

Canadian Board of Examiners for Professional Surveyors
Core Syllabus Item
C12: HYDROGRAPHIC SURVEYING

Syllabus Topics:

The hydrographic surveying elective syllabus item C12 covers all aspects of hydrographic surveying. The emphasis is placed on charting surveys given that, in most cases, they have the most stringent requirements. The learning outcomes are a subset of the outcomes defined in the IHO M5 document “Standards of Competence for Hydrographic Surveyors”. The learning outcomes are divided into several sections including acoustics, bottom determination (singlebeam, sidescan sonar, multibeam and non-acoustic), water levels, water flow, horizontal positioning, vertical positioning and hydrographic survey practice and standards.

The acoustics section covers all aspects of sound propagation through the water column, including the physical properties of water that affect that propagation. Bottom determination sections include the use of singlebeam echosounders, side scan sonars, multibeam sonars and non-acoustic depth determination techniques.

Vertical positioning includes tidal and non-tidal water level variations, datums as well as vessel orientation (heave, pitch, roll and heading). The primary horizontal positioning technique in hydrography is GPS. It is assumed that GPS is covered in C6: Geodetic Positioning and is not addressed here. Acoustic positioning techniques are addressed here.

Programmable calculators may be used in the examinations of this item; however, candidates must show all formulae used, the substitution of values into them, and any intermediate values to 2 more significant figures than warranted for the answer. Otherwise, full marks may not be awarded even though the answer is numerically correct. A collection of formulae are provided with the examination questions.

Recommended Prior Knowledge and Skills:

Item C1: Mathematics

Item C2: Least-Squares Estimation and Data Analysis

Item C3: Advanced Surveying

Item C4: Coordinate Systems and Map Projections

Item C5: Geospatial Information Systems

Item C6: Geodetic Positioning

Item C7: Remote Sensing and Photogrammetry

Learning Outcomes:

In order to fulfill the requirements of this syllabus item, candidates should be able to:

1. Underwater Acoustics

- Acoustic Velocity Describe effects of the physical properties of water on the calculation of sound speed. Calculate sound speed from measurements of temperature, pressure (depth), and salinity (conductivity).
- Ray Tracing Describe the basic principles of ray path development and analysis. Predict shadow zones and sound channels.

- Acoustic System Parameters Define frequency, beamwidth, pulse-length, pulse repetition rate, detection threshold, bandwidth, and resolution.
- Acoustic Devices Describe the purpose and operation of acoustic devices such as: transponders, pingers, tripping devices and sound speed meters, acoustic Doppler current profilers.

2. Single-beam Echosounders

- Transducers Discriminate between the following types of transducers: narrow beam, wide beam, parametric.
- Recording Differentiate between analogue and digital recording systems and media.
- Sounder Calibration Evaluate and select appropriate echosounder calibration methods and equipment for specific applications.
- Sounding Reduction Explain and apply the reductions to measured depths due to water level variations, draft, dynamic draft (settlement, sinkage, squat, fuel depletion, and buoyancy changes) and transducer separation. Evaluate and apply all appropriate factors affecting depth reductions for specific applications.
- Sounding Accuracy Calculate and assess the uncertainty in soundings due to errors in the positioning system, echo-sounder, water level measurement, vessel motion and seabed topography. Evaluate and select appropriate methods for controlling or reducing sounding uncertainty for specific applications.
- Acoustic Sweeps Explain the design of boom systems and the effect of transducer spacing and survey speed on full ensonification. Specify the transducer spacing and survey speed for a boom system, to ensure full sonar coverage for specific applications.
- System selection Identify echo sounder characteristics that affect performance in varying survey applications. Specify appropriate echo-sounder characteristics (e.g. resolution, depth capability, frequency, bandwidth, beamwidth) for specific applications.

3. Sidescan Sonar

- Side Scan Systems Explain the effect on sidescan sonar performance of frequency, beam angle, resolution, gain, towing speed, and deployment (deep tow, shallow tow, pole mount). Evaluate and select appropriate sidescan frequency, features and deployment, for specific applications.
- Side Scan Data Interpretation. Explain sonar signatures of such items as debris from wrecks, pipelines, gas, fish and fresh water.

4. Multibeam Sonar

- Multibeam Transducers Explain the basic principles of multibeam sonar transmit and receive beam forming, steering, shading and focussing, using flat or curved transducers. Describe the differences between the various methods of bottom detection (amplitude or mean time, bearing direction indicator, split-aperture differential phase, and fast Fourier transform).
- Coverage and Accuracy Explain the dependence of depth coverage and uncertainty on bandwidth, beam-width, beam elevation angle, depth, ping rate, sound speed uncertainty, vessel attitude and motion (speed, heave, roll, pitch, heading and yaw). Describe motion compensation techniques. Estimate depth coverage and uncertainty, taking all factors into account.

