Federal State Educational Institution of Higher Professional Education
"National Research Tomsk Polytechnic University"

APPROVED BY
vice-rector, director of
Institute of Cybernetics
_____ A.V. Zamyatin
«___»_____2013

SYLLABUS FOR THE SUBJECT
FUNDAMENTALS OF MECHANICAL ENGINEERING

DEGREE COURSE Educational Program 150700 Mechanical Engineering
SPECIALISATION Technology, Equipment and Automation of Mechanical Engineering Manufacturing
QUALIFICATION (DEGREE) bachelor
ADMISSION YEAR 2013
YEAR OF STUDY 3 SEMESTER 6
CREDITS 6
PREREQUISITES Б3.Б3 «Constructional Materials Engineering»; Б3.Б4 «Metrology, Standardisation and Certification»; Б3.Б8 «Materials Science»; Б3.В2.1 «Material Cutting and Cutting Tools».
COREQUISITES Б3.В2.2 «Metalworking Machinery»; Б3.В2.1 «Material Cutting and Cutting Tools»; Б3. В2.3 «Engineering Metrology in Mechanical Engineering».

ALLOCATION OF CLASS HOURS:

LECTURES	45 hours
PRACTICAL CLASSES	18 hours
LABORATORY WORKS	18 hours
CLASS HOURS IN TOTAL	81 hours
SELF-STUDY TRAINING	99 hours
TOTAL	180 hours

EDUCATION FORM full-time
ASSESSMENT FORM examination
PROVIDING DEPARTMENT Department of Automated Mechanical Manufacturing Engineering of Institute of Cybernetics

HEAD OF THE DEPARTMENT _____ A. Yu. Arlyapov

EDUCATIONAL PROGRAM SUPERVISOR _____ A. Yu. Arlyapov

TEACHERS _____ V. F. Skvortsov

_____ A. B. Kim

2013

1. Objectives

The objective of the «Fundamentals of Mechanical Engineering» course is to acquire knowledge, skills and experience in the field of analysis and design of the manufacturing processes.

2. Subject role in Educational Program

The «Fundamentals of Mechanical Engineering» course is a part of the discipline series Б3.Б (Professional disciplines, Compulsory section).

The study of the course is preceded by studying courses of «Constructional Materials Engineering»; «Metrology, Standardisation and Certification»; «Materials Science»; «Material Cutting and Cutting Tools».

After completion of the «Constructional Materials Engineering» the student is to know the following:

- methods of workpiece production;
- methods of cutting, constructions of the common metal cutting tools and machine tools;
- methods of electrophysical and electrochemical machining;
- basic welding methods.

After completion of the «Metrology, Standardisation and Certification» the student is to know the following:

- principles of the Russian unified system of tolerances and fits;
- drawing indications of dimensional tolerances, geometrical tolerances and fits;
- methods of tolerance analysis;
- basic means and methods of parts accuracy assessment.

After completion of the «Materials Science» the student is to know the following:

- mechanical properties and performance characteristics of the constructional materials;
- methods of heat and chemical heat treatment of metals and metal alloys.

After completion of the «Material Cutting and Cutting Tools» the student is to know the following:

- physics of material cutting;
- characteristics of the basic methods of machining;
- ways of improving machinability of the constructional materials;
- procedures of selection of the cutting tools and cutting parameters.

The courses of «Metalworking Machinery», «Material Cutting and Cutting Tools», «Engineering Metrology in Mechanical Engineering» are studied simultaneously with the «Fundamentals of Mechanical Engineering» course.

3. Course outcomes

The course outcomes are in agreement with the education results described in the Educational Program 150700 «Mechanical Engineering».

After completion of the «Engineering Metrology in Mechanical Engineering» course the student is to:

know

- basic concepts of mechanical engineering production;
- fundamentals of technological ensuring required machining accuracy;
- fundamentals of technological ensuring required properties of the part material and surface layer quality;
- principles and strategies of the manufacturing process design;
- principles of the manufacturing datum selection; methods of calculation of the machining allowances, workpiece dimensions, cutting parameters and standard time for manufacturing operations;

be able to

- determine types of manufacturing;
- choose methods of workpiece production;
- assign tooling for product manufacturing;
- assign manufacturing datums, calculate machining allowances, workpiece dimensions, cutting parameters and standard time for manufacturing operations;
- carry out statistical analysis of machining accuracy;
- analyze causes of manufacturing defects and assign ways to eliminate the defects;

apply the following methods

- tolerance analysis of the manufacturing processes;
- statistical analysis of machining accuracy;
- investigation of the surface layer quality;
- programming the CNC turning machines;
- deigning of the processes of simple parts job-production.

