National Technical University of Ukraine “Igor Sikorsky Kyiv Polytechnic Institute”

Department of machines and devices of chemical and oil refining industries

NAME OF THE COURSE

Calculations and design of equipment-1. Calculation and construction of the main elements of vessels and devices (Syllabus)

Details of the academic discipline

Level of higher education	First (bachelor's)
Field of knowledge	13 Mechanical engineering
Specialty	133 Industrial mechanical engineering
Educational program	Industrial Mechanical Engineering
Discipline status	Selective
Form of study	full-time
Year of training, semester	4 course, spring semester
Scope of discipline	4 (120)
Semester control/ control measures	Exam
Lessons schedule	https://rozklad.kpi.ua/ https://ecampus.kpi.ua/ 4 hours per week (2 hours of lectures and 2 hours of practical classes)
Language of teaching	Ukrainian
Information about head of the course / teachers	Lecturer: Ph.D., Assoc. Andreiev I. A. Practical/Seminar: Ph.D., Assoc. Andreiev I. A. che@kpi.ua
Placement of the course	https://ecampus.kpi.ua/, http://ci.kpi.ua

Program of educational discipline

1 Description of the educational discipline, its purpose, subject of study and learning outcomes

Description of the educational discipline

The course covers the basics of designing nodes and individual elements of vessels and devices, their application, theoretical information on the basics of engineering calculations, modern standard calculation formulas, normative methods of calculating strength, stiffness and stability.

Discipline "Calculations and design of equipment-1. Calculation and construction of the main elements of vessels and devices" considers the requirements for the design and manufacture of equipment and individual elements, the classification of steels and other structural materials, their application, methods of determining permissible stresses and regulatory parameters, the basics of momentless and moment theory of calculation, calculations on the strength of thin-walled cylindrical bushings, convex, flat and conical bottoms and lids, connection nodes of conical bushings that are under the influence of internal or external pressure, design and calculation of removable tight-tight joints.

The subject of the academic discipline

The discipline "Calculations and construction of equipment-1. Calculation and construction of the main elements of vessels and devices" is taught as the main component of the training of qualified specialists in the field of mechanical engineering, resource conservation, ecology and computer-integrated technologies.

Mastering the methods of construction and calculation involves not just mastering certain rules, but rather the development of a unique style of thinking, focused on the creation of modern technology in the field of chemical and oil refining engineering.

The purpose of the educational discipline

The purpose of studying this discipline is the formation of students of a complex of knowledge, skills, and abilities necessary for qualified design and calculation of typical equipment of the chemical industry. In accordance with the goal, the training of bachelors requires the formation of the following abilities:

• use and application in professional activity of normative methods of calculation of vessels and devices of chemical industries,

• using knowledge of design and construction of typical equipment,

• mastering the method of determining loads that occur during installation, testing and in working conditions,

• receiving information about the current state of equipment elements during operation,

• improvement of chemical production equipment,

• use of the method of calculating stresses and deformations that occur during the operation of typical equipment.

The main tasks of the credit module

According to the requirements of the educational and professional program, after mastering the academic discipline, students must demonstrate the following learning outcomes:

knowledge:

• basic designs of machines and devices, typical units and parts and requirements for them;

• materials used in chemical engineering and their properties;

• calculation parameters and rules for their determination;

• conditions of strength, stiffness, stability, vibration resistance, tightness;

• calculation models of shells, plates, rods;

• determination of stresses, analysis of the stress state, permissible and limit loads;

• regulatory methods of calculating vessels and devices;

• development of a structurally perfected product.

skill:

• based on the features of the technological process, determine the initial and limiting conditions and load scheme for the structure,

• on the basis of working conditions, determine the stress-strain state of the structure under static and dynamic thermoforce loads,

• based on the knowledge of theoretical training, using reference books and standards, choose structural materials and seal materials,

• using reference materials, perform calculations regarding the strength of typical equipment,

• perform parametric calculations of typical equipment using known analytical dependencies and reference information,

• take into account the need for assembly, disassembly, transportation and installation of the product,

• on the basis of the acquired knowledge, perform calculations on stiffness, stability, strength and develop design documentation,

• create constructions that are safe in operation.

experience:

• design development of a vessel or apparatus;

• ensuring strength, stability, rigidity, tightness, corrosion resistance, structural integrity and other requirements for elements of chemical equipment.

