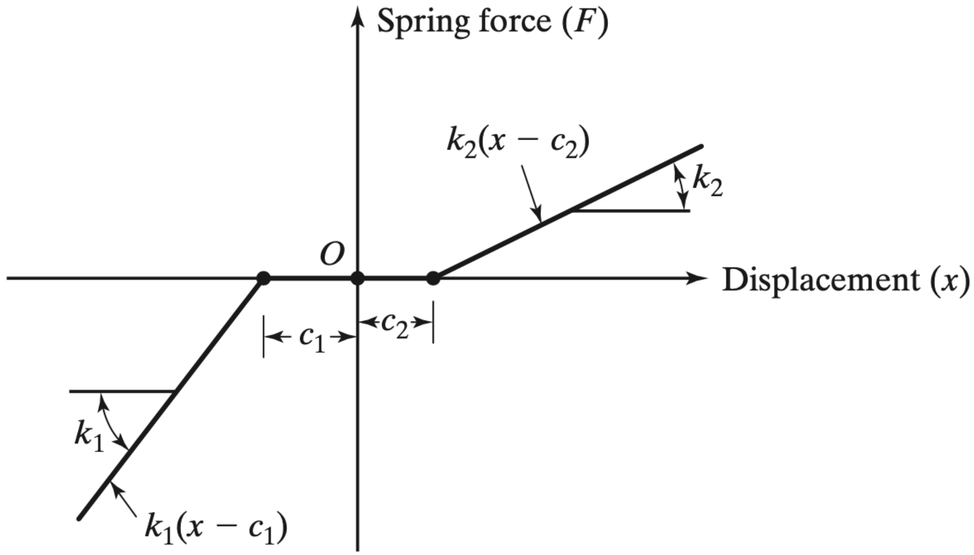


Rigidez

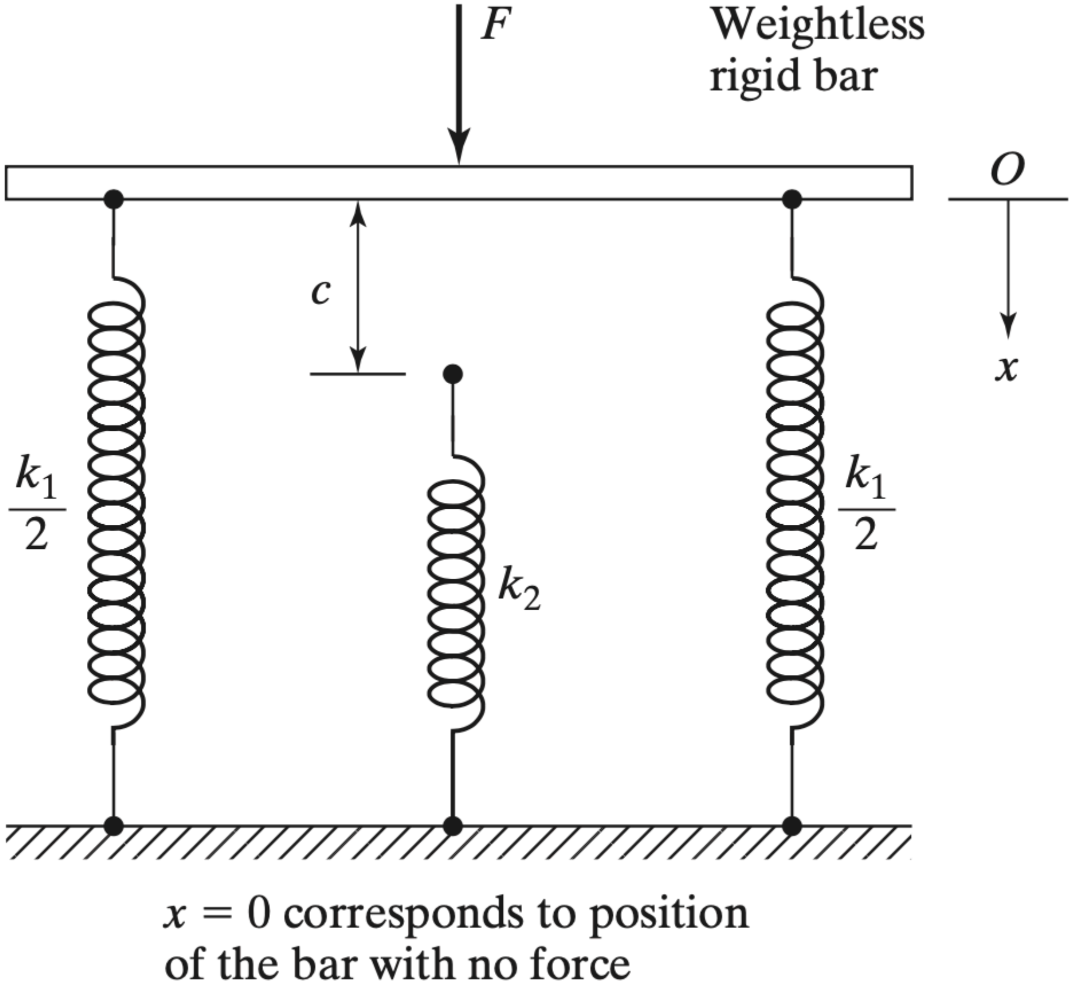