- Multibeam Calibration Explain the effects on depth and position uncertainty of errors in sensor locations and alignments within the vessel reference frame. Define the "patch test". Establish the vessel reference frame and sensor offsets and alignments. Select test area and lines to be run for "patch test". Calibrate the misalignments between transducer and motion sensor.
- Multibeam Data Management Describe issues affecting acquisition, processing, storage and retrieval of multibeam data. Explain methods for managing data quality. Specify and design a multibeam data management strategy, for specific applications.

5. Non-acoustic Bathymetric Techniques

- Laser Bathymetry Explain the principles, capabilities and limitations of laser bathymetry. Select survey areas suitable for laser bathymetry.
- Remote Sensing Bathymetry List remote sensing techniques applicable to bathymetry. Describe the basic principles of airborne and satellite techniques.
- Mechanical techniques Describe wire and bar sweeps.

6. Water Levels and Flow

- Tidal Fundamentals Describe tide generating forces and the static and dynamic tidal theories. Describe the major harmonic constituents. Identify and recognise the different types of tide. Explain the concept of amphidromic points and cotidal charts. Define different tidal levels. Classify tidal regimes.
- Tidal Measurements Explain the principles of various types of water level gauges and poles. Describe characteristics of river, coastal and offshore water level gauges. Evaluate and select appropriate instruments and sites for water level monitoring.
- Tidal Streams and Currents Describe the relation between streams and tides. Describe methods for measuring tidal streams and currents, including log ship, pole and current meters.
- Non-tidal Water Level Variations Describe the temporal and spatial effects on water level caused by: atmospheric pressure, wind, seiches, and precipitation. Identify water level variations occurring in rivers and lakes and due to dam operations. Evaluate and select appropriate locations for water level gauges in rivers, lakes, and near dams, for specific applications.

7. Horizontal Positioning

- Acoustic Positioning Concepts Describe the principles of long, short and supershort baseline acoustic positioning system modes. Describe the deployment and calibration, signal structure, sources of error, and expected uncertainties for each mode. Specify the deployment and calibration method. Predict and evaluate sources of error and expected uncertainties for each system and appropriate application (towed bodies, autonomous underwater vehicles, remotely operated vehicles).

8. Vertical Positioning

- Vertical Positioning Fundamentals Explain and describe the characteristics of height systems (e.g. dynamic, orthometric and normal heights). Differentiate between gravity-related and ellipsoidal heights.
- Datums Describe the role of, and methods of establishing, the various vertical datums used in hydrographic operations (e.g. Chart, Sounding, MSL, LAT, LW, and HW)

datums). Select, establish, interpolate and transfer datums in oceans, coastal waters, estuaries, rivers, and lakes for soundings and elevations.

- Elevation Measurements and Computations Describe methods for determining differences in elevation (e.g. by spirit level, vertical angle, and GNSS). Correct for effects of curvature and refraction, where appropriate. Describe the principles of satellite altimetry. Compare and evaluate the observing methods and procedures for the determination of elevation (e.g. by spirit level, theodolite, and satellite systems). Select an appropriate system for specific applications. Describe how bathymetry can be predicted from satellite altimetry.
- Heave Describe the principles and limitations of heave compensation systems. Describe the role of filtering in making heave measurements. Evaluate and select appropriate heave compensation systems for specific applications.
- Orientation Describe the operation of heading sensors (e.g. flux-gate and other magnetic, fibre-optic and gyro compasses). Explain the principles of inertial roll and pitch sensors. Describe the principles and limitations of GNSS attitude sensors. Evaluate and select appropriate heading, roll and pitch sensors, for specific applications. Describe field alignment checking procedures.

9. Types of Hydrographic Surveys and Specifications

- Nautical Charting Surveys Describe the purposes of nautical charting surveys - all essential data to ensure safety of navigation. Define the components of a nautical charting survey (general depths, wrecks and obstructions, shorelines, navigation aids, etc.). Explain IHO survey specifications.
- Surveys in Support of Port Management and Coastal Engineering Describe and distinguish between surveys for dredging, environmental monitoring and hydraulics, including surveys at a large scale. Describe the methods and instruments used (e.g. geotechnical, magnetic, diving, and cameras).
- Instrumentation Compare specifications of bathymetric systems (single beam echosounders, multibeam echosounders, interferometric sidescan sonar, and Lidar). Explain the importance of the correct installation and determination of the attitude and position of each sensor.
- Operations Describe the roles of the following survey parameters: scale, positional accuracy, survey speed, line orientation, interlines, cross lines, fix interval, data coverage. Explain methods for quality control of survey data, and the quality assurance of surveys. Describe cost estimating, and project scheduling. Create specifications for specific surveys, including appropriate requirements for scale, positional accuracy, survey speed, line orientation, interlines, cross lines, fix interval, and data coverage. Specify methods to be used for quality control of survey data, and the quality assurance of surveys.

