UNIVERSITY OF GOTHENBURG

DEPARTMENT OF MARINE SCIENCES

MARS5B Practical Hydrography, 30 credits

Praktisk hydrografi, 30 högskolepoäng

Second Cycle

Confirmation

This course syllabus was confirmed by Department of Marine Sciences on 2018-01-24 and was last revised on 2018-01-24 to be valid from 2018-09-03, autumn semester of 2018.

Field of education: Science 100%
Department: Department of Marine Sciences

Position in the educational system

The course can be taken as a freestanding course or as an elective course in a Master's Programme

The course can be part of the following programmes: 1) Master's Programme in Physical Oceanography (N2FOC), 2) Marine Science, Master's Programme (N2MAV), 3) Master's Programme in Earth Sciences (N2GVS) and 4) Physics, Master's Programme (N2PHY)

Main field of studies	*Specialization*
Marine Sciences	A1N, Second cycle, has only first-cycle course/s as entry requirements

Entry requirements

A Bachelor's degree in Natural Science/Engineering/Technology including at least 15 credits in Mathematics (calculus and linear algebra), or equivalent, is required.

Applicants must prove their knowledge of English: English 6/English B from Swedish Upper Secondary School or the equivalent level of an internationally recognized test, for example TOEFL, IELTS.

Learning outcomes

Introduction

Hydrography is the science of measuring and depicting those parameters necessary to describe the precise nature and configuration of the seabed, its geographical relationship to the land mass, and the characteristics and dynamics of the sea. These parameters include bathymetry, tides, currents, waves, physical properties of sea water, geology and geophysics (reference University of Southern Mississippi). Hydrographic information is used to create nautical charts for safety of navigation as well as for coastal zone management. Many of the parameters used in ocean research are measured using hydrographic techniques. Understanding hydrography and the methods and means of collecting and processing hydrographic information provides students with a unique and highly sought after set of skills for both research and the ocean mapping workforce. After this course, students will be able to:

1. Configure, operate and collect data with multibeam systems, and associated equipment and software
2. Process and combine that data in industry standard software
3. Perform quality control and evaluate the data against international standards
4. Create bathymetric surfaces
5. Understand the use of hydrographic in many marine applications; including: charting, coastal zone management, fisheries research, habitat mapping and environment monitoring

Knowledge and understanding

- Understanding of the concepts behind ocean mapping systems and information
- Understanding of the processes for hydrographic data collection and processing
- Knowledge of the products and uses of hydrographic information in research, renewable and non-renewable resource management, coastal zone management

Competence and skills

- Basic programming skills using Python
- Deployment and operation of Hydrographic survey equipment and data collection software
- Use of acoustic data processing software
- Use of satellite positioning equipment, data collection and processing techniques and software
- Develop and use Python code to help evaluate results.
- Create final bathymetric grid surfaces
- Create comprehensive reports detailing all aspects of a hydrographic survey including; data collection, data processing, products, results and quality

Judgement and approach

- Assess the quality of hydrographic information and products
- Diagnose and repair artifacts in bathymertic surfaces
- Create survey project specification given project requirements and necessary standards
- Develop survey project implementation plans (including equipment and methodology) given survey speifications

Course content

The aim of this course is to provide training in applied hydrography for anyone wishing to enter the field of hydrography. The course does not directly address the math, physics, and IT; however, the course does include a "computation tools" module that will cover many aspects of hydrography related aspects of math, physics and IT.

The program will begin with an overview of hydrography. This short course will include all aspects of hydrography from data collection through data processing and analysis to final product. It will include a day of data collection on the new GU research vessel Skagerak. A computation tools module, that will introduce the participants to programming in Python and provide a review of some math and physics concepts, will follow this course. A nautical science and meteorology module will come next, followed by remote sensing and water levels. This will complete the first 5-week section of the program.

The second and third 5-week sections will be comprised of a combination of theory and practical application. Much of the theory will be delivered through an on-line marine geophysics module, which will cover theoretical aspects of marine geology, acoustics, oceanography, positioning, acoustic systems, geodesy, magnetics and geophysics. This module was developed by SU and has been offered on-line for two years.

