Tallinn University of Technology
TalTech Estonian Maritime Academy

VLL1240 Celestial Navigation I (Spring 2026)

http://ois2.taltech.ee/uusois/aine/VLL1240

Extended curriculum

Spring 2026

General information

Volume of substance:	6 ECTS
Language of instruction:	Estonia
Faculty:	Heiki Erin, BSc , visiting lecturer, heiki.erin@taltech.ee .
Subject objectives:	To create prerequisites for the acquisition and application of practical marine astronomy. To provide skills in determining the position of a ship and compass bearing by astronomical means in accordance with the requirements of STCW-78, as amended, Part A-II/1.
Brief description of the subject content:	The aim of the subject is to provide the learner with theoretical knowledge and practical skills in determining the position of a ship and compass bearing at sea using celestial bodies. The course creates a foundation for understanding the principles of marine astronomy and their application in navigation using modern and traditional means. The course covers the basics of spherical trigonometry and basic concepts of marine astronomy, including the structure of the celestial sphere, coordinate systems of celestial bodies, and solving the polar triangle. The apparent motion of celestial bodies is analyzed and the structure of the Solar System, the apparent motion of the Sun on the ecliptic, and the characteristics of the Earth–Moon system are introduced. The concept of time is important in navigation, including determining time, the equation of time, and the role of precise time in astronomical observations. The course covers the instruments used in navigation – sextants, clocks, and star globes – and teaches the use of nautical almanacs and nautical charts. The practical part focuses on performing astronomical observations and improving measurement results, taking into account the inclination and refraction of rays. Students learn to determine latitude using meridian heights and the North Pole, and use bearing lines to determine the position of a ship, map them, and transfer them to a nautical chart. The course also covers methods for determining compass bearing and assessing position accuracy. During practical

exercises, the skills of using a star globe and star finder, correct handling and maintenance of a sextant, and determining the position of a ship using tasks based on observations of the Sun and two or more celestial bodies are acquired.
Upon completion of the subject, the student will be able to independently plan and conduct astronomical observations, process measurement results, and apply marine astronomy methods to solve navigational problems.

Learning outcomes:

A student who has successfully completed the subject:

- explains the basics of spherical trigonometry and the laws of the apparent motion of celestial bodies in the context of marine astronomy;
- describes and applies concepts of time used in navigation and the role of time in astronomical observations;
- knows the construction, operating principles and possible uses of instruments used in nautical astronomy;
- explains and applies the methodology of astronomical observations, including the improvement of measurement results;
- determines the ship's position and compass bearing based on observations of celestial bodies, using bearing lines and corresponding calculation methods;
- evaluates the accuracy of location determination by applying the foundations of probability theory;
- uses nautical almanacs and nautical tables in solving navigational tasks;
- uses astronavigation instruments and independently performs marine astronomical observations;
- applies marine astronomy computer programs to determine position and compass bearing.

Evaluation and coherence

"Accepted" (A) – the learner has acquired the learning outcomes at least at the minimum level.
"Not counted" (MA) – the learning outcome has not been acquired.

Evaluation method	Teaching methods	Relationship to learning outcomes

Coordinate system tasks. The student's ability to understand and combine the horizontal and equatorial coordinate systems is assessed.	Lecture and exercises	Understanding of different coordinate systems and their relationship to each other
Positioning tasks (based on two or more celestial bodies, mapping). The choice of methodology, the logic of calculations and the reliability of the result are assessed. (A / MA)	Task-based learning, work with nautical charts and nautical almanacs, guided exercises.	Determining the position of a ship using celestial bodies; use of bearing lines and mapping.
Compass bearing determination tasks . The suitability of the method, the correctness of the calculations and the interpretation of the result are assessed. (A / MA)	Sample problems, practical calculations, guided exercises.	Determining compass readings based on observations of celestial bodies.
Practical work and observations (use of a sextant, observations of the Sun and other celestial bodies, data correction). The accuracy of measurements, correctness of working techniques and safe handling of instruments are assessed. (A / MA)	Practical exercises, demonstrations, independent and guided observation.	astronavigation instruments; conducting astronomical observations and improving measurement results.