The following competences are formed upon completion of the course:

1. Universal (cultural) -

- an ability to apply basic and special knowledge of math, natural science, humanities and economic sciences in engineering (ОК-10).

2. Professional -

- an ability to apply basic laws of natural sciences, methods of mathematic analysis and simulation, basics of theoretical and experimental researches in engineering to design objects and engineering processes in mechanical engineering using standard CAD software (ПК-10);
- readiness to maintain engineering discipline during production, develop new engineering methods of production, apply methods of quality assessment of samples, parts, assemblies and products (ПК-1);
- readiness to apply state-of-the-art methods for developing low-waste, energy-saving and environmentally friendly mechanical engineering techniques, that ensure human safety and protection from potential accidents and natural disasters, readiness to apply methods of conservation of raw materials, energy and other resources (ПК-8).

4. Contents of the course

4.1. Topical contents of the course

The following topics are covered in the course.

4.1.1. Basic concepts of mechanical engineering production

Machine and its functional purpose. Components of the machines. Accuracy of the machine, accuracy of its parts. Production and manufacturing processes of the machine manufacture. Productivity and manufacturing cost of the machine. Types of manufacturing. Production planning. Maintenance procedures. Manufacturability of the machine designs.

4.1.2. Dimensional chains and principles of part locating

Basics of tolerance stack-ups. Ensuring the accuracy of resulting dimensions of the dimensional chains. Tolerance analysis of the manufacturing processes. Locating and datums in mechanical engineering. Errors of workpiece location. Principles of manufacturing datums selection.

4.1.3. Theory of ensuring required machining accuracy

Errors of machining: causes and ways of elimination. Adaptive control of machining accuracy. Attainable and cost-effective accuracy of manufacturing processes. Accuracy within an operation and through the whole production process. Statistical analysis of machining accuracy.

4.1.4. Theory of ensuring required properties of the part material and surface layer quality

Ensuring part material properties as provided by the part function. Components of surface layer quality and their performance characteristics. Means of surface layer quality ensuring. Technological heredity.

4.1.5. Ensuring efficiency of production process

Production time. Production time resource and expenditure. Structure of the time required for machining operation. Machining time rating and work measurement. Technological methods of productivity boosting and manufacturing cost reduction.

4.1.6. Fundamentals of production process design

Input data. Inspection of the part drawing for manufacture. Manufacturability analysis. Methods of production. Workpiece selection. Manufacturing datums selection. Selection of manufacturing routes, machine tools and equipment. Machining operation structure. Calculation of machining allowances and manufacturing dimensions. Selection of machining parameters, means of ensuring required productivity and accuracy of products. Analysis of production cost-effectiveness.

4.2. Course structure according to the content and studying activity category is given in the table below.

Table 1

Course structure

Section title	Class (hours)			Self-study (hours)	Project work	Total
	Lectures	Practical classes	Lab. works.			
1. Basic concepts of mechanical engineering production	5			9		14
2. Dimensional chains and principles of part locating	12			16	Test № 1	36
3. Theory of ensuring required machining accuracy	6			20	Test № 2	38
4. Theory of ensuring required properties of the part material and surface layer quality	6	6	10	12		22
5. Ensuring efficiency of the production process	6	2	8	20	Test № 3	46
6. Fundamentals of production process design	10	10		22	Test № 4	42
Total	45	18	18	99		180

4.3 Competences distribution with accordance to course sections

The distribution of the competences, indicated in section 3 of the syllabus, formed upon completion of the course with accordance to course sections is given in the table below.

Table 2

The competences distribution

№	Competences formed	Course sections					
		1	2	3	4	5	6
1.	З.7.2		+		+		
2.	З.7.3					+	
3.	З.10.2	+		+	+		+
4.	З.14.1	+	+		+		
5.	У.7.2	+	+	+	+		+
6.	У.7.3	+		+		+	+
7.	У.10.2	+				+	
8.	У.14.1	+	+		+	+	
9.	В.7.2	+		+		+	
10.	В.7.3			+		+	+
11.	В.10.2	+				+	+
12.	В.14.1	+	+	+	+		+

5. Educational methodology

A description of educational technology, ensuring the achievement of the expected results of development of the discipline are given in the section.

Combination of methods and forms of education organization is presented in the matrix (refer to Table 3).

Table 3

Methods and forms of education organization (FEO)

FEO / Methods	Lec-tures	Lab. works	Practical classes	Ws*., Mc**	Self-study	Project work
Team work		+	+		+	
Game						
Case-study						
Experience-based education	+		+			
Advanced self-study training	+				+	
Projects			+		+	
Exploring approach	+	+			+	
Researching approach	+	+				

* – Workshop, ** – Master-class

6. Program for students' self-study

The purpose of students' self-study is to develop common cultural and professional skills, ability and readiness for self-educational activity for a lifetime.

