Ministry of Health of Ukraine
Ukrainian Medical Stomatological Academy

It is approved
on meeting of department of
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Methodical instructions
for students' self-preparation work at preparation for a practical lesson
at home and at the classroom

Subject matter	**Medical and biological physics**
The unit	1. Fundamentals of higher mathematics and biological physics
Theme of lecture:	**Study of deformation properties of dental materials.**
Year	1
Faculty	Stomatological
Speciality	Stomatology

Poltava - 2020

The topic significance:

The meaning of durability of various materials and biological tissues measuring is using obtained data for necessary construction prosthetic devices, medical instruments and support constructions, development of different methods of treatment by mechanical influence. It has in medicine the large practical importance. Task and methods of research of durability, micro-hardness, elasticity, limits of elasticity, hardness and material fatigue are subjects of stomatological material engineering, as influence of temperature and long-term mechanical impact too.

In stomatological practice it is important to know the durability of dental materials and the durability of tooth substance, which depends significantly on the age of a man and his diseases.

The aims of the training course:

To have general knowledge of the topic studied;

To understand, to remember and to use the knowledge received;

To know definition of durability and methods of its measurement;

To know definition, aims, and tasks of stomatological material engineering;

To learn to determine hardness of dentist materials (basic and sealing up materials, crown, teeth) with the help of MPK-1 device;

To be able to carry out laboratory and experimental work.

Materials for the before – class work self – preparation work:

Basic knowledge, experience, skills necessary for studying the topic in connection with other subjects:

Science	To know	To be able to
– basis knowledge of physics	the concept of durability	to measure the durability of materials by different methods

Main terms:

Denture – tooth prosthetic device, dental prosthesis.
Dental bridge – dental pontic, bridge prosthesis.

Practical work executed in class

Task 1. To learn with devices MPK-1.
Task 2. To measure linear sizes of the sample, using micrometer:
a) calculating length;
b) width, thickness.
Task 3.
To research stomatological material sample at the elongation on the MPK-1 device.

Test procedure:

1. To fasten the sample in the device pincher in a vertical position.
2. To engage the MPK-1 device.
3. To engage an electrical drive and to feed a mechanical loading on the sample.
4. To write graph of elongation.
5. To shut off the engine.

Task 4.

N	***Step of execution***	***Recommendations***
1	Learn tensile-testing machine MPK-1 structure.	Read device description.
2	Measure cross-section sizes ***b*** and ***h*** of sample and minimal parallel length ***l*** of the sample. Calculate cross-section area of sample.	Use micrometric gauge and vernier.
3.	Set the sampe in machine clamps. Plug in machine. Engage engine and register sress/strain diagram. Switch off machine after sample break.	

4	Read L_{el}, L_y, L_{br}.	Use ready graph of stress/strain curve of presented sample.
		Take into attention:
		a) At horizontal axis 1 mm = 3,5 N;
		b) tape movement rate v_t=720 mm/h;
		c) micro-screw rate v_{ms}=0,25 mm/min;
		d) relative elongation.

5	To take the possession of measurement method of the material durability. Calculate limits values.	To put the results into the table.

Result table

Parameters		Material	
		Plastic	Steel
Size of sample	l, mm		
	b, mm		
	h, mm		
	S, mm		
Loading	L_{el}, N		
	L_y, N		
	L_{br}, N		
Absolute elongation	Δl, mm		
Characteristics	Elastic limit		

	σ_{el}, MPa		
	Yield point σ_y, MPa		
	Breaking point σ_{br}, MPa		
	Percentage reduction of area ε, %		

Draw a conclusions.

The contents of the topic:

The materiology (material engineering) is integrally interlinked to stomatology and is its integral part. One of main it's tasks is development of material for tooth stopping, prosthetic devices, medical instruments and support constructions. The special meaning has knowledge of physico-mechanical properties of stomatologic materials which allows the possibility of their most effective use. Durability (strength) as one of mechanical properties should be taken into account, for example, at manufacturing manifold constructions which should work in an oral cavity.

Durability [strength; soundness, solidity] is one of important mechanical characteristics of solid materials as elasticity [resiliency, resilience]; also flexibility (by *Young's modulus of elasticity*), afterflow (by *yield strain* ***)*** and failure strain (by *failure point*).

Durability

Durability is ability of material to resist to destruction, as well as to irreversible change of shape (plastic deformations) at influence of outer loading. In the narrow sense it is resist to destruction only. Durability is conditioned by interaction forces between substance molecules. It depend on deformation mode too (compression, stretching, bending, shear, torsion), on condition of loading (temperature, velocity of load grows, time of loading, quantity of load cycles, influence of environment). Correspondingly it distinguishes breaking point (limit of durability), yield point, endurance limit and other.