- Mola não linear



(a)

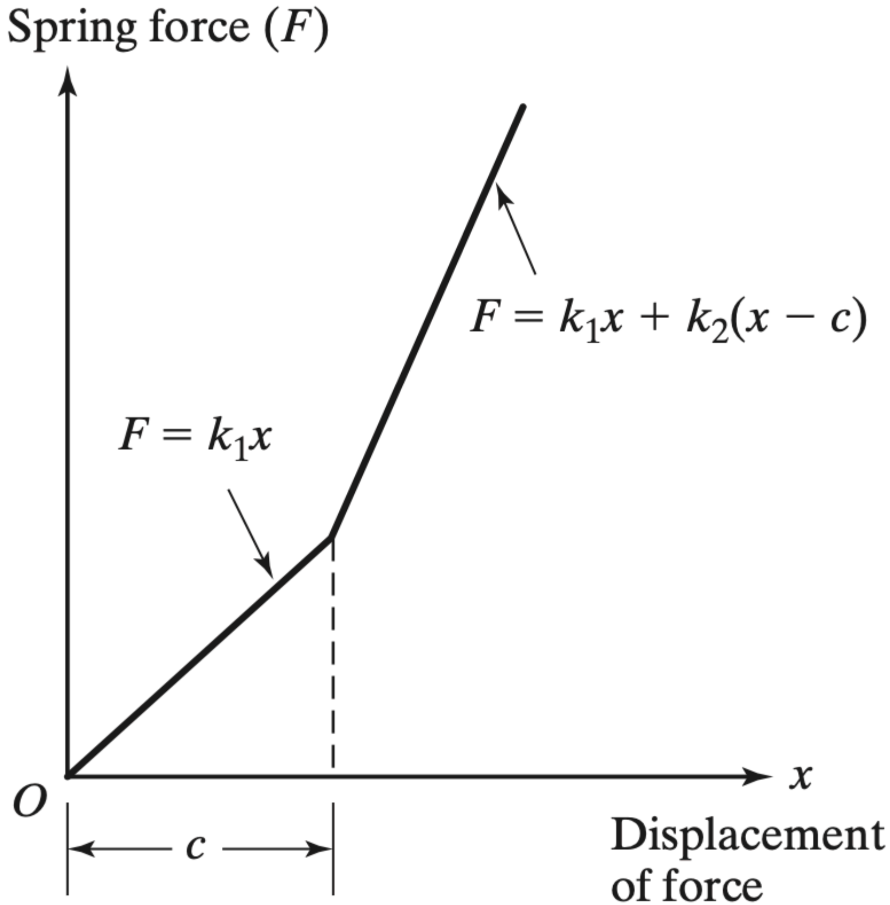


(b)



