Exercícios propostos

Livro do Prof. Brunetti

Exercícios 1.1 - 1.3 - 1.5

1.1 - Resolução

Objetivo: manuseio das propriedades e transformação de unidades.

Lembrar que ao transformar a unidade utiliza-se a regra seguinte:

$$\text{Valor da grandeza na unidade nova} = \text{Valor da grandeza na unidade velha} \times \frac{\text{Unidade nova x Fator de transformação}}{\text{Unidade velha}}$$

Exemplo

Transformar 3 m em cm.

$$3\,\text{m} = 3\,\cancel{\text{m}} \times \frac{\text{cm} \times 100}{\cancel{\text{m}}} = 3 \times 100\,\text{cm} = 300\text{cm}$$

Solução do exercício.

$$\mu = \nu\rho$$

1.1 - Resolução (cont)

$$\gamma = \gamma_r \gamma_{H_2O} = 0{,}85 \times 1.000 \frac{\text{kgf}}{\text{m}^3} = 850 \frac{\text{kgf}}{\text{m}^3}$$

$$\rho = \frac{\gamma}{g} = \frac{850}{10} = 85 \frac{\text{utm}}{\text{m}^3}$$

$$\mu = 0{,}028 \times 85 = 2{,}38 \frac{\text{kgf.s}}{\text{m}^2}$$

$$\mu = 2{,}38 \frac{\text{kgf.s}}{\text{m}^2} = 2{,}38 \frac{\cancel{\text{kgf}}\left(\frac{\text{N} \times 9{,}8}{\cancel{\text{kgf}}}\right)\text{.s}}{\text{m}^2} = 23{,}3 \frac{\text{N.s}}{\text{m}^2}$$

$$\mu = 23{,}3 \frac{\text{N.s}}{\text{m}^2} = 23{,}3 \frac{\cancel{\text{N}}\left(\frac{\text{dina} \times 10^5}{\cancel{\text{N}}}\right)\text{.s}}{\cancel{\text{m}^2}\left(\frac{\text{cm}^2 \times 10^4}{\cancel{\text{m}^2}}\right)} = 233 \frac{\text{dina.s}}{\text{cm}^2} \text{ ou poise}$$

1.2 - Resolução

$$\gamma = \gamma_r \times \gamma_{H_2O} = 0{,}82 \times 1000 = 820 \frac{kgf}{m^3}$$

$$\rho = \frac{\gamma}{g} = \frac{820}{10} = 82 \frac{utm}{m^3} (ou \frac{kgf \times s^2}{m^4})$$

$$\nu = \frac{\mu}{\rho} = \frac{5 \times 10^{-4}}{82} \cong 6{,}1 \times 10^{-6} \frac{m^2}{s} (MK^*S \text{ e } SI)$$

$$\nu = 6{,}1 \times 10^{-6} \times 10^4 = 6{,}1 \times 10^{-2} \frac{cm^2}{s} (ou \ St)$$

1.3 - Resolução

$$V = 3\ dm^3 = 3x10^{-3}\ m^3$$

$$\gamma = \frac{G}{V} = \frac{23,5}{3\times10^{-3}} = 7833\frac{N}{m^3}$$

$$\rho = \frac{\gamma}{g} = \frac{7833}{10} = 783,3\frac{kg}{m^3}$$

$$\mu = \nu\rho = 10^{-5}\times783,3 = 7,83\times10^{-3}\frac{N.s}{m^2} \quad \left(\text{não esquecer que kg} = \frac{N}{\frac{m}{s^2}}\right)$$

$$\mu = 7,83\times10^{-3}\frac{N.s}{m^2} = 7,83\times10^{-3}\frac{N\left(\frac{dina\times10^5}{N}\right).s}{m^2\left(\frac{cm^2\times10^4}{m^2}\right)} = 7,83\times10^{-2}\frac{dina.s}{cm^2}\ \text{ou poise}$$

$$\mu = 7,83\times10^{-3}\frac{N.s}{m^2} = 7,83\times10^{-3}\frac{N\left(\frac{kgf}{N\times9,8}\right).s}{m^2} = 8\times10^{-4}\frac{kgf.s}{m^2}$$

1.3 – Resolução (cont.)

$$\mu = 7{,}83\times10^{-3}\,\frac{\text{N.s}}{\text{m}^2} = 7{,}83\times10^{-3}\,\frac{\text{N.s}\left(\dfrac{\text{min}}{\text{s}\times60}\right)}{\text{m}^2\left(\dfrac{\text{km}^2}{\text{m}^2\times10^6}\right)} = 130{,}5\,\frac{\text{N.min}}{\text{km}^2}$$

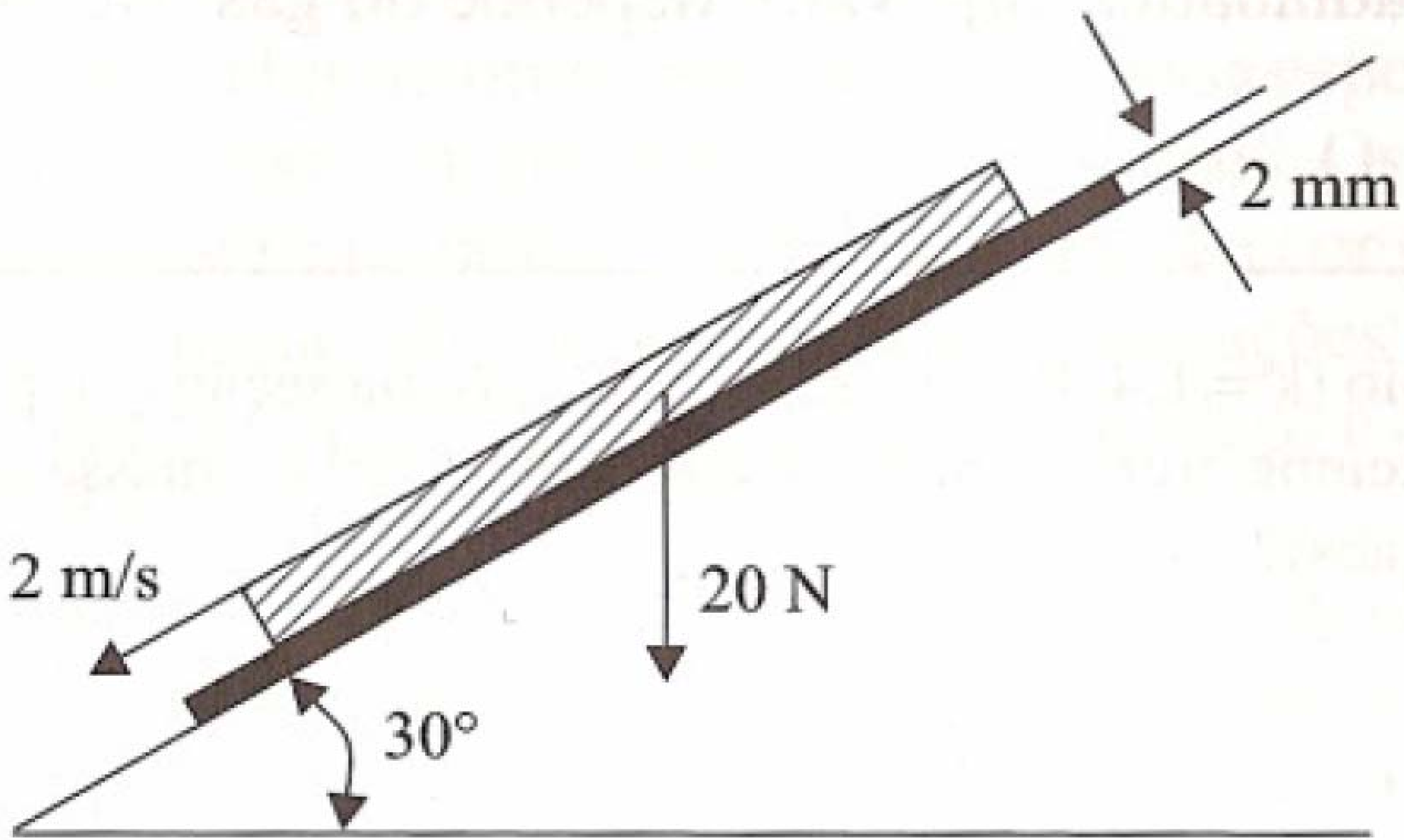
É claro que esta última unidade só foi considerada para que se pratique a transformação.

1.4 - Resolução

$$\nu = \frac{\mu}{\rho} \therefore \mu = \nu \times \rho = 0{,}1 \times 10^{-4} \times 830 = 0{,}0083\,\text{Pa} \times \text{s}$$

$$\tau = \mu \times \frac{v}{\varepsilon} = 0{,}0083 \times \frac{4}{2 \times 10^{-3}} = 16{,}6\,\frac{\text{N}}{\text{m}^2}\,(\text{ou Pa})$$

1.5 -



Resolução

Sendo constante a velocidade da placa, deve haver um equilíbrio dinâmico na direção do movimento, isto é, a força motora (a que provoca o movimento) deve ser equilibrada por uma força resistente (de mesma direção e sentido contrário).

