Group Calculation Exercise 1 - 2019

Exercise 1

Exercise 1 parameters

$D_1 := 0.032 \cdot m$

$d_1 := 0.020 \cdot m$

$v_1 := 0.1 \cdot \frac{m}{s}$

$D_2 := 0.040 \cdot m$

$d_2 := 0.032 \cdot m$

$D_{pipe} := 0.008 \cdot m$

$e_{pipe} := 0.0015 \cdot m$

Exercise 1 calculations

$A_{A1} := \frac{\pi}{4} \cdot D_1^{\,2}$

$A_{B1} := A_{A1} - \frac{\pi}{4} \cdot d_1^{\,2}$

$A_{A2} := \frac{\pi}{4} \cdot D_2^{\,2}$

$A_{B2} := A_{A2} - \frac{\pi}{4} \cdot d_2^{\,2}$

$q_{vA1} := v_1 \cdot A_{A1}$

$A_{pipe} := \frac{\pi}{4} \cdot \left(D_{pipe} - 2 \cdot e_{pipe}\right)^2$

$v_{MEAN} := \frac{q_{vA1}}{A_{pipe}}$

$q_{vA2} := q_{vA1} \cdot \frac{A_{A2}}{A_{B2}}$

$q_{vB1} := v_1 \cdot A_{B1}$

$q_{vTANK} := q_{vB1} - q_{vA2}$

$v_2 := \frac{q_{vA1}}{A_{B2}}$

Results 1

$A_{A1} = 0.000804\ m^2$

$A_{B1} = 0.00049\ m^2$

$A_{A2} = 0.001257\ m^2$

$A_{B2} = 0.00045\ m^2$

$q_{vA1} = 0.00008\ \frac{m^3}{s}$

$q_{vA1} = 4.825\ \frac{l}{min}$

$v_{MEAN} = 4.096\ \frac{m}{s}$

$q_{vA2} = 0.00022\ \frac{m^3}{s}$

$q_{vA2} = 13.404\ \frac{l}{min}$

$q_{vB1} = 0.00005\ \frac{m^3}{s}$

$q_{vB1} = 2.941\ \frac{l}{min}$

$q_{vTANK} = -1.744 \cdot 10^{-4}\ \frac{m^3}{s}$

$q_{vTANK} = -10.464\ \frac{l}{min}$

$v_2 = 0.178\ \frac{m}{s}$

Exercise 2

Exercise 2 parameters

$F_1 := 9000 \cdot N$

$p_{accu.1} := 0 \cdot Pa$

$p_{accu.2} := 50 \cdot 10^5 \cdot Pa$

PART 1 calculations

$p_{A1.1} := \frac{F_1}{A_{A1}}$

$F_{2.1} := p_{A1.1} \cdot A_{B2}$

$P_{1.1} := F_1 \cdot v_1$

PART 2 calculations

$P_{2.1} := F_{2.1} \cdot v_2$

$P_{accu.1} := q_{vTANK} \cdot p_{accu.1}$

$p_{A1.2} := \frac{F_1 + p_{accu.2} \cdot A_{B1}}{A_{A1}}$

$F_{2.2} := p_{A1.2} \cdot A_{B2} - p_{accu.2} \cdot A_{A2}$

$P_{1.2} := F_1 \cdot v_1$

$P_{2.2} := F_{2.2} \cdot v_2$

$P_{accu.2} := p_{accu.2} \cdot q_{vTANK}$

PART 1 results

$p_{A1.1} = (1.119 \cdot 10^7)\ \mathbf{Pa}$

$p_{A1.1} = 111.906\ \mathbf{bar}$

$F_{2.1} = (5.063 \cdot 10^3)\ \mathbf{N}$

$P_{1.1} = 900\ \mathbf{W}$

$P_{2.1} = 900\ \mathbf{W}$

$P_{accu.1} = 0\ \mathbf{W}$

PART 2 results

$p_{A1.2} = (1.424 \cdot 10^7)\ \mathbf{Pa}$

$p_{A1.2} = 142.375\ \mathbf{bar}$

$F_{2.2} = 157.688\ \mathbf{N}$

$P_{1.2} = 900\ \mathbf{W}$

$P_{2.2} = 28.034\ \mathbf{W}$

$P_{accu.2} = -871.966\ \mathbf{W}$

Exercise 3

Exercise 3 parameters

$D := 0.1 \cdot m$

$d := 0.060 \cdot m$

$x_{max} := 1 \cdot m$

$\Delta x := 0.001 \cdot m$

$\Delta x_A := \Delta x$

$\Delta x_B := -\Delta x$

$$x := \begin{bmatrix} 0.1 \\ 0.2 \\ 0.3 \\ 0.4 \\ 0.5 \\ 0.6 \\ 0.7 \\ 0.8 \\ 0.9 \end{bmatrix} \cdot m$$

