Ministry of Science and Higher Education of the Russian Federation

Federal State Budgetary Educational Institution of Higher Education

Perm National Research Polytechnic University

APPROVED BY

Pro-rector for Academic Affairs

_____ N.V. Lobov

"15" 03 2021

ACADEMIC COURSE WORKING PROGRAM

Academic course Theory of mechanisms and machines
(Name)

Form of education: Full-time studies
(Full-time /full-time – correspondence/correspondence)

Level of higher education: Bachelor's degree
(Bachelor's program/specialist program/
Master's program)

Workload in hours (in credits): 108 (3)
(Hours (CU))

Training program (degree): 21.03.01 Oil and Gas Engineering
(Code and denomination of degree)

Direction: Oil and Gas Engineering
(Title of curriculum)

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1. GENERAL PROVISIONS

1.1. GOALS AND OBJECTIVES OF THE COURSE

Goal of the course is an acquisition of systematic knowledge of common research and design techniques and machines widely used in various fields of technology that meet the modern requirements of efficiency, accuracy, reliability and efficiency.

Objectives of the course are:

- To know the main types of mechanisms, principles of implementation of different types of movement through mechanisms, common methods of analysis and synthesis of mechanisms and machines; Methods of describing the structure and analysis of kinematic and dynamic parameters of the movement of model mechanisms;
- Be able to assess the functional capabilities of typical mechanisms, carry out structural, kinematic and dynamic analysis and synthesis of mechanisms and machines using standard applied programs;
- Have the skill of a systematic approach to the study and synthesis of machines and mechanisms with the search of their optimal parameters for the given working conditions.

1.2. STUDIED OBJECTS OF THE COURSE

- The basic principles of implementing different types of movement through mechanisms;
- Structural, kinematic and dynamic diagrams of mechanisms, machines and instruments;
- General methods of analysis and synthesis of mechanisms and machines;
- Algorithms for calculating the basic parameters and characteristics of typical mechanisms.

1.3. STARTING CONDITIONS

Unstipulated

2. PLANNED RESULTS OF THE COURSE TRAINING

Compe-tence	Indicator's Index	Planned Results of the Course Training (to know, be able to, to master)	Indicator of Attaining Competence which the planned results of training are correlated with	Means of Assessment
1	2	3	4	5
GPC-1.	IA-1_{gpc-1}	**To know** general methods and techniques of designing mechanisms on specified basic and additional synthesis conditions	**Knows** principle features of modelling mathematical, physical and chemical processes assigned for the definite technological processes.	Test
	IA-2_{gpc-1}	**To be able** to design structural schemes of model mechanisms according to specified conditions	**Is able to** use general laws of the disciplines of mechanical-engineering module; use general laws of natural-scientific disciplines, the rules of technical drafting and plotting.	Coursework, test
	IA-3_{gpc-1}	**To master the skills** of the theoretical and experimental research of the kinematic mechanisms of different kinds	**Masters** basic procedures of technological and economic analysis, has the skill of drafting as a member of the creative team; participates knowledgeably in the work aimed at production processes improvement using experimental data and results of modelling; masters business interaction with maintenance department and can estimate their recommendations taking into account experimental work of the enterprise technological department.	Coursework, test
GPC-2.	IA-1_{gpc-2}	**To know** basic concepts of the theory of mechanisms and machines	**Knows** vital differences in approach to the project engineering of technical facilities, systems and technological processes.	Test
	IA-2_{gpc-2}	**To be able** to carry out theoretical and experimental studies of the kinematics of mechanisms of various types	**Is able to** determine the demand for commercial material necessary for making the detailed design; analyze the realization of the detailed design	Coursework, test

1	2	3	4	5
			requirements in the course of technological process; correct project data owing to his competence; estimate convergence of calculation results obtained by different procedures.	
	IA-3$_{gpc-2}$	**To master the skills** of synthesis of model mechanisms using automated design tools, looking for their optimal parameters according to the specified working conditions.	**Masters the skills of** collection and processing primary materials as assigned by the management of the project department; the skills of efficient fulfillment of the detailed design; the skills of computer work with realization of new methods and software packages.	Coursework, test

3. FULL TIME AND FORMS OF ACADEMIC WORK

Form of academic work	**Hours in all**	**Distribution in hours according to semesters**
		Number of semester
		4
1. Holding classes (including results monitoring) in the form: 1.1. Contact classwork, including:	**45**	**45**
– lectures (L)	16	16
– laboratory work (LW)	9	9
– practice, seminars and/or other seminar-type work (PW)	18	18
– control of self-work (CSW)	2	2
– test		
1.2. Students' self-work (SSW)	63	63
2. Intermediate attestation		
Exam		
Grading test	+	+
Test (Credit)		
Course Project (CP)		
Course Work (CW)	+	+
Workload in hours	**108**	**108**

4. COURSE OUTLINE

Name of the units with the course outline	Full time of classroom activity in hours according to the forms			Full time of extracurricular work in hours according to the forms
	L	LW	PW	SSW
semester				
Unit 1. Structural analysis and synthesis of mechanisms The goals and objectives of the theory of mechanisms and machines. Main types of mechanisms. Structural (Assur) group of the mechanism.	3		2	8
Unit 2. Kinematic analysis of a mechanism. Objectives and methods of a kinematic analysis. Kinematic analysis of gear mechanisms. Kinematic analysis of cam mechanisms.	4	4	2	11
Unit 3. Kinematic synthesis of a mechanism Stages of synthesis of mechanisms. Synthesis of cam mechanisms. Synthesis of transmission mechanisms.	3	2	6	14
Unit 4. Force analysis of a mechanism. Basic concepts and definitions. Tasks and methods of force analysis. Forces acting on the links of mechanisms.	2		2	6
Unit 5. Dynamic analysis and synthesis of a mechanism. Types of machine movement equations. Linear and non-linear motion equations in mechanisms. The stages of movement of the machine.	2,5		2	16
Unit 6. Vibration activity of machines and vibration protection. Vibrating machines. Unbalanced mechanisms and its types. Complete and static balancing of the masses of mechanisms	1,5	3	2	8
Total with regard to semester	16	9	18	63
Total with regard to the course	16	9	18	63

Topics of exemplary practical work

Sl.№	Topic of practical (seminar) work
1	Structural analysis and synthesis of mechanisms
2	Kinematic study of linkage
3	Calculating linkage parameters in synthesis tasks
4	Designing cam mechanisms
5	Kinematic synthesis of planetary mechanisms
6	Force analysis of planar linkage
7	Dynamic analysis and synthesis of mechanisms
8	Determining the efficiency of the machine unit
9	Static balancing of masses of planar linkage

Topics of exemplary laboratory practice

Sl.№	Topic of laboratory work
1	Kinematic analysis of planar cam mechanisms
2	Kinematic analysis of gears
3	Analysis of qualitative indicators of the involute profiles of gears formed by the generating method.
4	Static and dynamic rotor balancing

5. ORGANIZATIONAL AND PEDAGOGICAL CONDITIONS

5.1. EDUCATIONAL TECHNOLOGIES USED FOR COMPETENCES FORMATION

Holding lectures in the discipline is based on the active method of training in the process of which students are not passive but active participants of the lesson answering questions of the teacher. Teacher's questions are aimed at activating the process of learning material as well as at the development of logical thinking. The questions stimulating associative thinking and connecting new material with the previous one are identified by the teacher in advance.

Practical lessons are held by realization of the method based on active training: problem areas are determined, groups are formed. The following aims are pursued in the process of practical education: use of definite disciplines knowledge and creative methods in solving problems and decision-making; students' skill-building of teamwork, interpersonal communication and development of leadership skills; consolidation of the basic theoretical knowledge.

Laboratory classes are based on an interactive learning method in which students communicate not only with the teacher but also with each other. At the same time, students ' activity in the learning process dominates. The teacher's place in interactive classes is reduced to orienting students ' activities to achievement of the goals of studies.

Interactive lectures, group discussions, role-playing games, training sessions, and analysis of situations and simulation models are used in academic studies

5.2. STUDENTS' MANUAL FOR THE COURSE STUDY

Learning the course students are recommended to fulfill the following positions:

1. Learning of the discipline should be done systematically.

2. After learning one of the course unit with the help of the text-book or lecture notes it is recommended to reproduce in memory the basic terms, definitions, notions of the unit.

3. Special attention should be paid to the reports on practical studies, laboratory works and individual complex tasks for self-work.

4. The topic of questions studied individually is given by the teacher at the lectures. Also, the teacher refers to the literary resources (first of all, to the newly published in periodicals) in order the students understand the problems touched on the lectures in detail.

