RTU Course "Engineering Mechanics for Marine Engineers"

0J000 Latvian Maritime Academy

General data

Code	JA0020
Course title	Engineering Mechanics for Marine Engineers
Course status in the programme	Compulsory/Courses of Limited Choice
Responsible instructor	Ivars Boiko
Academic staff	Rauls Klaucāns Artūrs Koreņkovs
Volume of the course: parts and credits points	3 parts, 13.0 credits
Language of instruction	LV, EN
Annotation	The study course is developed in accordance with the requirements of the STCW Code A-III/1 and A-III/2, and taking into account the recommendations of IMO Model Courses 7.02 and 7.04 and other relevant regulatory documents. The study course covers theoretical mechanics, material resistance, theory of machinery, machine elements and hydraulics, as well as the fundamentals of equipment design and interchangeability, and the principles of operation of hydraulic pumps and turbines. The causes of vibration and measures to reduce vibration of the ship and its machinery are also covered and rules for the execution of detail working drawings are given. Part-time extramural studies are organized according to an individually developed study plan.
Goals and objectives of the course in terms of competences and skills	The aim of the study course is to provide knowledge of the design and operation of shipboard engineering systems and equipment in accordance with the requirements of the STCW Convention Code A-III/1 and A-III/2, as well as taking into account the recommendations of the relevant IMO Model Courses and other relevant regulatory documents. Tasks of the study course: 1) to teach how the simplest kinematic, dynamic, vibration and strength calculations of marine equipment are carried out; 2) to teach an understanding of structural properties and the correct choice of materials for equipment fabrication; 3) to provide skills in the development of working drawings of simple machinery structures and components; 4) to promote an understanding of basic hydraulics, the principles of operation of various pumps and turbines; 5) to provide knowledge of how maintenance measures are determined and planned.
Structure and tasks of independent studies	Independent work topics: 1.Equilibrium of a system of interacting forces; 2.Equilibrium of a system of compliant forces; 3.Compliant motion of a rigid body; 4.Dynamics of a material point; 5.Theorem of kinetic energy change; 6.Calculation of strength in tension and compression; 7.Calculation of strength and stiffness in torsion; 8. Strength calculations in bending; 9.Displacement calculations in bending; 10.Strength calculations in compound loading; 11.Connection strength calculations; 12.Rotational motion transfers; 13.Bearing life calculations; 14.Dynamic analysis of mechanisms; 15.Hydrostatics. Organisation: students are given individual calculation assignments, where the progress of the problem solutions and the results of the calculations are checked.

