Course title	Structural Mechanics (ECTS 12)
Course/module code	QM1312
Semesters offered	Semesters 3/4/5
Assigned instructor	Jo‘lanov Isoq Odilovich, Assistant Lecturer
Language of instruction	Uzbek
Course type	Compulsory
Study hours (including independent study)	**Total hours - 360.** **Contact hours - 144.** Lecture hours - 72 Laboratory hours - 12 Practical class hours - 60 **Independent study - 216 hours**
ECTS	12
Course aim and objectives / learning outcomes	**Course aim** – To develop students’ systematic theoretical knowledge and practical skills in the equilibrium and motion of mechanical systems, the stress–strain state of deformable solids, and the analysis of load-bearing systems of buildings and other structures using classical and matrix methods. **Course objectives** – To replace force systems with equivalent systems, release constraints and determine support reactions; develop justified analytical models for static and dynamic problems; determine internal force resultants, stresses and deformations; check strength and stiffness under tension, compression, shear, torsion and bending; assess the stability of compression members and support elements; analyse statically determinate and indeterminate systems using classical methods; apply influence lines, displacement calculations, the force method and the displacement method to practical problems; and verify and interpret matrix and computer analysis results using engineering judgement. Learning outcomes: 1. Explain the concepts of force, moment, constraint, equilibrium, kinematics and dynamics. 2. Explain stress, strain and the criteria for strength, stiffness and stability. 3. Distinguish between analytical models of beams, trusses, frames, arches and support systems. 4. Explain the limits of applicability of analysis methods for statically determinate and indeterminate systems. 5. Explain the main stages of matrix analysis and computer analysis. 6. Construct free-body diagrams and analytical models; 7. Determine support reactions and internal force resultants; 8. Calculate normal and shear stresses, normal strains and shear strains; 9. Calculate the geometric properties of cross-sections; 10. Apply strength, stiffness and stability criteria to practical problems; 11. Construct influence lines and analyse the effects of moving loads; 12. Apply Mohr’s integral, Vereshchagin’s rule, the force method and the displacement method; 13. Evaluate computer analysis results using independent manual check calculations.
Course content (topics)	**I. Core theoretical content (Lectures)** **Topic 1: Fundamental concepts of theoretical mechanics and the force vector.** *Mechanical models, particles and rigid bodies, scalar and vector quantities; resolution of a force into components.* **Topic 2: Constraints, supports and free-body diagrams.** *The axiom of constraints, ideal supports and reactions; free-body diagrams of a beam, a truss joint and a structural member.* **Topic 3: Coplanar concurrent force systems.** *Geometric and analytical addition of forces, the resultant force and equilibrium equations.* **Topic 4: Moment of a force and force couples.** *Moment about a point, Varignon’s theorem, couple moments and equivalent force systems.*