The on-line theory module will be intermingled with applied hydrography modules. Participants will have the opportunity to collect, process and analyse hydrographic information with the GU, SU MMT and/or SMA vessels, equipment and software. Each step of the instruction will include a discussion on the applicable theory. The on-line theory and practical application module will be synchronized with the applied modules. The applied component will begin with a module for land surveying practice that will include coordinate system transfer and map projections. This will be followed by two modules on hydrographic operations, which include hydrographic data collection. The final module of this section will be used to process the data collected in the previous module and will cover all aspects of hydrographic data management.

The final 5-week section will be dedicated to the Comprehensive Final Field Project (CFFP). The first module will be used to discuss survey standards, specifications and projects. The last 4 weeks of the program will be taken up by the CFFP where

participants will plan and execute a hydrographic survey as per specifications provided by the Swedish Maritime Administration (SMA). This survey will be conducted in an area designated by SMA and the results used in their charting program. Senior surveyors from the SMA and MMT will supervise the CFFP with GU oversite.

Sub-courses

1. **M01 Introduction to Hydrography** *(M01 Introduktion till hydrografi),* 1 higher education credits
   Grading scale: Pass (G) and Fail (U)
   Introduction to hydrography for those that are new to the science. It is comprised of a combination of lectures and demonstrations. The module material is covered over three days. The first day includes a lecture introducing the program and the science of hydrography followed by an on-water demonstration. On-water demonstration includes a small hydrographic survey using the GU research vessel Skagerak. Students are divided into groups of 5 or less and are given a tour of the vessel, which includes a description of all mapping equipment. During survey operations, each group participates in all collection tasks, including multibeam, sub-bottom, CTD, SVP, GNSS, and attitude. The second and third days are spent processing and analyzing the data using state of the art industry software. Experienced personnel conduct the data collection and processing, with students observing. All of the relevant hydrographic science concepts and theory are discussed throughout. At the end of the introductory lecture, students are given an overview of a report of survey. At the end of the module, groups are required to deliver a report of survey using the format discussed in the lecture. Upon completion, students are exposed to equipment, software, procedures and processes that are used through the remainder of the program. All of the information and material for the RoS are provided to the students.

   Learning Outcomes: At the end of the course, the students will be able to

   - Provide an overview of hydrographic data collection and processing methods and procedures.
   - Create a report of survey to the required standards.

   Evaluation Criteria: 100% of the grade for this module is derived from the report of survey. This is a group project and each member of a group will receive the same grade. The report must be completed successfully in order for the student to receive a passing grade. In the case of an unacceptable grade, the report can be corrected and resubmitted

2. **M02 Computation Tools** *(M02 Beräkningsverktyg),* 2 higher education credits
   Grading scale: Pass with Distinction (VG), Pass (G) and Fail (U)
   This course introduces programming and provides a review of the mathematics

and statistics necessary for field hydrographers. Topics covered in this course include programming and plotting in Python, trigonometry, linear algebra, statistics, error propagation, least squares methods, and time series analysis. Practical and hands-on experience on the above topics are conducted using Python with Numpy and MatPlotLib libraries.

Learning Outcomes: At the end of the course, the students will be able to understand the concepts and gain hands-on experience and skill to solve hydrography related problems in the following topics.

- Python Programming and plotting
- Trigonometry
- Basic statistics
- Waves
- Time Series analysis
- Theory of errors and the method of least squares

Evaluation Criteria: 100% of the grade for this course will be derived from the practical exercises. All exercises must be completed successfully in order for the student to receive a passing grade. In the case of an unacceptable grade, the exercise can be resubmitted

3. **M03 Nautical Science and Meteorology** *(M03 Nautisk vetenskap och meteorologi),* 1.5 higher education credits
Grading scale: Pass (G) and Fail (U)
This module covers aids to navigation at sea, safety at sea, instrumentation and equipment deployment and meteorology. Chalmers department of Mechanics, Maritime Sciences designed the module to address the S-5B basic subjects of Nautical Science and Meteorology. It is primarily lecture based with practical exercises, assignments and demonstrations.