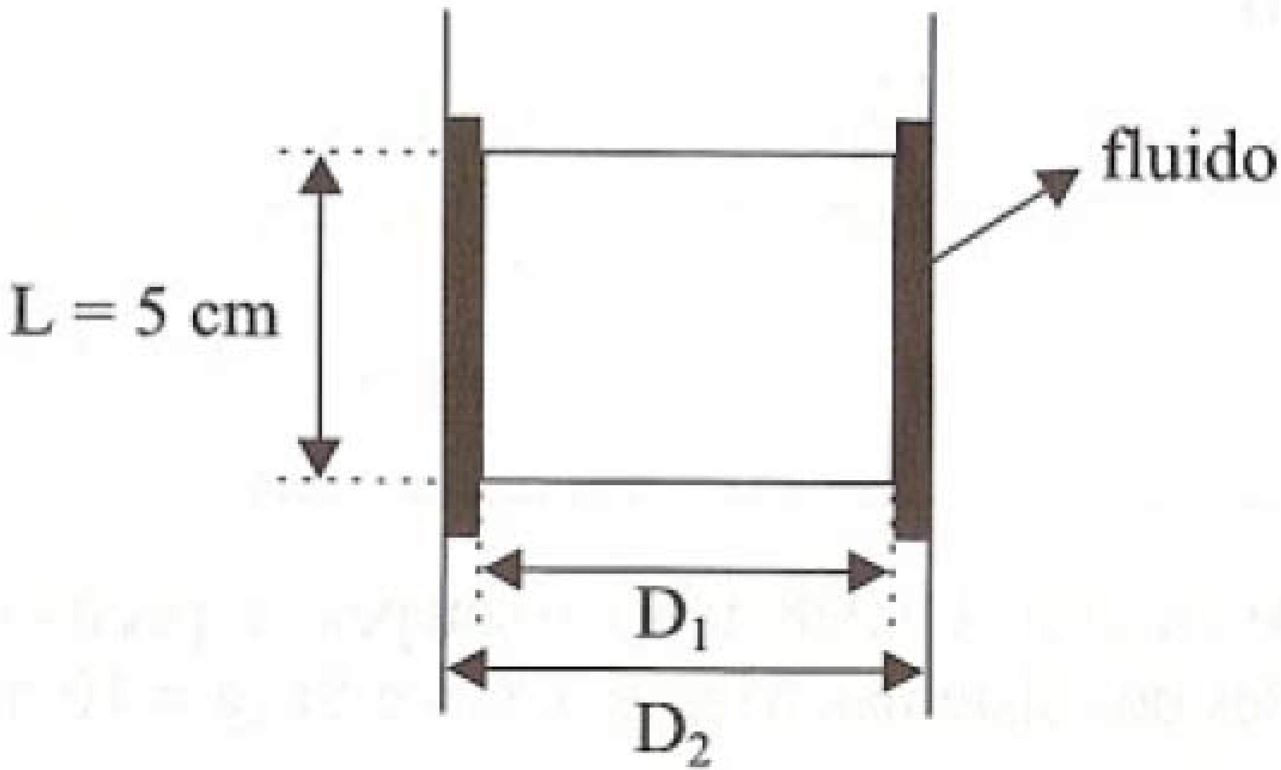
$$G \operatorname{sen} 30^{o} = F_t$$

$$G \operatorname{sen} 30^{o} = \tau A$$

$$G \operatorname{sen} 30^{o} = \mu \frac{v}{\varepsilon} A$$

$$\mu = \frac{\varepsilon G \operatorname{sen} 30^{o}}{vA} = \frac{2 \times 10^{-3} \times 20 \times \operatorname{sen} 30^{o}}{2 \times 1 \times 1} = 10^{-2} \frac{N.s}{m^2}$$

1.6



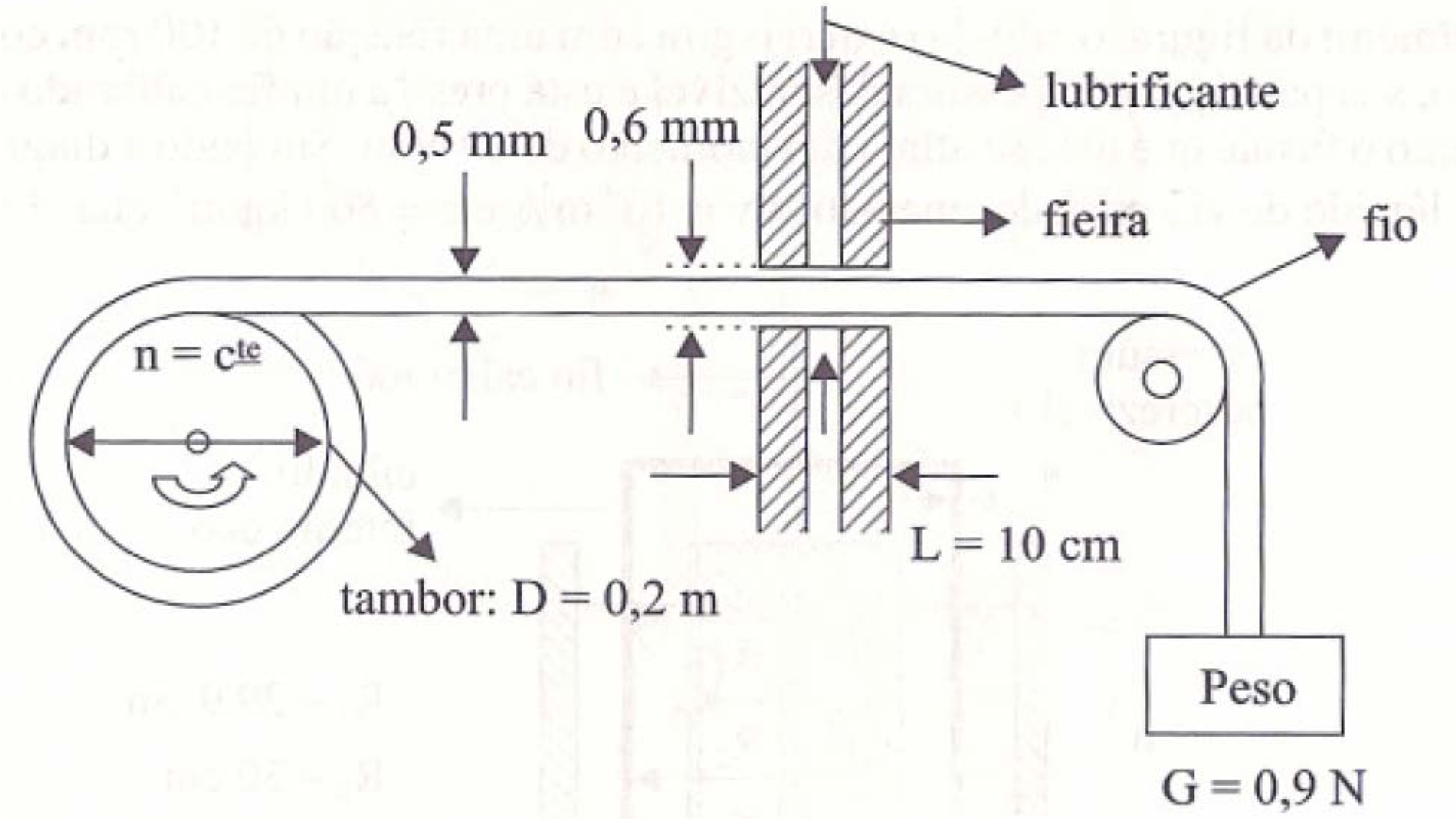
1.6 - Resolução

Supondo o cilindro em repouso tem - se :

$$0,5\times 10 = 10^{-4}\times \frac{8000}{10}\times \frac{v}{\frac{(10-9)\times 10^{-2}}{2}}\times \pi \times 0,09\times 0,05$$

$$\therefore v = \frac{0,5\times 10\times 10\times 0,5\times 10^{-2}}{10^{-4}\times 8000\times \pi \times 0,09\times 0,05} \cong 22,1\frac{m}{s}$$

1.7



lubrificante
0,5 mm
0,6 mm
fieira
fio
n = c^te
L = 10 cm
tambor: D = 0,2 m
Peso
G = 0,9 N

Resolução

Para o equilíbrio dinâmico, a força de tração será igual ao peso do esticador somada à força tangencial provocada pelo lubrificante na fieira.