$K_f := 1.2 \cdot 10^9 \cdot Pa$

Exercise 3 calculations

$A_A := \frac{\pi}{4} \cdot D^2$

$A_B := A_A - \frac{\pi}{4} \cdot d^2$

$\Delta V_A := -\Delta x \cdot A_A$

$\Delta V_B := \Delta x \cdot A_B$

$V_A := A_A \cdot x$

$V_B := A_B \cdot (x_{max} - x)$

$\Delta p_A := -\left(K_f \cdot \frac{\Delta V_A}{V_A}\right)$

$\Delta p_B := -\left(K_f \cdot \frac{\Delta V_B}{V_B}\right)$

$\Delta F_A := A_A \cdot \Delta p_A$

$\Delta F_B := A_B \cdot \Delta p_B$

$k_A := \frac{\Delta F_A}{\Delta x_A}$

$k_B := \frac{\Delta F_B}{\Delta x_B}$

$k_{spring} := k_A + k_B$

Results 3

$A_A = 0.007854\ m^2$

$A_B = 0.005027\ m^2$

$\Delta V_A = -7.854\ mL$

$\Delta V_B = 5.027\ mL$

$$V_A = \begin{bmatrix} 0.785398 \\ 1.570796 \\ 2.356194 \\ 3.141593 \\ 3.926991 \\ 4.712389 \\ 5.497787 \\ 6.283185 \\ 7.068583 \end{bmatrix} L \qquad V_B = \begin{bmatrix} 4.523893 \\ 4.021239 \\ 3.518584 \\ 3.015929 \\ 2.513274 \\ 2.010619 \\ 1.507964 \\ 1.00531 \\ 0.502655 \end{bmatrix} L$$

$$\frac{\Delta V_A}{V_A} = \begin{bmatrix} -0.01 \\ -0.005 \\ -0.003333 \\ -0.0025 \\ -0.002 \\ -0.001667 \\ -0.001429 \\ -0.00125 \\ -0.001111 \end{bmatrix} \qquad \frac{\Delta V_B}{V_B} = \begin{bmatrix} 0.001111 \\ 0.00125 \\ 0.001429 \\ 0.001667 \\ 0.002 \\ 0.0025 \\ 0.003333 \\ 0.005 \\ 0.01 \end{bmatrix}$$

$$\Delta p_A = \begin{bmatrix} 1.2 \cdot 10^7 \\ 6 \cdot 10^6 \\ 4 \cdot 10^6 \\ 3 \cdot 10^6 \\ 2.4 \cdot 10^6 \\ 2 \cdot 10^6 \\ 1.714 \cdot 10^6 \\ 1.5 \cdot 10^6 \\ 1.333 \cdot 10^6 \end{bmatrix} Pa \qquad \Delta p_B = \begin{bmatrix} -1.333 \cdot 10^6 \\ -1.5 \cdot 10^6 \\ -1.714 \cdot 10^6 \\ -2 \cdot 10^6 \\ -2.4 \cdot 10^6 \\ -3 \cdot 10^6 \\ -4 \cdot 10^6 \\ -6 \cdot 10^6 \\ -1.2 \cdot 10^7 \end{bmatrix} Pa$$

$$\Delta F_A = \begin{bmatrix} 9.425 \cdot 10^4 \\ 4.712 \cdot 10^4 \\ 3.142 \cdot 10^4 \\ 2.356 \cdot 10^4 \\ 1.885 \cdot 10^4 \\ 1.571 \cdot 10^4 \\ 1.346 \cdot 10^4 \\ 1.178 \cdot 10^4 \\ 1.047 \cdot 10^4 \end{bmatrix} \text{N} \qquad \Delta F_B = \begin{bmatrix} -6.702 \cdot 10^3 \\ -7.54 \cdot 10^3 \\ -8.617 \cdot 10^3 \\ -1.005 \cdot 10^4 \\ -1.206 \cdot 10^4 \\ -1.508 \cdot 10^4 \\ -2.011 \cdot 10^4 \\ -3.016 \cdot 10^4 \\ -6.032 \cdot 10^4 \end{bmatrix} \text{N}$$