6. LIST OF TEACHING MATERIALS AND INFORMATION SUPPLY FOR STUDENTS' SELF WORK IN THE DISCIPLINE

6.1. PAPER-BASED COURSEWARE

Sl.№	Bibliographic entry (author, title, mode of publication, place, publishing house, year of publication, number of pages)	Number of copies in the library
	1. Basic literature	
1	M. M. Stanisic, Mechanisms and Machines: Kinematics, Dynamics, and Synthesis, USA, Cengage learning, 2014, 608p.	1
	2. Additional literature	
	2.1. Educational and scientific literature	
1	C. S. SHARMA, K. PUROHIT, Theory of Machines and Mechanisms, New Delhi, Prentice-Hall of India Private Limited, 2006, 720p.	1
2	Hobbs G. M., Morrison L. H., Kuns R. F. Fundamentals of Machines. Chicago : American Technical Society, 1945. 294 p.	1
3	Oberg E., Jones F. D. Machinery's Handbook for Machine Shop and Drafting-Room : a Reference Book on Machine Design and Shop Practice for the Mechanical Engineer, Draftsman, Toolmaker, and Machinist. 12 ed New York London : The Industr. Press : Machinery Publishing Co., Ltd., 1945. 1815 p.	1
	2.2. Standardized and Technical literature	
	3. Students' manual in mastering discipline	
	4. Teaching and learning materials for students' self work	

6.2. ELECTRONIC COURSEWARE

Kind of literature	Name of training tool	Reference to information resource	Accessibility of EBN (Internet/local net; authorized free assess)
Additional literature	Oberg E., Jones F. D. Machinery's Handbook for Machine Shop and Drafting-Room : a Reference Book on Machine Design and Shop Practice for the Mechanical Engineer, Draftsman, Toolmaker, and Machinist. 12 ed New York London : The Industr. Press : Machinery Publishing Co., Ltd., 1945. 1815 p.	https://elib.pstu.ru/vufind/Record/RUPSTUbooks22732	the local network

6.3. LICENSE AND FREE DISTRIBUTED SOFTWARE USED IN THE COURSE EDUCATIONAL PROCESS

Type of Software	Software branding
OS	Windows 10 (Azure Dev Tools for Teaching)
Office Applications	Adobe Acrobat Reader DC
Image processing software	Corel CorelDRAW Suite X4
General purpose application software	Mathematica Professional Version (license L3263-7820*)
General purpose application software	Microsoft Office Visio Professional 2016 (Azure Dev Tools for Teaching)
General purpose application software	WinRAR (license №879261.1493674)
Management systems for projects, research, development, design, modeling and implementation	Autodesk AutoCAD 2019 Education Multi-seat Stand-alone

6.4. MODERN PROFESSIONAL DATA BASES AND INQUIRY SYSTEMS USED IN THE COURSE EDUCATIONAL PROCESS

Branding	Reference to information resource
Scopus database	https://www.scopus.com/
Web of Science Database	https://www.webofscience.com/
Scientific electronic library database (eLIBRARY.RU)	https://elibrary.ru/
Scientific Library of the Perm National Research Polytechnic University	https://lib.pstu/
Lan Electronic Library System	https://e.lanbook.com/
Electronic library system IPRbooks	https://www.iprbookshop.ru/
Information resources of the Network ConsultantPlus	https://www.consultant.ru/
Company database EBSCO	https://www.ebsco.com/

7. LOGISTICS OF THE COURSE EDUCATIONAL PROCESS

Type of classes	Name of the necessary basic equipment	Number of units
Lab equipment class	Models and stands for laboratory work	25

8. FUND OF THE COURSE EVALUATING TOOLS

Ministry of Science and Higher Education of the Russian Federation

Federal State Budgetary Educational Institution of Higher Education

Perm National Research Polytechnic University

FUND OF ESTIMATING TOOLS

For students' midterm assessment in the discipline
"Theory of mechanisms and machines"
Supplement to the Academic Course Working Program

Training program	21.03.01 Oil and Gas Engineering
Direction (specialization) of educational program	Oil and Gas Engineering
Graduate qualification	Bachelor's degree
Graduate academic chair	Oil and Gas Technology
Form of study	Full-time

Year (-s): 2 **Semester (-s)**: 4

Workload:
in credits: 3 CU
in hours: 108 h

The form of midterm assessment:
Test 4 semester

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Fund of estimating tools for midterm assessment of students' learning the subject **"Theory of mechanisms and machines"** is the part (supplement) to the academic course working program. Fund of estimating tools for midterm assessment of students' learning the discipline has been developed in accordance with the general part of the fund of estimating tools for midterm assessment of the basic educational program which determines the system of the midterm assessment results and criteria of putting marks. Fund of estimating tools for midterm assessment of students' learning the subject determines the forms and procedures of monitoring results and midterm assessment of the subject leaning by the students.

1. LIST OF CONTROLLED RESULTS OF STUDYING DISCIPLINE, OBJECTS OF ASSESSMENT AND FORMS OF CONTROL

According to the Academic Course Working Program mastering course content is planned during one semester (the fourth semester of curriculum) and is divided into six educational modules. Classroom activities, lectures, practice and laboratory work as well as students' self-work are provided for every module. In the frames of mastering course content such competences as *to know, to be able, to master* pointed out in the ACWP are formed. These competences act as the controlled results of learning the discipline "Theory of mechanisms and machines" (Table 1.1).

Monitoring of the acquired knowledge, abilities and skills is made in the frames of continuous assessment, progress check and formative assessment in the process of studying theoretical material, reports on laboratory works and during examination. Types of control is given in Table 1.1

Table 1.1 – List of controlled results of learning the discipline

Controlled results of learning the discipline (KAS)	**Type of control**					
	Continuous assessment		**Progress check**		**Formative assessment**	
	D	**CT**	**LWR/ PWR**	**T/CW**	**CoW**	**CT**
1	**2**	**3**	**4**	**5**	**6**	**7**
Acquired knowledge						
K.1 Knows general methods and techniques of designing mechanisms on specified basic and additional synthesis conditions	D1	CT1		T1		CT
K.2 Knows basic concepts of the theory of mechanisms and machines	D2	CT2		T2		CT
Acquired abilities						
A.1 Can design structural schemes of model mechanisms according to specified conditions			PWR1 PWR3 PWR4		CoW	CT

1	2	3	4	5	6	7
A.2 Is able to carry out theoretical and experimental studies of the kinematics of mechanisms of various types			PWR2 PWR5 PWR6 PWR7 PWR8 PWR9		CoW	CT
Mastered skills						
S.1. Has the skills of the theoretical and experimental research of the kinematic mechanisms of different kinds			LWR1 LWR2		CoW	CT
S. 2. Has the skills of synthesis of model mechanisms using automated design tools, looking for their optimal parameters according to the specified working conditions.			LWR3 LWR4		CoW	CT

D – topic discussion; CT – case-task (individual task); LWR – report on laboratory work; PWR – report on practical work; T/T – progress check (test); CoW – coursework; CT – complex task of grading test.

Final assessment of the learned discipline results is the midterm assessment which is made in the form of test taking into consideration the results of the running and progress check.

2. TYPES OF CONTROL, STANDARD CONTROL TASKS AND SCALES OF LEARNING RESULTS ASSESSMENT

Continuous assessment of the academic performance is aimed at maximum effectiveness of the educational process, at monitoring students' specified competencies formation process, at increase of learning motivation and provides the assessment of mastering the discipline. In accordance with the regulations concerning the continuous assessment of the academic performance and midterm assessment of students taught by the educational programs of Higher education – programs of the Bachelor's Course, Specialists' and Master's Course the next types of students' academic performance continuous assessment and its periodicity is stipulated in PNRPU:

– acceptance test, check of the student's original preparedness and his correspondence with the demands for the given discipline learning;

– continuous assessment of mastering the material (the level of mastering the component "to know" defined by the competence) at every group studies and monitoring of lectures attendance;

– interim and progress check of students' mastering the components "to know" and "to be able" of the defined competences by computer-based or written testing, control discussions, control works (individual home tasks), reports on laboratory works, reviews, essays, etc.

Discipline progress check is conducted on the next week after learning the discipline module, while the interim control is made at every monitoring during the discipline module study;

– interim assessment, summarizing of the current students' performance at least once a semester in all disciplines for every training program (specialty), course, group;

– retained knowledge control.

2.1. CONTINUOUS ASSESSMENT OF EDUCATION

Continuous assessment of learning is made in the form of discussion or selective recitation on every topic. According to the four-point system the results of assessment are put into the teachers' note-book and are considered in the form of integral marks in the process of the midterm assessment.

2.2. PROGRESS CHECK

For the complex assessment of the acquired knowledge, abilities and skills (Table 1.1) progress check is carried out in the form of laboratory and practical work presentation and midterm control tests (after learning every discipline module).

2.2.1. Presentation of practical work

There are 9 practical works all in all. Standard topics of practical work are given in ACWP.

Presentation of practical work is made by the student individually or by the group of students. The scale and criteria for the assessment are given in Table 2.1.

Table 2.1 – Criteria and scale of assessment of the level of mastering of disciplinary competences in practical work

Point for		**Level of mastering**	**Criteria for assessing the level of disciplinary competence after studying the training material**
Knowledge	**Abilities**		
5	5	Maximum level	*The job has been completed in full. The student accurately answered the control questions, is freely oriented in the proposed solution, and can modify it when changing the condition of the task. The report is carefully executed in accordance with the requirements or with minor shortcomings.*
4	4	Average	*The job has been completed in full. The student answered theoretical questions with little difficulty. The quality of the report to work is not fully compliant.*
3	3	Minimum level	*The student correctly completed the task to work. Compiled the report in the established form, presented the solutions of most of the tasks provided in the work. The student cannot fully explain the results.*
2	2	The minimum level is not reached	*The student has not completed all the work assignments and cannot explain the results.*

2.2.2. Presentation of laboratory work

It is planned 4 laboratory work is planned all in all. Standard topics of laboratory work are given in ACWP.

Presentation of laboratory work is made by the student individually or by the group of students. The scale and criteria for the assessment are given in Table 2.2.

Table 2.2 – Criteria and scale of assessment of the level of mastering of disciplinary competences in laboratory work

Point for		**Level of mastering**	**Criteria for assessing the level of disciplinary competence after studying the training material**
Knowledge	**Abilities**		
5	5	Maximum level	*The job has been completed in full. The student accurately answered the control questions, is freely oriented in the proposed solution, and can modify it when changing the condition of the task. The report is carefully executed in accordance with the requirements or with minor shortcomings.*
4	4	Average	*The job has been completed in full. The student answered theoretical questions with little difficulty. The quality of the report to work is not fully compliant.*
3	3	Minimum level	*The student correctly completed the task to work. Compiled the report in the established form, presented the solutions of most of the tasks provided in the work. The student cannot fully explain the results.*
2	2	The minimum level is not reached	*The student has not completed all the work assignments and cannot explain the results.*

2.2.3. Midterm control test

According to ACWP 3 midterm control tests (T) are planned to be realized after learning the educational units of the discipline by the students.