F
Weightless
rigid bar
O
c
x
$\frac{k_1}{2}$
k_2
$\frac{k_1}{2}$
$x = 0$ corresponds to position
of the bar with no force

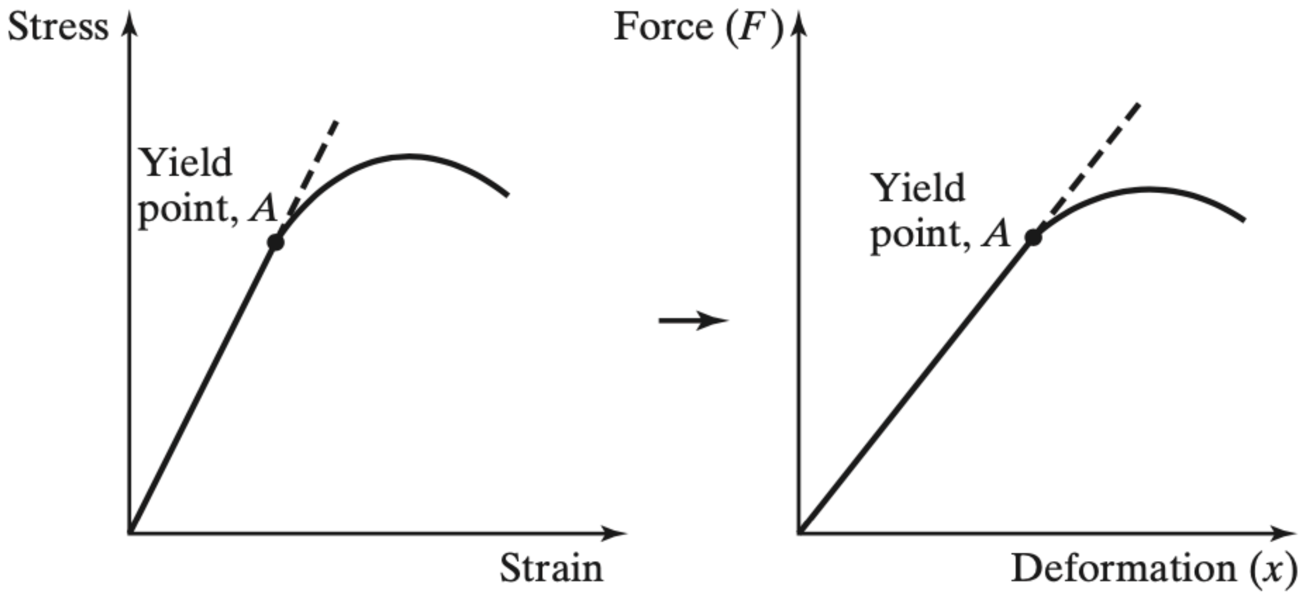
(a)

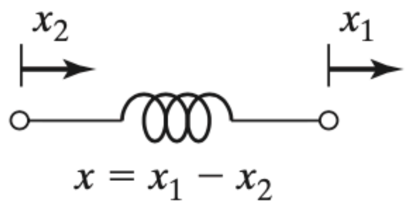


Spring force (F)
$F = k_1x + k_2(x - c)$
$F = k_1x$
O
c
x
Displacement
of force

(b)