$$T = F_t + G$$

$$\text{Logo:} \quad F_{t_{máx}} = T - G = 1 - 0{,}9 = 0{,}1\,\text{N}$$

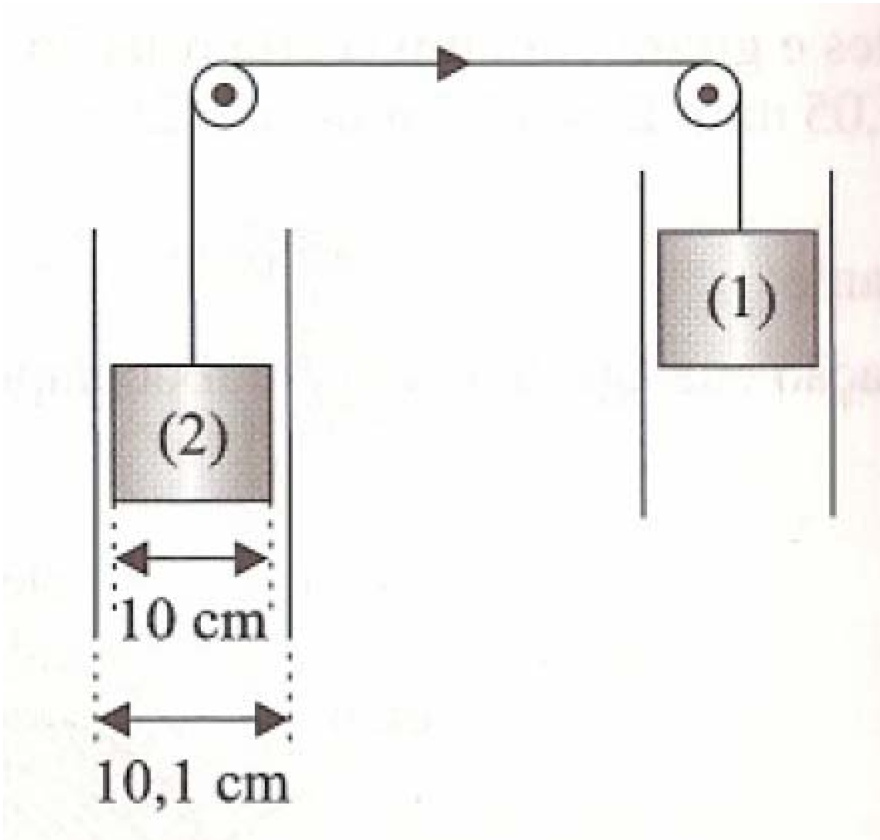
$$F_t = \tau A = \mu \frac{v}{\varepsilon} A \qquad \varepsilon = \frac{0{,}6 - 0{,}5}{2} = 0{,}05\,\text{mm}$$

$$v = \pi n D = \pi \times \frac{30}{60} \times 0{,}2 = 0{,}314\,\frac{\text{m}}{\text{s}}$$

$$\mu = \frac{\varepsilon F_t}{vA} = \frac{\varepsilon F_t}{v\pi dL} = \frac{0{,}05 \times 10^{-3} \times 0{,}1}{0{,}314 \times \pi \times 0{,}5 \times 10^{-3} \times 0{,}1} = 0{,}1\,\frac{\text{N.s}}{\text{m}^2}$$

$$M = T\frac{D}{2} = 1 \times \frac{0{,}2}{2} = 0{,}1\,\text{N.m}$$

1.8



1.8 - Resolução

$$A = \pi \times 0{,}1 \times L \text{ e } V = \frac{\pi \times 0{,}1^2}{4} \times L$$

$$F_{\mu_1} = F_{\mu_2} = 10^{-2} \times \frac{2}{\frac{0{,}1 \times 10^{-2}}{2}} \times A = 40 \times A$$

$$T = G_2 + 40 \times A \text{ e } G_1 = T + 40 \times A$$

$$\therefore G_1 = G_2 + 80 \times A$$

$$\text{Como } \gamma = \frac{G}{V} \text{ e } V_1 = V_2 \text{ tem-se que:}$$

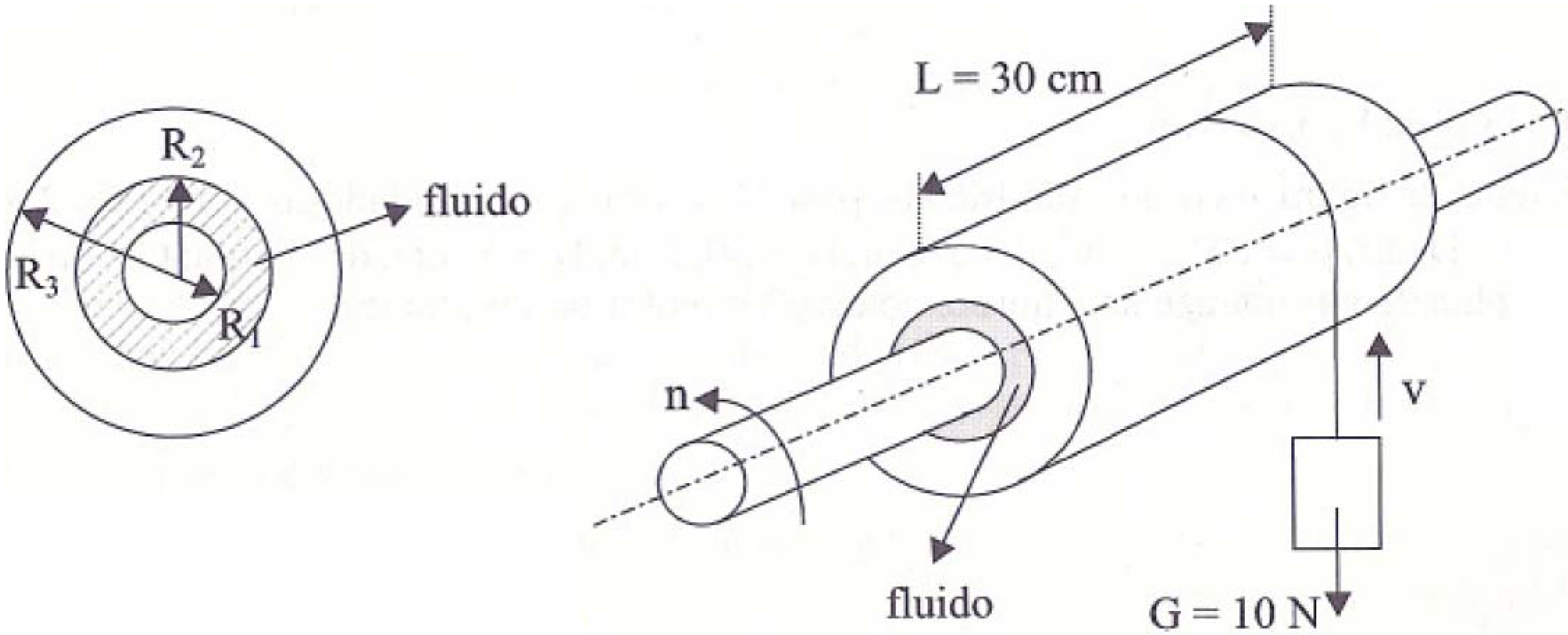
$$\gamma_1 \times V = \gamma_2 \times V + 80 \times A \ (\div V)$$

$$\gamma_1 = \gamma_2 + 80 \times \frac{A}{V} \therefore 20000 = \gamma_2 + 80 \times \frac{\pi \times 0{,}1 \times L}{\frac{\pi \times 0{,}1^2}{4} \times L}$$

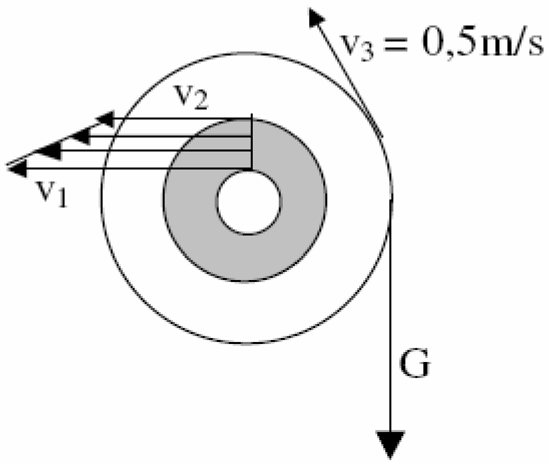
$$20000 = \gamma_2 + 80 \times 40 \therefore 20000 = \gamma_2 + 3200$$

$$\gamma_2 = 16800 \frac{N}{m^3}$$

1.9



Resolução



$$M_\tau = M_G$$

$$\mu \frac{\Delta v}{\varepsilon} 2\pi R_2 L R_2 = G R_3$$

$$\varepsilon = R_2 - R_1 = 10{,}1 - 10 = 0{,}1\,\text{cm}$$

$$\Delta v = \frac{G R_3 \varepsilon}{\mu 2\pi L R_2^2} = \frac{10\times 0{,}2\times 0{,}1\times 10^{-2}}{0{,}1\times 2\times \pi\times 0{,}3\times 0{,}101^2} = 1{,}04\,\text{m/s}$$

$$v_2 = v_3 \frac{R_2}{R_3} = 0{,}5\times \frac{0{,}101}{0{,}2} = 0{,}2525\,\text{m/s}$$