The first T is realized with respect to the unit 2 "Kinematic analysis of a mechanism", the second T – with respect to the unit 4 "Force analysis of a mechanism", the third T – with respect to the unit 6 "Vibration activity of machines and vibration protection. Vibrating machines". Standard tasks of the control tests are given in the annex 1.

The scale and criteria for the assessment are given in Table 2.3.

Table 2.3 – Criteria and scale of the level of mastering disciplinary competences at the frontier testing

Score	**Level of mastering**	**Criteria for assessing the level of learning material**
5	Maximum level	*The student answered more than 86% of the questions correctly.*
4	Average	*The student answered 71-85% of the questions correctly.*
3	Minimum level	*The student answered 51-70% of the questions correctly.*
2	The minimum level is not reached	*The student answered less than 51% of the questions correctly.*

2.3. FULFILLMENT OF THE INDIVIDUAL COURSEWORK

Coursework is used to assess skills and experience as a result of training the discipline.

Coursework is carried out with the aim of developing practical skills in the analysis and synthesis of various mechanisms of mining and oilfield equipment and to consolidate certain theoretical provisions of the course.

2.3.1 Typical coursework topics

The theme of the typical coursework "Kinematic and Dynamic Analysis and Synthesis of Mechanisms".

Structural and kinematic synthesis of mechanisms are solved in the work. The parameters and kinematic characteristics of the mechanism are calculated. Finding external forces and bond reactions in the mechanism. Determining the power of the drive mechanism. Dynamic analysis of the mechanism. The work consists of an explanatory note and 2-3 sheets of graphic part of the A1 format.

Examples of individual coursework assignments are available in Annex 2.

The scale and criteria for evaluating the results of the implementation and defense of the course work are shown in table 2.4.

Table 2.4 – Scale and criteria for assessing and defense of the coursework

Point	**Level of mastering**	**Criteria for assessing the level of disciplinary competence after studying the training material**
5	Maximum level	*The student has fully and correctly performed the coursework, is freely oriented in the proposed solution, and can modify it when the condition of the task is changed. The graphic part and explanatory note of coursework are done carefully and in accordance with the requirements. The student can fully explain the results.*
4	Average	*The student did the coursework with some shortcomings. The quality of coursework does not fully meet the requirements. The student can fully explain the results.*
3	Minimum level	*The student presented an incomplete solution to the coursework assignment. The quality of coursework does not fully meet the requirements. The student cannot fully explain the results.*
2	The minimum level is not reached	*The student did not complete the coursework.*

2.4. MIDTERM ASSESSMENT (FINAL CONTROL)

Admission for midterm assessment is made according to the results of continuous assessment and progress check. Preconditions for admittance are successful presentation of all laboratory and practical works and positive integral estimation with respect to the results of continuous assessment and progress check.

2.4.1. Midterm assessment procedure without additional evaluation testing

Midterm assessment is made in the form of a test. Credit on the discipline is based on the results of the previously fulfilled by the student individual tasks on the given discipline.

Criteria of putting the final mark for the components of competences in the process of midterm assessment made in the form of test are given in the general part of FET of the educational program.

2.4.2. Midterm assessment procedure followed by evaluation testing

In definite cases (for example, in case of re-attestation of the discipline) midterm assessment in the form of this discipline test can be made as the card-based evaluation test. Every exam card includes theoretical questions (TQ) aimed at control of the acquired knowledge, practical tasks (PT) aimed at mastered abilities, and complex tasks (CT) aimed at control of the acquired skills of all declared competences.

The exam card is formed so that the included questions and practical tasks could estimate the level of maturity of **all** declared competences.

2.4.2.1. Typical questions and tasks for the discipline test are given in Annex 1.

The scale and criteria for assessment test results are shown in Table 2.3.

2.4.2.2. Scales of test assessment of educational achievements

Evaluation of discipline achievements in the form of maturity level of the components *to know, to be able, to master the* declared competences is made according to the four-point assessment scale.

Standard scale and criteria of estimating educational achievements in the process of testing for the components *to know, to be able, to master* are given in the general part of FET of educational program.

3. ASSESSMENT CRITERIA FOR COMPONENTS AND COMPETENCES LEVEL OF MATURITY

3.1. ASSESSMENT OF COMPETENCES COMPONENTS LEVEL OF MATURITY

While estimating the level of competences maturity by selective control in the process of testing it is considered that *the mark obtained for the components of the examined competence is combined with the corresponding component of all competences formed in the frames of the given academic course.*

General assessment of maturity level of all competences is made by aggregation of marks obtained by the student for each component of the formed competences taking into account the results of continuous assessment and progress check in the form of integral mark according to the four-point scale. All control results are put into the assessment sheet by the teacher according to the results of midterm attestation.

The form of the assessment sheet and requirements for its completion are given in the general part of FET of the educational program.

While making the final assessment of the midterm attestation in the form of test standard criteria given in the general part of FET of the educational program are used.

Annex 1

Examples of typical questions for Midterm control test

Unit 1 & 2

1) A device that performs mechanical movements to convert energy, materials and information is called...

1) Mechanism	2) Node	3) Kinematic chain	4) Machine

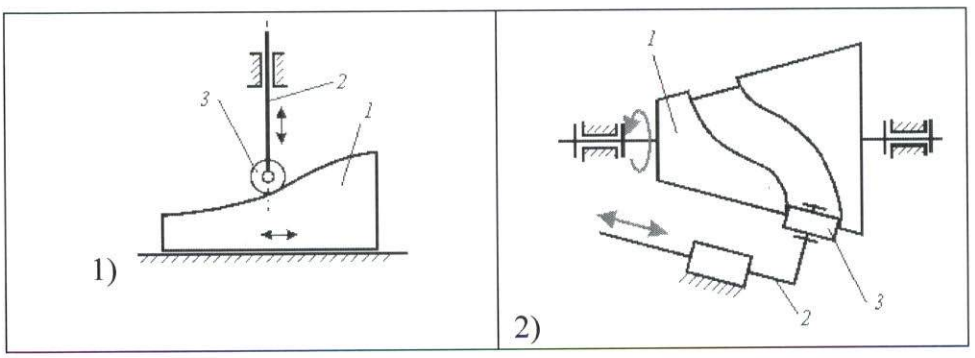
2) The system of bodies, designed to transform the movement of one or more hard bodies and/or forces acting on them into the required movements of other bodies and/or forces, is called...

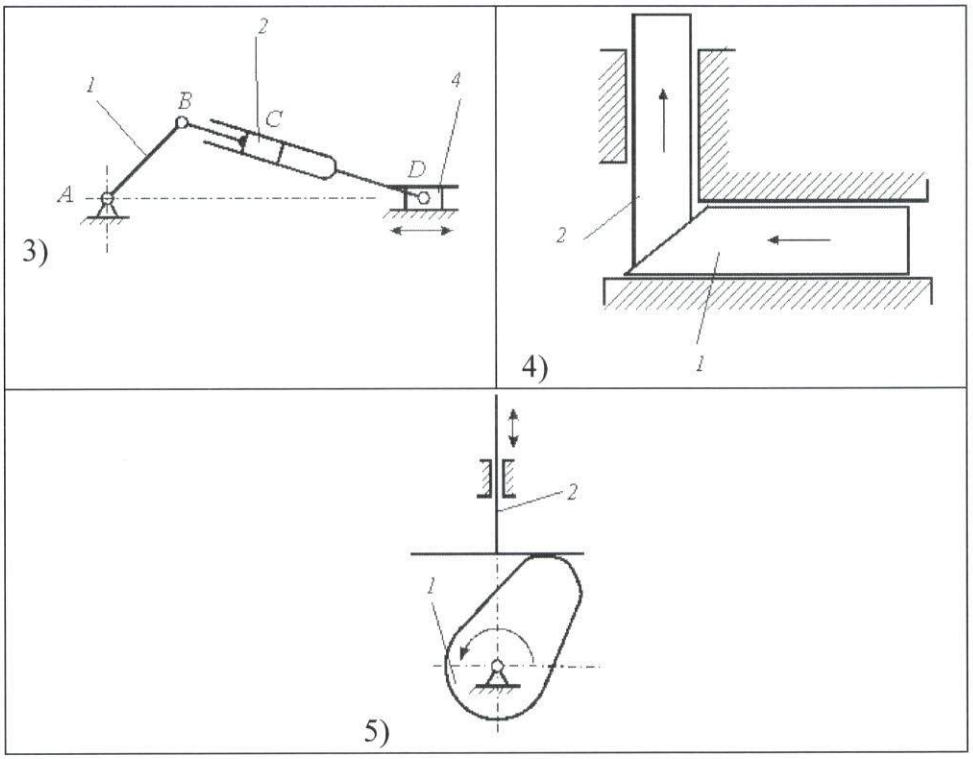
1) kinematic chain	2) Machine	3) Mechanism	4) structural (Assur) group

3) Coupler is called…

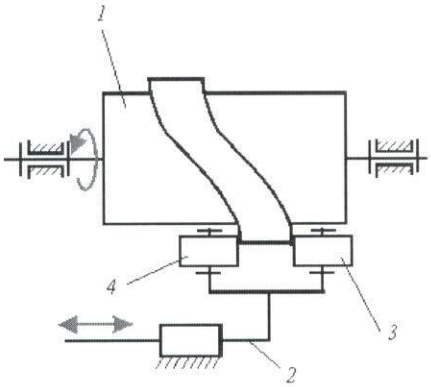
1) link that moves indirectly relative to the frame or other link	2) a link of the linkage that can make a full turn around the stationary axis	3) link making flat parallel movement(forming kinematic pairs only with movable links)	4) a link that performs incomplete rotation around the axis associated with the frame

4) What is the structural scheme of the spatial mechanism?