$$k_A = \begin{bmatrix} 9.425 \cdot 10^7 \\ 4.712 \cdot 10^7 \\ 3.142 \cdot 10^7 \\ 2.356 \cdot 10^7 \\ 1.885 \cdot 10^7 \\ 1.571 \cdot 10^7 \\ 1.346 \cdot 10^7 \\ 1.178 \cdot 10^7 \\ 1.047 \cdot 10^7 \end{bmatrix} \frac{\text{N}}{\text{m}} \qquad k_B = \begin{bmatrix} 6.702 \cdot 10^6 \\ 7.54 \cdot 10^6 \\ 8.617 \cdot 10^6 \\ 1.005 \cdot 10^7 \\ 1.206 \cdot 10^7 \\ 1.508 \cdot 10^7 \\ 2.011 \cdot 10^7 \\ 3.016 \cdot 10^7 \\ 6.032 \cdot 10^7 \end{bmatrix} \frac{\text{N}}{\text{m}}$$

$$k_{spring} = \begin{bmatrix} 1.009 \cdot 10^8 \\ 5.466 \cdot 10^7 \\ 4.003 \cdot 10^7 \\ 3.362 \cdot 10^7 \\ 3.091 \cdot 10^7 \\ 3.079 \cdot 10^7 \\ 3.357 \cdot 10^7 \\ 4.194 \cdot 10^7 \\ 7.079 \cdot 10^7 \end{bmatrix} \frac{\text{N}}{\text{m}}$$

Exercise 4

PARAMETERS

$D_1 := 0.08 \cdot m$

$D_2 := 0.125 \cdot m$

$d_1 := 0.04 \cdot m$

$D_3 := 0.1 \cdot m$

$F_{LOAD} := 10000 \cdot N$

$$d_{ROD} := 1 \cdot 10^{-3} \cdot \begin{bmatrix} \vdots \\ 28 \\ 32 \\ 36 \\ 40 \\ 45 \\ 50 \\ 56 \\ 63 \\ 70 \\ 80 \\ 90 \\ 100 \end{bmatrix} \cdot m$$

Exercise 4 calculations

$$A_{A.3} := \frac{\pi}{4} \cdot D_3^{\,2}$$

$$p_{A.3} := \frac{F_{LOAD}}{A_{A.3}}$$

$$A_{A.1} := \frac{\pi}{4} \cdot D_1^{\,2}$$

$$A_{B.1} := A_{A.1} - \frac{\pi}{4} \cdot d_1^{\,2}$$

$$p_{ACCU.MIN} := \frac{A_{A.1}}{A_{B.1}} \cdot p_{A.3}$$

$p_{resolution} := 5 \cdot 10^5 \cdot Pa$

$$p_{ACCU} := ceil\left(\frac{p_{ACCU.MIN} + p_{resolution}}{p_{resolution}}\right) \cdot p_{resolution}$$

$$A_{A.2} := \frac{\pi}{4} \cdot D_2^{\,2}$$

$$A_{B.2.MAX} := \frac{p_{A.3} \cdot A_{A.2}}{p_{ACCU}}$$

$$d_{2.MIN} := \sqrt[2]{D_2^{\,2} - \frac{4}{\pi} \cdot A_{B.2.MAX}}$$

$d_{2.MIN} = 0.08756\ m$

$smallerrods := match\left(d_{2.MIN}, d_{ROD}, \text{“lt”}\right)$

$smallerrods = \begin{bmatrix} 0 \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \\ 10 \\ 11 \\ \vdots \end{bmatrix}$

$max\left(smallerrods\right) = 12$

$d_2 := d_{ROD_{max\left(smallerrods\right)+1}}$

$d_2 = 0.09\ m$

$A_{B.2} := A_{A.2} - \frac{\pi}{4} \cdot d_2^{\,2}$

$F_{3.LIFT} := A_{A.3} \cdot p_{ACCU} \cdot \frac{A_{B.1}}{A_{A.1}}$

$F_{3.LOWER} := A_{A.3} \cdot p_{ACCU} \cdot \frac{A_{B.2}}{A_{A.2}}$

Results 4

$A_{A.3} = 0.007854\ m^2$

$p_{A.3} = 12.732\ bar$

$A_{A.1} = 0.005027\ m^2$

$A_{B.1} = 0.00377\ m^2$

$p_{ACCU.MIN} = (1.698 \cdot 10^6)\ Pa$

$p_{ACCU} = 25\ bar$

$A_{A.2} = 0.012272\ m^2$

$A_{B.2.MAX} = 0.00625\ m^2$

$d_{2.MIN} = 0.08756\ m$

$d_2 = 0.09\ m$

$A_{B.2} = 0.00591\ m^2$

$F_{3.LIFT} = 14.726216\ kN$

$F_{3.LOWER} = 9.456\ kN$