Students' self-study is organized in accordance with the following principles:

- systematic studying;
- effectiveness;
- planning;
- continuous monitoring and control;
- motivation;
- effective use of information technologies.

Timetable of students' self-study is given in the rating-list.

Self-study is carried out in the Scientific and Technical Library of TPU (ul. Belinsky, 55), with the help of the literature collection and computer laboratory of the department (ul. Timakova, 12, building 16a TPU).

6.1 Students' self-study forms

Self-study is organized at the following levels:

- reproductive;
- cognitive-search;
- creative.

Within these levels, the student's self-study includes routine and creative problem-oriented self-study.

Routine self-study aims to set and expand knowledge and develop the students' skills, it includes:

- doing exercises on the material studied, searching for and reviewing literature sources related to the specific topics of the course;
- homework;

- advanced self-study;
- study of material on given topics;
- self-study for laboratory works and practical classes;
- pre-test activity.

Creative self-study aims to develop rational skills and a set of universal competences, to raise creative potential. Creative self-study includes:

- search, analysis, structuring and presenting of the information;
- research activity and participation in scientific student conferences, seminars and contests.
- analysis of scientific works related to the tasks assigned by a teacher.

6.2. Students' self-study content according to the course:

6.2.1 List of scientific themes and research investigations:

– investigation of dimensional accuracy and surface layer quality of small diameter holes machined by mandrelling;
– controlling residual stresses and accuracy of the mandrelled small diameter holes;
– ways of increasing productivity and accuracy of the deep hole drilling;
– geometrical parameters of indexable cutting tools;
– investigation of non-free cutting by cutting tools with edges of a complex shape.

6.2.2 Topics of personal assignment:

– lathe self-centering chucks;
– collet chucks;
– magnetic and electromagnetic chucks;
– vacuum operated fixtures;
– centerless grinding;
– honing and siperfinishing;
– cold working of workpieces;
– methods of part labeling;
– methods of deburring;
– methods of sheet material cutting;
– trends in teat treatment and chemical-heat treatment;
– trends in machining with cutting tools;
– trends in machining with abrasive tools;
– trends in casting methods.

6.2.3 Topics for self study:

– design for manufacturing;
– technological heredity.

6.3. Self-studying results assessment

Assessment of the results of the self-studying is included in everyday assessment and progress assessment. It may use the following ways of assessment:

presentation in class, students' review each other's papers, teacher's assessment of the papers, etc.

6.4. Studying and methodological support of self-study

6.4.1. References:

1. Fundamentals of mechanical engineering: textbook / Skvortsov V.F., TPU
2. Основы технологии машиностроения: учебное пособие / В. Ф. Скворцов ; Национальный исследовательский Томский политехнический университет (ТПУ). — Томск: Изд-во ТПУ, 2012. — 352 с.: ил.
3. Скворцов В.Ф. Выбор технологических баз при изготовлении деталей. Учебное пособие. – Томск: Изд-во ТПУ, 2007. –56 с.
4. Скворцов В.Ф. Основы размерного анализа технологических процессов изготовления деталей. – Томск: Изд-во ТПУ, 2009. –91 с.
5. Altan, T., Ngaile, G. and Shen G., Cold and Hot Forging: Fundamentals and Application, ASM International, 2004
6. Baudin, M., Lean Assembly, Productivity Press, 2002
7. Brown, J., Advanced Machining Technology Handdbook, McGraw-Hill, 1998
8. Connor, J., Six Sigma and other Continuous Improvement Tools for the Small Shop, Society of Manufacturing Engineers, 2001
9. Darbyshire, Alan. Mechanical Engineering. BTEC National Option Units / A. Darbyshire. — Oxford : Newnes, 2003. — 411 p. : ил. — Index: p. 407-411. — ISBN 0-7506-5761-8.
10. Encyclopedia of Production and Manufacturing Management/ editor P. Swamidass. — 1,065 Items. — Berlin : Springer US, 2000.
11. Erdel, B., High-Speed Machining, Society of Manufacturing Engineers, 2003
12. Handbook of Surface Treatment and Coatings, ASME Press, 2003
13. Heine R., Principles of Metal Casting, McGraw-Hill, 1999
14. Lange, K., Handbook of Metalforming, McGrow-Hill, 1985
15. Machinery's Handbook, Industrial Press, revised periodically
16. Quensenberry, C.P., SPC Methods for Quality Improvement, Wiley, 1997
17. Shackelford, J.E., Introduction to materials Science fo Engineers, 5th ed., Prentice Hall, 2000
18. Shigley, Joseph E. Mechanical Engineering Design / J. E. Shigley, C. R. Mischke. — 6 Edition. — New York : McGraw-Hill, 2001. — 1248 p. : il. — Index: p. 1237-1248. — ISBN 0-07-365939-8.
19. Stenerson, J. and Curran, K.S., Computer Numerical Control: Operation and Programming, 2nd ed., Prentice Hall, 2000
20. Tozawa, B. Bodek, N., The Idea Generator: Quick and Easy Kaizen, PCS Press, 2001

