1. Exercise
Analysis of fibers cross-section.

Instructions:
- from the presented fibrous materials, create cross section using the hand microtome
- create images of cross sections

Calculate:
1. Shape characteristics by formulas below for two types of fibres.
2. Descriptive statistics, including confidence intervals, by supplement Data analysis in Excel.
3. Sort data to categories and draw histograms of absolute and relative frequencies.
4. Create Q-Q chart and compare with normal distribution. Decide whether the data comes from a normal distribution.
5. Create report with results.

Requisites: NIS-Elements image analysis, passing light microscope, hand microtome

Principe: NIS-Elements is a Laboratory Imaging system that processes and analyses colour images based on mathematical morphology. The principle of this mathematical discipline and its application in NIS-Elements is the concept of the analysed object as a set of points. NIS-Elements uses 1232 x 972 pixels to display the image, which is actually the maximum effective resolution of the system. NIS-Elements recognizes two basic types of images - binary and colour, each grey image is derived.

Binary images have two possible values, 0 for background and 255 for objects and structures. It is made up of functions like Threshold and is often referred to as segment images. This is particularly true when it is emphasized that they are linked to the original colour image from which they originated by segmentation. They are used to measure shape and size. **Colour images** consist of three RGB components that represent the intensity of red, green, and blue. Pixel values for each folder are from 0 to 255. For NIS-Elements, this is the most natural type of image converted by the digitization card. **Grey images** are images derived. Pixel values vary from 0 to 255 but are identical for all three components in each pixel.

Measurements in NIS-Elements. Before the measurement, it is necessary to decide whether we are interested in texture or object. NIS-Elements recognizes two types of measurements: textural measurements and object measurements. Object measurements will be used for this task.

Measurement procedure:
Once the adhesive has dried, the threads are placed in parallel to the handmade microtome. Fibers fastened in the microtome by turning microscreen out and cut. Prepare a preparation of several slices of 20 μm.
- Before scanning, the system must be calibrated, the measured quantities selected and the appropriate measurement procedure selected.
- First, we scan the cross-sections of the fibers with the camera (the scanned image can be further edited, for example by changing the contrast of the image, for better information, etc.).

- The next step is thresholding (this means the measured objects are marked); Once again, you can edit the image, this time in the binary editor or binary menu.
- The last step is the actual measurement in the measurement menu is done by using the function: *Measuring objects in the field*; the measured values are exported.

Measured variables: Perimeter of fiber O, Area of fiberes cross section S,

Calculated shape characteristics:

Equivalent fiber perimeter Oe (i.e. Perimeter of a circular filament having an area S):

$$O_e = 2\sqrt{\pi S}$$

The equivalent fiber surface Se (i.e., the area of the circular filament having the circumference O):

$$S_e = \frac{O^2}{4\pi}$$

Circularity as a share of the real and equivalent fiber surface:

$$c = \frac{S}{S_e} = \frac{4\pi S}{Ov^2} = \frac{1}{(q+1)^2}$$

Compactness as a fraction of the real and equivalent fiber perimeter:

$$ck = \frac{O}{O_e} = \frac{O}{2\sqrt{\pi S}} \quad \text{therefore} \quad c = \frac{1}{ck^2}$$

Form Factor by Malinowska:

$$q = \frac{1 - \sqrt{c}}{\sqrt{c}} = ck - 1$$

2. Exercise
Fiber Strength Distribution

Instructions:

For the present fiber material, do:

- fiber strength tests according to the standard ČSN EN ISO 5079

Calculate and create:

1. Weibull chart, use probability density or distribution function

2. Two types of regression model, one of them with regression line and second of them with polynomial. Show regression formula and correlation coefficient.

3. Calculate sum of square reziduals for suggested models and decide which of them is preferable for your data.

4. Create report with results.

Requisites: VIBROSKOP 400, VIBRODYN 400

Principe: The individual filaments of the present material are first measured on a Vibroscope 400 where the fiber fineness in dtex is measured (due to the fineness of the fiber, a suitable prestressing according to the table is also chosen). Then the fiber is clamped into a tensile machine (Vibrodyn 400) and a conventional tensile test according to ČSN EN ISO 5079 is performed on them.

Measurement:

Conditions according to the standard ČSN EN ISO 5079:

Clamping length: $l_0 = 10$ mm

Number of measurement: $n = 50$

Speed of test: 10 mm/min

weight of prestress [mg]	fineness of fiber [dtex]
30	0,30-0,70
50	0,50-1,20
70	0,70-1,70
100	1,00-2,40
150	1,50-3,60
200	2,0-4,80
300	3,0-7,0
500	5,0-12,0

3. Exercise

Relaxation of tension

Instructions:

For the present fiber material do stress relaxation after stress below the yield strength according to norm ČSN EN ISO 5079.