   Learning Outcomes: At the end of the course, the students will be able to

   - Describe the use various aids to navigation, including charts and other navigation publications as well as lights, buoys and AIS.
   - Describe the purpose execution of safety procedures and operation of safety equipment.
   - Describe the procedures for safely deploying and recovering ship related equipment and scientific instrumentation.
   - Understand weather observations and forecasting, especially in relation to wind and its effects in the marine environment.

   Evaluation Criteria: 60% of the grade for this course will be derived from the final exam and 40% from the exercises. All exercises must be completed successfully in order for the student to receive a passing grade. In the case of an unacceptable grade, the exercise can be resubmitted

4. **M04 Remote Sensing** *(M04 Fjärranalys),* 1.5 higher education credits
Grading scale: Pass (G) and Fail (U)
The module covers. Extracting bathymetry and topography from LiDAR, Extracting coastlines from LiDAR, extracting bathymetry from satellite imagery, and extracting coastlines from satellite imagery. Chalmers department of Space, Earth and Environment designed the module to address the S-5B Remote Sensing subject material. It is primarily lecture based with practical exercises and reading exercises. The module will use reading exercises and discussions to cover the current application of these technologies in hydrography.

   Learning Outcomes: At the end of the course, the students will be able to

   - Describe the basic concepts of airborne LiDAR
   - Describe the basic concepts of airborne bathymetric LiDAR
   - Describe the basic concepts of satellite derived bathymetry
   - Discuss how LiDAR and Satellite derived bathymetry can be used in hydrography

   Evaluation Criteria: 50% of the grade for this course will be derived from the final exam and 50% from the exercises. All exercises must be completed successfully in order for the student to receive a passing grade. In the case of an unacceptable grade, the exercise can be resubmitted.

5. **M05 Water Levels** *(M05 Vattennivåer),* 1.5 higher education credits
Grading scale: Pass (G) and Fail (U)
The module covers. Tidal and current theory, tide data analysis, vertical datums in hydrography and water level measurement methods. The University of Gothenburg department of Marine Sciences developed the module to address the theoretical aspects of the S-5B Water Levels and Flow subject material. It is primarily lecture based with practical exercises and reading exercises.

   Learning Outcomes: At the end of the course, the students will be able to

   - Describe tide generating forces and major constituent's, including period
   - Describe ocean currents, their driving forces and measurements
   - Identify water level measurement methods, describe their techniques and explain their uncertainties
   - Apply software to analyze tidal data

   Evaluation Criteria: 30% of the grade for this course will be derived from the final exam and 70% from the exercises. All exercises must be completed successfully in order for the student to receive a passing grade. In the case of an unacceptable grade, the exercise can be resubmitted.

6. **M06 Marine Geophysics** *(M06 Marin geofysik),* 7.5 higher education credits
Grading scale: Pass with Distinction (VG), Pass (G) and Fail (U)

Grading scale: Pass with Distinction (VG), Pass (G) and Fail (U)
This online course is offered by Stockholm University (SU) as GG5125. The course introduces marine geophysics aimed to establish a theoretical base for geological interpretation of marine geophysical data. The course covers the theory behind standard marine geophysical mapping methods, with focus on acoustic methods. The course includes a brief historical overview of how geophysical methods have been used to explore the oceans and how seafloor mapping has contributed to understanding of Earth's evolution. This course will be managed by SU and monitored by the GU S-5B program. It will be conducted simultaneously with modules: Positioning, Hydrographic Operations 1 and 2, and Hydrographic Data Management. All theory presented in Marine Geophysics will be augmented and reinforced in these other, applied, modules. Milestones for section (moment) and assignment completion will be set by the GU program to ensure appropriate flow and continuity between modules. The SU Marine Geophysics course, taught online, is divided into 8 Moments:

