APPROVED
Director of the Institute for International Education
and Language Communication
_____V. K. Erokhin
"_____" _____ 2015.

Metrology, Standardization and Technical Measurements
(Метрология, стандартизация и технические измерения)

Course Syllabus
for international students following the major 150700 – "Mechanical Engineering"

Teaching Providing Department: Interdisciplinary Department

Academic Semesters 6
Academic year: 2015/2016, changed in _____

Distribution of study hours

Semester 5:

Lectures	24 hours (class)
Laboratory works	16 hours (class)
Seminars	8 hours (class)
Assessment Tests	2 hours (class)
Total contact hours	**48 hours**
Self-Study	78 hours (including home assignment)
Summarized hours	**126 hours**
Final Exam	6 semester

2015

Preface

1. The course syllabus is drawn on the basis of State Educational Standard in the field of study 150700 "Mechanical Engineering", approved on 27.03.2000 year, number of state registration 256 тех/бак.

   CONSIDERED and **APPROVED** at the meeting of the Interdisciplinary department of the Institute for International Education and Language Communication
   "___" _____ 200__, minutes № _____

2. Author (Lecturer):
   Associate Professor
   of Interdisciplinary Department _____ Victor N. Kozlov

3. Head of Interdisciplinary Department _____ Galina V. Kashkan

4. The course syllabus **has been submitted** to the Head of the Teaching and Methodology Department of Institute for International Education and Language Communication and meets the curriculum requirements.

   Acting Head of Teaching
   and Methodology Department _____ Oksana N. Palmina

ANNOTATION

Metrology, Standardization and Technical Measurements
(Метрология, стандартизация и технические измерения)
Field of study 150700 – "Mechanical Engineering"
Institute for International Education and Language Communication
Interdisciplinary Department
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"Metrology, Standardization and Technical Measurements" is a one semester course for students pursuing the bachelor degree.
The main emphasis is made on: fundamentals of standardization, sertification and interchangeability; system of tolerances and fits for smooth parts, key, slot and thread junctions; an exactitude of angles and cones, mounting surfaces for rolling contact bearings, gear wheels both transmissions, roughness of surfaces, errors of form and dispositions of surfaces, methods and devices for monitoring parts of machines; designing an assembly and a design drawings.

Goal: to provide students with the knowledge, skills and practical experience in the area of machine building metrology, to examine issues involving system of tolerances and fits for smooth parts, key, slot and thread junctions, gear wheal transmitions, to offer each student the opportunuty to apply learned skills in experimental setting.

Objectives:
1. to introduce students to the various terminology used in experimental methods, concepts of metrology and its application;
2. to provide an introduction to the concepts and tools which will be developed further in the later years of studying special courses according to the chosen major;
3. to broaden student`s exposure to the practical application of knowledge, skills and tools.

Students Learning Outcomes

Students who successfully complete this course, should be able to:
1. understand the roule of interchangeability;
2. develop their knowledge of terminology, concept, basic principles and limitations of standardization, sertification, system of tolerances and fits for various parts and surfaces;
3. develop their knowledge of concept and basic principles of fixing of fits and roughness of surfaces, tolerances of form and dispositions of surfaces;
4. develop their knowledge of concept and basic principles of fixing of gear wheels accuracy and requirements.
5. comprehensively and accurately analyze dependence of accuracy of size, roughness of surface, tolerances of form and dispositions of surfaces;
6. develop their knowledge and skills in measument and control of various parts and surfaces;
7. develop their knowledge and skills in designing an assembly and a design drawings;

8. apply key techniques of mesurements and critical thinking skills to address metrology problems;
9. use a wide range of information, methods, etc in undertaking research tasks with minimum guidance;
10. reflect critically on their own and other`s functioning as a practitioner, operate in complex and unpredictable engineering environments with a critical awareness of good practice.

Assessment of these skills is monitored during lectures, seminars, laboratory works and consultations, and are evaluated through the variety of activities (oral discussions, presentations in seminars, written reports, quizzes, tests, home assignments).