2 Pre-requisites and post-requisites of the discipline (place in the structural and logical scheme of training according to the relevant educational program)

Mastering the discipline "Calculations and equipment design-1. Calculation and design of the main elements of vessels and devices" is based on the principles of integration of the complex of knowledge obtained by students during the bachelor's education when studying natural and engineering disciplines in the field of "Mechanical Engineering". To successfully master this discipline, it is necessary to have basic knowledge in the field of higher mathematics, physics, resistance of materials, hydraulics, processes and equipment of chemical industries, to be able to use a computer to provide the necessary calculations, to have skills in the field of applied programming, mathematical modeling of processes and systems.

As a result of mastering the discipline, the student will be ready to use fundamental and natural scientific knowledge and methods to solve complex scientific and technical problems in the field of professional and research and innovation activities.

3 Content of the academic discipline

Chapter 1. Requirements for machines and devices.

Topic 1. Purpose and objectives of the course. Course content. Basic requirements for machines and devices, construction and design.

Topic 2. Design pressure, temperature, permissible stresses.

Topic 3. Strength, stiffness, stability of parts, tightness of joints, durability and transportability of the structure.

Topic 4. Calculation models. A tense state. The procedure for determining stresses. Strength criteria.

Chapter 2. Calculation and construction of thin-walled vessels.

Topic 5. Thin-walled and thick-walled vessels. Thin-walled axisymmetric shells under internal pressure. Basic concepts of the moment and momentless theory of shells. Equilibrium conditions of the element and the shell zone.

Topic 6. Thin-walled cylindrical molds. Design requirements. Internal forces and stresses in a cylindrical shell. Calculation of a cylindrical joint.

Topic 7. Convex bottoms. Elliptical bottoms. Design requirements, Fields of application. Geometry of an elliptical shell. Determination of forces and stresses in an elliptical thin-walled shell. Calculation of elliptical bottoms. Designs and applications of hemispherical and torospheric bottoms. Requirements for constructions. Calculation of strength under the action of internal pressure.

Topic 8. Conical cones, bottoms and transitions. Application, design requirements. Sweeps of conical bottoms. Calculation of a smooth conical regular.

Topic 9. Flat bottoms and covers. Application, requirements for structures. Calculation model of flat bottoms. Internal forces and stresses in a flat circular plate. Calculation of bottoms and covers for strength.

Topic 10. Peculiarities of the operation of custom machines under external pressure. Buckling. Critical pressure. Calculation of a smooth cylindrical joint loaded by external pressure.

Topic 11. Customs with rings of rigidity, loaded with internal or external pressure.

Topic 12. Calculation of a cylindrical joint in the boundary zone. Definition of limit loads. Calculation of the strength of the joint in the edge zone.

Topic 13. Customs loaded with axial force. Loss of local and general stability under axial compressive force loading. Cylindrical bushings loaded with bending moment and transverse force.

Topic 14. Calculation of the joint under the combined action of external pressure, axial force, bending moment and transverse force.

Topic 15. The effect of holes on the strength of custom ties. Mutual influence of holes. Holes that do not require reinforcement. Methods of strengthening holes. Calculation of the geometric dimensions of the details of the reinforcement of the holes.

Chapter 3. Detachable tight-tight connections.

Topic 16. Detachable tight-tight connections. Classification, main designs and applications. Designs of sealing units.

Topic 17. Cuff seals.

Topic 18. Oil seals. Determination of the tightening force of the pins, which ensures the tightness of the stuffing box seal.

Topic 19. Slotted and labyrinth joints.

Topic 20. Flange connections. Classification.

Topic 21. Designs of flanges.

Topic 22. Connecting parts of flanges.

Topic 23. Calculation of the strength and tightness of flanged joints.