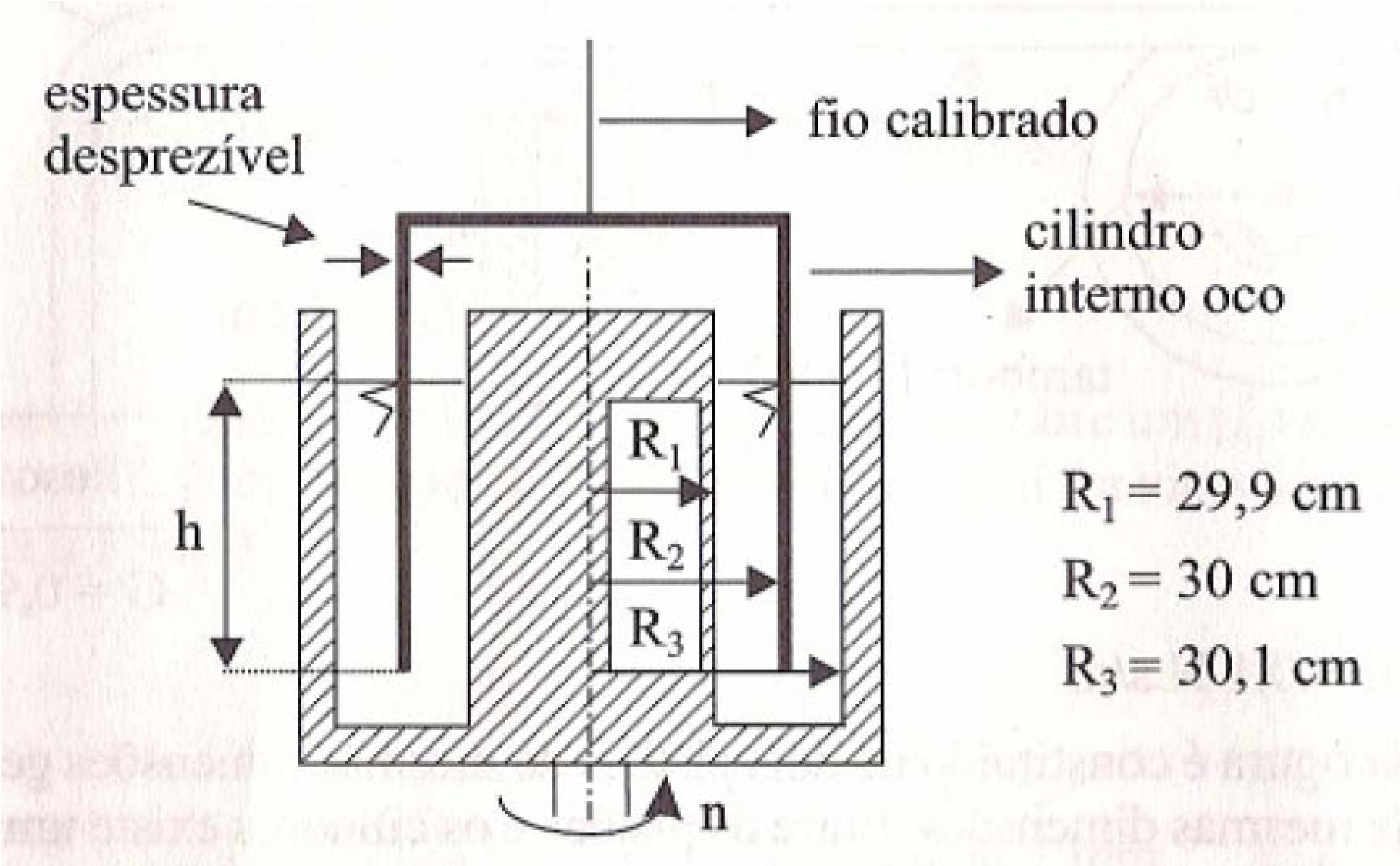
$$v_1 = \Delta v + v_2 = 1{,}04 + 0{,}2525 = 1{,}29\,\text{m/s}$$

$$v_1 = 2\pi n_1 R_1 \quad \rightarrow \quad n_1 = \frac{v_1}{2\pi R_1} = \frac{1{,}29}{2\times\pi\times 0{,}1}\times 60 = 123\text{rpm}$$

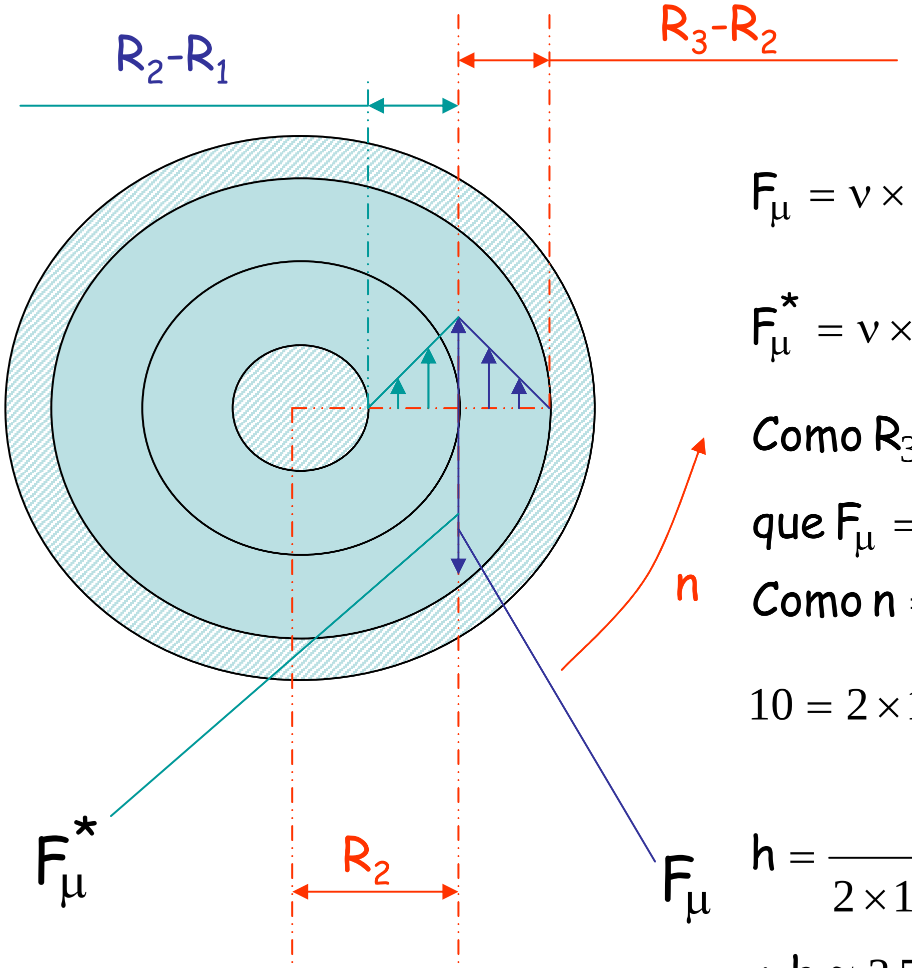
$$M_e = \tau A_1 R_1 = \mu \frac{\Delta v}{\varepsilon} 2\pi R_1 L R_1 = 2\pi\mu \frac{\Delta v}{\varepsilon} L R_1^2$$

$$M_e = 2\times\pi\times 0{,}1\times \frac{1{,}04}{0{,}1\times 10^{-2}}\times 0{,}3\times 0{,}1^2 = 2\,\text{N.m}$$

1.10


espessura
desprezível
fio calibrado
cilindro
interno oco
h
R1
R2
R3
n
R1 = 29,9 cm
R2 = 30 cm
R3 = 30,1 cm

1.10 - Resolução



$$F_\mu = \nu \times \rho \times \frac{2\pi n \times R_2}{R_3 - R_2} \times 2\pi R_2 h$$

$$F_\mu^* = \nu \times \rho \times \frac{2\pi n \times R_2}{R_2 - R_1} \times 2\pi R_2 h$$