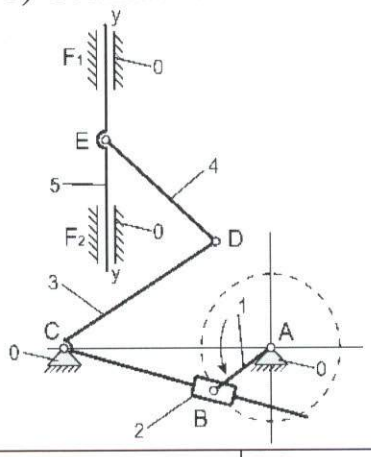


5) The mechanism, the structural scheme of which is shown in the picture, refers to ...



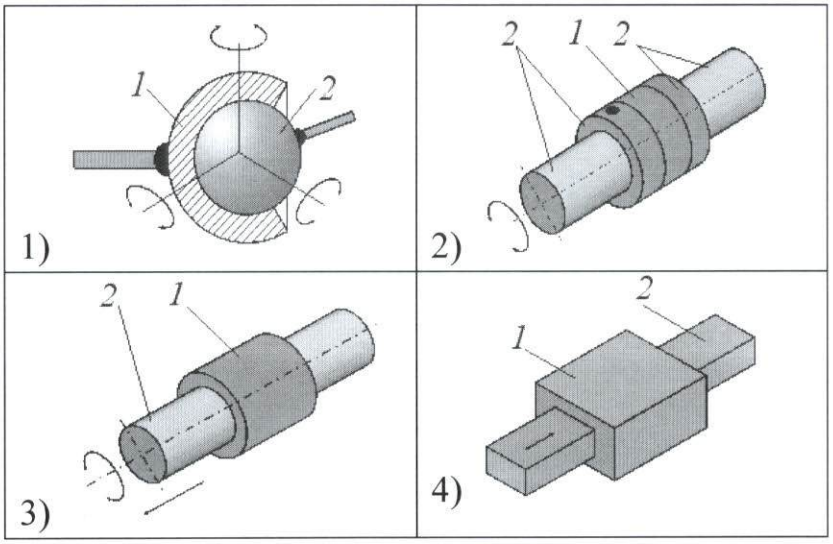
1) coulisse mechanism	2) cam-mechanisms	3) wedge mechanism	4) linkage with revolute pairs	5) Linkage

6) Coulisse is the link №…?



1) 1	2) 2	3) 3	4) 5

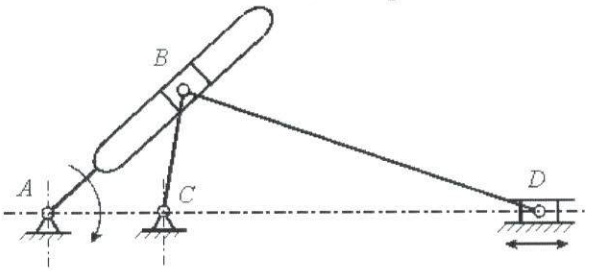
7) Specify a cylindrical kinematic pair



8) The figure shows the symbol of... (GOST 2.770-68*) ...

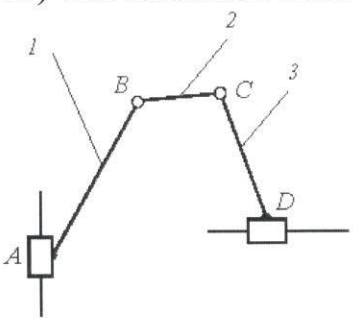
1) cylindrical cinematic pair	2) revolute kinematic pair	3) screw cinematic pair	4) prismatic cinematic pair

9) The number of rotary kinematic pairs in the mechanism, the structural diagram of which is shown, is equal to that of ...



1) 5	2) 1	3) 2	4) 3	5) 4

10) The cinematic chain shown in the image is ...

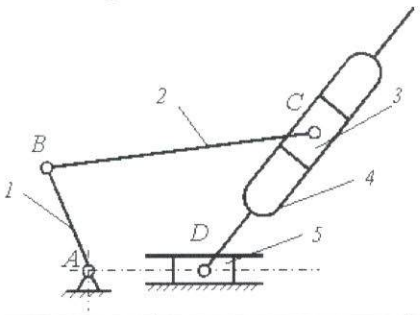


1) complex open	2) simple closed	3) simple open	4) complex closed

11) The number of degrees of freedom of spatial mechanisms (according to I.I. Artobolevsky) is calculated by the formula…

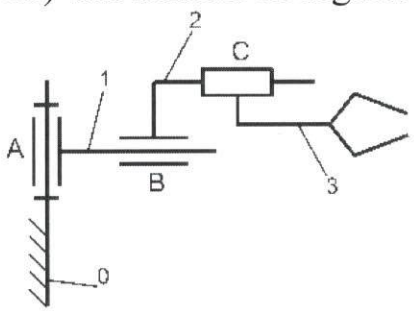
1) $q = W + 5p_5 + 4p_4 + 3p_3 + 2p_2 + p_1 - 6n$	2) $W = 6n - 5p_5 - 4p_4 - 3p_3 - 2p_2 - p_1$
3) $W = 3n - 2p_5 - p_4$	4) $W = 6n + 5p_5 + 4p_4 + 3p_3 + 2p_2 + p_1$

12) The number of degrees of freedom of the planar mechanism, the structural diagram of which is shown, equals to …



1) 0	2) 1	3) 2	4) 3	5) 4

13) The number of degrees of freedom W manipulator equals to …

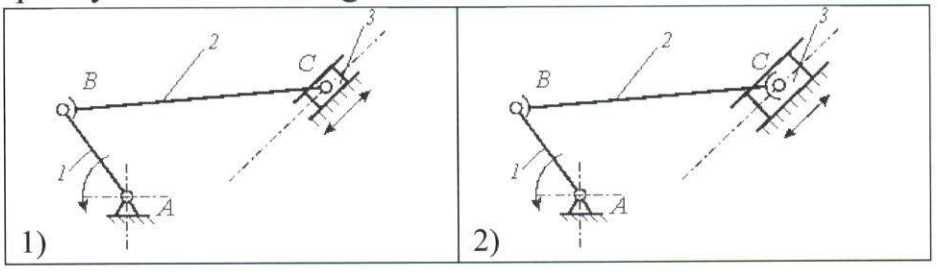


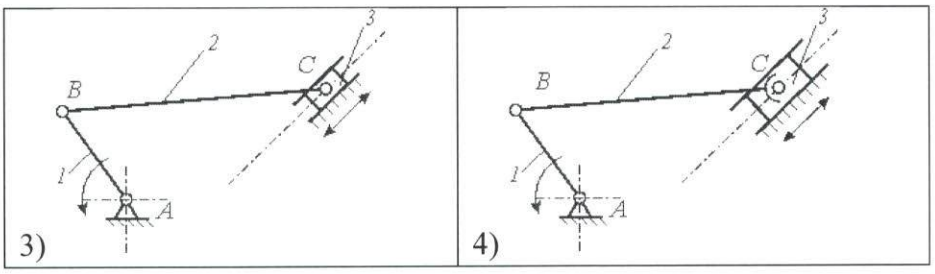
1) 3	2) 4	3) 5	4) 6	5) 7

14) The number of redundant (q) *constraint* for spatial mechanisms is determined by the formula ... (q – *number of redundant constraint*, W – *number of degrees of freedom*, p_1, p_2, p_3, p_4, p_5 – *number of cinematic pairs* 1, 2, 3, 4, 5 *Classes*)

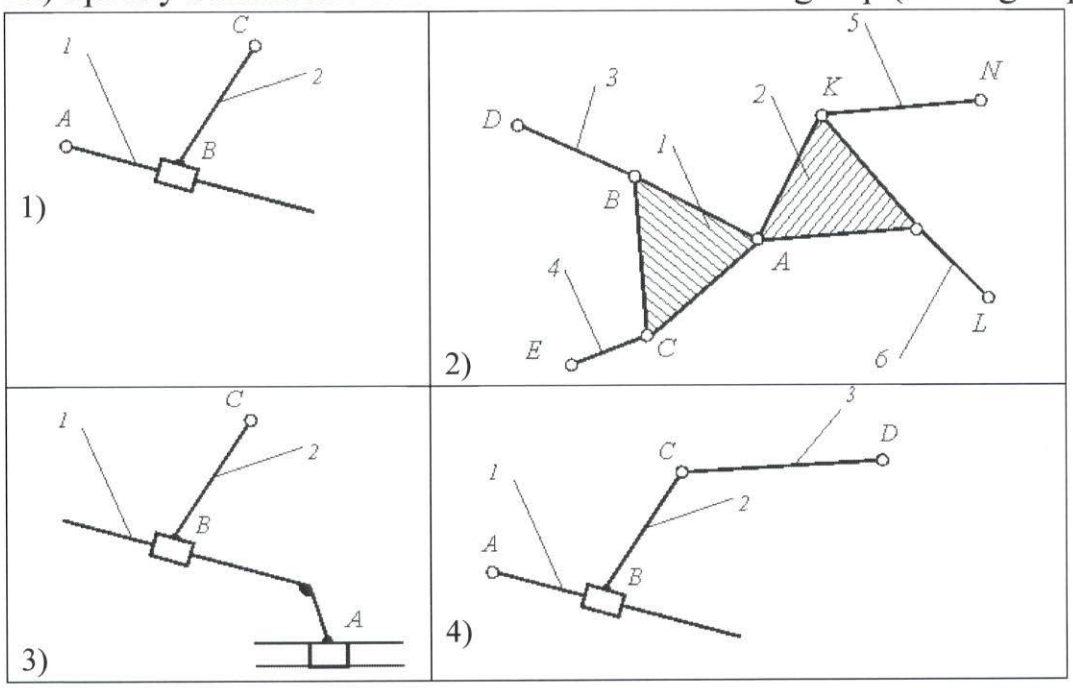
1) $q = 3n - 2p_5 - p_4$	2) $q = W + 2p_5 + p_4 - 3n$
3) $q = (W + 5p_5 + 4p_4 + 3p_3 + 2p_2 + p_1) - 6n$	4) $q = W + 5p_5 + 4p_4 + 3p_3 + 2p_2 + p_1 + 6n$
5) $q = 6n - (5p_5 + 4p_4 + 3p_3 + 2p_2 + p_1)$	