4 Educational materials and resources

Basic literature

1. Андреєв І.А. Конструювання і розрахунок типового устаткування хімічних виробництв. Основні положення. Елементи тонкостінних посудин, навантажених внутрішнім тиском. Навч. посібник. – К.: «Видавництво «Політехніка», 2011. – 272 с.
2. Андреєв І.А., Мікульонок І.О. Розрахунок, конструювання та надійність обладнання хімічних виробництв: Термінологічний словник. – К.: ІВЦ “Видавництво «Політехніка» , 2002. – 216 с.
3. Андреєв І.А., Зубрій О.Г., Мікуленок І.О. Застосування матеріалів у хімічному машинобудуванні. Сталі і чавуни,- К.: ІЗМН, 1999. – 148 с.
4. Андреєв І.А., Зубрій О.Г. Конструювання та розрахунок апаратів високого тиску, - К.: ІЗМН, 1999. – 144 с.
5. Посудини та апарати сталеві зварні. Загальні технічні умови: СОУ МПП 71.120-217:2009. – [Прийнято та надано чинності: наказ Мінпромполітики від 07.07.2009, №459]. – К.: Міністерство промислової політики України, 2009. – 339 с. – (стандарт Міністерства промислової політики України).
6. ГОСТ 34233.1–12–2017 (міждержавні стандарти).
7. Андреєв І.А. Методичні вказівки до практичних занять для студентів спеціальності «Галузеве машинобудування» (Спеціалізація: Інжиніринг, обладнання та технології хімічних та нафтопереробних виробництв) з дисципліни «Розрахунок і конструювання типового обладнання –
8. Розрахунок і конструювання тонкостінних посудин, опор та стропових пристроїв»: [Електронний ресурс] / КПІ ім. Ігоря Сікорського ; уклад. І. А. Андреєв. – Електронні текстові данні (1 файл: 7,66 Кбайт). – Київ: КПІ ім. Ігоря Сікорського, 2017. – 105 с. – Назва з екрана. – Доступ: http://ela.kpi.ua/handle/123456789/19172.
9. І. А. Андреєв. Роз’ємні міцно-щільні з’єднання [Електронний ресурс] : навч. посіб. для студ. спеціальності 133 «Галузеве машинобудування», освітньо-професійної програми «Обладнання хімічних, нафтопереробних та целюлозно-паперових виробництв» / КПІ ім. Ігоря Сікорського. – Електронні текстові данні (1 файл: 5,36Мбайт). – Київ: КПІ ім. Ігоря Сікорського, 2020. – 138 с. – Назва з екрана. – Доступ: https://ela.kpi.ua/handle/123456789/35927.
10. І. А. Андреєв. Конструювання і розрахунок елементів тонкостінних посудин та апаратів, які знаходяться під зовнішніми навантаженнями [Електронний ресурс] : навч. посіб. для студ. спеціальності 133 «Галузеве машинобудування», спеціалізацій «Інжиніринг, обладнання та технології хімічних та нафтопереробних виробництв» і «Інжиніринг, обладнання та технології целюлозно-паперового виробництва»: КПІ ім. Ігоря Сікорського. – Електронні текстові данні (1 файл: 6,86 Мбайт). – Київ: КПІ ім. Ігоря Сікорського, 2018. – 121 с. Доступ: http://ela.kpi.ua/handle/123456789/23885.
11. І. А. Андреєв. Укріплення отворів в посудинах та апаратах [Електронний ресурс]: навч. посіб. для студ. спеціальності 133 «Галузеве машинобудування», освітньо-професійної програми «Обладнання хімічних, нафтопереробних та целюлозно-паперових виробництв». Київ : КПІ ім. Ігоря Сікорського, 2021. – 72 с. Доступ: https://ela.kpi.ua/handle/123456789/42254.

12. Ігор Андреєв. Розрахунок та конструювання основних елементів посудин та апаратів: Розрахунково-графічна робота: навч. посіб. для здобувачів ступеня бакалавра за спеціальністю 133 Галузеве машинобудування. Київ: КПІ ім. Ігоря Сікорського, 2022. 97 с. URL: https://ela.kpi.ua/handle/123456789/48718.
13. Андреєв І. А. Конструювання і розрахунок основних елементів посудин та апаратів: підруч. для здобувачів ступеня бакалавра за спец. 133 Галузеве машинобудування. Київ: КПІ ім. Ігоря Сікорського, 2024. 428 с. URL: https://ela.kpi.ua/handle/123456789/65136.