Essential Reference Material:

All of the listed materials are available online.

1. International Hydrographic Organization (IHO):
http://www.iho.shom.fr/PUBLICATIONS/IHO_Download.htm
 - a. C-13 Manual on Hydrography, 1st Edition, May 2005,
http://www.iho-ohi.net/iho_pubs/CB/C13_Index.htm

A comprehensive treatment of hydrographic Surveying

- b. S-44 IHO, 5th Edition, Standards for Hydrographic Surveying,
http://www.iho.shom.fr/publicat/free/files/S-44_5E.pdf

International standards for hydrographic data collection

- 2. US National Oceanic and Atmospheric Administration (NOAA):
<http://tidesandcurrents.noaa.gov/pub.html>

- a. NOS Hydrographic Surveys Specifications and Deliverables,
<http://www.nauticalcharts.noaa.gov/hsd/docs/Specs2009.pdf>

A comprehensive treatment of hydrographic Surveying

- b. Tidal Datums and Their Applications, NOAA Special Publications NOS CO-OPS 1,
http://tidesandcurrents.noaa.gov/publications/tidal_datums_and_their_applications.pdf
- c. Computational Techniques for Tidal Datums Handbook, NOAA Special Publications NOS CO-OPS 2,
http://tidesandcurrents.noaa.gov/publications/Computational_Techniques_for_Tidal_Datums_handbook.pdf
- d. Understanding Tides, by Steacy Dopp Hicks,
http://tidesandcurrents.noaa.gov/publications/Understanding_Tides_by_Steacy_finalFINAL11_30.pdf
- e. Tidal Currents, Educational Pamphlet #4,
<http://tidesandcurrents.noaa.gov/publications/TidalCurrentsEducationalPamphlet4.pdf>
- f. Co-Ops Specifications And Deliverables For Installation, Operation, And Removal Of Water Level Station, http://tidesandcurrents.noaa.gov/publications/CO-OPS_Specifications_and_Deliverables_for_installation_operation_and_removal_of_water_level_stations_updated_November2008.pdf

- 3. US Army Corps of Engineers (USACE): Hydrographic Surveying,
<http://140.194.76.129/publications/eng-manuals/em1110-2-1003/toc.htm>

A comprehensive treatment of hydrographic Surveying

- 4. University of New Brunswick (UNB):

- a. GGE 3353, Imaging and Mapping II, Sub Marine Acoustic Imaging Methods,
http://www.omg.unb.ca/GGE/SE_3353.html

A comprehensive treatment of hydrographic Surveying

- b. GGE 5013, Oceanography and Tides for Hydrographic Surveyors,
http://www.omg.unb.ca/GGE/GGE5013_Current.html

Hydrographic applications of oceanography and tides

- c. The Calibration of Shallow Water Multibeam Echo-Sounding Systems, TR190, Andre Godin, 1998, <http://gge.unb.ca/Pubs/TR190.pdf>

A comprehensive treatment of Multibeam patch test calibration techniques

- 5. Canadian Hydrographic Service:

- a. Standards for Hydrographic Surveys, 2005, <http://chs-shc.gc.ca/data-gestion/hydrographic/standards-normes-eng.pdf>

A comprehensive treatment of hydrographic Surveying

- b. Canadian Tidal Manual, Forrester, W.D., Hydrographic Chart Distribution Office, DFO, 1675 Russell Road, Ottawa, ON. K1G 3H6 ISBN 0-66—11341-4. Also available in PDF online at: http://www.pol.ac.uk/psmsl/training/canadian_manual/index.html

A comprehensive description of tides and water level transfer techniques for hydrographic surveying

Supplementary Reference Material:

1. International Hydrographic Organization (IHO):
http://www.iho.shom.fr/PUBLICATIONS/IHO_Download.htm
- c. S-32 Hydrographic Dictionary, 5th Edition, <http://www.iho.shom.fr/publicat/free/files/S-32-eng.pdf>

A listing of hydrographic terms and acronyms