	Topic 5: Equilibrium of general coplanar force systems. *Reduction of a force system to a point, the resultant force and resultant moment; determination of support reactions.* **Topic 6: Equilibrium of spatial force systems.** *Three-dimensional force and moment vectors, force couples, the six equilibrium equations and spatial supports.* **Topic 7: Centre of gravity and centroids of cross-sections.** *Centre of parallel forces; centres of gravity of bodies and centroids of areas and lines; composite structural cross-sections.* **Topic 8: Friction.** *Laws of dry friction, sliding friction and rolling resistance; problems involving ladders, supports and connections.* **Topic 9: Particle kinematics.** *Vector, coordinate and natural-coordinate descriptions of motion; velocity and acceleration.* **Topic 10: Elementary motions of a rigid body.** *Translation and rotation about a fixed axis; angular velocity and angular acceleration.* **Topic 11: Particle dynamics.** *Newton's laws and differential equations of motion; unconstrained and constrained motion.* **Topic 12: Work, power, energy and general theorems of dynamics.** *Impulse, linear momentum, angular momentum and kinetic energy theorems; dynamic effects on building elements.* **Topic 13: External and internal forces. The method of sections.** *Analytical models, external loads and support reactions; the method of sections and internal force resultants N, Q, M and T.* **Topic 14: Stress and strain.** *Stress state at a point, normal and shear stresses, normal strain and shear strain.* **Topic 15: Tension and compression.** *Hooke's law, axial deformation and Poisson's ratio; statically determinate and simple statically indeterminate bars.* **Topic 16: Mechanical properties of materials and strength criteria.** *Tensile stress–strain diagrams, elasticity, plasticity, strength limits, allowable stress and factor of safety.* **Topic 17: Geometric properties of cross-sections.** *First moments of area, centroids, second moments of area, principal centroidal axes and radius of gyration.* **Topic 18: Shear deformation and shearing.** *Pure shear, Hooke's law, shear stress and shear strain; simplified analysis of bolts, rivets and welds.* **Topic 19: Torsion.** *Shear stress and angle of twist in circular shafts and tubes; strength and stiffness requirements.* **Topic 20: Internal force resultants in bending in a principal plane.** *Bending moment and shear force diagrams, differential relationships and selection of beam cross-sections.* **Topic 21: Bending stresses.** *Pure bending and bending with shear, normal and shear stresses, and the strength criterion.* **Topic 22: Beam displacements and stiffness.** *Differential equation of the elastic curve; introduction to the initial-parameter method and energy methods; deflection and slope.* **Topic 23: Combined loading.** *Unsymmetrical bending, eccentric tension and compression, and combined bending and torsion.* **Topic 24: Stability of compression members.** *Euler's buckling problem, critical load, effective length and slenderness ratio; checks of building columns and compression members.* **Topic 25: Analytical models in structural mechanics.** *Idealisation of buildings and other structures, loads, supports and joints; classification of systems of bars and beams.* **Topic 26: Kinematic analysis of structural systems.** *Degrees of freedom, geometric stability, instantaneous instability and the rigid-disc method; degree of static determinacy.* **Topic 27: Statically determinate beams and frames.** *Support reactions, internal force diagrams and verification checks; multi-span hinged beams.* **Topic 28: Statically determinate trusses.** *The method of joints and Ritter's method of sections, zero-force members and analysis of load-bearing trusses.* **Topic 29: Three-hinged systems.** *Support reactions and internal forces in three-hinged arches and frames; the concept of the optimal arch axis.* **Topic 30: Influence lines.** *Moving loads, kinematic and static methods; influence lines for beams, trusses and three-hinged systems.*

Topic 31: Structural displacements. *The principle of virtual displacements, the unit-load method, Mohr's integral and Vereshchagin's rule; reciprocal displacement theorems.*

Topic 32: Statically indeterminate systems. The force method. *Redundant constraints, the primary system, canonical equations, unit-load diagrams and verification of coefficients.*

Topic 33: Special applications of the force method. *Continuous beams, use of symmetry, and the effects of temperature changes and support settlement.*

Topic 34: The displacement method. *Kinematic indeterminacy, the primary system, joint rotations and translations, and canonical equations.*

Topic 35: Matrix analysis and the direct stiffness method. *Element and global stiffness matrices, coordinate transformations, assembly, boundary conditions and solution of equations.*

Topic 36: Fundamentals of computer-based structural analysis. *Model geometry, materials and cross-sections, loads, mesh and boundary conditions; verification and engineering interpretation of results.*

II. Guidelines and recommendations for laboratory classes.

L1 Obtaining a material's tensile stress–strain diagram and determining its mechanical properties

L2 Determining Young's modulus and Poisson's ratio for steel

L3 Compression testing of steel, cast iron, plastics and timber

L4 Determining beam deflection and slope

L5 Experimental verification of unsymmetrical bending theory using a cantilever beam

III. Guidelines and recommendations for practical classes

The instructor's preparation for a practical class begins with a review of the relevant documents (curriculum, topic schedule, etc.) and concludes with the preparation of a lesson plan. The instructor should have a clear understanding of the class aim and objectives and the amount of work each student is expected to complete.

The methodological guidelines are the instructor's principal reference document for preparing and conducting practical classes.

Practical classes aim to develop an understanding of theory and practical skills, the ability to apply them purposefully in academic and professional activities, and the ability to formulate a well-reasoned position.