6.4.1. Web links:

21. www.cours.polymtl.ca/mec4530/Anim/Menu.swf
22. https://www.asme.org/
23. http://www.ctemag.com/

24.http://icrank.com/
25.www.matweb.com/
26.www.shender4.com/eng-links.htm
27.www.thomasnet.com/
28.www.efunda.com/home.cfm
29.www.globalspec.com/
30.www.icademic.org/97445/Mechanical-Engineering
31.www.engcen.com/mechjobs.htm
32.www.theengineer.co.uk/
33.www.engc.org.uk/
34.www.engineersedge.com/
35.www.eef.org.uk/
36.www.researchgate.net

7. Means of the everyday and progress assessment of the results of studying "Engineering Metrology in Mechanical Engineering"

Everyday assessment is carried out with the help of class participation, written tests and questions asked during the defending of laboratory and practical classes' results, as well as assessment of students' self-study results (refer to the self-study tasks, mentioned in section 6.2).

Progress assessment includes tests, performance assessment, essay writing and personal home-works problem sets (Appendix 1).

8. Rating-list of results of studying the discipline

According to the rating-system the everyday assessment is carried out every month of a semester by pointed rating of theoretical and practical studying results.

The final assessment (examination) is carried out in the end of the semester. Total result is the sum of everyday and final assessment points. The maximum total rating is 100 points (60 – everyday assessment, 40 – final assessment).

9. Teaching, methodological and information support of the course

9.1. Required textbooks:

1. Основы технологии машиностроения : учебное пособие / В. Ф. Скворцов ; Национальный исследовательский Томский политехнический университет (ТПУ). — Томск : Изд-во ТПУ, 2012. — 352 с. : ил.
2. Суслов А.Г., Дальский А.М. Научные основы технологии машиностроения. –М.: Машиностроение, 2002. –684 с.
3. Колесов И.М. Основы технологии машиностроения: Учебник для машиностроительных специальностей вузов. – М.: Высшая школа, 1999. – 591 с.
4. Технология машиностроения: В 2 т. Т. 1. Основы технологии машиностроения: учебник для вузов / В.М. Бурцев, А.С. Васильев, А.М. Дальский и др.; под ред. А.М. Дальского. – М.: Изд-во МГТУ им. Н.Э. Баумана, 1997. –564 с.
5. Скворцов В.Ф. Выбор технологических баз при изготовлении деталей. Учебное пособие. – Томск: Изд-во ТПУ. 2007. –56 с.
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7. Drake P. Dimensioning and tolerancing handbook. McGraw-Hill, New York, 1999.
8. Encyclopedia of production and manufacturing management / Editor Paul M. Swamidass. Kluwer Academic Publishers, 2000.

9. Foster L.W. Geometrics III: The application of geometric and tolerancing technique. Addison-Wesley, 1994.
10. Handbook of Manufacturing Engineering / Edited by Jack M. Walker. Marcel Dekker, 1996.
11. Manufacturing Engineering and Technology. Fifth edition. Serope Kalpakjian, Steven R. Schmid, 2006.

