3.1 $R = U / I$ a) [illegible]

b) $\underline{F_{abs}} = \sum \frac{\partial f}{\partial x_i} \Delta x_i = \frac{\partial R}{\partial U} \Delta U + \frac{\partial R}{\partial I} \Delta I = \underline{\frac{1}{I} \Delta U - \frac{U}{I^2} \Delta I}$

$= \frac{-100\,mV}{700\,mA} - \frac{8000\,mV}{(700\,mA)^2} \cdot 15\,mA = \underline{-0{,}145\,\Omega.}$

$\underline{F_{rel}} = \varepsilon_U - \varepsilon_I = \frac{-100\,mV}{8000\,mV} - \frac{15\,mA}{700\,mA} = \underline{-0{,}034 \mathrel{\hat=} -3{,}4\,\%.}$

3.2 → Vorlesung

3.3

a) $\underline{F_{abs}} = \sum \frac{\partial f}{\partial x_i} \Delta x_i = \frac{\partial y}{\partial A} \Delta A + \frac{\partial y}{\partial B} \Delta B = \underline{\left((1+B)\Delta A + A \Delta B\right) K.}$

mit $\varepsilon_A = \frac{\Delta A}{A}$; $\varepsilon_B = \frac{\Delta B}{B}$ $\rightsquigarrow$ $= \underline{\left((1+B) A \varepsilon_A + A B \varepsilon_B\right) K.}$

b) $\underline{F_{rel}} = \frac{F_{abs}}{y} = \frac{(1+B) A \varepsilon_A + A B \varepsilon_B}{A (1+B)} = \underline{\varepsilon_A + \frac{1}{1 + 1/B} \varepsilon_B.}$

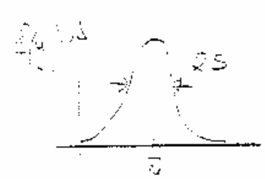
c) $\underline{F_{rel} = 1{,}5\,\%}$

d) Differentiale $\frac{\partial L}{\partial x_i}$ [illegible] $\Rightarrow F_{rel} = \frac{y(A+\Delta A, B+\Delta B) - y(A, B)}{y(A, B)}$

e), f) ...

g) $\underline{\bar{F}_{abs}} = \sqrt{\sum \left(\frac{\partial y}{\partial x_i}\right)^2 s_i^2} = \underline{\sqrt{(1+B)^2 s_A^2 + \ldots^2 s_B^2}.}$

$\underline{\bar{F}_{rel}} = \frac{\bar{F}_{abs}}{y} = \underline{\sqrt{\varepsilon_A^2 + \left(\frac{1}{1+1/B}\right)^2 \varepsilon_B^2}.}$

h) 

Parameter Mittelwert $\bar{x}$

Stdabw s

3.4 Fehlerrechnung allgemein

a) $\underline{F_{abs}} = 2\pi \left(\frac{R}{\sqrt{S}} \Delta U + \frac{U}{\sqrt{S}} \Delta R - \frac{1}{2} U R S^{-3/2} \Delta S \right).$

b) $\underline{F_{rel}} = \varepsilon_U + \varepsilon_R - \frac{1}{2} \varepsilon_S.$ c) ... d) ...

e) $\underline{F_{s\,abs}} = 2\pi \sqrt{\left(\frac{R}{\sqrt{S}}\right)^2 s_U^2 + \left(\frac{U}{\sqrt{S}}\right)^2 s_R^2 + \left(-\frac{1}{2} U R S^{-3/2}\right)^2 s_S^2}.$

$\underline{F_{s\,rel}} = \sqrt{\varepsilon_U^2 + \varepsilon_R^2 + \frac{1}{4} \varepsilon_S^2}.$ f) ...