General Teaching Methods and Strategies

Lectures are designed to introduce stutents to key ideas and stimulate interest and intellectual curiosity. Some lectures make use of videos, computer-based demonstrations and cases.

Seminars will entail group work and presentations, the use of problem sts which are discussed in the group. Some classes make use of video, competitive tests and exercises.

Laboratory works aims to develop practical skills through working with real equipment to fulfill the given tasks.

Consultations are used in various ways, and may involve varying numbers and be of varying length. They aim to discuss a student work that has been handed in, to suit the material and the needs and skills of the particular students, to provide an important incentive for the student`s independent learning.

Self-study aims to support and reinforce a culture of independing reading and learning. The students are encouraged to develop effective learning strategies through acquiring a range of self-study skills and performing systematic independent work to improve their competences according to their interests.

Self-study includes:

- reading on the topic – related texts;
- making oral or written reports on the topic indicated on the syllabus, on the results of laboratory works or seminars;
- working with various sources of information;
- preparation for tests;
- presentation of individual assignments.

The results of self-study activities are regularly in classroom work.

Assessment aims to check students' progress in all the areas covered by the course. Formative assessment is made through the academic semester via the lectures, consultations, class work and practical training. The aim is to monitor, test and provide feedback on each student's academic progress. Summative assessment takes the form of a one- hour written examination for each of the elements of the course at the end of the semester.

Quizzes will relate to current and previous topics. A quiz may be given at any time during any class period on a random basis (immediately after a lecture, at the beginning or end of a class, every class period, etc).

Midterm Tests (short-answer or multiple-choice on the readings and lectures) will be given once a month.

Final Exam will be given at the end of a semester to review the work done throughout the course, seeks to determine how well students have mastered the concepts and techniques contained in the course outline. The final exam consists of two sections:

1. a multiple-choice section (40 questions in 1 hour), which tests proficiency in a wide variety of topics;
2. a free-response section (3 questions in 1 hour), which requires the student to demonstrate the ability to solve problems involving more extended reasoning.

Students have the final responsibility for monitoring their academic progress and for satisfying all the requirements relevant to their degree.

Course Sullabus
Lectures Outline (18 hours)

1. Introduction. Measuring and layout tools (2 hours).

The International System of Units. The international standard for the meter. Gage blocks. Interchangeability. Measuring and layout tools. Steel rules, caliper rules, rule depth gages, combination depth and angle gages, squares, combination sets protractor heads, center heads, die maker's squares, cylindrical squares, calipers, center gages, radius gages, screw pitch gages, center punches, prick punches, machinist's vises, scribers, dividers, surface plates, straight-edges, V-blocks, telescoping gages, small-hole gages, adjustable parallels, vernier calipers, vernier height gages, vernier gear tooth calipers, vernier depth gages, universal bevel protractors, outside and inside micrometer calipers, depth micrometers. The parts and reading of a vernier caliper and micrometer. Thread micrometers, vernier micrometers and dial indicating micrometers.

Universal dial indicators, dial indicating depth gages, dial indicating hole and snap gages, dial indicating caliper gages, setting discs and setting rings. Measuring with a dial indicator by the methods of absolute and relative measurements.

2. Gages (1 hours).

Gage blocks and its classifications. Laboratory master gage blocks, inspection gage blocks, working gage blocks. Standard set of 48 metric gage blocks. Building up a specific gage block combination. Angle gage blocks. Peculiarity of building up a specific angle gage block combination. Toolmaker's microscopes and optical comparators. The sine bar. Limits gages.

3. Methods of Measurements (1 hours).

The methods of absolute measurements and methods of relative measurements. The advantages and disadvantages of relative measurement method.

4. Tolerances and Fits (2 hours).

Actual size. Notions “shaft” and “hole”. The basic size and zero line. Limit deviations and sizes. Fundamental deviation and tolerance. Schemes of fundamental deviations of shafts and holes. Marking of working size in accordance with the system ISO. Notion “fit”. Tolerance of the fit. Fits in systems hole and shaft. Types of fits.