- Moment 1: History of Marine Geophysics and Mapping of Seabed Morphology
- Moment 2: Offshore Navigation
- Moment 3: Speed of Sound in the Ocean
- Moment 4 L1: Principles of Echo Sounding Methods
- Moment 4 L2: High Resolution Acoustic Seafloor and Sub-bottom Mapping Methods
- Moment 4 L3: Errors and Artefacts
- Moment 4 L4: Water Column and Backscatter
- Moment 5: Marine Seismic Reflection and Refraction Methods
- Moment 6: The Marine Gravity Field
- Moment 7: The Earth’s Magnetic Field at Sea
- Moment 8: Marine Geophysical Mapping of Submarine Glacial Landforms

Learning Outcomes: After completing the course, the student is expected to:

- Know the most widely used marine physiographic mapping methods
- Understand the basic theories behind the most widely used marine physiographic mapping methods
- Understand the principles of how geophysical data are interpreted by geophysical measurement data
- be able to explain the role of marine physiological methods for understanding the Earth's geological development

Evaluation Criteria: Teaching consists of lectures, self-guided learning and exercises. Participation in exercises is mandatory, but they are not marked. The completed exercises are reviewed by the instructor and discussed with the students. Entire grade is based on the final written exam. Grades are based on a seven-

dimensional goal-related grade scale:

• A = Excellent	90-100%	
• B = Very good	80-89.5%	Pass with distinction
• C = Good	70-79.5%	
• D = Satisfactory	60-69.5%	
• E = Adequate	50-59.5%	Pass
• F = Insufficient	0-49.5%	Fail

For the passing grade, the lowest grade E is required and participation in all compulsory education.

Students who have failed in the ordinary exam are entitled to undergo further examinations as long as the course is given. The number of examinations is not limited.

7. **M07 Positioning** *(M07 Positionering),* 1.5 higher education credits
Grading scale: Pass (G) and Fail (U)
This is an instrumentation and data processing module where participants will use land surveying equipment and procedures to collect and process data. Students will learn to set-up a tripod over a point, turn angles and measure distances. They will also run level loops and collect GNSS measurements. A common set of traverse points will be used for all field measurements. All collected data will be reduced and processed to final coordinates. Final coordinates will also be translated from WGS84 to the local Swedish datum. A tide gauge will be installed and levelled in.

   Learning Outcomes: Acquire ability to setup and operate Total station, perform angle/distance measurements and reduction and traverse calculations, reduction and analysis of level loops. Ability to operate GNSS receivers and determine station coordinates. Ability to install a tide gauge.

   Prerequisite: M01 Introduction to Hydrography, M02 Computation Tools, M04 Water Levels

   Co-requisite: M06 Marine Geophysics

   Evaluation Criteria: 100% of the grade for this course will be derived from the practical exercises. All exercises must be completed successfully in order for the student to receive a passing grade. In the case of an unacceptable grade, the exercise can be resubmitted. All exercises will be delivered electronically and in report form

8. **M08 Hydrographic Operations 1** *(M08 Hydrografiska operationer 1),* 1.5 higher education credits
Grading scale: Pass (G) and Fail (U)
This module is primarily lecture based, with practical exercises used to expand on

the delivered material. The practical exercises (PE) include internet searches by students and readings designed to enhance the classroom material. PE deliverables are summaries of the readings. These summaries are discussed at the beginning of subsequent lectures.

Prerequisite: M01 Introduction to Hydrography, M02 Computation Tools, M03 Nautical Science, M04 Remote Sensing, M05 Water Levels, M07 Positioning

Co-requisite: M06 Marine Geophysics

Learning Outcomes: At the end of this course, students will be able to:

- Describe legacy hydrography in the context of charting data
- Describe modern hydrography requirements, such as eNav, under keel clearance and marine spatial data infrastructure
- Describe modern positioning methods (GNSS, ERS, INS and acoustic)
- Distinguish between various seafloor mapping methods and define their applications to hydrography, including both acoustic and optical methods)
- Discuss the legal aspects of hydrography in regard to hydrographer liability as well as maritime boundary delimitation
- Discuss the relationship between the practice of hydrography and its effects on the environment.