Como $R_3 - R_2 = R_2 - R_1$ pode-se afirmar

que $F_\mu = F_\mu^*$

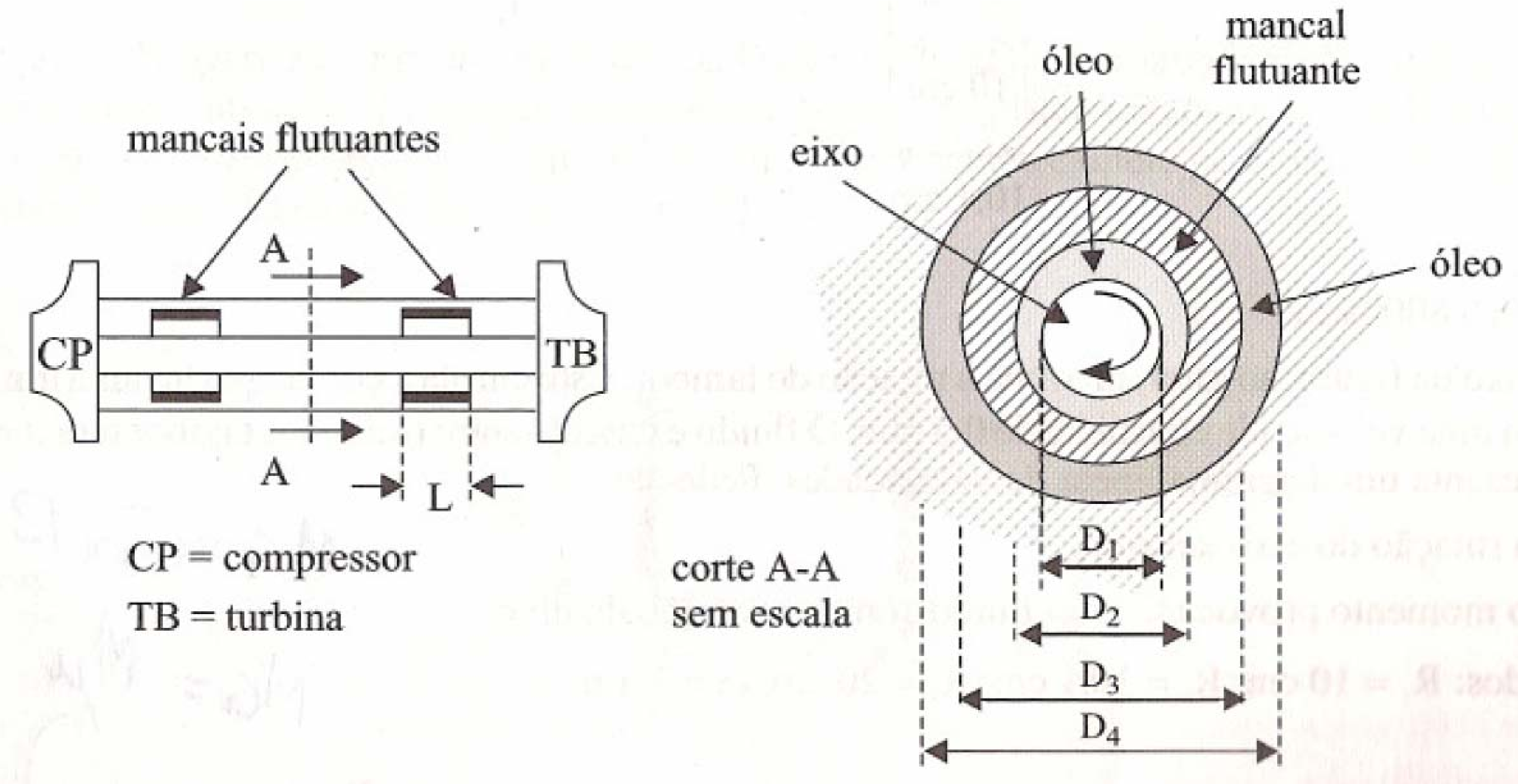
Como $n = cte \Rightarrow M_m = 2 \times F_\mu \times R_2$

$$10 = 2 \times 10^{-4} \times 800 \times \frac{2\pi \times 100 \times 0{,}3}{60 \times 0{,}1 \times 10^{-2}} \times 2\pi \times 0{,}3 \times h \times 0{,}3$$

$$h = \frac{10 \times 60 \times 0{,}1 \times 10^{-2}}{2 \times 10^{-4} \times 800 \times 2\pi \times 100 \times 0{,}3 \times 2\pi \times 0{,}3 \times 0{,}3}$$

$$\therefore h \cong 3{,}52 \times 10^{-2} m = 3{,}52 cm$$

1.11



mancais flutuantes
A
A
CP
TB
L
CP = compressor
TB = turbina
eixo
óleo
mancal
flutuante
óleo
corte A-A
sem escala
D1
D2
D3
D4

Resolução

$$M_{\tau_{int}} = M_{\tau_{ext}}$$

$$\mu \frac{v_1 - v_2}{\varepsilon_{1,2}} \pi D_2 L \frac{D_2}{2} = \mu \frac{v_3}{\varepsilon_{3,4}} \pi D_3 L \frac{D_3}{2}$$

$$\varepsilon_{1,2} = \frac{D_2 - D_1}{2} = \frac{12{,}05 - 12}{2} = 0{,}025\,\text{mm}$$

$$\varepsilon_{3,4} = \frac{D_4 - D_3}{2} = \frac{15{,}1 - 15{,}05}{2} = 0{,}025\,\text{mm}$$

$$\frac{v_1 - v_2}{v_3} = \left(\frac{D_3}{D_2}\right)^2 = \left(\frac{15{,}05}{12{,}05}\right)^2 = 1{,}56$$

$$\frac{\pi n D_1 - \pi n' D_2}{\pi n' D_3} = 1{,}56$$

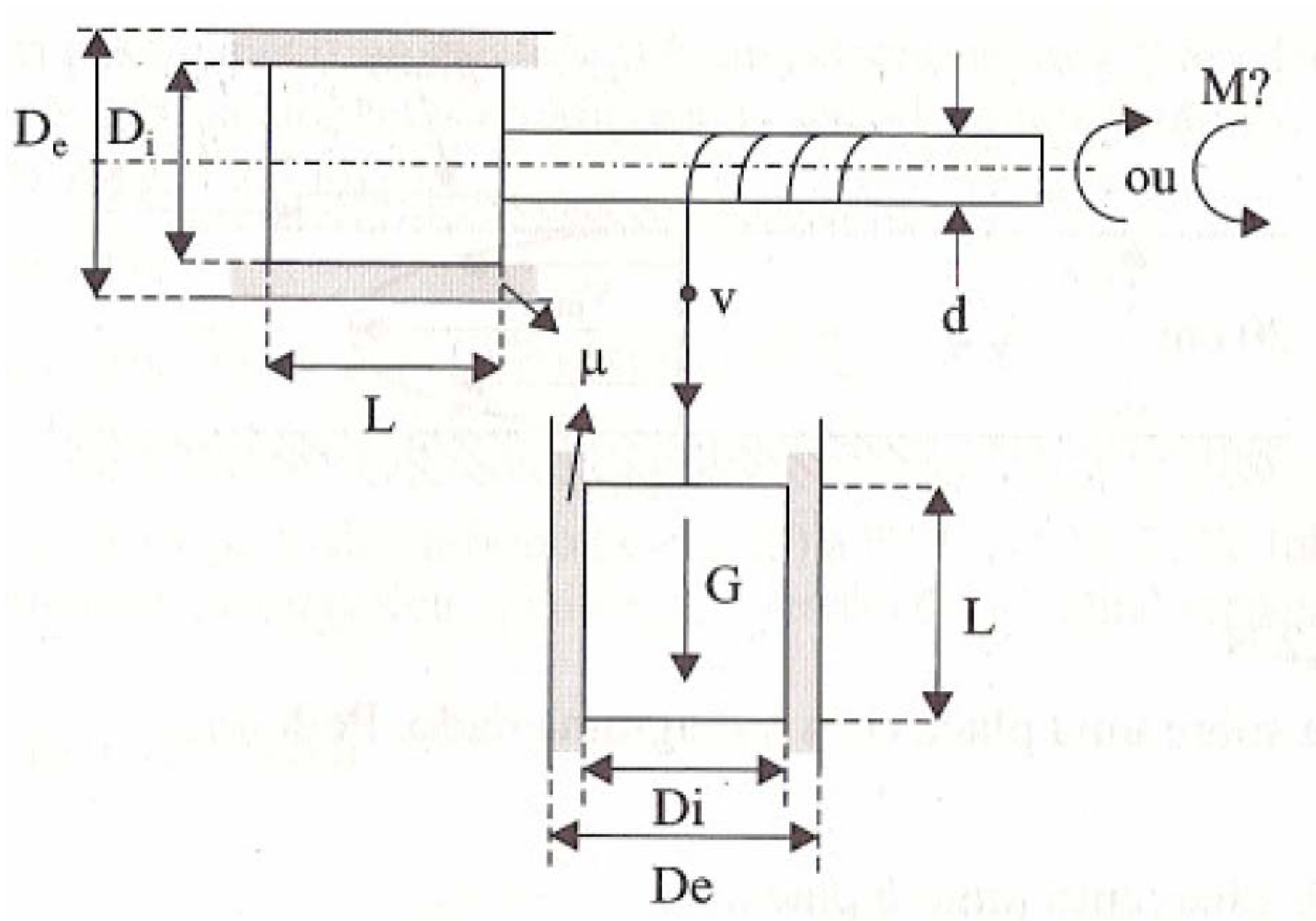
$$n' = \frac{n D_1}{1{,}56 D_3 + D_2} = \frac{120.000 \times 12}{1{,}56 \times 15{,}05 + 12{,}05} = 40.531\,\text{rpm}$$

$$M = 2\mu \frac{\Delta v}{\varepsilon} \pi D_1 L \frac{D_1}{2} = \frac{\pi \mu L D_1^2}{\varepsilon}(\pi D_1 n - \pi D_2 n')$$

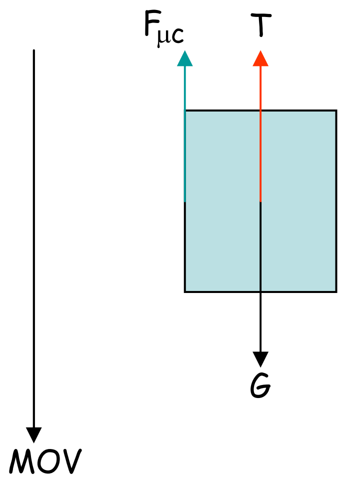
$$M = \frac{\pi^2 \mu L D_1^2}{\varepsilon}(D_1 n - D_2 n')$$

$$M = \frac{\pi^2 \times 8 \times 10^{-3} \times 0{,}02 \times 0{,}012^2}{0{,}025 \times 10^{-3}} \left(0{,}012 \times \frac{120.000}{60} - 0{,}01205 \times \frac{40.531}{60}\right) = 0{,}14\,\text{N.m}$$