5. Fits for rolling contact bearing. The method of selective assembly (1 hours).

6. Gages for Testing Parts (1 hours).

Limits gages. Schemes of gages tolerances zones for testing a hole and shaft. The advantages and disadvantages of gages. Sealed and unsealed snap gage. The single-end and the double-end type. Progressive-type plug gages. Plain, taper and thread ring gages.

7. Key and slit junctions. Tolerances of angles and cones (2 hours).

Key and slit fits. Centering diameter. Tolerances of angles and conical surfaces. Methods and tools for control of angles and cones.

8. Screw threads (2 hours).

Types of threads. Right-hand and left-hand threads. Straight and tapered threads. External and internal threads. Major, minor and pitch diameters. Pitch, lead. Multiple threads. Angle of thread. Crest, flank and root of thread. Height of thread. Maximum and minimum material limits Depth and length of engagement. Classes of fit: fine, medium, and coarse. Tolerance class of the thread. Basic and complete designations for ISO Metric threads.

Scheme of tolerance zones of an internal and external threads.

Square thread. Brown and Sharp Worm Thread. Pipe Threads. Tapping and threading. The taper, plug, and bottoming taps.

Screw Thread Measurement. The measurement of the minor and major diameters. The measurement of the pitch diameter. Measurements by thread micrometers, ring and screw thread plug gages, roll thread snap gages, thread comparators, optical comparators, by the three-wire method. Measurements by toolmaker's microscope. Profile of go- and not-go gages.

9. Inspection of surface form and disposition of surfaces (1 hours).

The tolerance of deviation of the form and disposition of surfaces. Degrees of accuracy. Deviation from a straightness, flatness, roundness, cylinderness.

Deviation of disposition of surface or profile, deviation from parallelism of plates and of axes in the space. Deviation from perpendicular of surfaces. Deviation from coaxiality. Deviation from symmetricity to a base plane. Item deviation. Radial and face palpitation. Dependent tolerance.

10. Control of surface finish (1 hours).

Waviness and roughness. Lay and flaws. Centerline. Roughness sampling length. Roughness average. Height of the profile roughness on ten points. Roughness spacing. Roughness spacing on the centerline. Relative profile length. Surface Finish Symbols. Roughness and grade of tolerance. Flatness measurement.

11. Control of gears (2 hours).

Types of gears. Gear terms and definitions. Fixing of accuracy. Degree of accuracy on norms of kinematics accuracy, on norms of smoothness of work, on norms of teeth contact, kind of interface and kind of the tolerance on a lateral clearance. Complexes of the control.

12. Drawing requirements (2 hours).

Requirements for the assembly and design drawings.

Laboratory Works (16 hours)

The List of Topics

1.	Measurement with a vernier caliper and micrometer ……	2 hours
2.	Measurements with a dial indicating gages ……..	2 hours
3.	Measurements of a limit plug gages ……..	2 hours
4.	Measurement of screw threads ……..	2 hours
5	Inspection of surface roughness …….	2 hours
6	Inspection of the surface form and disposition of surfaces …….....	2 hours
7.	Inspection of gears …….	4 hours

All tasks for the laboratory works, seminars and self-study activity can be found in [3].

Visual Aids of the Course

Posters, slides, nature exhibits of measuring tools and devices.

Every month – written test (under the diagram of dean's office MEF). Presentation of course paper – under the special diagram (with the indication of presentation percent). Presentation of laboratory works and seminars – by individual presentation of reports.

Final control – exams in 5 semester.

Students' Self-Studying Activity (34 hours)

Students' self-study consists in:

1. Studying the theoretical information with the use of the abstracts of lectures and recommended educational literature (18 hours);
2. Presentation of the laboratory works reports (8 hours);
3. Presentation of home assignment (8 hours).

Every month – oral or written test. Presentation of course paper - under the special diagram (with the indication of presentation percent). Presentation of laboratory and practice works - by individual presentation of reports.

Final control - examination in 5 semester.