Additional literature

14. Андреєв І.А. Методичні вказівки до практичних занять для студентів спеціальності «Обладнання лісового комплексу» з дисципліни «Розрахунок і конструювання елементів папероробних і картоноробних машин – 1» [Електронний ресурс]: / НТУУ «КПІ». – Електронні текстові дані (1 файл: 3,14 Мбайт). – Київ: НТУУ «КПІ», 2014. – 71 с. Доступ: http://ela.kpi.ua/handle/123456789/7698.

5 Methods of mastering an educational discipline (educational component)

Lecture classes

Lecture classes are aimed at providing modern, comprehensive knowledge in the discipline "Calculations and equipment design-1. Calculation and design of the main elements of vessels and devices", definition at the current level of scientific development in the field of calculation and design of machines and devices; ensuring fruitful work of students during the lecture; application of effective methods of teaching, presentation of material and its assimilation; education of students' professional qualities and development of creative thinking; formation of their scientific and practical interest in mastering the course material, the desire for independent work.

№№	The name of the topic of the lecture, a list of main questions, references to the literature and tasks for students' independent work	Hours
1	**Purpose and content of the course.** The purpose and objectives of the course. Course content. Basic requirements for machines and devices, construction and design. Literature: [1, 2, 5, 13]	2
2	**Normative parameters and permissible stresses.** Design pressure, temperature, permissible stresses. Literature: [1–4, 6, 13]	2
3	**Main characteristics of parts, joints and products.** Strength, rigidity, stability of parts, tightness of joints, durability and transportability of the structure. Literature: [1–6, 10, 12–14]	2
4	**Tension and strength.** Calculation models. A tense state. The procedure for determining stresses. Strength criteria. Literature: [1–4, 7, 13]	2
5	**Basics of calculating thin-walled shells.** Thin-walled and thick-walled vessels. Thin-walled axisymmetric shells under internal pressure. Basic concepts of the moment and momentless theory of shells. Equilibrium conditions of the element and the shell zone. Literature: [1–3, 5, 6, 13]	2
6	**Thin-walled cylindrical dishes.** Thin-walled cylindrical dishes. Design requirements. Internal forces and stresses in a cylindrical shell. Calculation of a cylindrical joint. Literature: [1, 5, 6, 13]	2
7	**Thin-walled lids and bottoms.** Convex bottoms. Elliptical bottoms. Design requirements, Fields of application. Geometry of an elliptical shell. Determination of forces and stresses in an elliptical thin-walled shell. Calculation of elliptical bottoms. Designs and	2

	applications of hemispherical and torospheric bottoms. Requirements for constructions. Calculation of strength under the action of internal pressure. Literature: [1, 5, 6, 13]	
8	**Conical bottoms.** Conical mandrels, bottoms and transitions. Application, design requirements. Sweeps of conical bottoms. Calculation of a smooth conical regular. Literature: [1, 5, 6, 13]	***2***
9	**Flat bottoms and lids.** Flat bottoms and lids. Application, requirements for structures. Calculation model of flat bottoms. Internal forces and stresses in a flat circular plate. Calculation of bottoms and covers for strength. Literature: [5, 6, 9, 10, 12, 13]	***2***
10	**The load of the customs by external pressure.** Peculiarities of the operation of custom-made machines under external pressure. Buckling. Critical pressure. Calculation of a smooth cylindrical joint loaded by external pressure. Literature: [6, 9, 10, 12, 13]	***2***
11	**Reinforcement of customs with rings of stiffness.** Rings with stiffness, loaded with internal or external pressure. Literature: [1, 5, 6, 9, 10, 12, 13]	***2***
12	**End loads.** Calculation of a cylindrical joint in the boundary zone. Definition of limit loads. Calculation of the strength of the joint in the edge zone. Literature: [1, 6, 13]	***2***
13	**Loads of custom forces and moments.** Customs loaded with axial force. Loss of local and general stability under axial compressive force loading. Cylindrical bushings loaded with bending moment and transverse force. Literature: [1, 5–8, 10, 11, 13, 14]	***2***
14	**Calculation of normals under the action of combined loads** Calculation of the joint under the combined action of external pressure, axial force, bending moment and transverse force. Literature: [1, 6, 9, 13]	***2***
15	**Reinforcement of holes.** The effect of holes on the strength of custom-mades. Mutual influence of holes. Holes that do not require reinforcement. Methods of strengthening holes. Calculation of the geometric dimensions of the details of the reinforcement of the holes. Literature: [1, 5, 6, 10, 13]	***2***
16	**Detachable strong-tight connections.** Detachable strong-tight connections. Classification, main designs and applications. Designs of sealing units. Cuff seals. Oil seals. Determination of the tightening force of the pins, which ensures the tightness of the stuffing box seal. Gap and labyrinth joints. Literature: [6, 8, 13]	***2***
17	**Classification and designs of flange connections.** Flange connections. Classification. Designs of flanges. Connecting parts of flanges. Literature: [6, 8, 13]	***2***
18	**Calculation of flange connections.** Calculation of the strength and tightness of flanged joints. Literature: [6, 8, 13]	***2***
	Hours in general	***36***