1.12



1.12 - Resolução



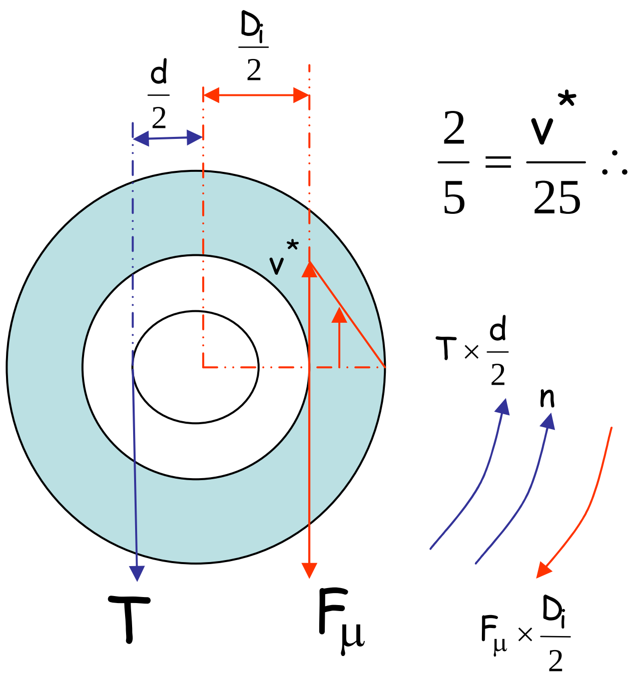
$v = 2\frac{m}{s} = cte$

$$T = G - F_{\mu c} = G - \mu \frac{v}{\varepsilon} \pi D_i L$$

$$T = 50 - 10^{-3} \times \frac{2}{(\frac{50{,}2 - 50}{2}) \times 10^{-2}} \times \pi \times 0{,}5 \times \frac{2}{\pi}$$

$$\therefore T = 48N$$

1.12 - Resolução (cont.)



$$\frac{2}{5} = \frac{v^*}{25} \therefore v^* = 10\frac{m}{s}$$

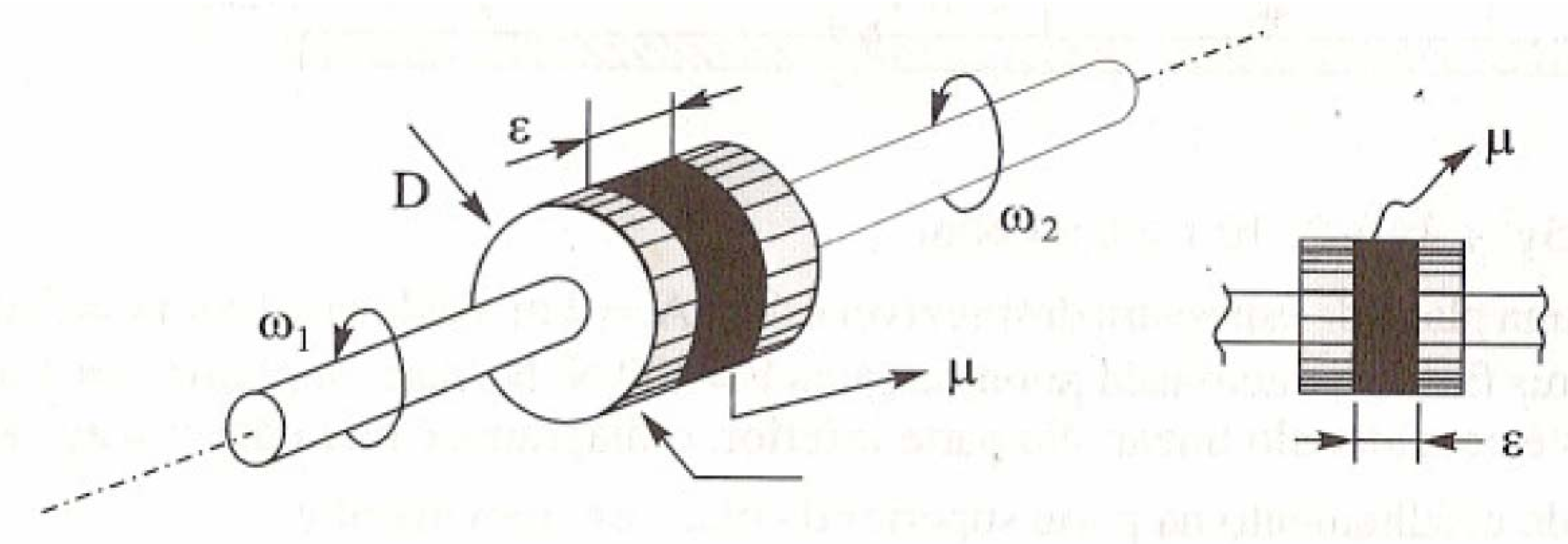
$$M_1 = T \times \frac{d}{2} = 48 \times \frac{0{,}1}{2} = 2{,}4\ Nm$$

$$M_2 = F_\mu \times \frac{D_i}{2} = 10^{-3} \times \frac{10}{\left(\frac{50{,}2 - 50}{2}\right) \times 10^{-2}} \times \pi \times 0{,}5 \times \frac{2}{\pi} \times \frac{0{,}5}{2} = 2{,}5\ Nm$$

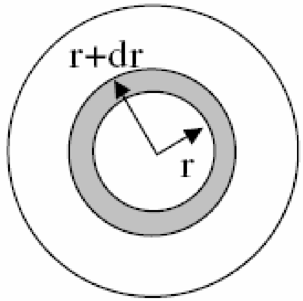
Como $M_2 > M_1$ pode - se concluir que deve existir um momento M na direção da rotação, ou seja, motor que será igual a $M = M_2 - M_1$

$M = 2{,}5 - 2{,}4 = 0{,}1\ Nm$

1.13



1.13 - Res



$$dM_t = \tau dAr = \mu \frac{v_1 - v_2}{\varepsilon} 2\pi r dr.r = \mu \frac{(\omega_1 - \omega_2)r}{\varepsilon} 2\pi r dr.r$$

$$dM_t = \frac{2\pi\mu(\omega_1 - \omega_2)}{\varepsilon} r^3 dr$$

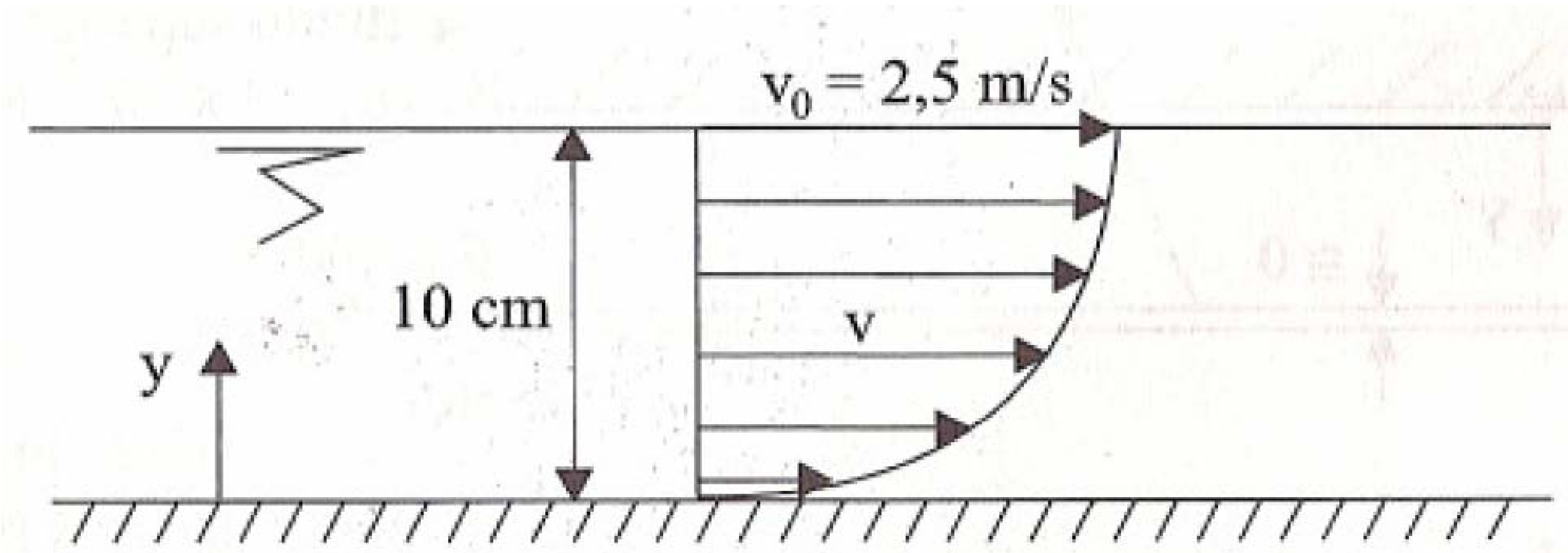
$$\int_0^{M_t} dM_t = \frac{2\pi\mu(\omega_1 - \omega_2)}{\varepsilon} \int_0^R r^3 dr$$