The tensile test may be used either to determine the yield strength of a steel for use in design calculations or to ensure that the steel (or other material) complies with a material specification's strength requirements.

Mechanical property data are obtained from a relatively small number of standard. These will include tensile and toughness tests.

Tensile testing

The test is made by gripping the ends of a suitably prepared standardised test piece in a tensile test machine and then applying a continually increasing uni-axial load until such time as failure occurs. Test pieces are standardised in order that results are reproducible and comparable as shown in fig 2.

Both the load (stress) and the test piece extension (strain) are measured and from this data an *engineering stress/strain curve* is constructed, fig.4a. From this curve we can determine:

a) the *tensile strength*, also known as the *ultimate tensile strength*, the load at failure divided by the original cross sectional area where the ultimate tensile strength, $\sigma_{max} = P_{max} / A_0$, where P_{max} = maximum load, A_0 = original cross sectional area.

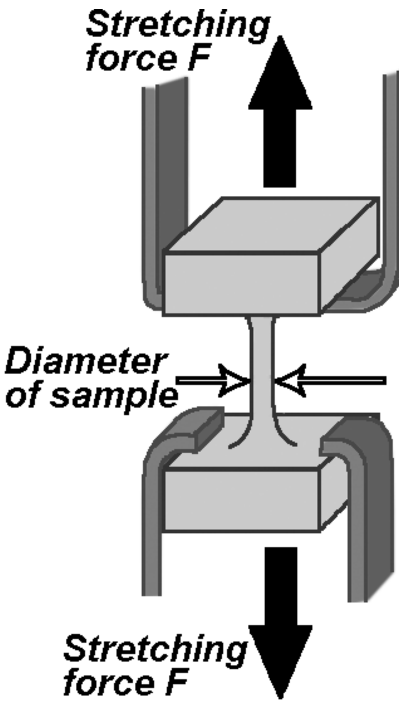

Fig.1. Tensile-testing machine (overview and scheme of working area).

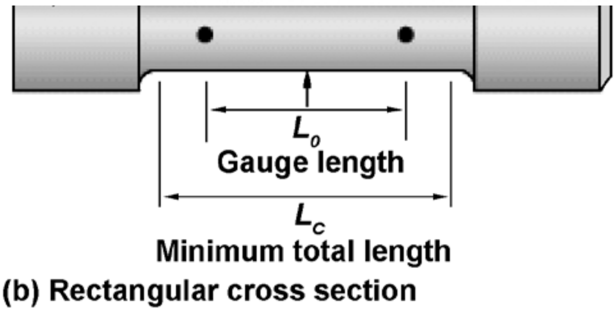

Fig.2. Standard shape tensile specimens.

b) the *yield point* (YP), the stress at which deformation changes from elastic to plastic behaviour ie below the yield point unloading the specimen means that it returns to its original length, above the yield point permanent plastic deformation has occurred, YP or $\sigma_y = P_{yp} / A_0$ where P_{yp} = load at the yield point.

c) By reassembling the broken specimen we can also measure the *percentage elongation*, El% how much the test piece had stretched at failure where El% = $(L_f - L_0/L_o)$ x100 where L_f – gauge length at fracture and L_0 – original gauge length (fig.3a*)*. Real tensile-testing machines register stress and corresponding strain simultaneously on the recorder or to the computer memory with simultaneous calculations and with following representation on the screen, on the paper.

d) the *percentage reduction of area*, how much the specimen has necked or reduced in diameter at the point of failure where R of A% =$(A_0 - A_f / A_0)$ x 100 where A_f –

cross sectional area at site of the fracture (fig.3b).

(a) and (b) are measures of the strength of the material, (c) and (d) indicate the *ductility* or ability of the material to deform without fracture.

The slope of the elastic portion of the curve, essentially a straight line, will give *Young's Modulus of Elasticity*, a measure of how much a structure will elastically deform when loaded.