Practical training

When studying a credit module, 0.5 of the classroom load is allocated to practical classes. A practical lesson on a separate topic of this discipline is aimed at consolidating the material presented in the lecture by considering specific examples, exercises and problems on this topic. This enables students to systematize and deepen their theoretical knowledge. The practical session is conducted in a dialogue mode with educational discussions. At the beginning of the class, a control survey of the students is conducted based on the materials of the previous lectures, their familiarization with literary sources on the subject of the discipline.

№№	Name of the subject of the practical session, list of main questions, references to the literature	Hours
1	**Requirements for machines and devices** Materials and their properties. Calculated, conditional, test pressure; calculated temperature; allowable stress, increase to the calculated thickness; weld strength coefficient. Thermophysical properties of environments and their definition. Literature [1 – 4, 7, 13].	2
2	**Calculation and construction of thin-walled vessels** Calculation of a cylindrical joint that is under the influence of internal pressure. Literature [1-7, 13].	2
3	**Convex bottoms and lids** Calculation of bottoms and covers that are under the influence of internal pressure. Literature [1-7, 13].	4
4	**Conical bottoms** Calculation of conical bottoms that are under the influence of internal pressure. Literature [1-7, 13].	2
5	**Flat bottoms and lids** Calculation of flat bottoms and covers for strength. Literature [1 – 7, 9, 13].	2
6	**Cylindrical bushings under external pressure** Calculation of a cylindrical joint that is under the influence of external pressure. Literature [1 – 7, 9, 13].	2
7	**Cylindrical bushings under the joint action of external pressure and axial compressive force** Calculation of a cylindrical joint that is under the joint action of external pressure and axial compressive force. Literature [1 – 7, 9, 13].	2
8	**Conical bottom under external pressure** Calculation of the conical bottom, which is loaded with external pressure. Literature [1 – 7, 9, 13].	2
9	**Elliptical and hemispherical bottoms under external pressure** Calculation of elliptical and hemispherical bottoms, which are loaded with external pressure. Literature [1 – 7, 9, 13].	2
10	**End loads** Calculation of limit loads: limit moment and limit force. Literature [2, 3, 13].	2
11	**Boundary stresses** Calculation of the strength of the custom on the edge. Literature [2, 3, 13].	2
12	**Reinforcement of holes** Reinforcement of holes. Need for reinforcement, mutual influence of holes. Voltage near the hole.	2

	Literature [2, 3, 7, 10, 13].	
13	**Calculation of hole reinforcement** Calculation of the geometric dimensions of the details of the reinforcement of a single hole. Literature [2, 3, 7, 10, 13].	***2***
14	**Design and calculation of removable strong-tight connections.** Flange connections. Selection of the type of flanges, determination of geometric dimensions. Literature [2, 3, 5, 7, 8, 13].	***2***
15	**Calculation of the flange connection** Calculation of forces in connection bolts. Calculation of bolts. Calculation of flanges for strength and tightness. Checking the strength of the gasket. Calculation algorithm. Literature [2, 3, 5, 7, 8, 13].	***4***
16	**Stuffing box seal** Stuffing box seal. Constructive calculation. Determination of bolt tightening force and power to overcome frictional forces. Literature [2, 3, 5, 7, 13].	***2***
	Hours in general	***36***

6 Independent work of the student

When teaching the educational discipline "Calculations and construction of equipment-1. Calculation and design of the main elements of vessels and apparatus" independent work of the student takes 56% of the time of studying the credit module, taking into account the preparation for the exam. Independent work of students includes preparation for classroom classes, execution of modular control work, calculation and graphic work, and study of sections of the program and topics that are not included in the list of lecture questions or require more detailed study. The acquisition of knowledge on these topics is carried out through a detailed study of the relevant sections of the recommended basic and additional literature and an independent scientific and informational search on one's own initiative. The student's preparation for the next classroom classes involves mastering the material of the previous lectures in the process of independent work.

