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

Design and calculation of load-bearing structural elements
Working program of the academic discipline (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	Test
Lessons schedule	*https://rozklad.kpi.ua/* *https://ecampus.kpi.ua/* 6 hours per week (2 hours of lectures and 4 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., Senior Lecturer Husarova O.V. che@kpi.ua
Placement of the course	*https://ecampus.kpi.ua/*, http://ci.kpi.ua

Програма навчальної дисципліни

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 supports and sling devices, their application, theoretical information on the basics of engineering calculations, modern standard calculation formulas, normative calculation methods.

The discipline "Design and calculation of load-bearing structural elements" examines the requirements for the design and calculation of equipment and individual elements, their application.

The subject of the academic discipline

The discipline "Design and calculation of load-bearing structural elements" is taught as an optional component of training 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 load-bearing elements of structures of vessels and apparatuses 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:

• the main designs of the load-bearing elements of the structures of machines and devices and requirements for them;

• materials used in chemical engineering and their properties;

• calculation parameters and rules for their determination;

• conditions of strength, rigidity, and stability of load-bearing elements of structures;

• calculation models of shells, plates, rods;

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

• normative methods of calculating the load-bearing elements of 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 knowledge of theoretical training, using reference books and standards to choose construction materials,

• using reference materials, perform calculations regarding the strength of the load-bearing elements of typical equipment,

• perform 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 perfection and other requirements for the load-bearing elements of chemical equipment structures.

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

The mastery of the discipline "Design and calculation of load-bearing structural elements" is based on the principles of integration of the complex of knowledge acquired 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

Topic 1. Supports of vessels and devices. Basic constructions.

Topic 2. Sling devices of vessels and devices.

Topic 3. Determination of the thickness of the stiffening rib of the "paw" type support.

Topic 4. Calculation of the load-bearing capacity of the joint in the place of welding of the support leg.

Topic 5. Checking the bearing capacity of the convex bottom when using a cylindrical support rack.

Topic 6. Calculation of the reference custom.

Topic 7. Checking the load-bearing capacity of the joint when using saddle supports.

Topic 8. Checking the load-bearing capacity of the dowel at the place of welding of the sling eye.

4 Educational materials and resources

Basic literature

1. Андреєв І. А. Конструювання і розрахунок опорних вузлів посудин і апаратів хімічних виробництв: навч. посіб. Київ: КПІ ім. Ігоря Сікорського, 2021. 94 с. URL: https://ela.kpi.ua/handle/123456789/45669.

2. Андреєв І. А. Конструювання і розрахунок типового устаткування хімічних виробництв. Основні положення. Елементи тонкостінних посудин, навантажених внутрішнім тиском: навч. посіб. Київ: “Видавництво «Політехніка» ”, 2011. 272 с

3. Андреєв І. А., Мікульонок І. О. Розрахунок, конструювання і надійність обладнання хімічних виробництв: термінологічний словник. Київ: ІВЦ “Видавництво «Політехніка»”, 2002. 216 с.

4. Андреєв І. А., Зубрій О. Г., Мікульонок І. О. Застосування матеріалів у хімічному машинобудуванні. Сталі й чавуни: навч. посіб. Київ: ІЗМН, 1999. 148 с.

5. Андреєв І. А. Конструювання і розрахунок елементів тонкостінних посудин та апаратів, які знаходяться під зовнішніми навантаженнями: навч. посіб. Київ: КПІ ім. Ігоря Сікорського, 2018. 121 с. URL: http://ela.kpi.ua/handle/123456789/23885.

6. Андреєв І. А. Роз’ємні міцно-щільні з’єднання: навч. посіб. Київ: КПІ ім. Ігоря Сікорського, 2020. 138 с. URL: https://ela.kpi.ua/handle/123456789/35927.

7. Андреєв Ігор. Розрахунок колонних апаратів на міцність і стійкість: навч. посіб. Київ: КПІ ім. Ігоря Сікорського, 2021. 112 с. URL: https://ela.kpi.ua/handle/123456789/38716.

8. Андреєв Ігор. Укріплення отворів в посудинах та апаратах: навч. посіб. Київ: КПІ ім. Ігоря Сікорського, 2021. 72 с. URL: https://ela.kpi.ua/handle/123456789/42254.

9. ГОСТ 34233.5-2017. Сосуды и аппараты. Нормы и методы расчёта на прочность. Расчёт обечаек и днищ от воздействия опорных нагрузок. (Межгосударственный стандарт). [Чинний від 2018-08-01]. Вид. офіц. М.: Стандартинформ, 2019. 33 с.

10. ГОСТ 34233.2-2017. Сосуды и аппараты. Нормы и методы расчёта на прочность. Расчёт цилиндрических и конических обечаек, выпуклых и плоских днищ и крышек. (Межгосударственный стандарт). [Чинний від 2018-08-01]. Вид. офіц. М.: Стандартинформ, 2018. 54 с.

