

演習問題 5 解答

問題 5.1

5.5 節参照のこと

問題 5.2

5.7 節参照のこと

問題 5.3

0.833 mm (円筒の変形は 9.09×10^{-3} mm にすぎない)

問題 5.4

5.6 節参照のこと

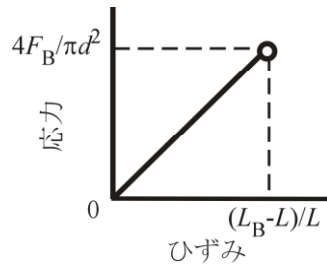
問題 5.5

(1) 真の値に対して $\frac{2E_0}{E_1} \frac{A_0 L_1}{A_1 L_0}$ 大きい値となる (2) $2\sigma_2 A_2 + \sigma_1 A_1 = F$
 $\frac{\sigma_2 (L_0 + 2L_1)}{E_2} = \frac{\sigma_1 L_1}{E_1} + \frac{\sigma_0 L_0}{E_0}$

(3) $\sigma_0 = \frac{F}{A_0} \frac{A_0 A_a E_0 E_a L_b}{A_0 A_a E_0 E_a L_b + 4A_0 A_b E_0 E_b L_a + 2A_a A_b E_a E_b L_0}$

問題 5.6

(1) $E = \frac{4F_B}{\pi d^2} \frac{L}{L_B - L}$

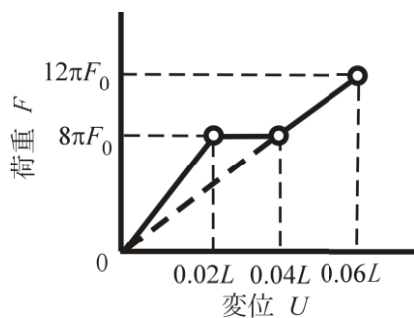


(2) $\frac{P_0}{F_B} \left(\frac{d^2}{d_1^2} \frac{L_1}{L} + \frac{d^2}{d_2^2} \frac{L_2}{L} + \frac{d^2}{d_3^2} \frac{L_3}{L} \right) (L_B - L)$ (3) $\frac{d_1^2}{d^2} F_B$

問題 5.7

(1) $E_I = \frac{200F_0}{d^2}$, $E_{II} = \frac{50F_0}{d^2}$ (2) $P = \frac{400\pi F_0}{L} U$

(3)



問題 5.8

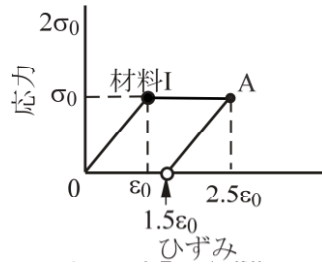
(1) $\frac{PL}{2A_a E_a + A_b E_b}$ (2) $\frac{PL}{2A_a E_a}$

問題 5.9

(1) $E_A = \frac{4P_{A1}L_A}{\pi D_A^2(L_{A1} - L_a)}$, $E_B = \frac{4P_{B2}L_{B1}}{\pi D_B^2(L_{B2} - L_{B1})}$ (2) $\frac{4L_A L_B F}{\pi(D_A^2 E_A L_B + D_B^2 E_B L_A)}$

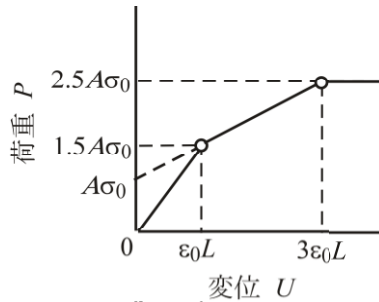
問題 5.10

(1) $E_I = \frac{\sigma_0}{\varepsilon_0}$, $E_{II} = \frac{\sigma_0}{2\varepsilon_0}$



(2) $\sigma_1 = \frac{2P}{3A}$, $\sigma_2 = -\frac{P}{3A}$

(3)



問題 5.11

(1) $P_A = \frac{A}{A_0} P_{A3}$, $P_B = \frac{A}{A_0} P_{B2}$ (2) $\sigma_B = \frac{L_1 - L}{L} E_A$ (3) $\sigma_B = \frac{L_1 - L}{L} \frac{E_A E_B}{E_A + E_B}$

問題 5.12

(1-a) $\frac{\sigma_A}{E_A} = \frac{\sigma_B}{E_B}$ (1-b) $u_1 = \frac{L}{A_A E_A + A_B E_B} P_1$

(2-a) $P_2 = \frac{A_A E_A}{L} u_2$ (2-b) $P_2 = \frac{L A_B E_B + (L - C) A_A E_A}{L(L - C)} u_2 - \frac{C A_B E_B}{L - C}$

問題 5.13

(1) $E_A = \frac{4xP_0}{\pi D^2(a-1)}$, $E_B = \frac{8yP_0}{\pi D^2(b-2)}$ (2) $\sigma_B = \frac{(a-1)y}{(b-2)x + (a-1)y} \frac{4F}{\pi D^2}$

(3) $F_1 = \frac{(b-2)x + (a-1)y}{(b-2)x} xP_0$ (4) $u_B = \frac{\{(b-2)x + (a-1)y\}L}{y}$