$$M_t = \frac{2\pi\mu(\omega_1 - \omega_2)}{\varepsilon} \frac{R^4}{4} \qquad \text{mas,} \quad R = \frac{D}{2}$$

$$M_t = \frac{2\pi\mu(\omega_1 - \omega_2)}{\varepsilon} \frac{D^4}{4 \times 16}$$

$$\omega_1 - \omega_2 = \frac{32\varepsilon M_t}{\pi\mu D^4}$$

1.14



1.14 - Resolução

$$v = ay^2 + by + c$$

$$1)\ \text{para } y = 0{,}1m \Rightarrow v = 2{,}5\frac{m}{s} \therefore 2{,}5 = a \times 0{,}1^2 + b \times 0{,}1 \ \ (1)$$

$$2)\ \text{para } y = 0 \Rightarrow v = 0 \therefore c = 0$$

$$3)\ \text{para } y = 0{,}1m \Rightarrow \frac{dv}{dy} = 0 \therefore 0 = 2 \times a \times 0{,}1 + b \therefore b = -0{,}2a\ (2)$$

$$\text{De (2) em (1)}: 2{,}5 = a \times 0{,}1^2 - 0{,}1 \times 0{,}2 \times a \therefore a = -250\frac{1}{ms}$$

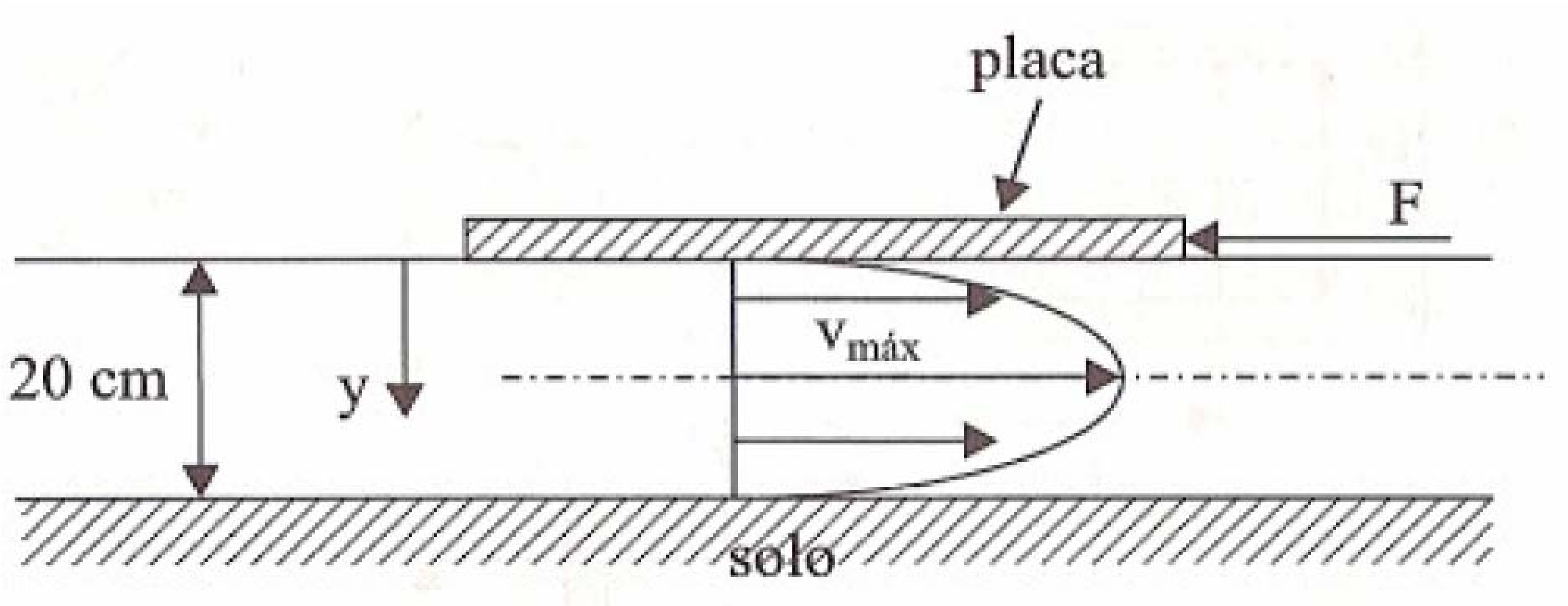
$$\therefore b = 50\frac{1}{s} \Rightarrow v = -250y^2 + 50y \text{ e } \frac{dv}{dy} = -500y + 50$$

$$\text{para } y = 0 \Rightarrow \frac{dv}{dy} = 50\frac{1}{s} \therefore \tau = 400 \times 10^{-2} \times 50 = 200\frac{dina}{cm^2}$$

$$\text{para } y = 0{,}05m \Rightarrow \frac{dv}{dy} = -500 \times 0{,}05 + 50 = 25\frac{1}{s} \therefore \tau = 400 \times 10^{-2} \times 25 = 100\frac{dina}{cm^2}$$

$$\text{para } y = 0{,}1m \Rightarrow \frac{dv}{dy} = -500 \times 0{,}1 + 50 = 0 \therefore \tau = 400 \times 10^{-2} \times 0 = 0$$

1.15



1.15 - Resolução

$$v = 20yv_{máx} - 100y^2 v_{máx}$$

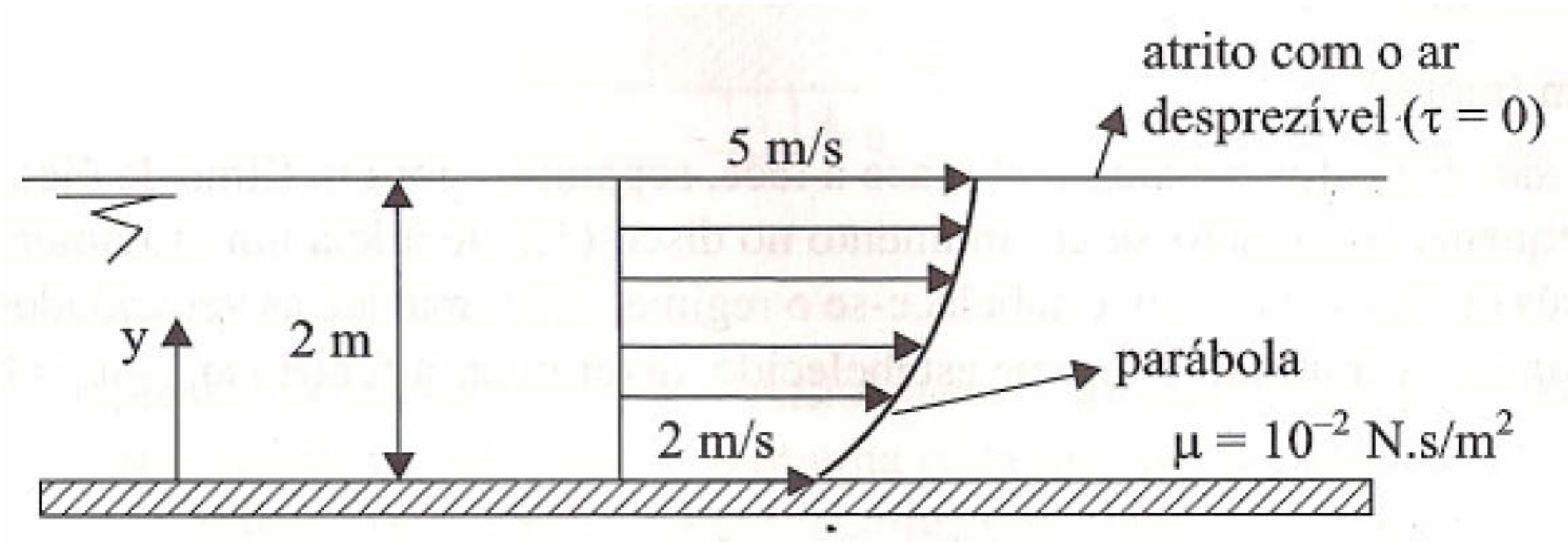
$$\left(\frac{dv}{dy}\right)_{y=0,2m} = 20v_{máx} - 200yv_{máx} = 20 \times 4 - 200 \times 0,2 \times 4 = -80\,s^{-1}$$

$$\left(\frac{dv}{dy}\right)_{y=0} = 20v_{máx} = 80\,s^{-1}$$

$$\tau_{y=0} = \mu\left(\frac{dv}{dy}\right)_{y=0} = 10^{-2} \times 80 = 0,8\frac{N}{m^2}$$

$$F = \tau A = 0,8 \times 4 = 3,2\,N$$

1.16


atrito com o ar
desprezível (τ = 0)
5 m/s
y
2 m
parábola
2 m/s
μ = 10⁻² N.s/m²

1.16 - Resolução

a)

$$\text{para } y = 0 \Rightarrow v = 2\frac{m}{s} \therefore c = 2\frac{m}{s}$$

$$\text{para } y = 2m \Rightarrow v = 5\frac{m}{s} \therefore 5 = a \times 2^2 + b \times 2 + 2 \Rightarrow b = \frac{3-4a}{2} \ (1)$$

$$\text{para } y = 2m \Rightarrow \frac{dv}{dy} = 0 \therefore 0 = 2 \times a \times 2 + b \Rightarrow b = -4a \ (2)$$