11. Андреєв І. А., Гусарова О. В. Розрахунок і конструювання несучих елементів конструкцій. Розрахунок несучої здатності обичайки в місці розташування сідлової опори: навч. посіб. Київ: КПІ ім. Ігоря Сікорського, 2024. 93 с. URL: https://ela.kpi.ua/handle/123456789/66731.

12. Андреєв І. А., Гусарова О. В. Розрахунок і конструювання несучих елементів конструкцій: рекомендації до виконання розрахунково-графічної роботи: навч. посіб. Київ: КПІ ім. Ігоря Сікорського, 2024. 74 с. URL: https://ela.kpi.ua/handle/123456789/66732.

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. 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).

5 Methods of mastering an educational discipline (educational component)

Lecture classes

The lecture classes are aimed at providing modern comprehensive knowledge in the discipline "Design and calculation of load-bearing structural elements", definition at the modern level of the development of science 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	**Supports of vessels and devices.** Supports of vessels and devices. Basic constructions. Literature: [1–14]	1
2	**Sling devices of vessels and devices.** Sling devices of vessels and devices. Basic constructions. Literature: [1–3, 9, 13]	1
3	**Support of the "paw" type.** Determination of the thickness of the stiffening rib of the "paw" type support. Literature: [1–3, 9, 13]	2
4	**Checking the load-bearing capacity of the joint at the place of welding of the support leg.** Calculation of the load-bearing capacity of the joint at the place of welding of the support leg. Literature: [1–3, 9, 13]	4
5	**Checking the load-bearing capacity of the bottom at the place of welding of the support rack.** Checking the bearing capacity of the convex bottom when using a cylindrical support rack. Literature: [1–3, 9, 13]	2
6	**Calculation of the reference custom.** Calculation of the reference custom. Literature: [1–3, 5, 7, 13, 14]	4
7	**Checking the load-bearing capacity of the crossbar at the place of installation of the saddle supports.** Checking the load-bearing capacity of the joint when using saddle supports. Literature: [[1–3, 9, 11, 12, 13]	2
8	**Checking the load-bearing capacity of the joint in the place of welding of the sling eye.** Checking the load-bearing capacity of the dowel at the place of welding of the sling eye. Literature: [1–3, 9, 13]	2
	Hours in general	18

Practical training

When studying a credit module, 2/3 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	**Design and calculation of "paw" support.** Determination of the thickness of the stiffening rib of the "paw" type support. Literature: [1–3, 9, 13]	4
2	**Checking the load-bearing capacity of the joint at the place of welding of the support leg.** Calculation of the load-bearing capacity of the joint at the place of welding of the support leg. Literature: [1–3, 9, 13]	6
3	**Calculation of the reference custom.** Calculation of the reference custom. Literature: [1–3, 5, 7, 13]	8
4	**Checking the load-bearing capacity of the joint when using saddle supports.** Checking the load-bearing capacity of the joint when using saddle supports. Literature: [1–3, 9, 11–13]	14
5	**Checking the load-bearing capacity of the joint in the place of welding of the sling eye.** Checking the load-bearing capacity of the dowel at the place of welding of the sling eye. Literature: [1–3, 9, 13]	4
Hours in general		36

6 Independent work of the student

When teaching the academic discipline "Design and calculation of load-bearing structural elements", the student's independent work takes up 55% of the time of studying the credit module, taking into account the preparation for the credit. Independent work of students includes preparation for classroom classes, performance of modular control work, 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 detailed familiarization with the relevant sections of the recommended basic and additional literature and independent scientific and informational research 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**	10
2	**Performance of individual practical tasks on the topic of the module**	25
Working out sections of the program and topics that are not taught in lectures		
3	**Design and calculation of supports and sling eyes.** Basic designs of supports and sling eyes. Analysis of loads and stresses in the structures of supports and sling eyes. Analyze the construction of new structures of supports and slinging eyes based on the results of literature and patent searches. Literature [1-14].	16
6	**Preparation for the test**	15
Hours in general		66

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
4	120	18	36	–	66	1	1	test

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 – test.

2. Scoring criteria:

2.1. Work in practical classes:

– fruitful work – 4 points;

– untimely completed task – 3 points;

– passive work or absence from class – 0 points.

Up to 5 incentive points can be awarded for active work in practical classes.

The maximum number of points for work during practical classes is 72.

2.2. Evaluation criteria for calculation and graphic work:

– "excellent" – 15–18 points;

– "good" – 9–14 points;

– "satisfactory" – 5–8 points;

– "unsatisfactory" – 0 points.

Calculation and graphic work must be completed before the start of the assessment session. If the deadline is violated, the maximum number of points is reduced by 20%.

The maximum number of points for calculation and graphic work is 18.

2.3. Evaluation criteria for modular control work:

– "excellent" – 10 points;

– "good" – 8–9 points;

– "satisfactory" – 6–7 points;

– "unsatisfactory" – 0 points.

The maximum number of points for a modular test is 10.

Failure to complete the modular test on time reduces the number of points earned by half.

For 9 weeks of study, the maximum number of points that a student can score is 100 points based on the results of the educational work and the performance of the control module and calculation-graphic works.