№№	**Type of work and titles of topics submitted for independent study**	**Hours**
1	**Preparation for classroom classes**	***18***
2	**Performance of individual practical tasks on the topic of the module**	***34***
Working out sections of the program and topics that are not taught in lectures		
3	**Chapter 1. Requirements for machines and devices.** Materials used in chemical engineering. Compare the values of the calculated pressure in the presence of hydrostatic pressure of the liquid and safety valves. Literature [1 – 8, 10, 12, 13].	***3***
4	**Chapter 2. Calculation and construction of thin-walled vessels.** Constructions of cylindrical custom. Requirements for bottom structures. Internal forces and stresses in a flat circular plate. Methods of strengthening holes. The main designs of removable tight-tight joints. To analyze the effect of various factors on the thickness of the wall of the mold. Analyze the influence of the design of the bottoms and covers on their thickness. Determination of bending moments and stresses in sections, comparison with convex bottoms. Compare the values of allowable pressures, which were determined from the conditions of strength and stability in the limits of elasticity. To analyze the calculation of the beam for stability under the combined action of external pressure, axial and transverse forces, as well as bending moment. Consider methods of strengthening the conical bottom. Compare the metal capacities of elliptical and hemispherical bottoms, which are loaded with the same external pressure. Analyze the influence of the shape of the shell on the value of the ultimate moment and ultimate force. Proposals for reducing edge loads. Ways	***10***

	of strengthening holes. Suggestions for reducing stresses over the hole. Literature [1-14].	
5	**Chapter 3. Design and calculation of detachable strong-tight connections.** The main designs of removable tight-tight joints. Classification of flanges. Suggestions for ways to increase the tightness of the flange connection. Constructive performance of packing seals. Literature [2, 3, 5, 7, 12–14].	***8***
6	Preparation for the exam	***20***
Hours in general		***93***

Policy and control

1 Policy of academic discipline (educational component)

Rules for attending lectures and practical classes

Attending lectures and practical classes is a mandatory component of studying the material. At the lecture, the teacher uses his own presentation material. Students are obliged to take an active part in the educational process, not to be late for classes and not to miss them without a good reason, not to be distracted by actions unrelated to the educational process.

Policy of deadlines, rescheduling and incentive rules

Missed classes must be made up. The student independently prepares a synopsis of the missed lecture or practical session, answers control questions to the teacher on the materials of the topic of the missed session. Individual practical tasks should be performed carefully and in a precisely defined time. Fulfillment of these requirements ensures an increase in the rating assessment of the results of mastering the educational discipline.

Academic Integrity Policy

The policy of the academic discipline is built taking into account the norms of Ukrainian legislation on academic integrity, the Code of Honor of the National Technical University of Kyiv "Ihor Sikorsky Kyiv Polytechnic Institute" and is determined by the system of requirements that the teacher presents to the student when studying the discipline (rules of behavior in classes, absences, retakes, etc.).

2 Types of control and rating system for evaluating learning outcomes (RSO)

Distribution of study time by types of classes and tasks in the discipline according to the working study plan:

Training time		Distribution of study hours				Control measures		
Credits	Hours	Lectures	Practical	Laboratory	Independent work of students	Modular control work	Calculation and graphic work	Semester control
5,5	165	36	36	–	93	1	1	Exam

Control of students' knowledge is carried out with the help of an interview during practical classes, the results of individual practical tasks, and at the exam - with the help of tickets.

During the evaluation, the following is taken into account:

Attending lectures and practical classes, fruitfulness of work during classroom classes.

Timely and accurate performance of control practical tasks for independent work.

Study of basic and auxiliary literature.