3.5 Fehlerberechnung einer Durchflussmessung

a) Empfindlichkeit $E = \dfrac{\text{Änderung d. Ausgangsgröße}}{\text{" d. Eingangsgröße}}$

$\underline{E} = \frac{\partial I}{\partial Q} = \underline{\frac{1}{2} a \sqrt{b/Q_F}}.$

b) $\underline{F_{rel}} = \varepsilon_a + \frac{1}{2} \varepsilon_b = |1\%| + |5\%| = \underline{|6\%|\,max}$

3.6 Fehler eines Kapazitätsnormals

a) $\underline{C} = \varepsilon_0 \frac{A}{a} = \varepsilon_0 \frac{(D/2)^2 \pi}{a} = \underline{\frac{\varepsilon_0 \pi}{4} \frac{D^2}{a}}.$

b) $\underline{F_{abs}} = \sum \frac{\partial f}{\partial x_i} \Delta x_i = \underline{\frac{\varepsilon_0 \pi}{4} (2 D \Delta D - a^2 D^2 \Delta a)}.$

$\underline{F_{rel} = 2 \varepsilon_D - \varepsilon_a}.$

c) $\underline{F_{s\,abs}} = \sqrt{\sum \left(\frac{\partial f}{\partial x_i}\right)^2 s_i^2} = \underline{\frac{\varepsilon_0 \pi}{4} \sqrt{(2D)^2 s_D^2 + (a^2 D^2)^2 s_D^2}}.$

$\underline{F_{s\,rel}} = \sqrt{\sum \left(\frac{\partial f}{\partial x_i}\right)^2 \varepsilon_i^2} = \underline{\sqrt{4 \varepsilon_D^2 + \varepsilon_a^2}}.$

3.7 Meßdatenauswertung

a) Gauß- oder Normalverteilung $N(\bar{x}; s)$

~ Mittelwert $\bar{x}$

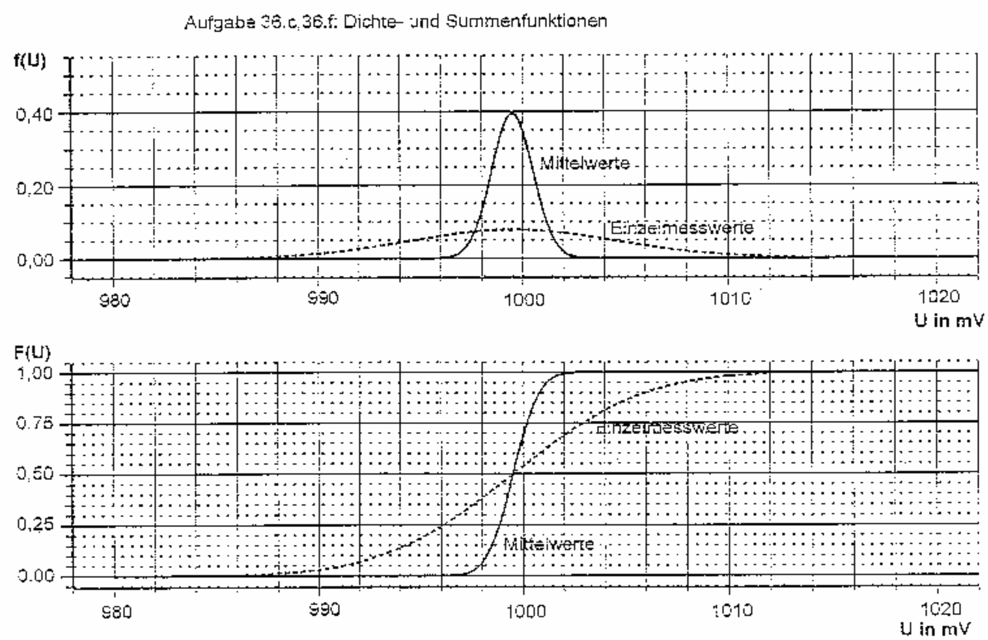
~ Standardabweichung s

b) ...

c) $\bar{U}_{SE} = \frac{\sum U_i}{N} = \frac{995 + \ldots + 999}{8} = 999{,}5\,mV$

$$s_E = \sqrt{\frac{1}{N-1}\sum_1^N \left(U_i - \bar{U}_{SE}\right)^2} = 5{,}1\,mV$$

d)



e) 68,3%-Intervall $\Delta U = 2 \cdot s_E = 10{,}1\,mV$

99,7%- " $\Delta U = 3 \cdot s_E = 17{,}1\,mV$

f) $s_{MQ} = \frac{s_E}{\sqrt{M}} = \frac{s_E}{5} = 1{,}014\,mV$ $\quad \mu_{sMQ} = \mu_E$

g) => Mittelwerte streuen um Faktor $1/\sqrt{M} = \frac{1}{5}$ weniger als die Einzelmeßwerte

h) siehe c)

Aufgabe 3.7 : Dichte- und Summenfunktionen