

Processing of Time and Dimensions Data

Calculation of the Enclosed Volumes and Surface Areas

Measurement error of a calliper:

$$m(x) = 0,1 \text{ mm}$$

Measurement error of a micrometre:

$$m(x) = 0,01 \text{ mm}$$

$$u_{xB} = \frac{m(x)}{\sqrt{3}}$$

Sphere:

$$V = \frac{\pi d^3}{6}$$

$$S = \pi d^2$$

$$u_{rd} = \frac{u_d}{d}$$

$$u_{rV} = 3u_{rd}$$

$$u_{rS} = 2u_{rd}$$

$$u_V = u_{rV}V$$

$$u_S = u_{rS}S$$

Measurement error of a calliper:

$$m(x) = 0,1 \text{ mm}$$

Measurement error of a micrometre:

$$m(x) = 0,01 \text{ mm}$$

$$u_{xB} = \frac{m(x)}{\sqrt{3}}$$

Cylinder:

$$V = \frac{\pi d^2 h}{4}$$

$$S = \frac{\pi d^2}{2} + \pi d h$$

$$u_{rd} = \frac{u_d}{d} \quad u_{rh} = \frac{u_h}{h}$$

$$u_{rV} = \sqrt{4u_{rd}^2 + u_{rh}^2}$$

$$\begin{aligned} u_S &= \sqrt{\left(\frac{\partial S}{\partial d}\right)^2 u_d^2 + \left(\frac{\partial S}{\partial h}\right)^2 u_h^2} = \\ &= \pi \sqrt{(d+h)^2 u_d^2 + d^2 u_h^2} \end{aligned}$$

$$u_V = u_{rV} V$$

$$u_{rS} = \frac{u_S}{S}$$

Measurement error of a calliper:

$$m(x) = 0,1 \text{ mm}$$

$$u_{xB} = \frac{m(x)}{\sqrt{3}}$$

Measurement error of a micrometre:

$$m(x) = 0,01 \text{ mm}$$

Cuboid:

$$V = abc$$

$$S = 2(ab + ac + bc)$$

$$u_{rV} = \sqrt{u_{ra}^2 + u_{rb}^2 + u_{rc}^2}$$

$$u_{ra} = \frac{u_a}{a}$$

$$u_{rc} = \frac{u_c}{c}$$

$$u_V = u_{rV} V$$

$$\begin{aligned} u_S &= \sqrt{\left(\frac{\partial S}{\partial a}\right)^2 u_a^2 + \left(\frac{\partial S}{\partial b}\right)^2 u_b^2 + \left(\frac{\partial S}{\partial c}\right)^2 u_c^2} = \\ &= 2\sqrt{(b+c)^2 u_a^2 + (a+c)^2 u_b^2 + (a+b)^2 u_c^2} \end{aligned}$$

$$u_{rS} = \frac{u_S}{S}$$

Swing time τ of a pendulum

For our purpose, the period T was recorded.

$$T = 2\tau \quad u_{r\tau} = \frac{u_\tau}{\tau} = \frac{u_T}{T} = u_{rT}$$

Human reaction time for single measurement: **0.5 s**

One period as a single measurement:

$$u_T = \frac{0,5}{\sqrt{3}} \text{ s} \quad u_\tau = \frac{0,5}{2\sqrt{3}} \text{ s}$$

10 periods as a single measurement: $t = 10 T = 20 \tau$

$$u_t = \frac{0,5}{\sqrt{3}} \text{ s} \quad u_T = \frac{0,5}{10\sqrt{3}} \text{ s} \quad u_\tau = \frac{0,5}{20\sqrt{3}} \text{ s}$$

Repeated measurement of one period $t = T = 2\tau$

$$u_{r\tau} = \frac{u_\tau}{\tau} = \frac{u_T}{T} = u_{rT}$$

$$\bar{t} = \frac{\sum_{i=1}^{10} t_i}{10}$$
$$s_{\bar{t}} = u_{tA} = \sqrt{\frac{\sum_{i=1}^{10} (\bar{t} - t_i)^2}{10(10-1)}}$$
$$u_{\tau A} = \frac{u_{tA}}{2}$$

$$u_{\tau_B} = \frac{u_{tB}}{2} = \frac{0,01}{2\sqrt{3}} \text{ s}$$

Stop-watch error

$$u_\tau = \sqrt{u_{\tau A}^2 + u_{\tau B}^2}$$

$$t = T = 2\tau$$

$$u_{r\tau} = \frac{u_\tau}{\tau} = \frac{u_T}{T} = u_{rT}$$

Sequential measurement of one period (10 data points):

Linear regression: $y = ax$

$$y = ax + b$$

$$a = T$$

$$\tau = \frac{a}{2}$$

$$u_{\tau A} = \frac{u_{tA}}{2} = \frac{s_a}{2}$$

$$u_\tau = \sqrt{u_{\tau A}^2 + u_{\tau B}^2}$$

$$u_{\tau B} = \frac{u_{tB}}{2} = \frac{0,01}{2\sqrt{3}} \text{ s}$$

Sequential measurement of one period (computer controlled)