Visual Aids of the Course

Posters, slides, nature exhibits of measuring and cutting tools.

Rating List

Type of activity	Number of hours	Maximum per activity	Total maximum
Lectures	24	–	–
Seminars	8	2	8
Laboratory works	16	2	32
Assessment tests	2	5	10
Home assignment	*12*		10
			Total: 60 points
Final exam – 22 - 40 points			
Total – 55 - 100 points			

Quantity of points total – 100 (for each part)

Excellent (5): 90 – 100 points;
Good (4): 71 – 89 points;
Satisfactory (3): 55-70 points;
Maximal points at the end of semester: 60 points;
Minimum points for permitting to exam – 33 points;
Maximal points for final exam – 40 points.

Course goals and objectives are realized in the following form of education activity.

1. **Lectures** are used for understanding theoretical aspects of course.
2. **Seminars** are used for developing practical skills of work to fulfillment of necessary calculations.
3. **Laboratory works** are used for developing practical skills of work with real equipment for fulfillment of necessary calculations and manufacturing.
4. **Consultations** are used for supporting student's self-study activity.

5. **Self-study activity** is the very important part of educational process. It gives essential skills in course tasks execution**.**
6. **Home assignment** is the most important part of educational process. It gives essential skills in course tasks execution with self-study activity.
7. **Exam** is realized in the same form as testing for all course material, questions for oral answers and additional questions.
8. **Rating list** is used for estimation of student's course activity.

Course Methodical Support

Course methodical support consists of the following components:

1. Course Syllabus with Rating List.
2. Textbook.
3. Workbook.
4. Methodical instructions for performing laboratory works.

Recommended Books

Main

1. Kozlov V.N. Technology of Mechanical Engineering. Part 1. Textbook. TPU Press, Tomsk, 2001. -134 pp.
2. Repp V.E., McCarthy W.J. "Machine Tool Technology". McKnight Publishing Company, Glencol, 1984.
3. Kozlov V.N. Technology of Mechanical Engineering. Part 1. Methodical instructions for seminars and performing laboratory works. TPU Press, Tomsk, 2010 -120 pp.
4. Kozlov V.N. Technology of Mechanical Engineering. Part 1. Workbook. TPU Press, Tomsk, 2010 -50 pp.
5. Допуски и посадки: Справочник в 2-х частях. В.Д.Мягков и др. –Л.:Машиностроение, 1982. – часть 1. –543 с., ил.
6. Допуски и посадки: Справочник в 2-х частях. В.Д.Мягков и др. –Л.:Машиностроение, 1982. –часть 2. –448 с., ил.

Additional

7. Взаимозаменяемость, стандартизация и технические измерения. А.И.Якушев и др. Учебник для ВУЗов. Издание 6-ое, переработанное и допол. М.:Машиностроение, 1986. –352 с., ил.

Supplement

Samples of Tests for Seminar № 1

1. Define deviations of the tolerance zones:

1) 60g6
2) 60g7
3) 60G6
4) 60G7
5) 60h6
6) 60H6
7) 60s7

2. Define the minimum and maximum clearances for the fit 20H7/g6

_____
_____

3. Define the limiting interferences for the fit 80H7/s7

_____
_____

4. Define the limiting interference and clearance for the fit 50H7/n6

_____
_____

5. Define the deviations of shaft group tolerance zones for the fit with $S_{max}<[S_{max}]=18$ μm and $S_{min}>[S_{min}]=2$ μm for the basic size 20 mm when we can produce parts with tolerance T=16 μm. Use the method of selective assembly.