Development of the final result:

The final grade is the average of the written and oral parts of the exam.
Must have acquired the concepts and nature of marine astronomy, be able to determine location by stars, and have a clear and correct calculation structure.
Additional oral questions if there is an error in the location calculations or the student has been absent from lectures/practice classes

The prerequisite for passing the exam is to attend at least 80% of lectures and practice sessions, with all tests "counting" towards the completed result.

A student of the VDLR curriculum (except for the group leader) has been on watch duty during the academic year in accordance with the number of hours required by the internal regulations of the Estonian Maritime Academy for students of curriculums regulated by the Maritime Safety Act.

"0" – at least one learning outcome has not been acquired; the learner is unable to independently solve basic astronavigational tasks and does not demonstrate the required practical skills. Positioning accuracy is more than 1.51 NM

"1" – the student has acquired all learning outcomes of the subject at a minimum level; is able to solve typical tasks under supervision, use instruments and almanacs, and determine the ship's position and compass bearing in simpler cases. Positioning accuracy 1.31 – 1.5 NM

"2" – the learner applies the learning outcomes mostly correctly; solves most tasks independently, but there are methodological or computational inaccuracies. Positioning accuracy 1.11 – 1.3 NM

"3" - the learner applies knowledge and skills independently and correctly; is able to justify the methods used and assess the reliability of the results in common situations. Positioning accuracy 0.91 - 1.1 NM

"4" - the learner demonstrates a very good theoretical and practical level; solves more complex tasks with few errors, critically evaluates measurement results and location accuracy. Location accuracy 0.71 - 0.9 NM

"5" – the learner demonstrates excellent and systematic application of knowledge and skills; solves astronavigational tasks independently and accurately, justifies choices and links theory and practice into a comprehensive solution. Positioning accuracy up to 0.7 NM

Coherence with the curriculum

Required prior knowledge and/or prerequisite subjects: Basic knowledge of navigation charts

Relationship to the curriculum: Entering an astronomically found location on a navigation chart

Teaching aids

Subject e-support : Materials related to the subject are available in the e-learning environment Moodle under the subject name:
VLL1210 Celestial Navigatin II (Spring 2026)
https://moodle.taltech.ee/course/view.php?id=36528

Educational literature: Mereastronoomia (Ilmar Noor)

Resources needed: MS Office programs. To get the free installation option as a student, see the instructions here .

Contacting a teacher: Preferred contact method is e-mail, response will be made within 5 business days.

Schedule and topics, including a list of tasks to be performed

During the semester, teaching is **combined with theoretical lectures and practical exercises** , with the aim of achieving sufficient proficiency in conducting astronomical observations and processing the results.

- **The theory lectures** provide knowledge of the basics of spherical trigonometry, the motion of celestial bodies, the construction and use of astronavigation instruments, time concepts, and methods of compass reading and location determination. The lectures support the skills applied during practical classes, allowing an understanding of the background of measurements and the selection of correct calculation methods.
- **Practical exercises** focus on determining the position of a ship by celestial bodies, using bearing lines, observing two or more celestial bodies, using UPSs and stargazers, and processing and correcting measurement results.
- **An outdoor lesson with a sextant** is planned for April–May , the initial planned location is **Cape Ninamaa** , the aim of which is to apply theoretical knowledge in a real environment and consolidate the correct use of the sextant and processing of measurement results.

The semester schedule and order of topics are **preliminary** and may change depending on the availability of contact learning, the updating of learning materials, or the learning pace of the cadets. If necessary, the volume of topics and the order of discussion will be adjusted.

To support their studies and revise independently, learners have the opportunity to use lecture materials published in **the Moodle environment** .

Lectures

Topic 1. Fundamentals of spherical trigonometry
Great and small circles on a sphere and their properties. Properties of spherical triangles. Basic formulas for solving spherical triangles.

Topic 2. Introduction
Historical overview. The necessity of nautical astronomy today. The difference between nautical astronomy and general astronomy .

Topic 3. Celestial sphere
The concept and graphic representation of the celestial sphere. The main points, lines and circles on the celestial sphere.

Topic 4. Coordinates of celestial bodies
Horizon and equatorial coordinate systems. Azimuth, altitude, hour angle and declination of a celestial body. Transition from one coordinate system to another. Solving graphical problems.

Topic 5. Polar triangle
Formation of a polar triangle and determination of its sides and angles. Calculation of the altitude and azimuth of a celestial body based on the elements of the polar triangle. Different calculation methods.