15) Specify a structural diagram of a mechanism with local mobility

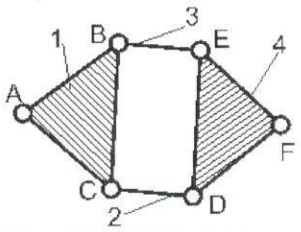




16) Specify a kinematic chain that is not a structural group (Assur group)

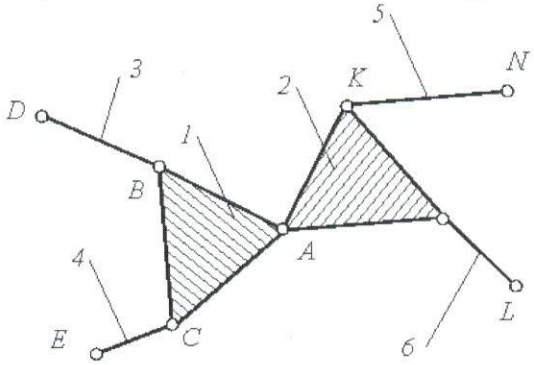


17) The class of the structural group shown in the picture is ...



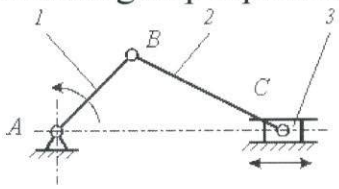
1) 4	2) 2	3) 1	4) 5	5) 3

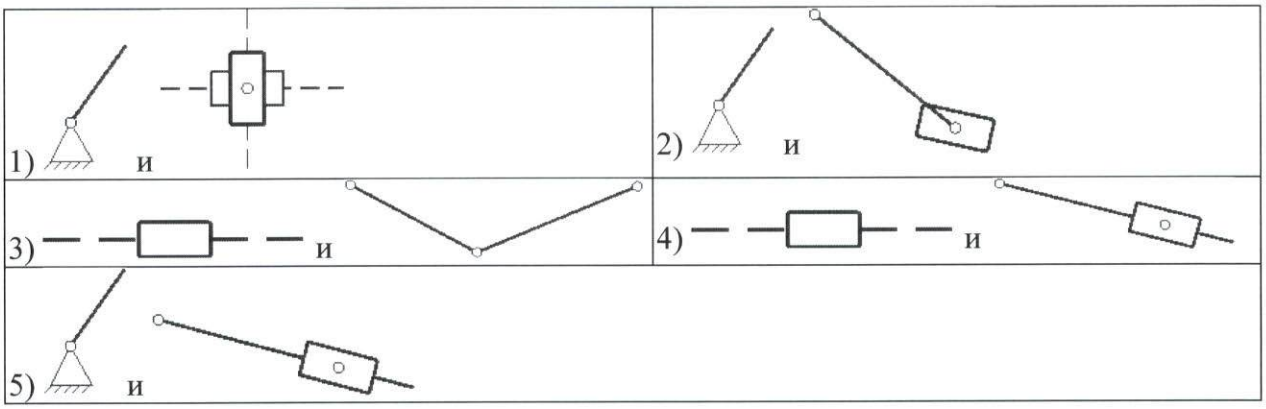
18) The order of the structural group shown in the picture is equal to ...



1) 3	2) 4	3) 5	4) 2	5) 1

19) The slider-crank mechanism is made up of the primary mechanism and the structural group represented in the picture...





20) Structural synthesis of the mechanism is called...

1) Determining the parameters of the mechanism diagram by specified kinematic properties	2) Determining the structural diagram of a mechanism suitable for a given assignment	3) Determining the parameters of the mechanism diagram by specified dynamic properties	4) Determining the number of degrees of freedom of the mechanism

Unit 2 & 3

1) The purpose of kinematic analysis of the mechanism is …

1) Determining the characteristics of the kinematic diagram of the mechanism by specified kinematic properties	2) Determining the kinematic characteristics of the mechanism at known sizes, masses and moments of inertia of the links	3) Determining the number of degrees of freedom of the mechanism according to a given structural diagram	4) designing a kinematic mechanism scheme and selecting the inertial characteristics of links, the rigidity of links and mass distribution	5) Determining the movement of the mechanism links by the given movement of the initial links

2) The generalized coordinate of the mechanism is called …

1) any of the coordinates that determine the position of the mobile link of the mechanism relative to the frame	2) any of the coordinates that determine the position of the moving link's center of the mass relative to the frame	3) each of the independent coordinates determining the position of all the links of the mechanism relative to the frame	4) each of the independent coordinates which determine the relative position of the links that make up the cinematic pair

3) The second derivative of the angle of the link turning according to the generalized coordinate of the mechanism is called…

1) angular speed	2) analogue of angular acceleration	3) transmission function	4) angular acceleration	5) analogue of angular speed

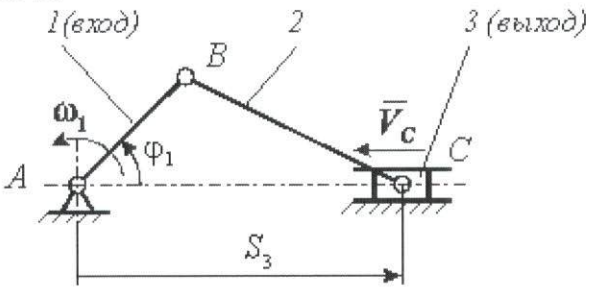
4) The method of converting coordinates refers to ...

1) graphic methods of kinematics	2) grapho-analytical methods of kinematics	3) analytical methods of kinematics	4) experimental methods of kinematics

5) Computing scale is called…

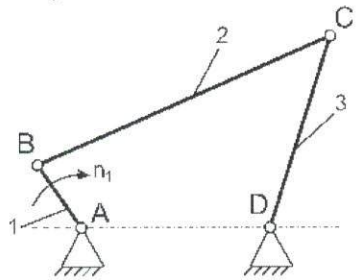
1) the first derivative of the link angle on the generalized coordinate of the mechanism	2) the ratio of the actual value of the physical value to the length of the segment by which this value depicted in the drawing	3) large-scale value in the main inscription of the drawing	4) the ratio of the segment in the drawing to the actual value of a certain physical value

6) The picture shows a kinematic diagram of the crank-slider mechanism of the compressor. The function of the position of this mechanism is recorded in the form of …



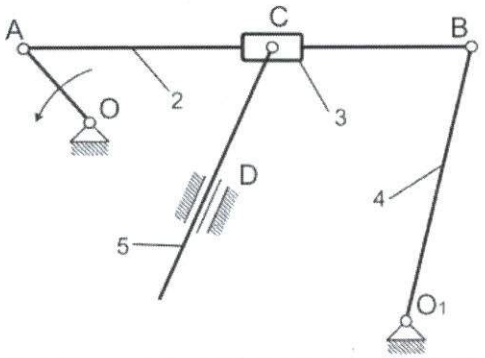
1) $\omega_1=f(\varphi_1)$	2) $S_3=f(\varphi_1)$	3) $V_C=f(\varphi_1)$	4) $V_C=f(\omega_1)$

7) Acceleration of point *B* crank-and-rocker mechanisms defined as (n_1=const) …



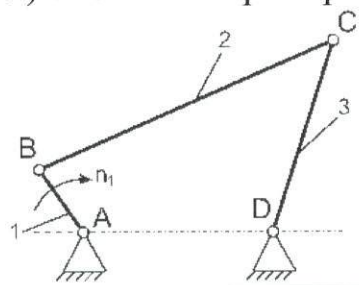
1) $a_B=\omega_1^2\cdot l_{AB}$	2) $a_B=\omega_1\cdot l_{AB}$
3) $\{\bar{a}_B=\bar{a}_B+\bar{a}^n_{CA}+\bar{a}^\tau_{CA}\ \bar{a}_B=\bar{a}_D+\bar{a}^n_{CD}+\bar{a}^\tau_{CD}$	4) $\{\bar{a}_B=\bar{a}_B+\bar{a}^n_{CB}\ \bar{a}_B=\bar{a}_D+\bar{a}^n_{CD}$
5) $\{\bar{a}_B=\bar{a}^n_{CB}+\bar{a}^\tau_{CB}\ \bar{a}_B=\bar{a}_D+\bar{a}^n_{CD}+\bar{a}^\tau_{CD}$	