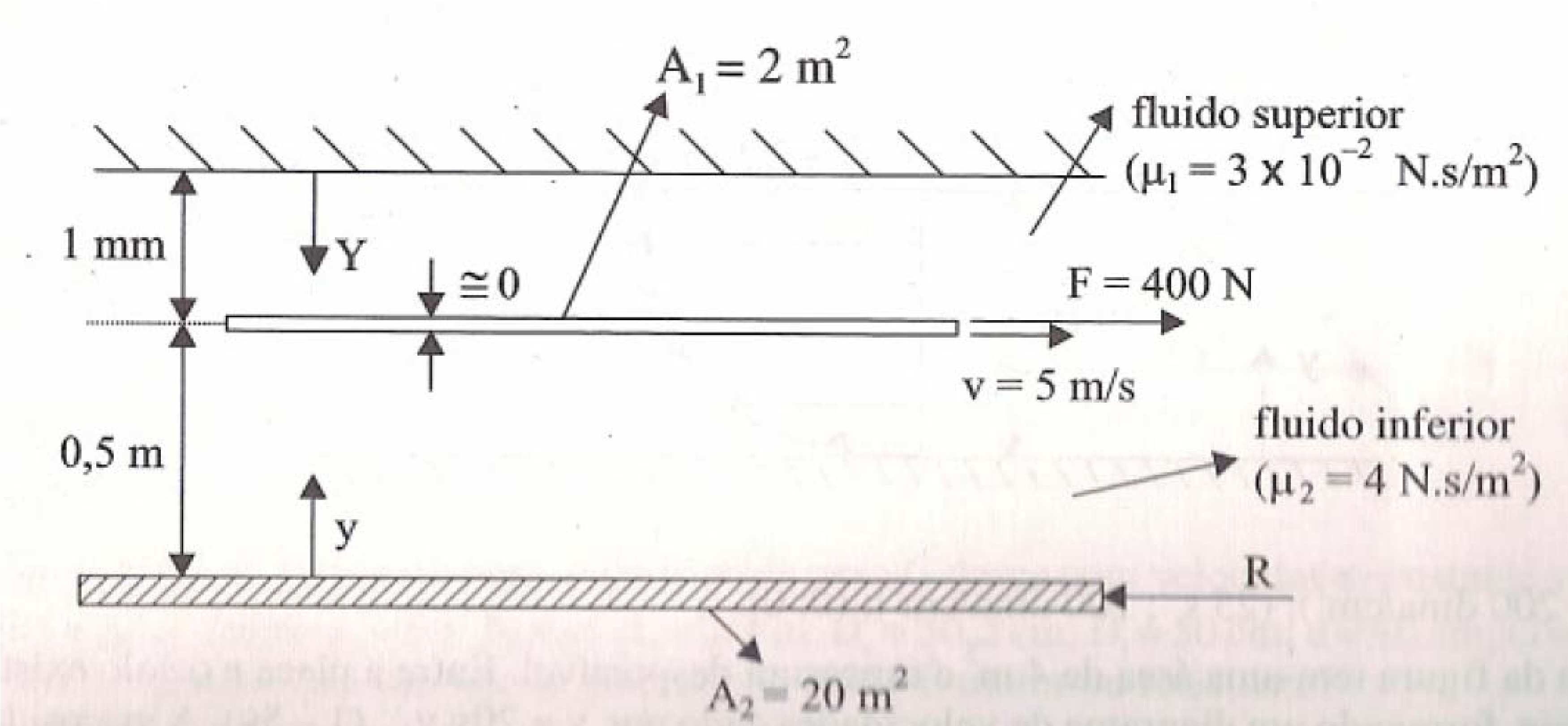
$$\text{De (1) e (2)}: \frac{3-4a}{2} = -4a \Rightarrow a = -0{,}75\frac{1}{ms} \therefore b = 3\frac{1}{s}$$

$$v = -0{,}75y^2 + 3y + 2 \text{ com v em } \frac{m}{s} \text{ e y em m}$$

b)

$$\frac{dv}{dy} = -1{,}5y + 3 \Rightarrow \text{para } y = 0 \text{ que } \frac{dv}{dy} = 3\frac{1}{s} \text{ e } \tau = \mu \times \frac{dv}{dy} = 10^{-2} \times 3 = 0{,}03\frac{N}{m^2}$$

1.17



A1 = 2 m2
fluido superior
(μ1 = 3 x 10-2 N.s/m2)
1 mm
Y
≅0
F = 400 N
v = 5 m/s
fluido inferior
(μ2 = 4 N.s/m2)
0,5 m
y
R
A2 = 20 m2

Resolução

a) $\tau_1 = \mu_1 \dfrac{v}{\varepsilon_1} = 3\times10^{-2} \times \dfrac{5}{10^{-3}} = 150\dfrac{N}{m^2}$

b) $F_2 = F - \tau_1 A_1 = 400 - 150\times 2 = 100\,N$

$\tau_2 = \dfrac{F_2}{A_1} = \dfrac{100}{2} = 50\dfrac{N}{m^2}$

c) $v = AY + B$

para $Y = 0 \quad \rightarrow \quad v = 0 \quad \Rightarrow \quad B = 0$

para $Y = 10^{-3} \quad \rightarrow \quad v = 5 \quad \Rightarrow \quad 5 = A\times10^{-3} \quad \Rightarrow \quad A = 5.000$

Logo: $\quad v = 5.000Y$

d) $v = ay^2 + by + c$

para $y = 0 \quad \rightarrow \quad v = 0 \quad \Rightarrow \quad c = 0$

para $y = 0{,}5 \quad \rightarrow \quad v = 5 \quad \Rightarrow \quad 5 = a\times 0{,}25 + b\times 0{,}5$

para $y = 0{,}5 \quad \rightarrow \quad \tau = 50\dfrac{N}{m^2}$

Resolução (cont.)

$$\tau_2 = \mu_2 \left(\frac{dv}{dy}\right)_{y=0,5} \quad \rightarrow \quad \left(\frac{dv}{dy}\right)_{y=0,5} = \frac{\tau_1}{\mu_1} = \frac{50}{4} = 12,5$$

$$\text{como} \quad \frac{dv}{dy} = 2ay + b \quad \text{então} \quad \left(\frac{dv}{dy}\right)_{y=0,5} = 2a \times 0,5 + b = 12,5$$

deve – se resolver o sistema :

$$0,25a + 0,5b = 5$$

$$a + b = 12,5$$

resultando : $a = 5$ e $b = 7,5$

logo : $v = 5y^2 + 7,5y$

e) $$\left(\frac{dv}{dy}\right)_{y=0} = 10y + 7,5$$

$$\tau_{y=0} = \mu_2 \left(\frac{dv}{dy}\right)_{y=0} = 4 \times 7,5 = 30 \frac{N}{m^2}$$

$$R = \tau_{y=0} \times A = 30 \times 20 = 600\,N$$

1.18 - Resolução

$$\%\Delta\rho = \left(\frac{\rho_1 - \rho_2}{\rho_1}\right) \times 100 = \left(\frac{\frac{200000}{287 \times 323} - \frac{150000}{287 \times 293}}{\frac{200000}{287 \times 323}}\right) \times 100$$

$$\%\Delta\rho \cong 17{,}32\%$$

1.19 - Resolução

$$\rho_{ar} = \frac{p}{RT} = \frac{9,8 \times 10^4}{287 \times 288} = 1,186 \frac{kg}{m^3} \quad \Rightarrow \quad \gamma_{ar} = \rho_{ar} g = 1,186 \times 9,8 = 11,62 \frac{N}{m^3}$$

$$\gamma = \gamma_r \gamma_{ar} = 0,6 \times 11,62 = 7 \frac{N}{m^3} \quad \Rightarrow \quad \rho = \frac{\gamma}{g} = \frac{7}{9,8} = 0,71 \frac{kg}{m^3}$$

$$R = \frac{p}{\rho T} = \frac{9,8 \times 10^4}{0,71 \times 288} = 479 \frac{m^2}{s^2 K}$$

1.20 - Resolução

$$\gamma_{ar_{38^\circ C}} = \frac{441000}{287 \times (38 + 273)} \times 10 \cong 49{,}4 \frac{N}{m^3}$$

1.21 - Resolução

Isotérmico

$$p_1V_1 = p_2V_2$$

$$p_2 = p_1\frac{V_1}{V_2} = 133{,}3 \times \frac{10}{2} = 666{,}5\,\text{kPa}(\text{abs})$$

Adiabático

$$p_2 = p_1\left(\frac{V_1}{V_2}\right)^k = 133{,}3 \times \left(\frac{10}{2}\right)^{1{,}28} = 1046\,\text{kPa}(\text{abs})$$