1 The rating of the student from the credit module consists of the points he receives for work in practical classes, for the performance of control module and calculation-graphic works on the topic of the module, and according to the results of the semester control – exam.

2 Scoring criteria:

2.1 Work in practical classes:

– fruitful work - 2 points;

– passive work or absence from class – 0 points.

The maximum number of points for work during practical classes is 34.

2.2 Evaluation criteria for calculation and graphic work

Completeness and timeliness of task performance	Points
Complete execution, proper design of work, submission on time	16
The work was completed in a timely manner, but there are certain shortcomings in the performance of the work	12
The work was completed on time, but with significant shortcomings	10
The work is submitted later than the specified deadline	10
The work was completed late with certain shortcomings	7
The work was completed late with significant deficiencies	5
The work is not done	0

2.3 Evaluation criteria for modular control work

– "excellent" - 9-10 points;

– "good" ¬– 6-8 points;

– "satisfactory" - 3-5 points;

– "unsatisfactory" - 0 points.

For 18 weeks of study, based on the results of the educational work and the execution of control modular and calculation-graphic works, the maximum number of points that a student can score is 60 points.

2.4 Compilation of examination exams

At the exam, students receive an exam ticket. Each ticket contains four questions (two of which are more difficult).

Each difficult question is valued at 12 points, and easier - 8 points.

The system of evaluating difficult questions:

– "excellent", complete answer (at least 90% of the required information) - 11-12 points;

– "good", sufficiently complete answer (at least 75% of the required information, or minor inaccuracies) - 9-10 points;

– "satisfactory", incomplete answer (at least 60% of the required information and some errors) - 7-8 points;

– "unsatisfactory", an unsatisfactory answer - 0 points.

Evaluation system for simpler questions:

– "excellent", complete answer (at least 90% of the required information) - 7-8 points;

– "good", sufficiently complete answer (at least 75% of the required information, or minor inaccuracies) - 5-6 points;

– "satisfactory", incomplete answer (at least 60% of the required information and some errors) - 3-4 points;

– "unsatisfactory", an unsatisfactory answer - 0 points.

The maximum number of points that a student can receive as a result of successfully passing the exam is 40 points.

According to the rating scale (R), the maximum number of points is 100.

A prerequisite for admission to the exam is a rating of at least 30% of the rating scale (R), i. e. 30 points.

Distribution of rating points that students receive after studying a credit module and passing exams.

Content module	Total points
Practical training	34
Control module work	10
Calculation and graphic work	16
Semester control	
Exam	40
Together:	**100**

The procedure for enrolling missed lectures and practical classes: the student independently prepares a synopsis of the missed lecture and/or practical class, answers the teacher's control questions.

The sum of the rating points received by the student after mastering the discipline and passing the exam is transferred to the final grade according to the table:

Scores	Rating
95...100	perfectly
85...94	very good
75...84	good
65...74	satisfactorily
60...64	enough
< 60	unsatisfactorily
Admission conditions not met	not allowed

7 Additional information on the discipline (educational component)

Preliminary list of questions submitted for semester control

1 To substantiate the determination of the amount of attachments C to the calculated thickness.
2 Classify requirements for machines and devices.
3 Classify special requirements for machines and devices that ensure reliability during operation (strength, stiffness, stability, tightness, durability).
4 Define the calculated temperature.
5 Define working, calculated, test and conditional pressures.
6 Define the permissible stress.
7 Analyze the stages of preparation of design documentation.
8 Classify steel.
9 To analyze carbon steels of ordinary quality. Properties, purpose and labeling.
10 Analyze high-quality carbon steels. Properties, purpose and labeling.
11 Analyze alloy steels. Properties, purpose and labeling.
12 Classify cast iron. Properties and use.
13 Analyze the use of non-ferrous metals and non-metallic materials in chemical engineering.
14 Analyze the main theories of strength.
15 Explain the difference between a thin-walled shell and a thick-walled shell when calculating strength.
16 Define the envelope, median surface, meridian plane, meridian, parallel, first and second principal radii.
17 Justify the derivation of Laplace's equation.
18 Justify the requirements for the manufacture of a thin-walled cylindrical mold.
19 Determine the stress in a thin-walled cylindrical shell that is loaded with internal pressure.
20 Justify the derivation of the formula for calculating the strength of the wall thickness of a thin-walled cylindrical sleeve that works under internal pressure.
21 Show the designs of spherical bottoms and covers.
22 Find the stress in a thin-walled spherical bottom, which is loaded with internal pressure.
23 Justify the derivation of the formula for calculating the strength of the thickness of a thin-walled spherical bottom that works under internal pressure.
24 Classify torospheric bottoms and provide examples of their use.
25 Calculate the strength of the thickness of torospheric thin-walled bottoms that work under internal pressure.
26 Analyze the construction of elliptical bottoms.