Recommended literature	Obligātā / Obligatory: 1. R.Indriksons. Tehniskās mehānikas pamati. Lekciju konspekts kuģu vadītāju specialitātes studentiem. LJA – 2010. – 79 lpp. 2. R.Indriksons. Teorētiskā mehānika. 1.daļa. Statika un kinemātika. Lekciju konspekts LJA mehānikas specialitātes studentiem. LJA – 2016. – 49 lpp. 3. R.Indriksons. Teorētiskā mehānika. 2.daļa. Dinamika. Lekciju konspekts LJA Mehānikas specialitātes studentiem. LJA – 2016. – 32 lpp. 4. R.Indriksons. Materiālu pretestība. Lekciju konspekts LJA mehānikas specialitātes studentiem. LJA – 2016. – 81 lpp. 5. R.Indriksons. Mašīnu elementu pamati. Lekciju konspekts. LJA – 2017. – 58 lpp. 6. R.Indriksons. Mašīnu un mehānismu teorijas pamati. Lekciju konspekts. LJA – 2015.– 9 lpp. 7. R.Indriksons. Hidraulikas pamati. Lekciju konspekts. LJA – 2012. – 26 lpp. 8. R.Indriksons. Savstarpējās apmaināmības pamati. Lekciju konspekts kuģu mehāniķu specialitātes studentiem. LJA – 2016. – 9 lpp. 9. Russel P. Reeds Vol 2: Applied Mechanics for Marine Engineers. Bloomsbury Publishing, 2022. 10.Russel P. Reeds Vol 8: General Engineering Knowledge for Marine Engineers. Bloomsbury Publishing, 2024. 11. Russel P. Reeds Vol 12: Motor Engineering Knowledge for Marine Engineers. Bloomsbury Publishing, 2025. Papildu / Additional: 1. O.Kepe, J.Vība. Teorētiskā mehānika. Rīga, "Zvaigzne",1982. – 577 lpp. 2. E. Lavendelis. Materiālu pretestība. Rīga, „Zvaigzne”, 1986. – 341 lpp. 3. S.Černavskis u.c. Mašīnu elementi. Kursa projektēšana. Rīga, „Zvaigzne”, 1983. – 370 lpp. 4. G.Ickovičs u.c. Mašīnu elementi. Rīga.”Zvaigzne”, 1974. – 534 lpp. 5. J.Rudņevs, K.Ziņģis. Mehānismu un mašīnu teorija (kursa projektēšana). Rīga, “Zvaigzne”, 1986. – 286 lpp. 6. Ozols O. Mehānismu un mašīnu teorija.Rīga. „Zvaigzne”, 1973.– 418 lpp. 7. P.Lielpēters un citi. Fluidtehnika. Rīgā, RTU, 2005. – 183 lpp. 8. Palm III W.J. Mechanical Vibration. USA., 2006. – 700 p. 9. Rao S.S. Mechanical Vibrations. USA New Jersey, 2004. – 1078 p. 10. J.Hannah and M.J.Hillier. Applied Mechanics. “Longman Scientific & Technical”,1988. – 512 p. 11. E.Šīrons. Savstarpējā apmaināmība un standartizācija. Rīgā, „Zvaigzne”, 1988. – 229.lpp. 12. V.Dirba, J.Uiska, V.Zars. Hidraulika un hidrauliskās mašīnas. Rīga. „Zinātne”, 1980.– 456 lpp.
Course prerequisites	Basic knowledge of higher mathematics, physics and engineering graphics.

Course contents

Content	Full- and part-time intramural studies		Part time extramural studies	
	Contact Hours	Indep. work	Contact Hours	Indep. work
Static. Introduction to theoretical mechanics: basic concepts of theoretical mechanics; axioms of statics; bonds and bond reactions. (IMO 7.04 Annex A4.1.1)	2	2	2	2
Static. System of convergent forces: Reduction to simplest form; Equations of equilibrium for a system of convergent forces; Theorem of the equilibrium of three forces. (IMO 7.04 Annex A4.1.1)	4	8	4	8
Static. Theory of force pairs: moment of force against a point; Force pair and its moment; Theorem of the sum of moments of a force pair against a point; Theorem of parallel transmission of a force; Reduction of a force system to a centre. (IMO 7.04 Annex A4.1.1)	2	2	2	2
Static. Complane force system: algebraic moment of a force against a point; Reduction of a system of compplane forces to its simplest form; equilibrium equations for a system of compplane forces; Replacement of a system of distributed forces by a total force; statically determinate and indeterminate systems of bodies; Flat trusses; Determination of truss bar forces by knot cutting and truss splitting methods. (IMO 7.04 Annex A4.1.1)	6	8	6	8
Static. Friction: sliding friction. Laws of sliding friction; friction forces; friction angle and friction cone. Self-braking; Friction in sliding bearing inserts; Friction in bolted joints; Friction in flat belt transmissions and belt brakes; Friction in V-belt transmissions and V-groove pulleys; Rolling friction and its laws; Rolling friction moment and rolling friction coefficient. (IMO 7.04 Annex A4.1.1)	4	3	4	3
Static. Spatial force system. Centre of gravity:Moment of force against axis; Equations of equilibrium for a spatial system of forces; Centre of parallel forces, determination of its position; Determination of the centre of gravity of a rigid body and a system of bodies; Determination of the centre of gravity of a homogeneous body and a plane figure; Experimental method for finding the centre of gravity; Stability of the equilibrium position (IMO 7.04 Appendix A4.1.1.).	8	8	8	8
Resistance of materials. Introduction to material resistance: Real objects and their calculation schemes; Concept of stress, displacement and strain; External forces and internal forces; Slit method for internal forces. Method for determining factors; Basic types of bar members. (IMO 7.02.-1.2.2.3)	4	3	4	3
Resistance of materials. Stresses in cross-sections of an axially loaded bar; Determination of displacements in a stretched (compressed) bar. Huck's law;Transverse deformations in tension and compression;Experimental determination of mechanical properties of materials in tension (compression);Reserve strength and factors affecting it;Types of strength calculations. Strength calculations in tension and compression; Statically indeterminate member systems (IMO 7.02.-1.2.2.3).	6	7	6	7
Resistance of materials. Strength calculations in shear and surface compression. Axe as a form of body loading. Determination of stresses; Surface compression. Determination of stress in surface compression; Torsion of a bar of circular cross section. Hypotheses and assumptions; Determination of tangential stresses in bar cross-sections; Calculation of torsional angle in torsion of a bar of circular cross-section; Torsion of bars of non-circular cross-section; Calculation of strength and stiffness of bars in torsion. (IMO 7.02.-1.2.2.4)	6	2	6	2