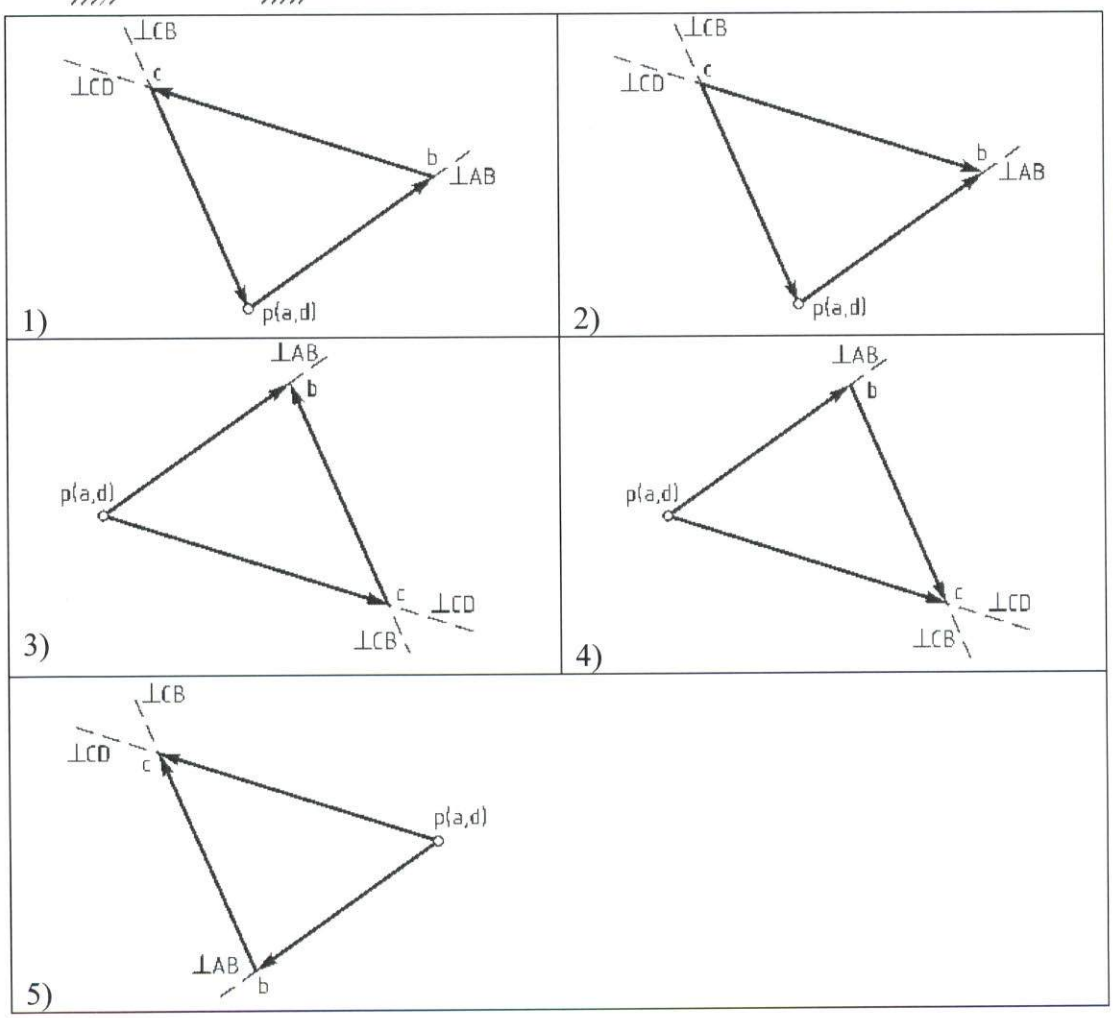
8) The correct system of vector equations to determine the velocity of the *B* point mechanism is…



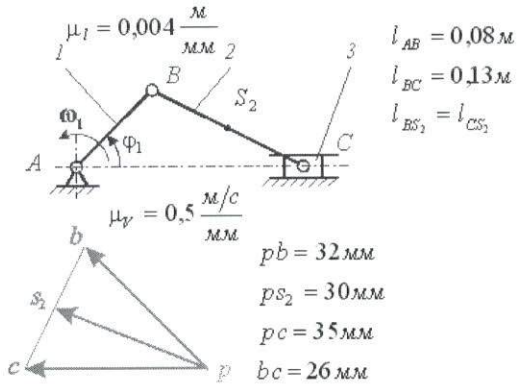
1) $\{\bar{V}_B = \bar{V}_A + \bar{V}_{BA}\ \bar{V}_B = \bar{V}_{O_1} + \bar{V}_{BO_1}$	2) $\{\bar{V}_B = \bar{V}_A + \bar{V}_{BC}\ \bar{V}_B = \bar{V}_{O_1} + \bar{V}_{BO_1}$	3) $\{\bar{V}_B = \bar{V}_{BC}\ \bar{V}_B = \bar{V}_{O_1} + \bar{V}_{BO_1}$	4) $\{\bar{V}_B = \bar{V}_A + \bar{V}_{BA}\ \bar{V}_B = \bar{V}_{BC}$

9) The correct speed plan for this provision of the mechanism is …

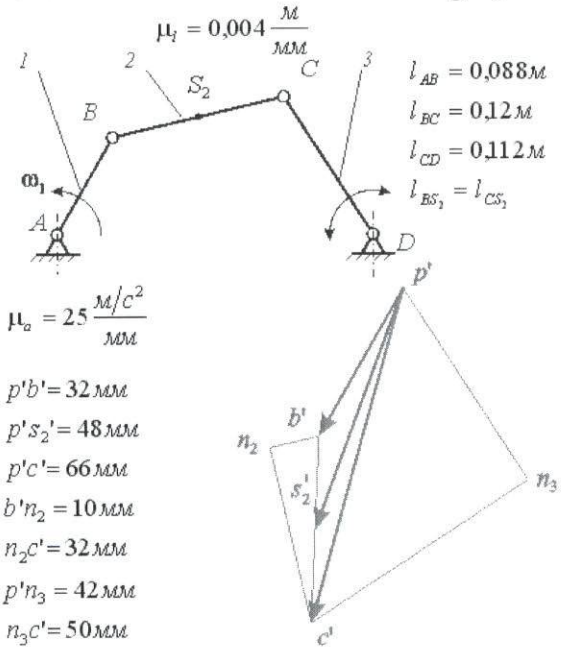




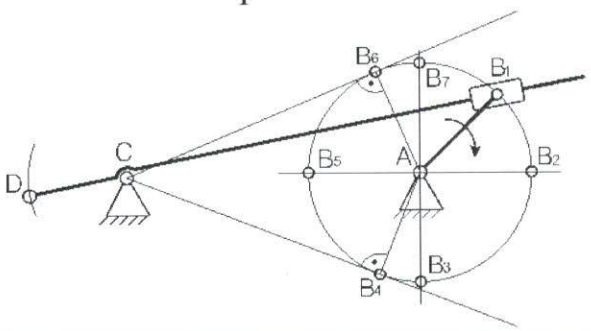
10) The picture shows the state plan and the speed plan of crank-slide mechanism. The angular speed of the coupler 2 is equal _____ rad/s (round the answer to the nearest integer)



11) The picture shows a plan of positions and a plan of acceleration of the four-bar linkage. Acceleration of point. S_2 of the coupler is equal _____ m/s^2 (round the answer to the nearest integer)

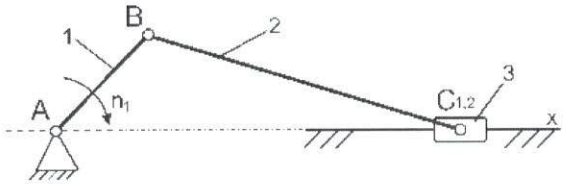


12) Point D of the coulisse will occupy extreme positions if the point B of the crank is located at points…



1) B_2 & B_5	2) B_3 & B_7	3) B_6 & B_7	4) B_4 & B_6

13) For a crank-slide mechanism, it is necessary to determine the length of the links in order to implement the predetermined law of movement. In general, the task will be called …

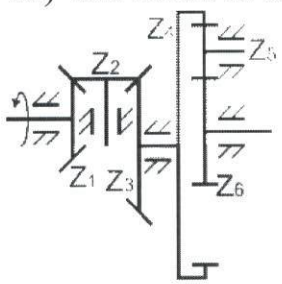


1) structural analysis	2) dynamic synthesis	3) Dynamic analysis	4) kinematic synthesis	5) kinematic analysis

14) The transmission number (*u) of* gearbox should satisfy the ratio ...

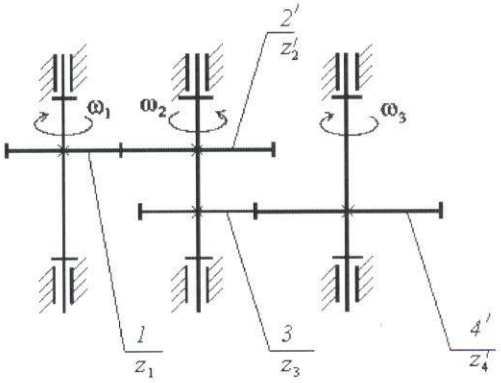
1) $u<1$	2) $u\leq 0$	3) $u>1$	4) $0\leq u\leq 1$

15) The idlers in this gearbox are…



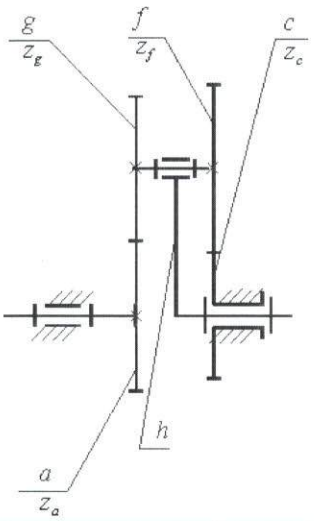
1) 1 & 6	2) 3 & 4	3) 2 & 5	4) 1 & 3

16) Multi-stage gear mechanism transmission ratio $i_{13}=\dfrac{\omega_1}{\omega_3}$ (see picture) calculated by formula...