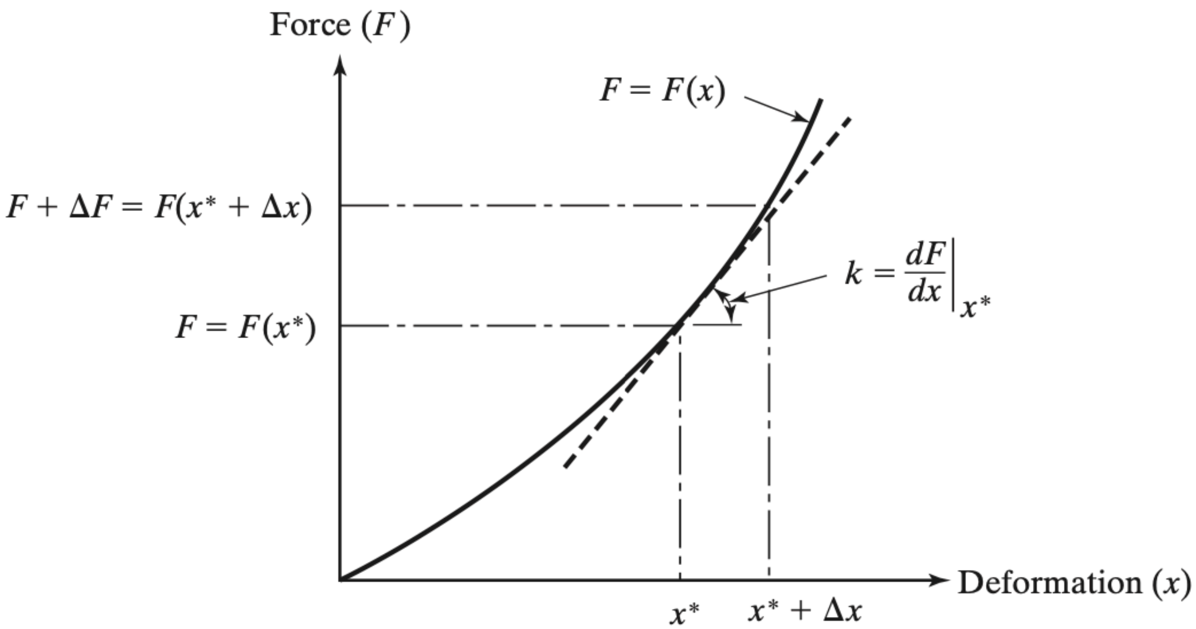
Linearização



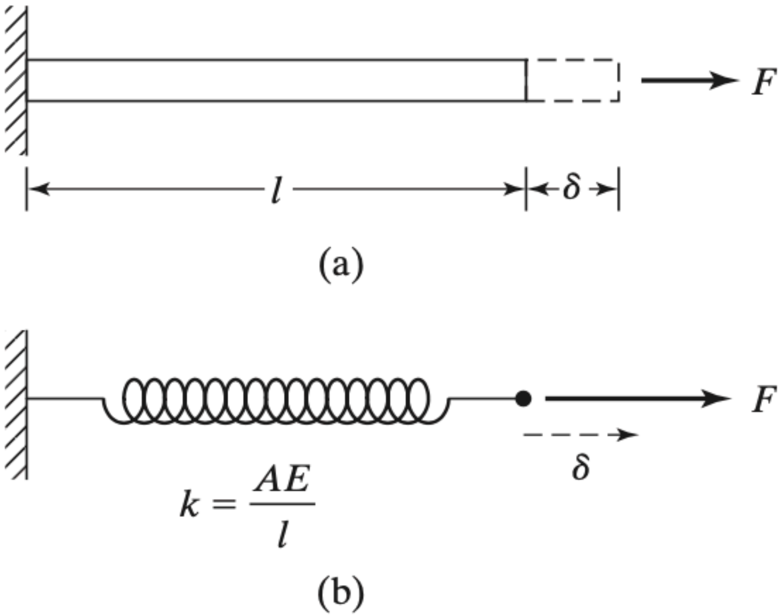


Linearização

$$F + \Delta F = F(x^* + \Delta x)$$
$$= F(x^*) + \left.\frac{dF}{dx}\right|_{x^*} (\Delta x) + \frac{1}{2!}\left.\frac{d^2F}{dx^2}\right|_{x^*} (\Delta x)^2 + \ \ldots$$



Rigidez de uma barra extendida



elongação

extensão (deformação)