Recommended topics for practical classes:

1. Force vectors and projections
2. Free-body diagrams and support reactions
3. Equilibrium of concurrent forces.
4. Problems involving moments and force couples.
5. Equilibrium of a general coplanar force system
6. Spatial equilibrium.
7. Centre of gravity and friction.
8. Particle kinematics
9. Rigid-body motion.
10. General theorems of dynamics.
11. Determination of internal force resultants.
12. Analysis of tension and compression.
13. Material properties and allowable stress
14. Geometric properties of cross-sections
15. Shear and torsion
16. Strength and stiffness in bending
17. Analytical models and kinematic analysis
18. Internal force diagrams for statically determinate beams
19. Statically determinate frames
20. Truss member forces
21. Three-hinged systems
22. Influence lines
23. Determination of displacements
24. The force method
25. The displacement method

	26. Stiffness matrices and computer models **IV. Independent study and independent assignments.** Independent learning competence supports students' autonomous development and improves their professional effectiveness. Students complete independent assignments under the instructor's guidance, either in a traditional format or electronically using their mobile devices. **Recommended topics for independent study:** 1. An annotated table of mechanical models and systems of units. 2. A free-body diagram of a building element. 3. Equilibrium of concurrent forces at a truss joint. 4. Moments and distributed loads. 5. Determination of beam support reactions. 6. Support reactions in three dimensions. 7. Centroid of a composite cross-section. 8. A structural connection involving friction. 9. Particle trajectory in kinematics. 10. Parameters of rotational motion. 11. Equation of motion of a particle 12. Comparison of work–energy and impulse–momentum methods 13. Internal force resultants and sign conventions 14. Terminology relating to the stress–strain state 15. Analysis of a stepped bar under tension and compression 16. Comparison of material test diagrams 17. Geometric properties of a composite cross-section 18. Shear analysis of a bolted or welded connection 19. Torsion analysis of a circular shaft and tube 20. Beam shear force (Q) and bending moment (M) diagrams 21. Selection of cross-sections based on bending stresses 22. Beam stiffness verification 23. Cross-section of an eccentrically compressed column 24. Critical load and slenderness ratio of a column 25. Justification of an analytical model for a building frame 26. Kinematic analysis of a system of bars and beams 27. Analysis of a multi-span hinged beam 28. Member forces in a load-bearing truss 29. A three-hinged arch or frame 30. Influence lines for moving loads 31. Mohr's integral and Vereshchagin's rule 32. A frame with one degree of static indeterminacy 33. Effects of temperature changes or support settlement 34. Frame analysis using the displacement method 35. Stiffness matrix of a truss or frame 36. Computer modelling and verification
Guidelines and recommendations for calculation and graphical assignments	Calculation and graphical assignments are a key means of helping students master the course and develop and deepen the reasoning skills required for independent problem solving. The work comprises three assignments in the semester concerned, taking account of the contact hours and degree programme. The instructor conducting practical classes is allocated one hour per student per semester to supervise this work. Determination of the support reactions of a rigid body. S-1 Determination of a particle's velocity and acceleration from its prescribed equations of motion. K-1 Integration of the differential equations of motion of a particle subjected to constant forces. D-1 Strength analysis of statically determinate stepped bars. Determination of the geometric properties of complex composite plane cross-sections. Strength analysis of beams subjected to bending.
Student assessment	Student assessment is based on demonstrated mastery of the course material during the semester and in the final assessment, as evidenced by tests,