Calculate:

1. Average relaxation curve and draw her chart.
2. Regression line with formula and correlation coefficient.
3. Create report.

Requisites: Tiratest

Principe: For the fiber we will perform the strength test. From the resulting tensile curve, we determine the yield point that will determine the deformation sizes below and above the yield strength for the relaxation test itself.

Relaxation test: Fit the thread into the Tiratest jaws, we load as fast as possible until the selected stress (voltage) and register the voltage dependence on time for 5 minutes.

Measurement:

Conditions according to the standard ČSN EN ISO 5079:

Clamping length: $l_0 = 20$ mm
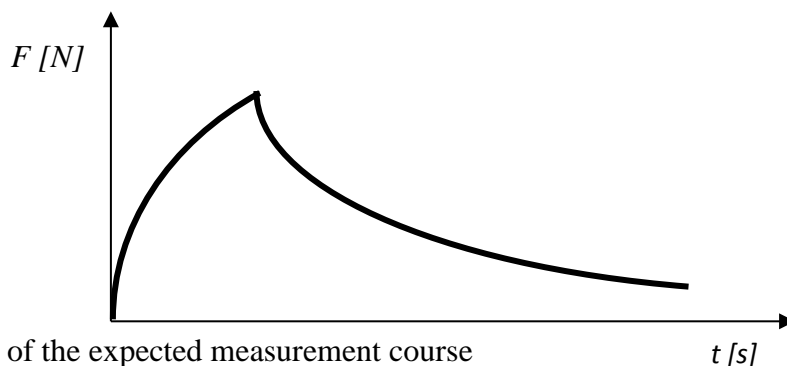
Number of measurement: $n = 5$

Speed of test: 20 mm/min

Figure 1: Graph of the expected measurement course

Data processing:

The simplest model describing stress relaxation, creep and working curves is the standard linear viscoelastic body shown in Figure 2.
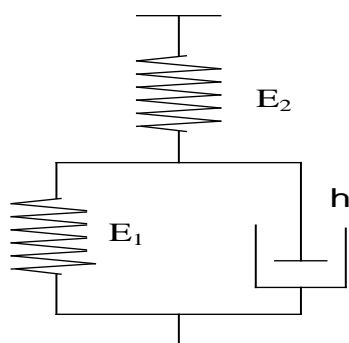

Figure 2: Standard linear viscoelastic body

4. Exercise
Fiber electron microscopy

5. Exercise

Evaluation of electrical properties of textiles

Instructions:

- carry out surface R_S [Ω] and volume R_V [Ω] resistance measurements samples
- the samples differ in the conductive component P content of the sample
- for subsequent statistical analysis, measure each parameter 10x (different locations sample), see table 1
- calculate the surface and volume resistivity of the formulas:

$$\rho_S = R_S . k_1; \quad \rho_V = \frac{k_2 . R_V}{t}$$

where ρ_S - surface resistivity [Ω], ρ_V - volume resistivity [Ω.cm], R_S - surface resistence [Ω], R_V - volume resistance [Ω], k_1 - dimensionless constant depending on electrode size, k_1 = 9.99; k2 - electrode area, k_2 = 19.95 cm^2, t - sample thickness [cm].

- perform basic statistical evaluation of measured data (average, authoritative) deviation, 95% confidence intervals)
- perform a graphical evaluation of the measured data, plot: a) average dependence values of surface resistivity on the content of the conductive component in the samples, b) dependence the average resistivity values on the content of the conductive component in the samples. Also plot the calculated average confidence intervals in both graphs.
- obtained point dependencies (surface resistivity versus conductive component content, volume resistivity versus fit the content of the conductive component with a suitable model
- draw a general conclusion from the graphical evaluations. Confirm or. disprove the hypothesis that the content of the conductive component affects both types of resistivity.
- elaborate a protocol containing a brief work goal, sample characteristics, used measurement instruments, measured data incl. state. evaluation, graphical evaluation, discussion and conclusion.

Requisites: Three-electrode tool for surface and volume resistivity measurement, HP 34970A Data Acquisition / Switch Unit.

Figure 1. Standard device for measurement electric properties of textile materials

Caption: 1 … internal circular electrode, 2 … ring electrode, 3 … connector, 4 … shielding board, 5 … insulating board, 6 … insulating cylinder, 7 … support electrode, 8 … sample, 9 … insulating layer

Table 1: Measured values of surface and volume resistance

P [%]	15		20		40		75	
t [mm]	0,71		0,67		0,64		0,47	
	R_S [Ω]	R_V [Ω]	R_S [Ω]	R_V [Ω]	R_S [Ω]	R_V [Ω]	R_S [Ω]	R_V [Ω]
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								