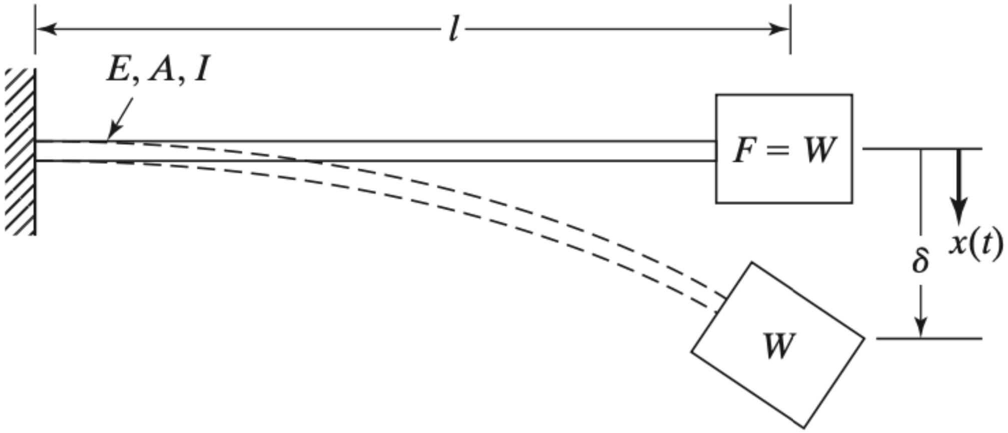
tensão

Módulo de elasticidade (Young)

$$\delta = \frac{\delta}{l}\,l = \varepsilon l = \frac{\sigma}{E}\,l = \frac{Fl}{AE}$$

$$k = \frac{\textit{force applied}}{\textit{resulting deflection}} = \frac{F}{\delta} = \frac{AE}{l}$$