	assignments, and written and oral work. Students in the Structural Mechanics course are assessed on a 100-point scale. Of these, 50 points are allocated to continuous and midterm assessment (60% of the 50 points for continuous assessment and independent study, and 40% for midterm assessment), and 50 points to the final assessment. Students whose combined continuous and midterm assessment score is below 30 points are not admitted to the final examination. A student who earns 30 points or more in the final assessment is considered to have passed the course.
Examination requirements	Students must fully understand the theoretical and practical concepts covered and accurately present the results of their analyses. They must complete the independent assignments and the tasks set for continuous and midterm assessment. They must also obtain the required scores in continuous assessment, midterm assessment, independent study and final assessment within the prescribed period. Students who have not submitted their continuous assessment, midterm assessment and independent study assignments, or who have earned fewer than 30 points in these assignments and assessments, are not admitted to the final assessment. A student who misses 25% or more of the scheduled contact hours without a valid reason is withdrawn from the course, is not admitted to the final examination and is considered not to have earned the corresponding course credits. A student who fails the final examination or scores within the range of 0–29.9 points in that examination is considered to have an outstanding academic requirement for the course.
Recommended literature	*1.* Sh.A. Shoobidov. Theoretical Mechanics. Textbook. Tashkent, 2008. 240 pp. *2.* T. Bultakov, G‘.G‘. Egamnazarov, X.X. Igamberdiyev. Practical Course in Theoretical Mechanics: Statics. Study guide. Jizzakh: Jizzakh Polytechnic Institute, 2019. 266 pp. URL: https://unilibrary.uz/literature/880109. *3.* X.X. Igamberdiyev, A.T. Axmedov. Strength of Materials. Study guide. Jizzakh: Jizzakh Polytechnic Institute, 2023. 220 pp. URL: https://unilibrary.uz/literature/636427 *4.* S. Ubaydullayev, X.X. Igamberdiyev. Structural Mechanics. Textbook. Jizzakh: Jizzakh Polytechnic Institute, 2023. 292 pp. URL: https://unilibrary.uz/literature/499041. *5.* X.Sh. To‘rayev, M.X. Ismatov, F.X. Yo‘ldashev, B.K. Javliyev. Structural Mechanics: Theoretical Foundations and Practical Problems. Study guide. Tashkent: Moliya, 2002. 460 pp. 6. E.T. Achilov. Structural Mechanics. Textbook. Jizzakh: Jizzakh Polytechnic Institute, 2023. 292 pp. 7. E.T. Achilov. Structural Mechanics. Part 1. Study guide. Jizzakh: Jizzakh Polytechnic Institute, 2022. 227 pp. 8. B.I. Ahmedov. Structural Mechanics. Textbook. Jizzakh: Jizzakh Polytechnic Institute, 2022. 318 pp. 9. R.D. Xamraqulov. Structural Mechanics and Structures. Textbook. Jizzakh: Jizzakh Polytechnic Institute, 2022. 208 pp. 10. N.N. Narbekov. Strength of Materials. Textbook. Tashkent: Lesson Press, 2023. 251 pp. 11. K. Ismayilov, S.K. Toshev, O.I. Eshniyazov, S.S. Amanov. Strength of Materials. Study guide. Tashkent: Mashhur-Press, 2017. 272 pp. 12. N.X. Mirzakabilov, S.D. Quralov. Strength of Materials. Study guide. Jizzakh: Jizzakh Polytechnic Institute, 2022. 109 pp. 13. A.Q. Usmanqulov, K. Ismayilov, O.K. Adilov, A.B. Gadayev. Strength of Materials. Part 2. Study guide. Tashkent: Mashhur-Press, 2019. 336 pp. 14. Z.S. Turdaliyev. Theoretical Mechanics. Study guide. Jizzakh: Jizzakh Polytechnic Institute, 2023. 197 pp. 15. T. Bultakov, G‘.G‘. Egamnazarov, X.X. Igamberdiyev. Practical Course in Theoretical Mechanics: Statics. Study guide. Jizzakh: Jizzakh Polytechnic Institute, 2020. 219 pp. 16. T. Bultakov. Practical Course in Theoretical Mechanics: Kinematics. Study guide. Jizzakh: Jizzakh Polytechnic Institute, 2022. 153 pp. 17. N.N. Narbekov, B.U. Qabilov. Worked Examples and Problems in Theoretical Mechanics. Study guide. Tashkent: Lesson Press, 2023. 131 pp.

18. University of California San Diego. Structural Engineering Course Catalogue (SE 101A–B, SE 103, SE 105, SE 110A–B, SE 130A–B). URL: https://catalog.ucsd.edu/courses/SE.html (accessed: 1 August 2026).
19. The University of Queensland. Structural Mechanics (CIVL2330), Semester 1, 2026. URL: https://course-profiles.uq.edu.au/course-profiles/CIVL2330-21217-7620 (accessed: 1 August 2026).
20. The University of Queensland. Structural Analysis (CIVL3340), Semester 1, 2025. URL: https://course-profiles.uq.edu.au/course-profiles/CIVL3340-21312-7520 (accessed: 1 August 2026).
21. QS. The University of Queensland — QS World University Rankings 2027: #=40. URL: https://www.topuniversities.com/universities/university-queensland (accessed: 1 August 2026).
22. QS. University of California, San Diego (UCSD) — QS World University Rankings 2027: #81. URL: https://www.topuniversities.com/universities/university-california-san-diego-ucsd (accessed: 1 August 2026).
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25. UniLibrary — Unified Electronic Library Information System for Higher Education Institutions. URL: https://unilibrary.uz/ (accessed: 1 August 2026).
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28. www.lex.uz – National Database of Legislation of the Republic of Uzbekistan.
29. www.ilm.uz.
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31. http://www.ziyo.net