A low modulus means that a structure will be flexible, a high modulus a structure

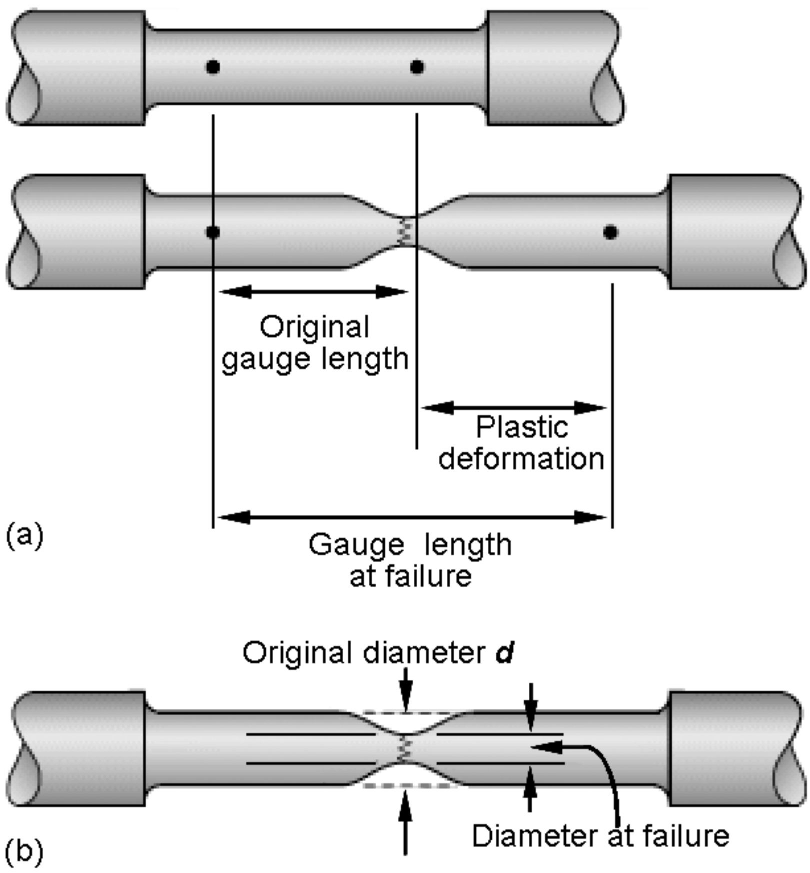

Fig.3. a) Calculation of percentage elongation; b) Reduction of area.

that will be stiff and inflexible.

Some materials such as annealed copper, grey iron and plastics do not have a straight line elastic portion on the stress/strain curve.

Some stress-strain curves (obtained at testing of different materials) are represented on figures 4 and 5. Tensile strength is defined by the maxima of a stress-strain curve and typically indicates when the test sample necks down. There are 3 common definitions of tensile strength:

Ultimate tensile strength - The maximum stress a material can withstand. It is the maximum stress on the stress-strain curve (see Fig.5, point 1)

Tensile yield strength - The stress at which material strain changes from elastic to plastic deformation (see Fig.5, point 2).

Tensile Break strength - The stress coordinate on the stress-strain curve at the point of rupture (see Fig.5, points 3).

Tensile tests are the most common material strength test and measure properties such as yield strength, modulus, ultimate tensile strength, poissons ratio, reduction of area and elongation to failure.