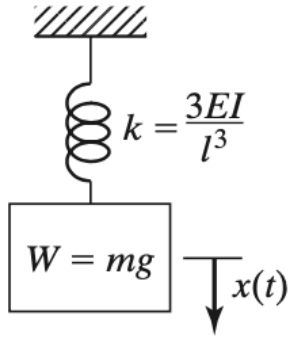
Rigidez equivalente de barra defletida



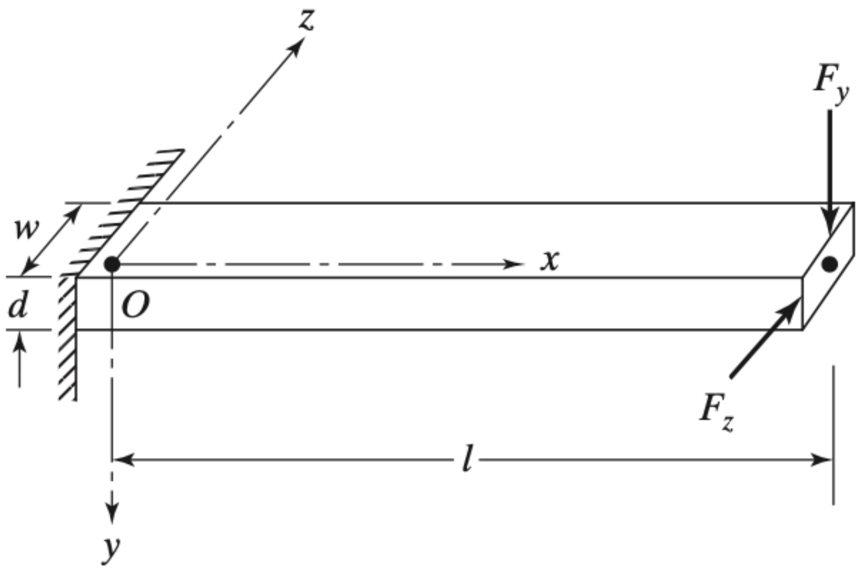
(a) Cantilever with end force

$$\delta = \frac{Wl^3}{3EI}$$

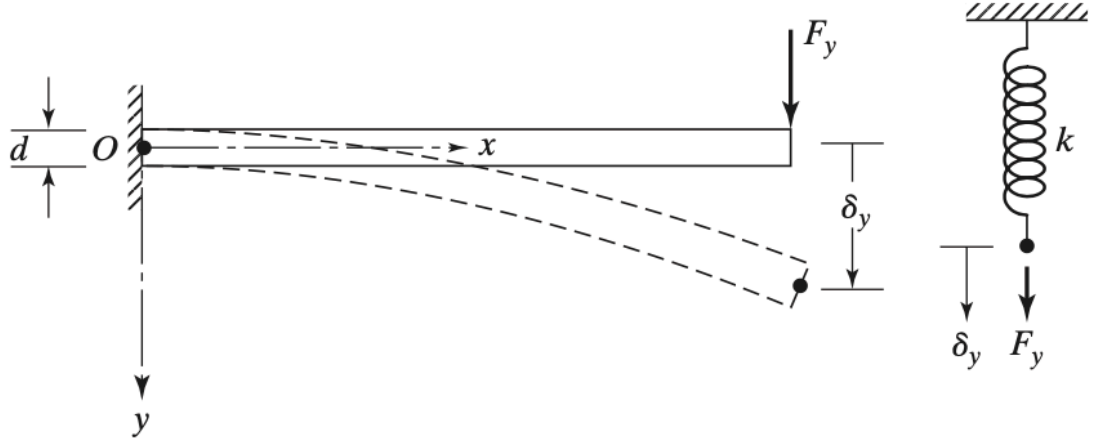
$$k = \frac{W}{\delta} = \frac{3EI}{l^3}$$



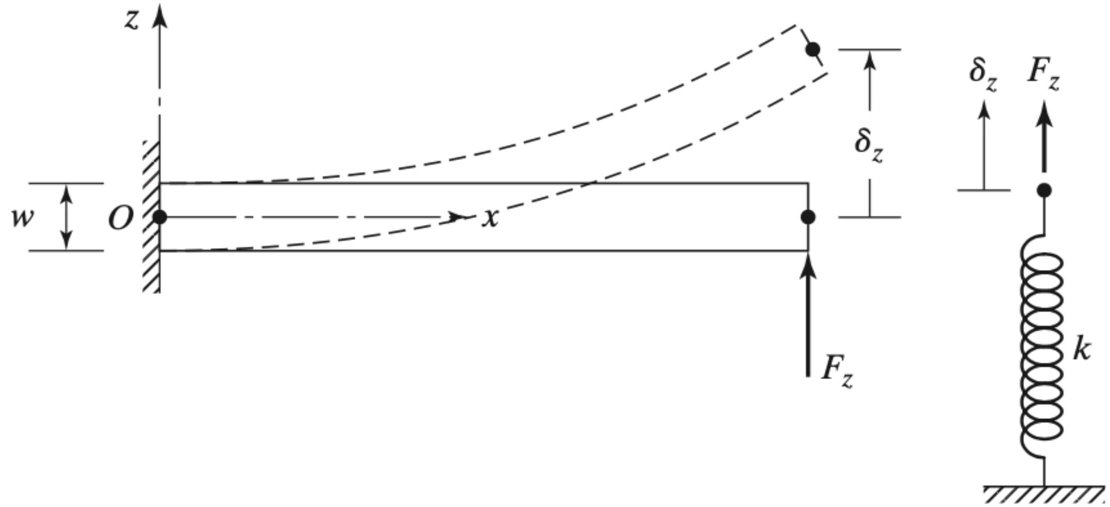
(b) Equivalent spring



(a)