9.2. Recommended textbooks:

12. Машиностроение. Энциклопедия. Т. III-3. Технология изготовления деталей машин / А.М. Дальский, А.Г. Суслов, Ю.Ф. Назаров и др.; под общ. ред. А.Г. Суслова. –М.: Машиностроение-1, 2000. –840 с.
13. Справочник технолога-машиностроителя. В 2-х т. Т. 1 / Под ред. А.М. Дальского, А.Г. Косиловой, Р.К. Мещерякова, А.Г. Суслова. – М.: Машиностроение-1, 2003. –912 с.
14. Справочник технолога-машиностроителя. В 2-х т. Т. 2 / Под ред. А.М. Дальского, А.Г. Косиловой, Р.К. Мещерякова, А.Г. Суслова. – М.: Машиностроение-1, 2003. –944 с.
15. Ashby, M.F., Materials selection in Mechanical Design, 3rd ed., Elsevier, 2005
16. ASM Handbook, Vol. 4: Heat Treating, ASM International, 1991
17. Boljanovic, V., Sheet Metal Forming Process and Die Design, Industrial Press, 2004
18. Boothroyd, G., Dewharst, P. and Knight, W., Product Design for Manufacture and Assembly, 2nd edition, Marcel Dekker, 2001
19. Dieter, G.E., Kuhn, H.A. and Semiatin, S.L., Handbook of Workability and Process Design, ASM International, 2003
20. Drake P. Dimensioning and tolerancing handbook. McGraw-Hill, New York, 1999.
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27. Luggen, W.W., Flexible Manufacturing Cells and Systems, Prentice Hall, 1991
28. Machine Shop Practice. Fifth edition. Karl Hans Moltrecht, 1979.
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30. Mechanical Engineer's Handbook / Edited by Dan B. Marghitu. Academic Press, 2001.

31. Precision Manufacturing, by David Dornfeld and Dae-Eun Lee, Springer, 2008.
32. Rechetov, D.N. and Portman, V.T., Accuracy of Machine Tools, ASME International, 1989
33. Shaw, M.C., Metal Cutting Principles, 2nd ed., Oxford, 2005
34. Shetty, D., Design for Product Success, Society of Manufacturing Engineers, 2002
35. The fundamentals of product design. R. Morris. AVA Publishing, 2009.

9.3 Internet sources

1. http://e-le.lcg.tpu.ru/public/OTM_0771/index.html
2. http://www.mitcalc.com/doc/tolerances/help/en/tolerances.htm – Calculation packet MITCalc

10. Course equipment

Practical and laboratory classes are held in the mechanical engineering laboratory and interactive training room equipped with CNC machines.

The mechanical engineering laboratory is equipped with a lathe 1K62, surface grinding machine 3Г71П, two CNC turning machines 16К20Ф3, Linnik microscope for roughness measurements МИС-11 and instruments for linear and angular measurements.

The interactive training room is equipped with CNC machines EMCO CONCEPT TURN 55 and EMCO CONCEPT MILL 155 and six workplaces with computers; both machines and workplaces are equipped with replaceable CNC panels of Fanuc and Siemens systems.

Appendix 1

Means of the everyday, progress and final assessment

The following materials refer to the course FME and are to be used for everyday, progress and final assessment.

Samples of the tests for progress assessment

Test 1

1. Name types of products in mechanical engineering.
2. What is the sequence of development of a uniform manufacturing process?
3. What requirements must be met by the part design for assemblability?

Test 2

1. Give classification of assembling processes according to stages of the assembly process and level of mechanization and automation.
2. How do grinding parameters influence surface layer quality?
3. What are manufacturing means?

Test 3

1. What parameters characterize quality of products?
2. What parameters are used to evaluate productivity?
3. What is the essence of ensuring accuracy of the resulting dimension by the adjustment method?

Test 4

1. How does chemical-heat treatment (carburizing, nitriding, carbonitriding) change properties of workpieces?
2. What is the aim of setting a manufacturing system for machining a batch of workpieces?
3. What is manufacturability of a product design?

Samples of the exam tasks for final assessment

Version 1

1. What parameters characterize accuracy of a part and of a machine?
2. What is the essence of ensuring accuracy of the resulting dimension by the complete interchangeability method?
3. Task

Version 2

1. How can the dimensional diagram of the manufacturing process be constructed?
2. How do grinding parameters influence surface layer quality?
3. Task

Version 3

1. How can you construct assembly diagrams?
2. What is an operation?
3. Task

Version 4

1. What part of the operation cycle per part is called machining time?
2. What are the requirements that the workpiece design must comply with for manufacturability?
3. Task

Version 5

1. What part of the operation cycle per part is called auxiliary time?
2. What is the essence of ensuring accuracy of the resulting dimension by the complete interchangeability method?
3. Task

Version 6

1. What parameters characterize accuracy of a part and of a machine?
2. What is the essence of ensuring accuracy of the resulting dimension by the fitting method?

Version 7

1. What dimensions are resulting in dimensional chains formed during the manufacture of parts?
2. Why does the method of trial cuts provide higher accuracy compared to machining on pre-set machine tools?
3. Task

Version 8

1. What is set-up time?
2. How can you enhance material properties of the cast and formed workpieces?
3. Task

The syllabus is based on the TPU Organization Standard in accordance with Federal State Educational Standard for the 150700 “Mechanical Engineering” program and “Technologies, Equipment and Automation of Engineering Manufacturing” course.

The syllabus is examined and approved at the seminar of AMME Department

(Record № 2 «1» October 2013).

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