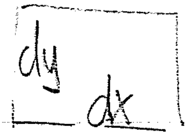
SL



Problem 1

$$\sum F_y = 0 \uparrow$$

$$\left(\sigma_{yy} + \frac{\partial \sigma_{yy}}{\partial y} dy\right)\cdot dx \cdot 1 - \sigma_{yy} \cdot dx \cdot 1 + \left(\sigma_{xy} + \frac{\partial \sigma_{xy}}{\partial x} dx\right)\cdot dy \cdot 1 - \sigma_{xy} \cdot dy \cdot 1 + Y\, dy\, dx \cdot 1 = 0$$

multiply everything by $\frac{1}{dx\,dy}$

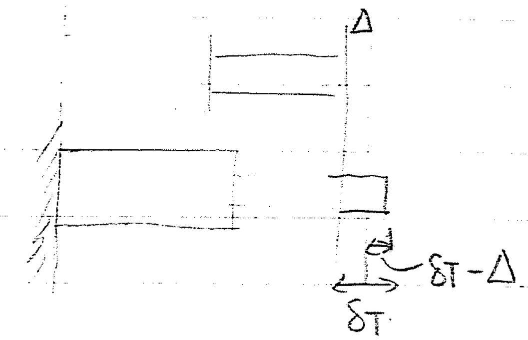
$$\frac{\left(\cancel{\sigma_{yy}} + \frac{\partial \sigma_{yy}}{\partial y}\cancel{dy}\right) \cancel{- \sigma_{yy}}}{\cancel{dy}} + \frac{\left(\cancel{\sigma_{xy}} + \frac{\partial \sigma_{xy}}{\partial x}\cancel{dx}\right) \cancel{- \sigma_{xy}}}{\cancel{dx}} + Y = 0$$

$$\boxed{\frac{\partial \sigma_{yy}}{\partial y} + \frac{\partial \sigma_{xy}}{\partial x} + Y = 0}$$

SL

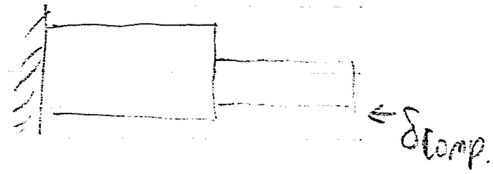
problem 2. $\delta_F = fP$ $\delta_T = \alpha(\Delta T)L$.

① $\Delta \le (\alpha_1 L_1 + \alpha_2 L_2)\Delta T$



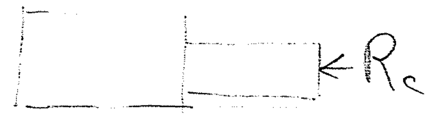
$\delta_{Thermal} = (\alpha_1 L_1 + \alpha_2 L_2)\Delta T$

$(\delta_{thermal} - \Delta) + \delta_{compression} = 0$



$\delta_{compression} = -f_1 P_1 - f_2 P_2$

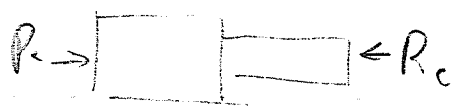
$P_2 = P_1 = R_c$



$\delta_{compression} = \underset{\uparrow}{-} R_c(f_1 + f_2)$

denote compression

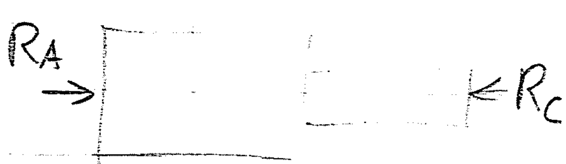
$(\delta_{thermal} - \Delta) + \delta_{compression} = 0$



$(\alpha_1 L_1 + \alpha_2 L_2)\Delta T - \Delta - R_c(f_1 + f_2) = 0$

$R_c(f_1 + f_2) = (\alpha_1 L_1 + \alpha_2 L_2)\Delta T - \Delta$

$$\boxed{R_c = \frac{(\alpha_1 L_1 + \alpha_2 L_2)\Delta T - \Delta}{f_1 + f_2}}$$



$R_A = R_C$

$$\boxed{R_A = \frac{(\alpha_1 L_1 + \alpha_2 L_2)\Delta T - \Delta}{f_1 + f_2}}$$

S.L

Problem 2

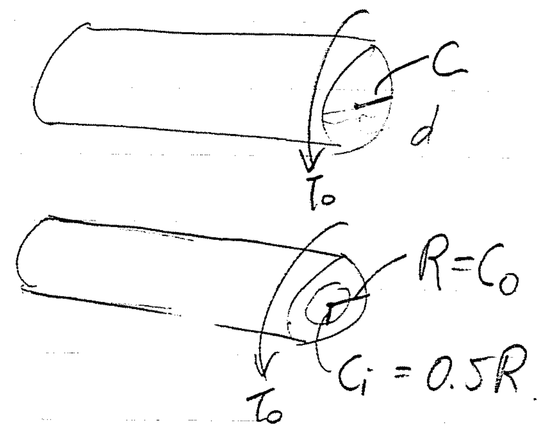
(2) $\Delta > (\alpha_1 L_1 + \alpha_2 L_2)\Delta T$

Since the gap is big enough for thermal expansion, therefore, there will be no compression force or Reaction needed

$\therefore \boxed{R_C = R_A = 0}$

S.L.