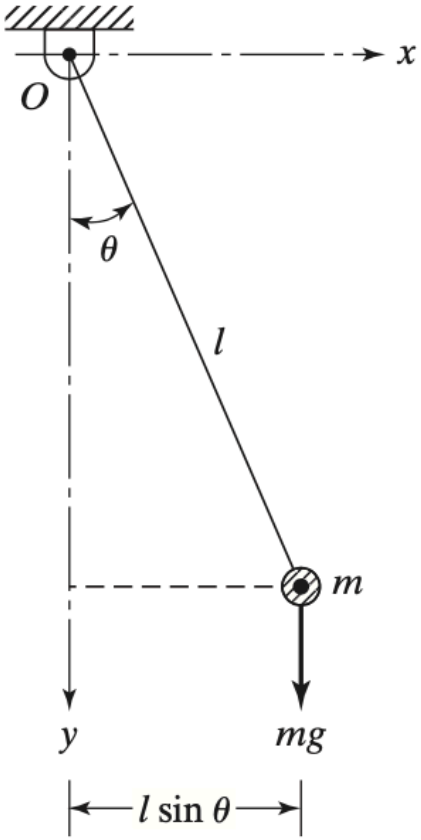


(b)



(c)

Restauração gravitacional



$$T = mg(l \sin \theta)$$

$$T = mgl\theta$$

$$k_t = mgl$$