_____
_____
_____
_____
_____
_____

Answer: 1-st gr. $20^{-0.002}_{-0.01}$ mm
2-nd gr. $20^{+0.006}_{-0.002}$ mm

Samples of Laboratory Work № 3

1. Define the deviations of limit gages to check the shaft and the hole of the fit 30H7/g6.

_____
_____
_____
_____
_____
_____
_____

Answer: 30H7 NOT-GO → $30.023_{-0.004}$ mm

$30H7GO \rightarrow 30.005_{-0.004}$ mm
$30H7GO_{wear} \rightarrow 30.005_{-0.007}$ mm
$30g6\ NOT\text{-}GO \rightarrow 29.978^{+0.004}$ mm
$30g6\ GO \rightarrow 29.988^{+0.004}$ mm
$30g6\ GO_{wear} \rightarrow 29.988^{+0.007}$ mm

Samples of Control Work № 1

1. Define the deviations of tolerance zones for the slot free junction with the basic size b = 6 mm.

_____
_____
_____

Answer: Shaft slot $\rightarrow 6H9(^{+0.03})$ mm
Hole slot $\rightarrow 6D10(_{+0.03}{}^{+0.078})$ mm
Key $\rightarrow 6h9(_{-0.03})$ mm

2. Write a lubrication of the slit junction for centring on an external diameter if the slit junction has 8 slit, external diameter 50 mm, the internal diameter is 46 mm, the slit width is 7 mm. (for example: d-8 x 36H7/e8 x 40H12/a11 x 7D9/f8.)

_____

Answer: D-8 x 46H12/a11 x 50H7/e8 x 7D9/f8.

3. Define limit diameters of a screw and a nut for the thread junction M16 x 2–7H/6g.

_____
_____
_____
_____
_____
_____
_____

Answer: $D_{min} = 16$ mm
$d = 16^{-0.038}_{-0.318}$ mm
$D_2 = 14.701^{+0.265}$ mm
$d_2 = 14.701^{-0.038}_{-0.163}$ mm
$D_1 = 13.835^{+0.475}$ mm
$d_{1max} = 13.707$ mm

4. Explain designations of deviations on Fig. 1:

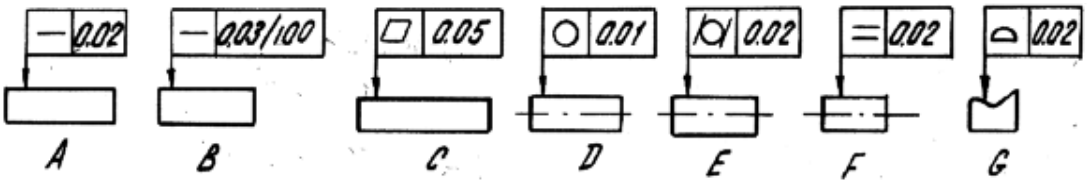


Fig. 1

A. _____

B. _____

C. _____

D. _____

E. _____

F. _____

G. _____

Exam

1. Exam: final test № 1

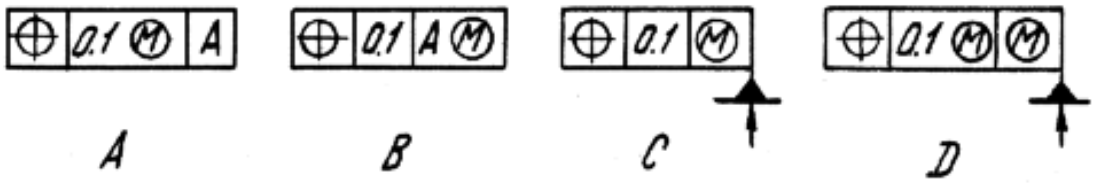
1. What parameters of roughness of surface do you know? Write designations roughness of surface. How to measure and check roughness of surface?
2. Define the deviations of shaft group tolerance zones for the fit with $N_{max}<[N_{max}]=28$ μm and $N_{min}> [N_{min}]=8$ μm for the basic size 50 mm when we can produce parts with 7 grade of tolerance. Use the method of selective assembly.
3. Define limit diameters of a screw and a nut for the thread junction M12–7H/8g.

2. Tasks oral-response section:

1. For what purposes are the dial indicating instruments used? Enumerate its principal kinds. How to check and set the indicating hole gage?
2. What does 7-6-7-Ca/V -128 mean?

3. Additional questions:

1. Explain the following symbols:



2. What is necessary to mark on the assembly and design drawings?