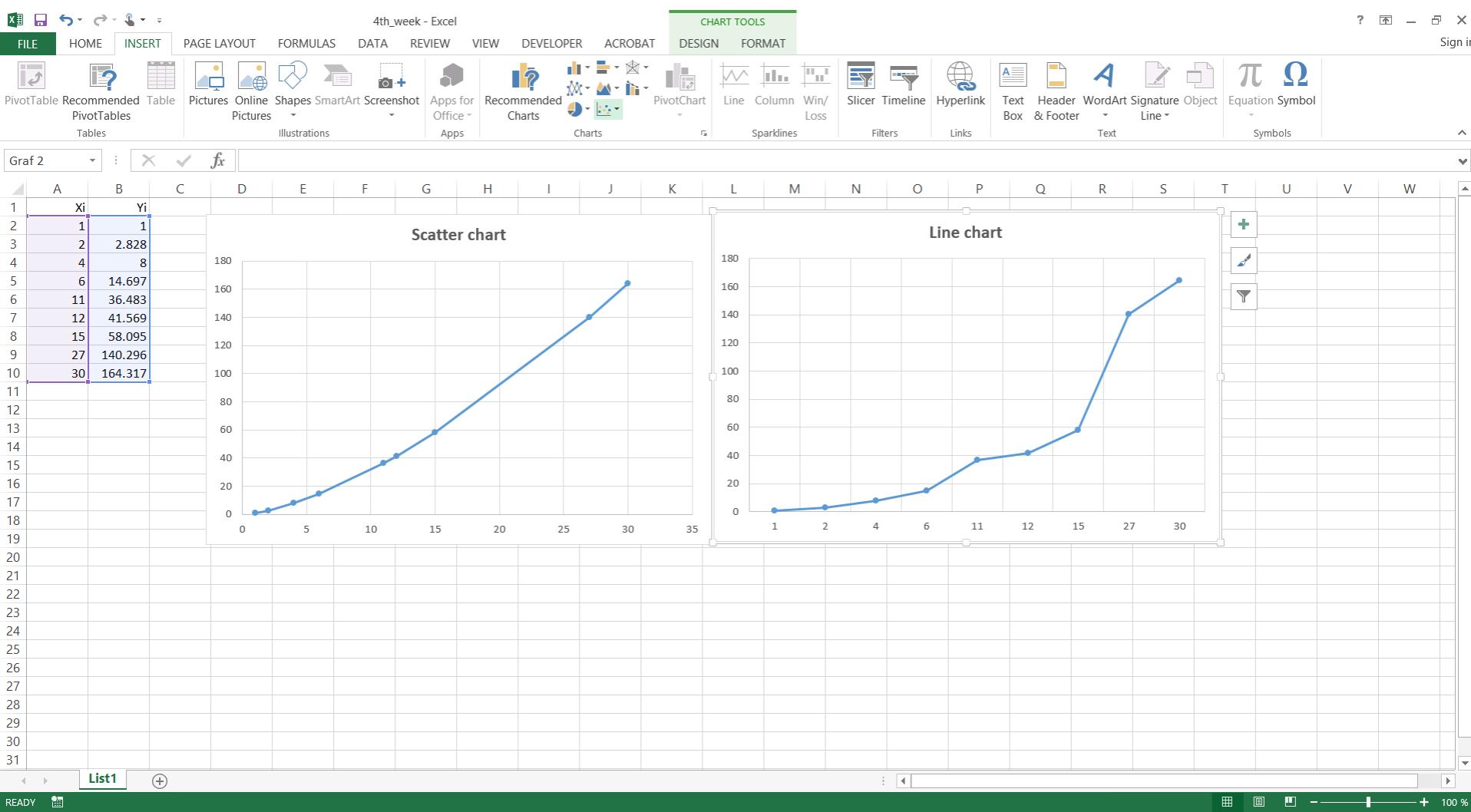
$$a = T$$

$$\tau = \frac{a}{2}$$

$$u_{\tau A} = \frac{u_{tA}}{2} = \frac{s_a}{2}$$

$$u_\tau = u_{\tau A}$$

$$u_{\tau B} = \frac{u_{tB}}{2} = 0$$



The screenshot shows a Microsoft Excel spreadsheet titled "4th_week - Excel". The ribbon tabs are FILE, HOME, INSERT, PAGE LAYOUT, FORMULAS, DATA, REVIEW, VIEW, DEVELOPER, ACROBAT, CHART TOOLS (DESIGN selected), and FORMAT. The DESIGN tab has sub-options for Add Chart Element, Quick Layout, Change Colors, Chart Styles, Data, Type, and Location.

The worksheet contains a table of data with columns A, B, and C. Column A has values from 1 to 30. Column B has values: 1, 2.828, 8, 14.697, 36.483, 41.569, 58.095, 140.296, and 164.317. Column C is empty. The chart area is highlighted with a red oval and contains the text "Scatter chart".

The chart itself is a scatter plot with a quadratic regression curve. The x-axis is labeled "Title X" and ranges from 0 to 30. The y-axis is labeled "Title Y" and ranges from 0 to 160. The data points are represented by blue 'x' marks, and the regression equation $y = 0.1061x^2 + 2.4001x - 2.5377$ is displayed on the plot.