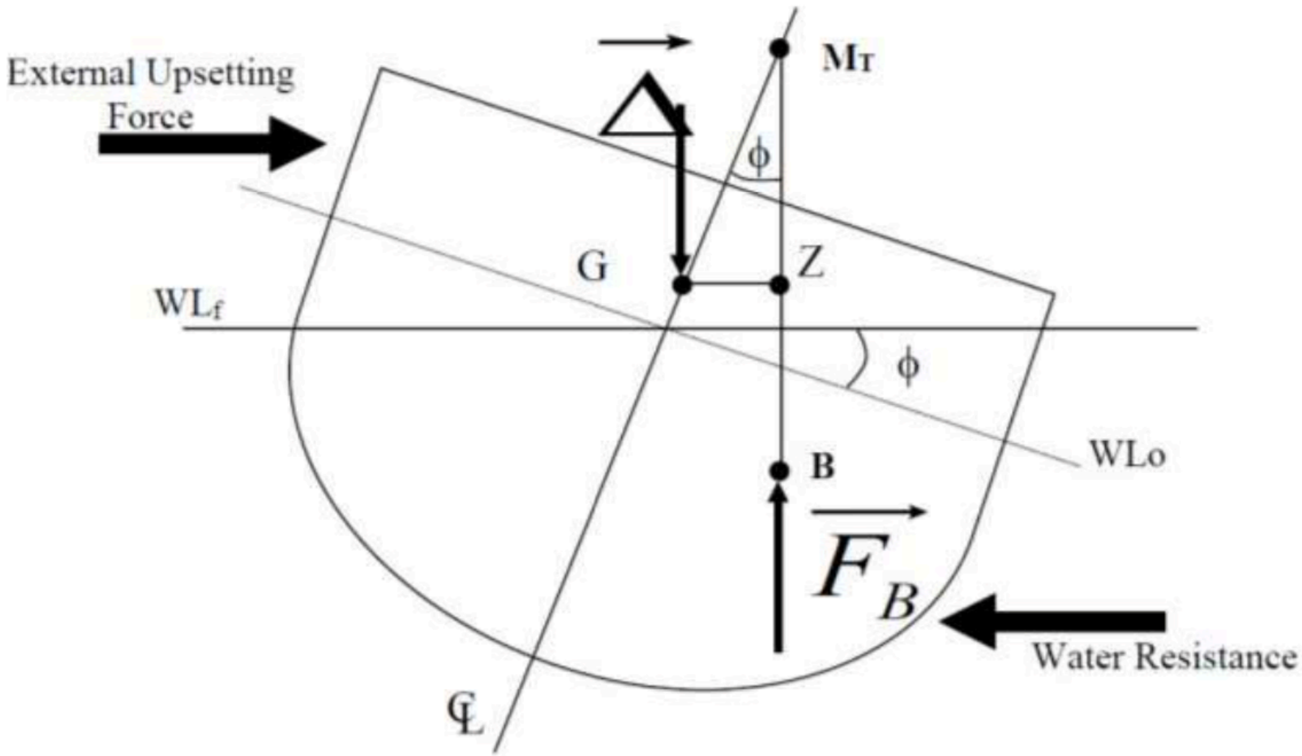


Figure 2.1: Heeled Ship due to an external moment

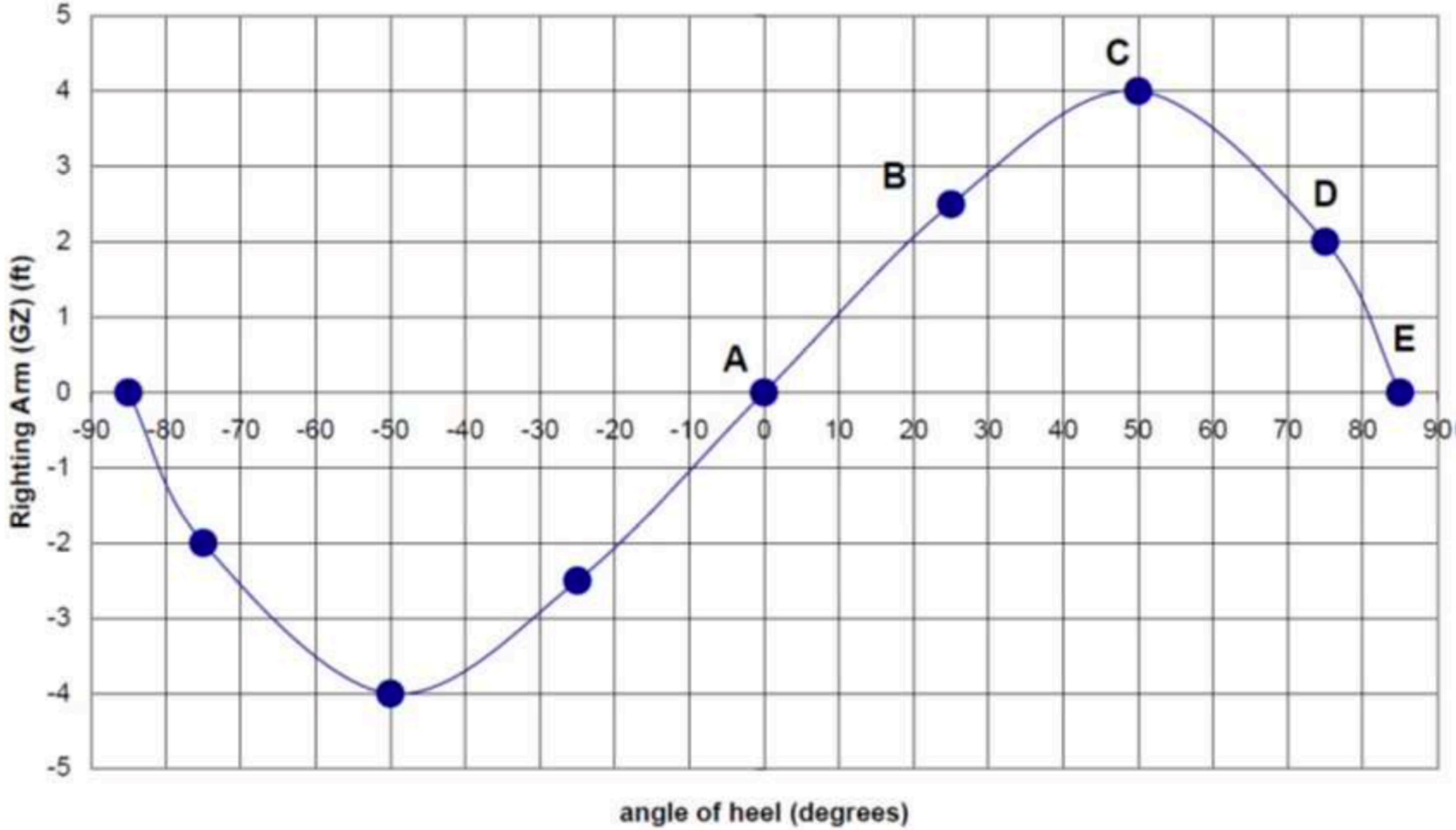


Figure 2.2: Curve of Intact Statical Stability