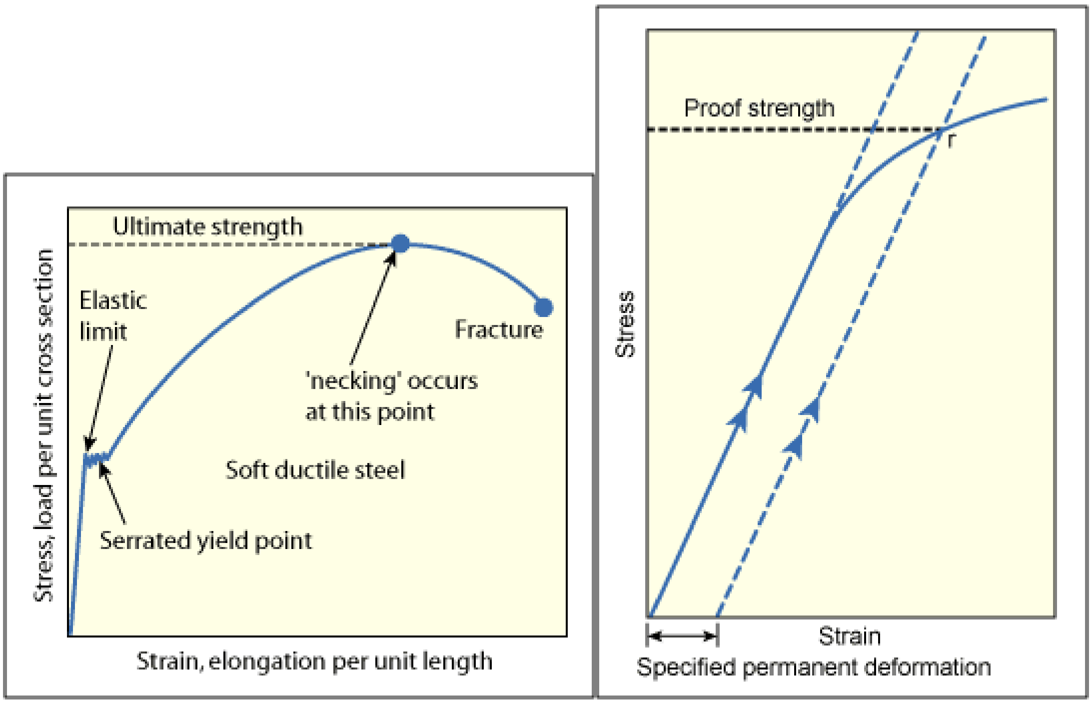

Fig.4. a) Stress/strain curve; b) Determination of proof (offset yield) strength.

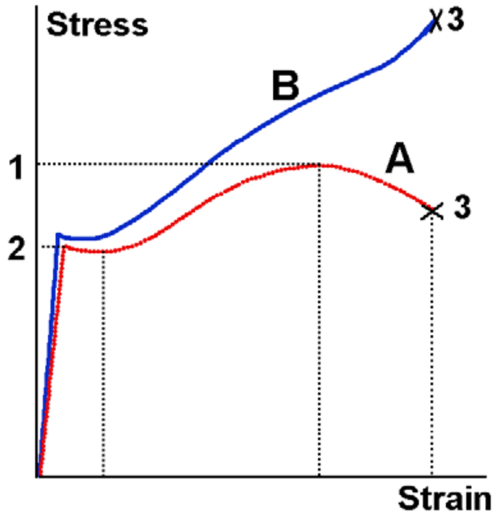

Fig.5. Some experimental stress-strain curves.

How to work with the literature recommended:

Main tasks	***Recommendations***
Learn	
Durability [strength, soundness, solidity] of the material.	To give the definition of the material durability and the units of measurements.
Ductility [plasticity, ductility property, unctuosity] of the material.	To give the definition of the material ductility and the units of measurements.
Methods of measurement of material durability.	To explain the essence of the method of measurement of material durability.
Tensile-testing machine MPK-1 using.	To explain the essence of the tensile-testing machine MPK-1 using.

Self-control material:

A. Questions to be answered:

1. What is the durability of the material?
2. What is the ductility of the material?
3. What is the durability fatigue ability of the material?
4. Draw the graph of solid body stretching and explain it.
5. What is the elastic limit (σ_{el})? How it can be found on the graph?
6. What is the breaking point (σ_{br})? How it can be found on the graph?
7. What is the relative yield point (σ_{y})?
8. How relative elongation of the sample (ε) can be found on the graph?
9. Explain appearance of strain in denture (dental bridge) at presence of teeth:

a) if a person masticates foodstuff;
b) if a person bites foodstuff.

10. Explain appearance of strain in dentures (dental bridges) at presence of dentures only:

a) if a person masticates foodstuff;
b) if a person bites foodstuff.

B. Test tasks to be done:

1. What does " durability of a tooth" mean:
   a) durability of enamel;
   b) durability of dentine;
   c) durability of cement;
   d) average durability of the organ.
2. Doctor has material, which durability is more, than the durability of the tooth. What can be result of use this material as prosthetic material:
   a) the prosthetic device can break after a time;
   b) the teeth near prosthetic device can break after a time;
   c) the teeth opposite to prosthetic device can break after a time;
   d) the prosthetic device can be used long time without problems.

Literature recommended

Main sources.

– Chaliy at all., Biological and medical physics. – A.V. Chaliy et all.– Ed.A.V. Chaliy. – Vinnitsia, Nova Knyha. –2013. – 480 pp.

– L.D.Korovina. Biophysics with beginnings of mathematical analysis and statistics. Extended course of lectures. Vol.1. Bases of mathematical analysis, probability theory and mathematical statistics. Methods of obtaining of the biophysical information. Biomechanics. Second supplemented edition. –Poltava, 2017. –127 p.

***Additional sources**:*

– Compendium of Medical Physics, Medical Technology and Biophysics for students, physicians and researchers. Nico A.M. Schellart. – Department of Biomedical Engineering and Physics Academic Medical Center University of Amsterdam.– Amsterdam.– 2009 (electronic book).

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