1.1)

a) Ruhelage bei $\dot{\vec{x}} = \vec{0}$

$$\vec{u} = \begin{pmatrix} V \\ f_L \end{pmatrix}$$

$$\vec{f} = \dot{\vec{x}} = \begin{pmatrix} \dot{\psi} \\ \dot{\delta} \\ \dot{w} \end{pmatrix} = \begin{pmatrix} -\frac{R(p_1 + p_2 \delta)}{N^2} \psi + V \\ w \\ -\frac{1}{2} \frac{p_2}{N^2 m} \psi^2 + g + \frac{f_L}{m} \end{pmatrix} = 0$$

$\vec{x}_R$ ist die Lösung wir suchen ψ_R, δ_R, w_R

$\vec{0} = f(\vec{x}, \vec{u})$ $\rightarrow$ $0 = -\frac{R(p_1 + p_2 \delta_R)}{N^2} \psi_R + V_R$

$0 = w_R$

$0 = -\frac{1}{2} \frac{p_2}{N^2 m} \psi_R^2 + g + \frac{f_{L,R}}{m}$

$$\psi_R = \sqrt{\frac{\left(\frac{f_{L,R}}{m} + g\right) \cdot 2N^2 m}{p_2}}$$

$$\delta_R: \; 0 = -\frac{R(p_1 + p_2 \delta_R)}{N^2} \sqrt{\frac{2N^2 \cdot (f_{L,R} + g m)}{p_2}} + V_R$$

$$\Rightarrow \frac{V_R \cdot N}{R \sqrt{\frac{2(f_{L,R} + g m)}{p_2}}} = p_1 + p_2 \delta_R$$

$$\delta_R = \left(\frac{V_R \cdot N}{R \sqrt{\frac{2(f_{L,R} + g m)}{p_2}}} - p_1 \right) \frac{1}{p_2}$$

für $f_{L,R} = 0$; $V_R = ?$; $\bar{\delta}$ ist eine Ruhelage

$$\bar{\delta} = \left(\frac{V_R \cdot N}{R \sqrt{\frac{2(0 + g m)}{p_2}}} - p_1 \right) \frac{1}{p_2} \rightarrow \left(\frac{V_R \; N}{R \sqrt{\frac{2 g m}{p_2}}} - p_1 \right) \frac{1}{p_2}$$

$$V_R = \left(\bar{\delta} \cdot p_2 + p_1\right) \cdot \frac{R \sqrt{\frac{2 g m}{p_2}}}{N}$$

$$\vec{f}(\vec{x}_R, \vec{u}_R) = \begin{pmatrix} \sqrt{\frac{\left(\frac{f_{L,R}}{m} + g\right) \cdot 2N^2 m}{p_2}} \\ \left(\frac{V_R \cdot N}{R \sqrt{\frac{2(f_{L,R} + g m)}{p_2}}} - p_1 \right) \frac{1}{p_2} \\ 0 \end{pmatrix}$$

b) Linearisierung: $A = \frac{\partial}{\partial \vec{x}} \vec{f}(\vec{x}_R, \vec{u}_R) = \frac{\partial}{\partial \vec{x}} \begin{pmatrix} -\frac{\varrho(p_1 + p_2 \delta)}{N^2} \psi + v \\ w \\ -\frac{1}{2} \frac{p_2}{N^2 m} \psi^2 + g + \frac{f_L}{m} \end{pmatrix} \Rightarrow$

$$\Rightarrow \begin{pmatrix} -\frac{\varrho(p_1 + p_2 \delta)}{N^2} & \frac{-p_2}{N^2} \cdot \psi & 0 \\ 0 & 0 & 1 \\ -\frac{p_2}{N^2 m} & 0 & 0 \end{pmatrix}$$

$$C = \frac{\partial}{\partial \vec{x}} \underbrace{\vec{h}(\vec{x}, \vec{u})}_{\text{aus Angabe}} = \frac{\partial}{\partial \vec{x}} \frac{p_1 + p_2 \delta}{N^2} \psi$$

$$B = \frac{\partial}{\partial \vec{u}} \vec{f}(\vec{x}_R, \vec{u}_R) = \begin{pmatrix} 1 & 0 \\ 0 & 0 \\ 0 & \frac{1}{m} \end{pmatrix}$$

$$\Rightarrow \begin{pmatrix} \frac{p_1 + p_2 \delta}{N^2} & \frac{p_2}{N^2} \psi & 0 \end{pmatrix}$$

$$c^T = \begin{pmatrix} \frac{p_1 + p_2 \delta}{N^2} \\ \frac{p_2}{N^2} \psi \\ 0 \end{pmatrix}$$

$$D = \frac{\partial}{\partial \vec{u}} h(\vec{x}_R, \vec{u}_R) = \begin{pmatrix} 0 & 0 \end{pmatrix}$$

$$\Delta \dot{\vec{x}} = \begin{pmatrix} -\frac{\varrho(p_1 + p_2 \delta_R)}{N^2} & \frac{-p_2}{N^2} \cdot \psi_R & 0 \\ 0 & 0 & 1 \\ -\frac{p_2}{N^2 m} & 0 & 0 \end{pmatrix} \Delta \vec{x} + \begin{pmatrix} 1 & 0 \\ 0 & 0 \\ 0 & \frac{1}{m} \end{pmatrix} \Delta \vec{u}$$

$$\Delta y = \begin{pmatrix} \frac{p_1 + p_2 \delta_R}{N^2} \\ \frac{p_2}{N^2} \psi_R \\ 0 \end{pmatrix} \Delta x$$