27 Give the algorithm for calculating the thickness of the elliptical bottom, which is loaded with internal pressure.
28 Analyze the types of conical bottoms.
29 Justify the determination of stresses in a thin-walled conical bottom that operates under internal pressure.
30 Justify the derivation of the formula for calculating the strength of the wall thickness of a thin-walled conical bottom that works under internal pressure.
31 Analyze the use of flat bottoms.
32 Give calculation schemes of round plates. To justify the formulas for calculating the thickness of round plates.
33 Give an algorithm for calculating the strength of the thickness of flat round bottoms and covers that are under pressure.
34 Analyze the design of flat bottoms and covers.
35. To substantiate the calculation of round covers with an additional marginal moment, which are loaded with internal pressure.
36 To analyze the peculiarities of the calculation of the elements of devices that are loaded with compressive forces.
37 Justify obtaining a simplified Sutherland formula of the form.
38 Justify the derivation of the Bress formula.
39 Justify the formula for calculating the critical length of a pipe that is loaded with external pressure.
40 Provide an algorithm for calculating the thickness of a cylindrical joint that is loaded with external pressure.
41 To analyze the strengthening of custom-made rings of rigidity.
42 Provide an algorithm for calculating the thickness of a cylindrical joint that is loaded with an axial tensile force.
43 To provide an algorithm for the calculation of beams under the joint action of an axial force, a bending moment and a transverse force for stability.
44 Provide an algorithm for calculating the thickness of convex thin-walled bottoms that are loaded with external pressure.
45 Provide an algorithm for calculating the stability of conical thin-walled bottoms that are loaded with external pressure.
46 Provide an algorithm for calculating the stability of a conical thin-walled bottom, which is loaded with an axial tensile force.
47 Provide an algorithm for calculating the stability of a conical bottom, which is loaded with an axial compressive force.
48 To provide division of holes in devices according to purpose. Equipment of openings of devices.
49 Analyze the stress concentration over the hole.
50 To analyze the methods of strengthening holes.
51 Provide an algorithm for calculating the strength of hole reinforcement by the geometric method.
52 To justify obtaining the formula for the condition of strengthening a single hole due to the thickening of the walls of the shell and the fitting, as well as the use of an overlay ring.
53 Determine the estimated diameter of a single hole that does not require additional reinforcement.
54 Analyze the design and use of support legs and support risers.
55 Check the load-bearing capacity of the beams from the action of the reaction of the supporting legs.
56 Give the algorithm for calculating the thickness of the stiffening rib of the support leg.
57 Analyze the construction and application of supporting customs.
58 Classify the designs of saddle supports of horizontal machines.
59 Causes of boundary stresses.
60 Give an algorithm for calculating the ultimate force and ultimate moment.
61 Calculate the ultimate stresses.
62 Classify removable strong connections.
63 Classify flange connections.
64 Classify flange designs.
65 Analyze the connecting parts of the flanges.
66 Give an estimate to gaskets of flange connections.

67 Provide an algorithm for calculating steel flange connections.
68 State the requirements for oil seals. Give an assessment of stuffing box materials.
69 Justify the formula for determining the tightening force of the studs, which ensures the density of the stuffing box seal.
70 Calculate the strength of the bolts of the flange connection.
71 Calculate the strength of the gasket of the flange connection.
72 Calculate the tightness of the flange connection.

Working program of the academic discipline (syllabus) was compiled by an associate professor of the Department of the Academy of Sciences of the Russian Academy of Sciences, Ph.D. Andreev Ihor Anatoliyovych
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Agreed by the Methodical Commission of the Faculty of Engineering and Chemistry (protocol No. 11 dated 28.06.2024)