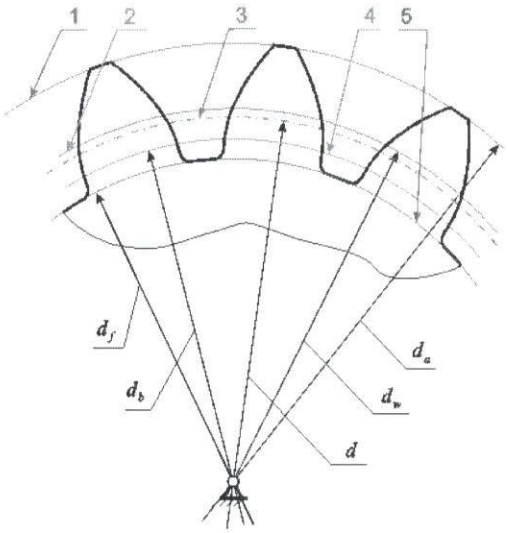
1) $i_{13}=-\dfrac{z_1\cdot z_3}{z_4'\cdot z_2'}$	2) $i_{13}=\dfrac{z_1\cdot z_3}{z_4'\cdot z_2'}$	3) $i_{13}=\dfrac{z_4'\cdot z_2'}{z_1\cdot z_3}$	4) $i_{13}=-\dfrac{z_4'\cdot z_2'}{z_1\cdot z_3}$

17) The transmission ratio of planetary mechanism, the structural diagram of which is shown, is determined by the formula



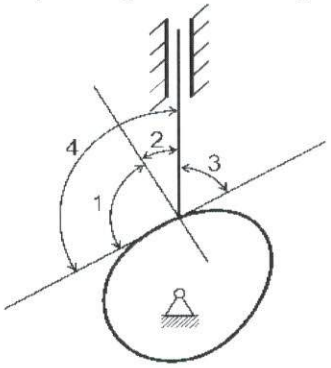
1) $i_{ah}^{(c)} = 1 + \frac{z_g \cdot z_c}{z_a \cdot z_f}$	2) $i_{ah}^{(c)} = 1 - \frac{z_a \cdot z_f}{z_g \cdot z_c}$	3) $i_{ah}^{(c)} = 1 + \frac{z_g \cdot z_c}{z_a \cdot z_f}$	4) $i_{ah}^{(c)} = 1 - \frac{z_g \cdot z_c}{z_a \cdot z_f}$

18) The picture shows a cylindrical, an involute gear wheel. The standard circle of the gear is marked by a digit …



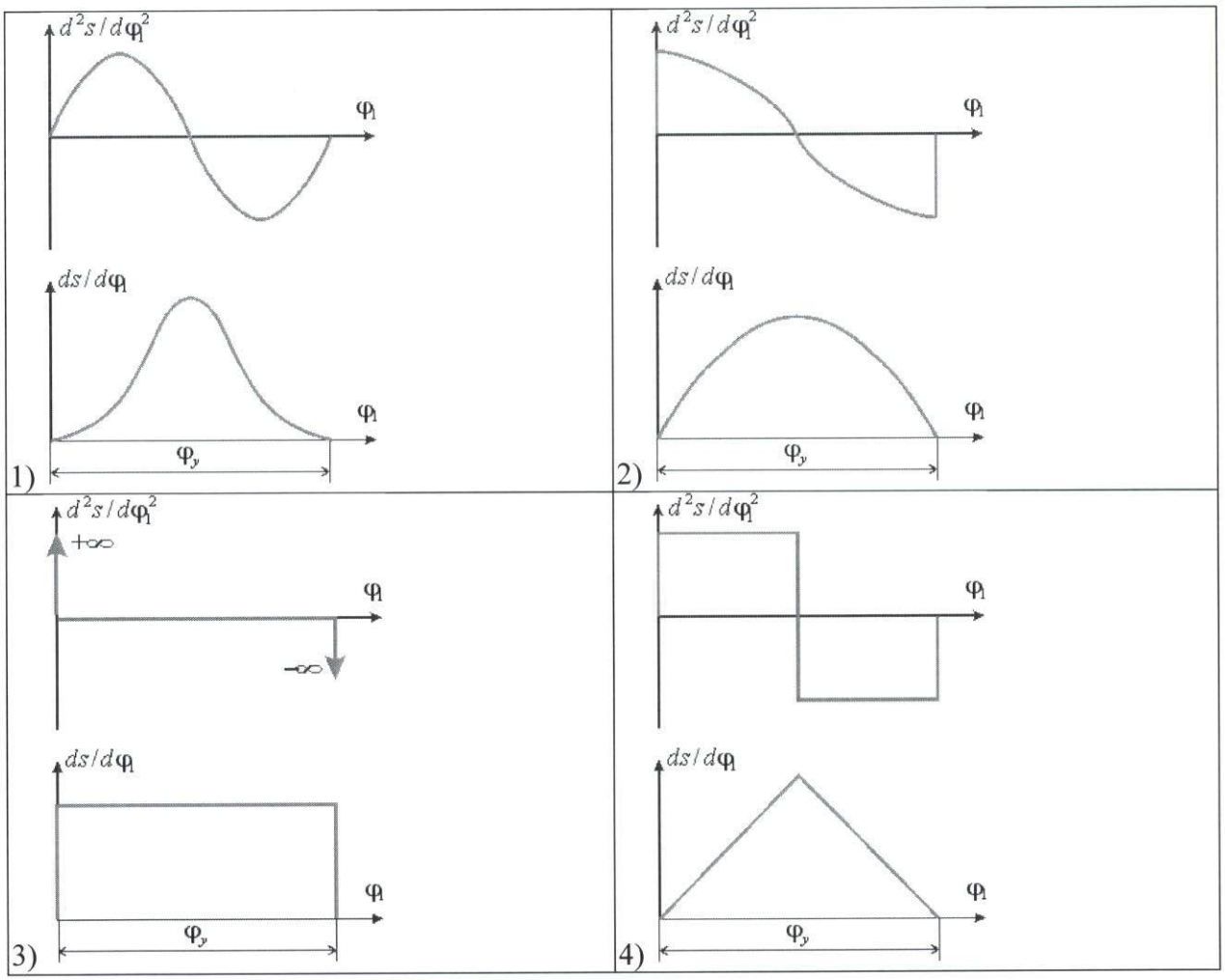
1) 1	2) 2	3) 3	4) 4

19) The pressure angle in the cam mechanism is marked by a number…



1) 1	2) 2	3) 3	4) 4

20) The pictures of the answers show graphs of the dependence of analogues of acceleration and speed from the angle of the cam. Point out the law of the cam follower movement in which there are "hard" blows.



Unit 5 & 6

1) The goal of dynamic synthesis mechanism is ...

1) Determining the number of degrees of freedom of the mechanism according to a given structural diagram	2) designing a kinematic mechanism layout and selecting inertial parameters based on its dynamic properties	3) establishing relationships between the speeds of the input and the output links of the mechanism	4) Determining the size of the links of the mechanism that ensure the set movement of output link	5) Determining the kinematic characteristics of the mechanism at known sizes, masses and moments of inertia of the links

2) The equation of movement of the mechanism with one degree of freedom in the integral form is recorded in the form...

($I^{EQ}(\varphi)$ – equivalent(reduced) moment of inertia of a mechanism; $M^{EQ}(\varphi,\omega,t)$ – equivalent(reduced) moment; $M_{DF}^{EQ}(\varphi,\omega,t)$ – equivalent(reduced) moment of driving forces; $M_{RF}^{EQ}(\varphi,\omega,t)$ – equivalent(reduced) moment of resistance

forces; φ – angular coordinate of the reference link; ω – angular speed of the reference link; φ_0, ω_0 – angular coordinates and angular speed of the reference link at the initial point of time, respectively; t – time)

1) $\frac{I^{EQ}(\varphi)\omega^2}{2} - \frac{I^{EQ}(\varphi_0)\omega_0^2}{2} = \int_{\varphi_0}^{\varphi} M^{EQ}(\varphi,\omega,t)d\varphi$	2) $\frac{I^{EQ}(\varphi_0)\omega_0^2}{2} + \frac{I^{EQ}(\varphi)\omega^2}{2} = \int_{\varphi_0}^{\varphi} M_{RF}^{EQ}(\varphi,\omega,t)d\varphi$
3) $\frac{I^{EQ}(\varphi)\omega^2}{2} - \frac{I^{EQ}(\varphi_0)\omega_0^2}{2} = \int_{\varphi}^{\varphi_0} M_{DF}^{EQ}(\varphi,\omega,t)d\varphi$	4) $\frac{I^{EQ}(\varphi)\omega^2}{2} + \frac{I^{EQ}(\varphi_0)\omega_0^2}{2} = \int_{\varphi_0}^{\varphi} M^{EQ}(\varphi,\omega,t)d\varphi$

3) Equivalent (reduced) moment of inertia of a planar mechanism is determined from the condition …

1) equilibrium mechanism	2) equality of the reduces moment of inertia and the sum of moments of inertia of all the parts of the mechanism, relative to the axis of rotation of the reference link	3) equality of kinetic energy of the dynamic model of the mechanism and the sum of kinetic energies of all links of the mechanism	4) equality of the reduced moment of inertia and the sum of moments of inertia of all the links of the mechanism, relative to the axes passing through their centers of mass perpendicular to the planes of movement of the points of the links of the mechanism

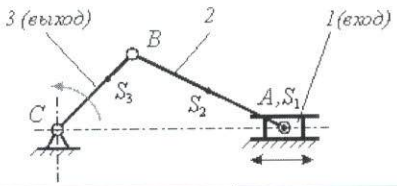
4) Steady-state motion of a machine is called …

1) movement in which the kinetic energy of the mechanism is constant or is a periodic function of time	2) movement in which the kinetic energy of the mechanism increases	3) movement in which the kinetic energy of the mechanism decreases	4) movement in which the angular speed of the initial link of the mechanism does not change

5) The flywheel is designed to ...