Resistance of materials. Strength and stiffness calculations in bending. Hypotheses and assumptions; Calculation of normal stresses; Geometrical characterisation of bar cross-sections. Principal axes of inertia and principal moments of inertia; General case of bending of bars. Calculation of tangential stresses;Strength calculations in bending;Transverse force and bending moment epicycles, their correctness check; Calculation of deflections in bending. (IMO 7.02.-1.2.2.4)	10	8	10	8
Resistance of materials. Composite loading:General case of composite loading;Determination of stresses at an arbitrary point of a loaded member; Dangerous slits and dangerous points;Strength calculations for composite loading. Theories of strength;Buckling; Bending with torsion or compression; Bending of a circular section bar with torsion; Moore's integral for calculating displacements; Cylindrical twisted tension, compression and torsion springs and their calculation; Momentless theory for calculating thin-walled, axisymmetric rotating shells. (IMO 7.02-1.2.2.3; 1.2.2.4)	6	3	6	3
Resistance of materials. Buckling of tension rods: stability of the equilibrium shape of a rigid deformable body; concept of critical load; buckling of an axially loaded rod; Euler problem. Determination of the critical force; Strength calculations in slack; Use of the allowable stress reduction factor in strength calculations of compression members. (IMO 7.02-1.2.2.3; 1.2.2.4)	2	2	2	2
Resistance of materials. Durability calculations under cyclically varying stresses: modern concepts of durability under cyclically varying stresses; main characteristics of stress cycling; durability calculations under symmetrical stress cycling; durability calculations under unsymmetrical stress cycling; durability calculations under compound loading.	2	2	2	2
Kinematics. Point kinematics: vectorial method for detecting the motion of a point. Trajectory, velocity and acceleration of a point; Coordinate method for inferring motion of a point; Determination of velocity, acceleration and trajectory by coordinate method for inferring motion; Natural method for inferring motion of a point; Determination of velocity, normal and tangential acceleration by natural method for inferring motion; Uniform and uniformly varying motion of a point. (IMO 7.02-1.2.2.2)	6	3	6	3
Kinematics. Kinematics of a solid body: directional motion of a solid body; rotational motion of a solid body and its equation; angular velocity and acceleration; frequency of rotation; velocities and accelerations of points of a rotating body; complanar motion of a solid body and its equation; determination of velocities and accelerations of body points in complanar motion; spherical motion. Its equations; Determination of velocities and accelerations of body points in spherical motion; General case of rigid body motion. (IMO 7.02.-1.2.2.2)	12	8	12	8
Kinematics. Composite motion of a point of matter: relative, translational and absolute motions; Adding velocities in composite motion of a point; Adding accelerations in composite motion of a point. (IMO 7.02.-1.2.2.2)	4	2	4	2
Dynamics. Dynamics of a material point: Introduction to dynamics. Basic concepts and Newton's laws; Differential equations of motion of a point of matter; First and second fundamental problems of dynamics. (IMO 7.04 Annex A4.1.2)	4	7	4	7
Dynamics. Introduction to the dynamics of a mechanical system: internal and external forces; principal vector and moment of a system of internal forces; centre of mass. Moments and radii of inertia of the mass; Relations between moments of inertia with respect to parallel axes; Relations between moments of inertia with respect to rotated axes; Principal axes of inertia and principal moments of inertia. (IMO 7.04 Annex A4.1.2)	4	2	4	2
Dynamics. General theorems of dynamics: Theorem of the motion of the centre of mass of a mechanical system; Quantity of motion of a material point and a mechanical system; Momentum of force; Theorem of the variation of the quantity of motion of a material point and a mechanical system; Kinetic moment of a material point and a mechanical system; Kinetic moment of a rigid body rotating about a stationary axis; Theorem of the variation of the kinetic moment of a material point and a mechanical system; Differential equations for the motion of a rigid body. (IMO 7.04 Annex A4.1.2)	8	2	8	2
Dynamics. Work and energy. Theorem of kinetic energy change: Work and power of a force; Work of gravity and elastic force; Work and power of forces applied to a body rotating about a stationary axis; Kinetic energy of a point of matter and of a mechanical system. Kinetic energy of a rigid body; Theorem of change of kinetic energy; Potential energy and law of invariability of mechanical energy. (IMO 7.04 Annex A4.1.2; IMO 7.02- 1.2.2.1)	6	8	6	8
Dynamics. Kinematics: Point inertia of a material; Principal vector and moment of inertial forces of a rigid body; Dalambaire's principle; Dynamic reactions of bearings of rotating bodies; Static and dynamic balancing of rotating shafts; Primary and secondary balancing of multi-cylinder machines. (IMO 7.04 Annex A4.1.2; IMO 7.02- 1.2.2.1)	6	7	6	7
Dynamics. Impact theory: Impact force and impact momentum; Rigid body straight central impact on a rigid surface; Rigid body straight central impact of two bodies; Oblique impact of a point of material on a rigid surface; Impact force on a body rotating about a rigid axis. Centre of impact. (IMO 7.04 Annex A4.1.2; IMO 7.02- 1.2.2.3)	4	2	4	2
Dynamics. Orthogonal oscillations of a point of matter: free and damped orthogonal oscillations of a point of matter; forced orthogonal oscillations of a point of matter. Resonance;Free and forced oscillations of systems with several degrees of freedom of motion. (IMO 7.04 Annex A4.1.2; IMO 7.02- 1.2.2.2)	6	8	6	8
Dynamics. Vibration of ship's components: causes of ship vibration; transverse vibrations of beams; transverse vibrations of rotating shafts. Critical shaft rotation frequency; Rotating shaft torsional oscillations. Critical rotational frequency; Axial vibration of shafts; Vibration reduction techniques.	6	2	6	2
Hydraulics. Basic properties of fluids - specific gravity, density, compressibility, thermal expansion, viscosity; Hydrostatic pressure. Basic equation of hydrostatics;Equilibrium conditions of fluids in connected vessels. Pressure measurement;Pressure force on immersed surfaces. Centre of pressure. (IMO 7.04 Annex A4.1.3)	8	2	8	2
Hydraulics. Hydrodynamics:Pressure energy, potential and kinetic energies of fluids; Bernoulli's equation for an ideal fluid; Ideal fluid flow in a pipe; Flow of real fluids. Different flow regimes; Measurement of fluid flow; Discharge through small boreholes; Jet pressure force on obstacles. (IMO 7.04 Annex A4.1.4; IMO 7.02- 1.2.2.6)	6	2	6	2