Topic 6. Apparent motion of celestial bodies
Apparent diurnal motion of celestial bodies as a result of the Earth's rotation. Relationship between time and arc units. Changes in the coordinates of celestial bodies during diurnal motion. Setting and non-setting celestial bodies.
Points of culmination, ascension and sunset. Passage of the first vertical, meridian and zenith. Special cases of apparent motion of celestial bodies. Graphical tasks.

Topic 7. Solar System
Composition and dimensions of the solar system. Kepler's laws and their consequences. Perihelion and aphelion of the Earth's orbit .

Topic 8. Apparent motion of the Sun and the ecliptic. Earth–Moon system
The inclination of the Earth's axis relative to the orbital plane and the resulting annual change in the declination of the Sun. The ecliptic. The equinoctial coordinate system. Mental calculation of the declination

of the Sun and the times of sunrise and sunset .
Changes in the coordinates of the Moon, phases of the Moon. Solar and lunar eclipses.

Topic 9. Time and the equation of time
The concept of time, time measurement and time measurement systems. The basic formula of time. Sidereal time. True and mean solar time. Equation of time. Time on different meridians. Greenwich Mean Time. Zone time. Daylight saving time. Ship time and its change. UTC and UT.

Topic 10. Sextant, clocks and star globe
The working principle and construction of a sextant. Sextant errors, their determination, calculation and correction. Using a sextant to measure vertical and horizontal angles.
Construction and use of an inclinometer. Construction of a chronometer. Determining the chronometer's accuracy and daily course. Chronometer logbook. Deck clocks. Organization of military service on a ship. Construction of a star globe and tasks to be solved on it. Finding celestial bodies using a computer program.

Topic 11. Nautical almanacs and nautical tables
The task, content and structure of MAE and NA. Finding the data necessary for solving astronomical problems from nautical almanacs.
Nautical tables and their use for calculating the altitude and azimuth of a celestial body (VAS 58, HO 229). Using the corresponding computer programs.

Topic 12. Astronomical observation
Finding the most important constellations in the starry sky. Selecting suitable celestial bodies for observation. Instruments required for observation. Preparing and conducting the observation. Recording and processing the observation results.

Topic 13. Incline and bend of rays. Correction of heights
The nature of the inclination and refraction of rays and the factors affecting them. Finding and summing the components of the height correction. Correcting heights.

Topic 14. Determining latitude by meridian height and North Pole
Theoretical justification of the method. Calculation scheme. Specific features of the movement of the North Pole and its use in determining latitude and compass bearing.

Topic 15. Calculation, mapping and transfer of location lines
Theoretical justification for obtaining astronomical coordinates. Saint- Hilaire's method. Different ways of calculating the elements of coordinates. Mapping and transferring coordinates. Use of computer programs.

Topic 16. Determining compass bearing
Selection of suitable celestial bodies. Observation methodology. Calculation methods. Tables of ready-made answers. Possible errors and their prevention.

Topic 17. Determining the accuracy of an astronomically derived position
Causes and probability of systematic and random errors. Summation of deviations based on the theory of mean square deviations. Relevant IMO standards.

Exercises
Topic 1
Problems for solving spherical triangles.

Topic 4
Tasks for finding the coordinates of a celestial body in different coordinate systems.

Topic 8
Tasks to determine the position of the Sun in relation to its annual movement along the ecliptic.

Topic 9
Time conversion tasks.

Topic 11
Finding the data you need Nautical From the Almanac and MAE . Problems that can be solved directly with their help. Problems using nautical tables.

Topic 12
Methodology and organization of astronomical observations.

Topic 13
Tasks for correcting the altitudes of various celestial bodies.

Topic 14
Tasks for finding culminating moments and determining latitude by meridian height.

Topic 15
Practical tasks with given source data for finding and mapping location lines using the Saint- Hilaire method.

Topic 16
Tasks for determining compass readings using formulas.

Topic 17
Tasks for determining the mean square error.

Topic 18
Tasks to be solved on the star globe.

Topic 19
Aligning a sextant, measuring horizontal and vertical angles, observing the Sun and processing data.

Topic 20
Positioning tasks based on combinations of different celestial bodies, with recording on a map or paper.

Topic 21
Compass orientation tasks by finding azimuths from various tables.

Topic 22
Accuracy of location determined by two and three celestial bodies.