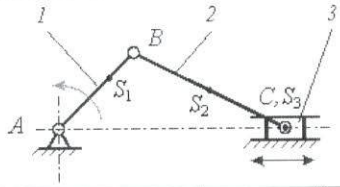
1) balance the mechanism	2) remove the pressure of the frame on the foundation from the forces of inertia of the links of the mechanism	3) Reduce the uneven movement of the mechanism	4) reduce the time of the mechanism's starting regime

6) Balancing power for crank-slide internal combustion engine (see pic.) determined from the kinetho-statics equation compiled for…

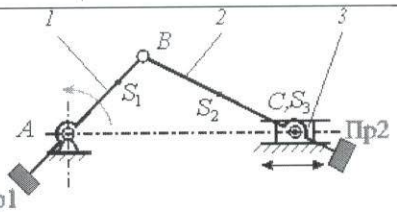


1) link 2	2) link 1	3) group 2-3	4) link 3

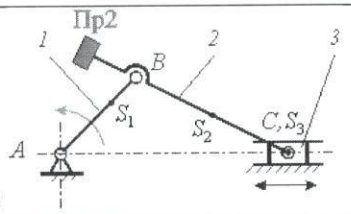
7) The crank-slide mechanism has three mobile links, the mass centers of which are marked S_1, S_2, S_3 respectively. What is the scheme of the counterweights Пр*i*, which allows for a complete static balancing of the mass of the mechanism?



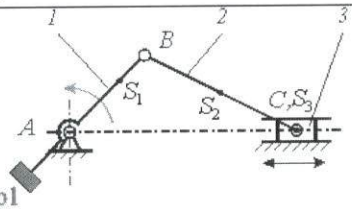
1) Пр1



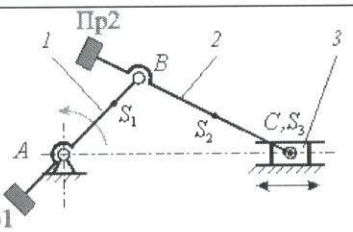
2)



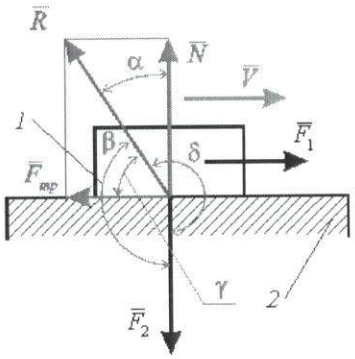
3) Пр1



4) Пр1

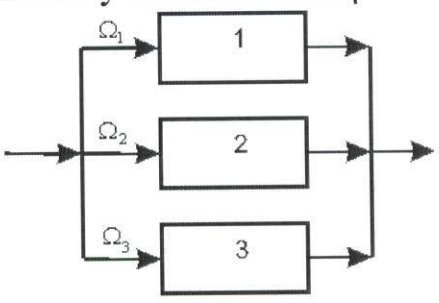


8) Slider 1 moves on guide 2 at speed under the influence of external forces $\bar{V} \cdot \bar{F}_1, \bar{F}_2$. The angle of friction is the angle



*1) α	2) β	3) γ	4) δ

9) Mechanisms 1, 2, 3 with efficiency η_1, η_2, η_3 respectively are cconnected in parallel. Load distribution between the mechanisms is characterized by load distribution ratios Ω_1, Ω_2, Ω_3. The overall efficiency of the system mechanisms is determined by the formula ...η



1) $\eta = \frac{\eta_1 \cdot \eta_2 \cdot \eta_3}{\Omega_1 + \Omega_2 + \Omega_3}$	2) $\eta = \frac{\eta_1 + \eta_2 + \eta_3}{\Omega_1 + \Omega_2 + \Omega_3}$
3) $\eta = \Omega_1 \cdot \eta_1 + \Omega_2 \cdot \eta_2 + \Omega_3 \cdot \eta_3$	4) $\eta = \frac{\eta_1 \cdot \eta_2 \cdot \eta_3}{\Omega_1 \cdot \Omega_2 \cdot \Omega_3}$

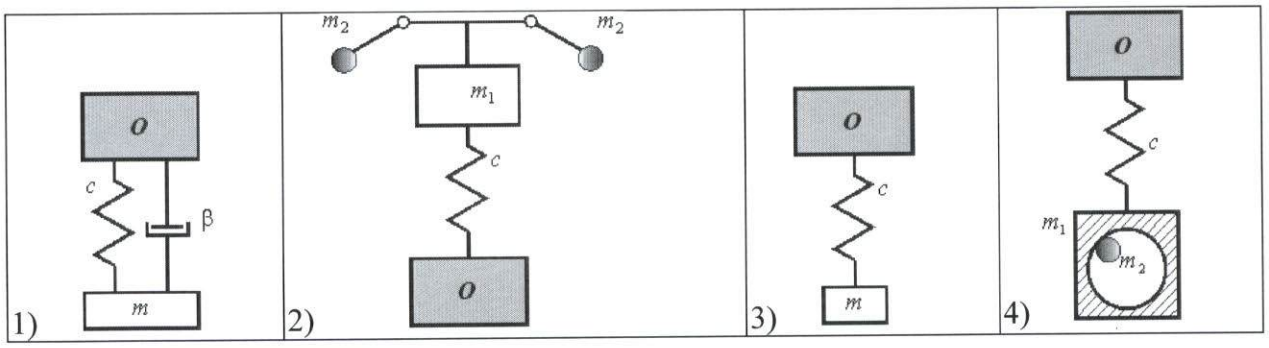
10) Beats are called mechanical fluctuations, which ...

1) occur with cinematic arousal of oscillations	2) are the result of the addition of two or more harmonic oscillations with close frequencies	3) are the result of the addition of two or more harmonic oscillations with multiple frequencies	4) are the result of the addition of two harmonic oscillations with multiple frequencies

11) The task of determining the law of movement of the machine is solved by the usual algebraic methods if...

1) $I = I(\varphi)$, $M = M_д(\omega) - M_c(\varphi)$	2) I = const, M = const
3) I = const, $M = M_д(\omega) - M_c(\varphi)$	4) $I = I(\varphi)$, $M=M(\varphi)$

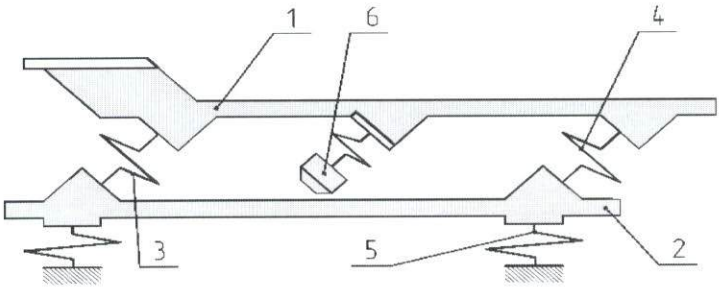
12) The pictures show the object of vibrating protection (**O**) with the inertial (m_i), elastic (c) and dissipative (β) elements attached to it. ***Specify a diagram of a spring single-gas dynamic damper with friction***



13) The combination of devices to excite vibration, its transformation and transmission to the executive body of the machine is called ...

1) dynamic damper	2) vibration drive	3) vibration exciter	4) vibration isolator

14) The structural circuit of the electromagnetic vibratory conveying machine is... (1 – *cargo-carrying body*; 2 – *reactive mass*; 3, 4 – *auxiliary elastic ties*; 5 – *vibro-isolators*; 6 – *reactive part of the vibrator*).



1) single-mass	2) three-mass	3) multi-mass	4) two-mass

15) Expression of the basic synthesis condition in the form of a function, the extreme of which determines the output parameters of synthesis, is called …

1) penalty function	2) State function	3) target function	4) synthesis restriction

16) The pressure angle is called …

1) the angle between the force and speed of her app's point	2) angle between speed and acceleration of the link's center of the mass	3) angle between the full and normal reaction that arises between the contact links	4) the angle between the force and acceleration of the point of its application

Annex 2.
Typical individual tasks of the course

Ministry of Science and Higher Education of the Russian Federation

Federal State Budgetary Educational Institution of Higher Education
"Perm National Research Polytechnic University"

Department of Innovation Engineering

Task № 1
variant № ___

The subject of coursework discipline
"Theory of mechanisms and machines":
"Kinematic and Dynamic Analysis and Synthesis of the Piston Drilling Pump Mechanism"

General performance requirements

1. Using the original data presented in the table: to determine the size of the links, to build a kinematic diagram of a given mechanism in twelve equilibrium positions on the corner of the curve (φ_1).

2. For the initial (zero) position of the mechanism to take: the extreme right position of the piston (i.e. *B*) of the drilling pump.

3. Build a graph of the piston's movement in the crank angle function (S=S (φ_1)). By the method of graphic differentiation to find analogs of speed and acceleration S=$S(\varphi_1)$.

4. Plot 12 speed plans and 6 plans for accelerating the characteristic points of the mechanism.

5. Calculate the reactions in the kinematic pairs of the mechanism for the given position of the work course (1...5), as well as find a balancing point attached to the crank. Take the position of the center of gravity of the coupler to it's $l_{AS_2} = \frac{2}{3}$ of the length.

6. Find the balancing point attached to the crank by the method of the lever of Zhukovsky.

7. Determine the actual law of motion of the main shaft of the working machine.

The graphic part of the work is done on A1 sheets, and the relevant calculations are given in an explanatory note.

The work is made in accordance with the requirements of the State Standards for technical documentation.