A prerequisite for receiving credit for the credit module "automatic" is the completion of tasks in practical classes, control module and calculation and graphic works, and a rating of at least 60 points.

Students who have a rating of less than 60 points at the end of the semester, as well as those who want to improve their grade in the rating points system, complete a credit test. The test task consists of three questions from different sections of the work program. An unsatisfactory answer to an additional question reduces the total score by 4 points.

Кожне питання контрольної роботи (*r*1, *r*2 , *r*3) оцінюється у 33 бали відповідно до системи оцінювання:

– «відмінно», повна відповідь (не менше 90% потрібної інформації) – 33-30 балів;

– «добре», достатньо повна відповідь (не менше 75% потрібної інформації або незначні неточності) – 29-25 бал;

– «задовільно», неповна відповідь (не менше 60% потрібної інформації та деякі помилки) – 24-20 балів;

– «незадовільно», незадовільна відповідь – 0 балів.

Each test question (r1, r2, r3) is evaluated at 33 points according to the evaluation system:

– "excellent", complete answer (at least 90% of the required information) – 33–30 points;

– "good", sufficiently complete answer (at least 75% of the required information or minor inaccuracies) – 29–25 points;

– "satisfactory", incomplete answer (at least 60% of the required information and some errors) – 24–20 points;

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

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 Classify the supports of vessels and devices.
2 Design the supports of horizontal devices.
3 Design the supports of vertical devices.
4 Design the sling eyes.
5 Draw the structures of the support legs.
6 Design the support racks.
7 Give the constructions of the supporting customs.

8 To justify the purpose of supporting vessels and devices.
9 Justify the purpose of sling eyes.
10 Explain when there is a need for an adjustment screw for a support leg.
11 Explain when a support leg with an increased reach is used.
12 State the conditions of application of calculation formulas when determining the load-bearing capacity of the joint at the place of welding of the support leg.
13 Explain how the vertical force acting on the support leg is calculated.
14 State the condition of the load-bearing capacity of the joint in the place of welding of the support leg without a backing sheet.
15 Explain the influence of the design of the support leg on the calculation of the load-bearing capacity of the joint.
16 Show how the ultimate bending stress is calculated at the point of attachment of supports.
17 To justify the calculation of the total membrane meridian and ring stresses in cylindrical and conical tubes.
18 State the condition of the load-bearing capacity of the joint in the place of welding of the support leg with the backing sheet.
19 Justify the use of a cover sheet.
20 Provide an algorithm for calculating the load-bearing capacity of the joint at the place of welding of the support leg.
21 Give formulas for calculating the stresses that occur in the stiffener of the support leg.
22 Provide an algorithm for calculating the thickness of the stiffener of the support leg.
23 To analyze the specific load acting on the stiffener of the support leg.
24 Show how the coefficient of reduction of allowable stresses during longitudinal bending is determined in the calculation of the thickness of the stiffening rib of the support leg.
25 To justify the cases of the use of support racks.
26 Distinguish between cylindrical and plate support racks.
27 Explain how the vertical force acting on the support post is calculated.
28 State the condition of the bearing capacity of the convex bottom at the location of the support rack.
29 Explain how the permissible axial force acting on the support post is determined.
30 State the conditions for checking the bearing capacity of the convex bottom when using a cylindrical support rack.
31 Specify the permissible areas of attachment of the support struts to the spherical segment and to the elliptical bottom.
32 Explain what loads affect the magnitude of the vertical force on the support post. 33 Justify the use of saddle supports.
34 Provide calculation models of vessels in which saddle supports are used.
35 To justify the implementation of part of the saddle supports with movable ones.
36 Explain how the distance between fixed and movable supports is chosen.
37 State the conditions for checking the load-bearing capacity of the beam under the saddle supports.
38 Give calculation schemes of a cylindrical horizontal vessel of constant cross-section, which are used to determine support forces, moments and transverse forces.
39 Explain in which places of the horizontal vessel the load-bearing capacity of the vessel, conditions of strength and stability should be determined.
40 To justify the use of support rings and stiffness rings in the locations of slinging eyes.
41 Explain how the load acting on the sling eye is calculated.
42 State the condition of the load-bearing capacity of the dowel at the location of the sling eye.
43 Guide the places of welding of sling eyes to spherical and elliptical bottoms.
44 To state the peculiarities of checking the load-bearing capacity of the brick depending on the presence of a backing sheet and stiffening elements.
45 To justify the use of cylindrical and conical support rods.
46 Designate the constructions of the support nodes of the support rods.
47 Give an algorithm for checking the stability of a reference rule.
48 Justify the calculation of the support node of the support rod.
49 Give the algorithm for calculating the foundation bolts of the support base.

50 Draw sections where it is necessary to check the strength of the supporting rod.
51 List the standard implementations of support units of column apparatus.

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

Approved by the Department of Machines and Apparatus of Chemical and Oil Refining Industries (Protocol No. 20 dated 12.06.2025)

Agreed by the Methodical Commission of the Faculty of Engineering and Chemistry (protocol No. 11 dated 27.06.2025)