Hydraulics. Pump principles:Pump classification. Main pump operating characteristics; Reciprocating pumps - single-acting and double-acting, single-cylinder and multi-cylinder. Degree of inhomogeneity of delivery; Rotor pumps - Plate, gear and screw pumps; Vane pumps - Centrifugal, axial and vortex pumps; Jet pumps - Injectors and ejectors. (IMO 7.02- 1.2.2.6)	6	2	6	2
Hydraulics.Principles of turbine operation: classification of turbines. Main characteristics of turbine operation. Pressure turbines; Jet turbines; Pelton turbine; Pressure losses in turbines. Turbine efficiency.	4	2	4	2
Theory of machine mechanisms and machine elements. Connections:Classification of connections; Riveted connections and their calculation; Welded connections and their calculation; Soldered and glued connections and their calculation; Press connections; Threaded connections and their calculation; Pin connections and their calculation; Groove connections and spline connections. Their calculation. (IMO 7.04-3.2.5)	8	8	8	8
Theory of machine mechanisms and machine elements. Rotary motion transmissions: Classification of rotary motion transmissions; Main characteristics of rotary motion transmissions - gear ratio and efficiency; Friction transmissions - kinematics, forces transmitted and power transmitted; Belt transmissions - kinematics, forces transmitted and power transmitted; Chain transmissions - kinematics, forces in transmission and power in transmission; Gear transmissions - main parameters; Forces in gear transmissions and power in transmission; Worm transmissions - main parameters; Forces in worm transmissions and power in transmission. (IMO 7.04-3.2.5)	8	8	8	8
Theory of machine mechanisms and machine elements. Mechanisms of excavators: Classification and main components of excavator mechanisms; Laws of motion of sliders; Sliding speed of the slider relative to the exciter and acceleration; Graphical design of the profile of the exciter; Necessary clamping force of the slider; Moment of resistance acting on the shaft of the exciter. (IMO 7.04-3.2.5)	8	7	8	7
Theory of machine mechanisms and machine elements. Analysis of motion of a mechanism: Forces and moments acting on a mechanism;Reduction of forces to a principal term; Reduction of masses to a principal term; Differential equations of motion of a mechanism;Stationary motion velocity inequalities;Calculation of the moment of inertia of a flywheel. (IMO 7.04.-3.2.5)	8	4	8	4
Theory of machine mechanisms and machine elements. Basic concepts of interchangeability; Surface roughness norming; Tolerances and seating. (IMO 7.04.-3.2.5)	4	8	4	8
Theory of machine mechanisms and machine elements. Axles, shafts and bearings: Classification of shafts and axles; Calculation scheme for shafts and axles; Orientation calculation for shafts; Precision life calculation for shafts; Plain bearings and their calculation; Roller bearings and their main components; Calculation of roller bearings. (IMO 7.04-3.2.5)	4	7	4	7
Total:	192	159	192	159