問題 5.14

$$(1) E = \frac{P_1}{\pi d_0^2/4} \frac{a_0}{a_1 - a_0} = \frac{4P_1 a_0}{\pi d_0^2 (a_1 - a_0)}, \quad \sigma_B = \frac{4P_1}{\pi d_0^2}, \quad d = d_0 - \nu \frac{a_1 - a_0}{a_0} \frac{P}{P_1} d_0$$

$$(2) a_0 + \frac{f_a}{\pi d_0^2/4} \frac{1}{E} a_0 = b_0 + \frac{f_b}{k}$$

$$(3) L_0 = \frac{4b_0 k + \pi d_0^2 E}{\pi d_0^2 E + 4a_0 k} a_0$$

$$(4) k = \frac{\pi \sigma_B d_0^2 E}{4E(b_0 - a_0) + 4a_0 \sigma_B}$$

問題 5.15

$$(1) P_1 = \sigma_y A, \quad P_2 = \sigma_B A, \quad L_1 = L + \frac{\sigma_y L}{E}$$

$$(2) U = \frac{F}{3} \frac{1}{A} \frac{L}{E} = \frac{FL}{3AE}$$

$$(3) F(A) = 3\sigma_y A, \quad F(B) = \frac{9\sigma_y A}{4} = 2.25\sigma_y A, \quad F = 3\sigma_y A$$

問題 5.16

(1) 縦弾性係数 σ_1/ε_1 , 降伏応力 σ_1 , 引張強度 σ_2 降伏荷重 $\sigma_1 A$, 最大荷重 $\sigma_2 A$

$$(2) 2A_0 \text{ の部分 } \sigma = 0, \quad A_0 \text{ の部分 } \sigma = \frac{F}{A_0}$$

(3) $x = L_0$ において破断する 応力集中のため

$$(4) L_1 \text{ の部分の伸び } \lambda = \frac{P_1}{A_0 E} L_1, \quad L_0 \text{ の部分の伸び } \lambda = \frac{P_0}{2A_0 E} L_0$$

$$\text{力のつり合い } P_1 + P_0 = 0$$

$$L = L_1 + \frac{-P_0}{A_0 E} L_1 = L_0 + \frac{P_0}{2A_0 E} L_0, \quad L = \frac{3L_1 L_0}{2L_1 + L_0}$$

問題 5.17

$$(1) \text{縦弾性係数: } \frac{P_1}{A_0} \frac{L_0}{L_1 - L_0}, \quad \text{降伏応力: } \frac{P_1}{A_0}, \quad \text{引張強度: } \frac{P_2}{A_0}, \quad L_A - \frac{P_A}{P_1} (L_1 - L_0)$$

$$(2) \sigma_I = \frac{1}{3} \alpha E \Delta T, \quad \sigma_{II} = \frac{4}{3} \alpha E \Delta T$$

$$(3) \Delta T < \frac{3\sigma_y}{4S\alpha E \Delta T}$$

問題 5.17

$$(1) \text{縦弾性係数: } \frac{P_1}{A_0} \frac{L_0}{L_1 - L_0}, \quad \text{降伏応力: } \frac{P_1}{A_0}, \quad \text{引張強度: } \frac{P_2}{A_0}, \quad L_A - \frac{P_A}{P_1} (L_1 - L_0)$$

(2) 力のつり合い $\sigma_I 4A = \sigma_{II} A$ 変形の拘束条件 $-\alpha \cdot \Delta T \cdot 2L + \frac{\sigma_I}{E} 2L + \frac{\sigma_{II}}{E} L = 0$, $\sigma_{II} = 4\sigma_I$,

$$2\sigma_I + 4\sigma_I = 2\alpha E \Delta T, \quad \sigma_I = \frac{1}{3} \alpha E \Delta T, \quad \sigma_{II} = \frac{4}{3} \alpha E \Delta T$$

(3) $\sigma_{II} = \frac{4}{3} \alpha E \Delta T = \frac{\sigma_Y}{S}$, $\Delta T < \frac{3\sigma_Y}{4S\alpha E \Delta T}$

問題 5.18

(1) $\sigma_I = \frac{F_0}{\pi a^2}$, $\sigma_{II} = 0$

(2) $u_A = \frac{F}{\pi E a^2} 16a = \frac{16F}{\pi E a}$

(3) $u_A = \frac{R_1}{\pi E a^2} 16a + \frac{R_1 - F}{2\pi E a^2} 32a = 0$, $R_1 = -R_2 = \frac{F}{2}$, $\sigma_I = \frac{F}{2\pi a^2}$, $\sigma_{II} = -\frac{F}{2\pi a^2}$

(4) $u_B = \frac{F}{2\pi E a^2} 16a = \frac{8F}{\pi E a^2}$

(5) $u_A = \frac{R_1}{\pi E a^2} 16a + \frac{R_1 - F}{2\pi E a^2} 32a = Ca$, $R_1 = \frac{\pi C E a^2}{32} + \frac{F}{2}$, $R_2 = \frac{\pi C E a^2}{32} - \frac{F}{2}$

(5) $\sigma_I = \left(\frac{\pi C E a^2}{32} + \frac{F}{2} \right) \frac{1}{\pi a^2} = \frac{CE}{32} + \frac{F}{2\pi a^2}$, $\sigma_{II} = \frac{CE}{32} - \frac{F}{2\pi a^2}$