Evaluation Criteria: 40% of the grade for this course is derived from the practical exercises. All exercises must be completed successfully in order for the student to receive a passing grade. 30% of the final grade is derived from each of the two exams.

9. **M09 Hydrographic Operations 2** *(M09 Hydrografiska operationer 2),* 1.5 higher education credits
Grading scale: Pass (G) and Fail (U)
The delivery method for this module is through practical exercises and lectures. Students use industry software designed for hydrographic data collection. The module begins with a discussion on the software requirements for hydrographic data collection. The next section is comprised of software training where discussions during the setup and operation of various software packages are used to reinforce theory (i.e. Positioning, attitude, SB, MB, SSS, CTD, SVP, WL, geodetics….). Instrument software, as well as integrated navigation software, are used. Software "playback" functions are used in the classroom to prepare students for field operations. The classroom portion is followed by data collection operations in the field. The GU RV Skagerak (or equivalent) is used to collect calibration information at a calibration site. Data collected during this module is processed in the HDM modules.

   Each piece of equipment or software package is assigned to one or two students, who become the subject matter expert (SME) and are responsible for developing

who become the subject matter expert (SME) and are responsible for developing standard operating procedures (SOP). These SMEs are then responsible for training the other students in the class. The students use the practical exercises to create and update the SOP and RoS. The RoS will carry to the next module (M10 HDM) where it will be completed.

Prerequisite: M01 Introduction to Hydrography, M02 Computation Tools, M03 Nautical Science, M04 Remote Sensing, M05 Water Levels, M07 Positioning, M08 Hydrographic Operations 1

Co-requisite: M06 Marine Geophysics

Learning Outcomes: At the end of this course, students will be able to:

- Configure and operate MB, CTD, SVP, GNSS, attitude and water level instruments
- Develop standard operating procedures
- Train others in the use of equipment
- Conduct CTD, SVP, WL and GNSS water level calibrations (for ERS)
- Configure data collection software and plan a MB calibration survey
- Operate data collection software and conduct a MB calibration survey

Evaluation Criteria: 100% of the grade for this course is derived from the practical exercises. All exercises must be completed successfully in order for the student to receive a passing grade. In the case of an unacceptable grade, the exercise can be resubmitted. All exercises will be delivered electronically and in report form.

10. **M10 Hydrographic Data Management** *(M10 Hydrografisk datahantering),* 3 higher education credits
Grading scale: Pass (G) and Fail (U)
The delivery method for this module is through practical exercises and demonstrations. Students use industry software designed for hydrography to process and analyze the data collected in the Hydrographic Operations module. The module progresses through the data management process from data conversion to a final surface. The software processes are used to reinforce theory. The RoS started in the Hydro Proj2 module will be completed in this module. The material from each practical exercise updates the RoS.

Prerequisite: M01 Introduction to Hydrography, M02 Computation Tools, M03 Nautical Science, M04 Remote Sensing, M05 Water Levels, M07 Positioning, M08 Hydrographic Operations 1, M09 Hydrographic Operations 2

Co-requisite: M06 Marine Geophysics

Learning Outcomes: At the end of this course, students will be able to:

- Compare CTD and SVP data
- Processes High-accuracy GNSS data.

- Compare the GNSS water line against the WL gauge data
- Process MB bathymetry and associated hydrographic information
- Calibrate MB data
- Create a final bathymetric surface
- QC all data and the final surface
- Write an RoS

Evaluation Criteria: 100% of the grade for this course is derived from the practical exercises. All exercises must be completed successfully in order for the student to receive a passing grade. In the case of an unacceptable grade, the exercise can be resubmitted. All exercises will be delivered electronically and in report form.