Learning outcomes and assessment

Learning outcomes	Assessment methods
Knowledge. 1) Knowledge of mechanics and hydromechanics. 2) Able to understand how the simplest kinematic, dynamic, vibration and strength calculations are performed on marine equipment. 3) Understands the fundamentals of hydraulics, the principles of operation of various pumps and turbines. 4) Able to demonstrate knowledge of the facts, principles, and general concepts of mechanics in the field of teaching and professional activity.	Methods: control work, homework, final examinations. Assessment criteria: 1) Able to demonstrate a thorough knowledge of mechanics and hydromechanics. 2) Correctly performed solutions of the types of calculations, principles learned in the course of study. 3) Able to demonstrate knowledge of facts, principles, and general concepts of mechanics in the field of study and professional activity.
Skills. 1) Able to apply basic practical skills required to solve simple problems. 2) Able to prepare working drawings of simple machine structures and components.	Methods: control work, homework, final examinations. Assessment criteria: 1) Correct answers to the control work questions. 2) Able to read drawings.
Competences. Able to demonstrate competence in accordance with the requirements of sections A-III/1 and A-III/2 of the STCW Code: 1) In solving problems, be able to adapt actions to the circumstances and be responsible for the results of work. 2) Design characteristics and choice of materials for equipment 3) Interpret machinery drawings and manuals. 4) Determine and plan maintenance operations.	Methods: control work, homework, final examinations. Assessment criteria: 1) Able to apply acquired knowledge in the field of professional activity, to critically analyse a problem and to solve tasks according to the situation. 2) Selection of materials and spare parts is appropriate. 3) Able to independently apply acquired knowledge and skills in practice, by reading mechanical drawings or making detail and general drawings or sketches. 4) Planning and preparation of operations is appropriate to the design parameters of the power equipment and to the needs of the excursion.

Evaluation criteria of study results

Criterion	%
Homework	30
Control works	30
Final assessments	40
Total:	100

Study subject structure

Part	CP	Hours			Tests		
		Lectures	Practical	Lab.	Test	Exam	Work
1.	5.0	42.0	30.0	0.0	*		
2.	5.0	42.0	30.0	0.0	*		
3.	3.0	32.0	16.0	0.0		*	