Problem 3



① $\tau_{max\ solid} = \tau_{max\ hollow}$.

$$\tau_{max\ solid} = \frac{Tc}{J} = \frac{T_0 \cancel{c}}{\frac{\pi}{2} c^{\cancel{4}3}} = \frac{2T_0}{\pi c^3}$$

$$\tau_{max\ hollow} = \frac{Tc_0}{\frac{\pi}{2}(c_0^4 - c_i^4)}$$

$$\tau_{max\ H} = \frac{T_0 R}{\frac{\pi}{2}(R^4 - (0.5R)^4)}$$

$$\frac{\cancel{2}\cancel{T_0}}{\cancel{\pi} c^3} = \frac{\cancel{2}\cancel{T_0} R}{\cancel{\pi}(R^4 - (0.5R)^4}$$

$$\frac{1}{c^3} = \frac{R}{R^4 - 0.0625R^4} \Rightarrow R^4 - 0.0625R^4 = c^3 R.$$

$$R^3 - 0.0625R^3 = c^3$$

$$c = \sqrt[3]{R^3 - 0.0625R^3}$$

$$\boxed{c = \sqrt[3]{0.9375R^3} = R\sqrt[3]{0.9375}}$$

or

$$\boxed{c \simeq 0.9787R}$$

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Problem 3.

2

$$\phi_S = \phi_H$$

$$\phi_S = \frac{T_0 \cdot L}{G_1 \cdot \frac{\pi}{2}(c^4)} \qquad \phi_H = \frac{T_0 \cdot L}{G_2 \frac{\pi}{2}(c_0^4 - c_i^4)}$$

$$\phi_S = \frac{T_0 \cdot L}{G_1 \frac{\pi}{2}\left(\frac{d}{2}\right)^4} = \frac{T_0 \cdot L}{G_1 \frac{\pi}{32} d^4} \qquad \phi_H = \frac{T_0 L}{G_2 \frac{\pi}{2}\left(R^4 - (0.5R)^4\right)}$$

$$\frac{\cancel{T_0 L}}{G_1 \frac{\cancel{\pi}}{32} d^4} = \frac{\cancel{T_0 L}}{G_2 \frac{\cancel{\pi}}{2}(R^4 - (0.5R)^4)}$$

$$\frac{32}{G_1 d^4} = \frac{2}{G_2(R^4 - 0.0625R^4)}$$

$$\overset{16}{\cancel{32}} G_2(R^4 - 0.0625R^4) = \cancel{2} G_1 d^4$$

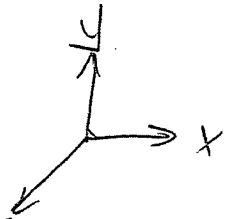
$$d^4 = 16\frac{G_2}{G_1}(R^4 - 0.0625R^4)$$

$$d = \sqrt[4]{16\frac{G_2}{G_1} R^4 (0.9375)} \qquad 0.9375 = \frac{15}{16}$$

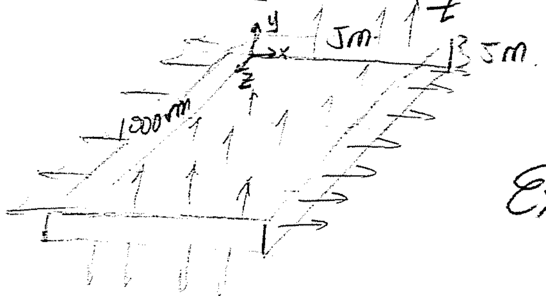
$$d = \sqrt[4]{\frac{G_2}{G_1} R^4 \frac{15}{\cancel{16}} \cdot \cancel{16}}$$

$$\boxed{d = R\sqrt[4]{\frac{G_2}{G_1} \cdot 15}} \quad \text{or} \quad \boxed{d \approx 1.97R\sqrt[4]{\frac{G_2}{G_1}}}$$

S.L



Problem 4



$\sigma_{xx} = 5\,MPa \qquad \sigma_{yy} = 10\,MPa.$

$$\varepsilon_x = \frac{\sigma_x}{E} - \frac{\nu\sigma_y}{E} - \frac{\nu\sigma_z}{E}$$

$$\varepsilon_{zz} \xrightarrow{} 0 = -\frac{\nu\sigma_{xx}}{E} - \nu\frac{\sigma_{yy}}{E} + \frac{\sigma_{zz}}{E}$$

$$0 = -\nu\sigma_{xx} - \nu\sigma_{yy} + \sigma_{zz}$$

$$\sigma_{zz} = \nu(\sigma_{xx} + \sigma_{yy})$$

$$\sigma_{zz} = 0.3(5MPa + 10MPa)$$

$$\boxed{\sigma_{zz} = 4.5\,MPa}$$

$$\varepsilon_{xx} = \frac{\sigma_{xx}}{E} - \frac{\nu\sigma_{yy}}{E} - \frac{\nu\sigma_{zz}}{E}$$

$$\varepsilon_{xx} = \frac{1}{E}(\sigma_{xx} - \nu\sigma_{yy} - \nu\sigma_{zz})$$

$$\varepsilon_{xx} = \frac{1}{100MPa}(5MPa - 0.3 \cdot 10MPa - 0.3 \cdot 4.5MPa)$$

$$\varepsilon_{xx} = \frac{1}{100\cancel{MPa}}\, 0.65\cancel{MPa} \qquad \boxed{\varepsilon_{xx} = 0.0065}$$

$$\varepsilon_{yy} = -\frac{\nu\sigma_{xx}}{E} + \frac{\sigma_{yy}}{E} - \frac{\nu\sigma_{zz}}{E} = \frac{1}{100MPa}(10MPa - 0.3 \cdot 5MPa - 0.3 \cdot 4.5MPa)$$

$$\boxed{\varepsilon_{yy}} = \frac{1}{100\cancel{MPa}} \cdot (7.15\cancel{MPa}) = \boxed{0.0715}$$