11. **M11 Hydrographic Projects** *(M11 Hydrografiska projekt),* 1.5 higher education credits
Grading scale: Pass (G) and Fail (U)
Standards, specifications and project management. Use case studies of various survey types. Start with Hydro survey for charting (SMA), then discus other project types at the end (MMT). Majority of the material delivered by guest lecturers from MMT and SMA, and through self-guided study. Each student will develop their own project implementation plan for a specific project, given a set of survey specifications.

    Prerequisite: M01 Introduction to Hydrography, M02 Computation Tools, M03 Nautical Science, M04 Remote Sensing, M05 Water Levels, M06 Marine Geophysics, M07 Positioning, M08 Hydrographic Operations 1, M09 Hydrographic Operations 2, M10 hydrographic Data Management

    Learning Outcomes: At the end of this course, students will be able to:

    - Describe S-44 and FSIS 44 standards
    - Describe various hydrographic survey projects
    - Write a hydrographic survey implementation plan given survey specification

    Evaluation Criteria: 100% of the grade for this course is derived from the project implementation report. This is an individual exercise. In the case of an unacceptable grade, the exercise can be resubmitted. All exercises will be delivered electronically and in report form

12. **M12 Project - Hydrographic Survey** *(M12 Projekt - hydrografisk undersökning),* 6 higher education credits
Grading scale: Pass (G) and Fail (U)
This is a field based course that follows the Hydrographic Projects module. Participants will be divided into groups of 4 or 5 and will be tasked with completing a hydrographic survey in accordance with the survey instructions. The surveys will be conducted in close collaboration with the Swedish Maritime

Administration, who will provide the survey area, vessels and equipment, and project oversight. Participants will spend the first week developing project implementation plans and establishing tide gauges. The first part of the second week will be spent preparing equipment and software, including all calibrations. The latter part of the second week and into the third week will be spent collecting data, including both marine and land based information. The latter part of the third week and into the fourth week will be spent processing and analyzing the collected data. The last day of the final (fourth) week will be used to present the results of the project to an examining committee. All students will present a portion of the project and will be subjected to questions on any part of the project.

Prerequisite: M01 Introduction to Hydrography, M02 Computation Tools, M03 Nautical Science, M04 Remote Sensing, M05 Water Levels, M06 Marine Geophysics, M07 Positioning, M08 Hydrographic Operations 1, M09 Hydrographic Operations 2, M10 hydrographic Data Management, M11 Hydrographic Projects.

Learning Outcomes: Upon the completion of the module, student will be able to apply all of the learning outcomes from the previous modules.

Evaluation Criteria: Each individual will be graded on their presentation and oral exam (50%), participation (10%), and final report of survey contribution (40%).

Form of teaching

The teaching takes place mainly in the form of: Lectures, exercises / calculations / field work, seminars, oral presentations and written reports.

Language of instruction: English

Assessment

Each module (sub-course) is assessed using one or more of the following:

- Written examinations
- Oral presentations
- Solved exercises as written reports
- Written reports

The course will be assesses through a comprehensive exam consisting of a written report, oral presentation and oral exam

For students who have not passed, additional examination sessions are offered. The possibilities to supplement not completed practical components can be limited and are determined in consultation with the course responsible teacher.

If a student, who has failed the same examined component twice, wishes to change examiner before the next examination, a written application shall be sent to the department responsible for the course and shall be granted unless there are special reasons to the contrary (Chapter 6, Section 22 of Higher Education Ordinance).

In cases where a course has been discontinued or has undergone major changes, the student shall normally be guaranteed at least three examination occasions (including the ordinary examination) during a period of at least one year from the last time the course was given.

Grades

The grading scale comprises: Pass with Distinction (VG), Pass (G) and Fail (U).
The grade Pass (G) for the whole course requires the grade G on all modules (sub-courses). Pass with Distinction (VG) for the whole course will be given according to a weighted average mark on all modules (sub-courses).

Concerning application of the ECTS grading scale please see 28/05/2007, D No. G 8 197/07 as well as 28/02/2011, D No. O 2009/05545.

Course evaluation

A written course evaluation will be done after the end of the course. The evaluation will be used to improve the course next year.