Canadian Board of Examiners for Professional Surveyors
Study Guide (V3, 2017)
C12: HYDROGRAPHIC SURVEYING

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.

Links to reference material can be found at the end of this document.

1. Underwater Acoustics and Oceanography

- Name the three properties of sea water that affect the speed of sound through the ocean. What are their units and typical ranges? What is the typical range of sound velocity in ocean water?
- Which property has the greatest effect in the upper layer?
- What is the thermocline?
- Which property has the greatest effect below the thermocline?
- What is the sound channel and why does it exist?
- Draw a typical sound velocity profile from the warm upper layers, through the thermocline to the deep ocean, near the equator and near 60° north. Explain why they are different.
- Describe two different methods of measuring sound velocity.
- How does the variation in sound velocity affect vertical incident sound waves (e.g. from a single beam echoshouder)?
- How does the variation in sound velocity affect oblique incident sound waves (e.g. off nadir multibeam sonar returns)?
- Describe Snell's Law and how it is used in acoustic ray tracing
- Describe how the following acoustic system parameters effect sound wave propagation; frequency, beamwidth, pulse-length, pulse repetition rate, detection threshold, bandwidth.
- Draw a wave and label the components

2. Single-beam Echosounders

- Discriminate between narrow beam and wide beam transducers.
- Describe the difference between analogue and digital recording systems and media.
- Describe one method of calibrating an analogue echosounder
- With the help of a diagram, describe the components necessary for reducing water depth measurements from the transducer face to a chart datum.
- Describe the components affecting the vertical uncertainty of a reduced depth from a single beam system. Use a diagram to support your answer.
- How does the acoustic footprint (beamwidth) affect horizontal uncertainty? Is it necessary to measure pitch and roll? Why?
- Specify appropriate echo-sounder characteristics (e.g. resolution, depth capability, frequency, bandwidth, beamwidth) for a shallow water, single beam survey in a soft bottom Harbour.
- Describe the advantages and disadvantages of various transducer mounting options (e.g. over the side, or fixed hull).
- Describe in detail how (and why) you would conduct a single beam survey in the following scenarios:
    - Order 1B in shallow water
    - Pipeline River crossing
    - Dredging
    - Deep water

3. Multibeam Sonar

- Explain the basic principles of multibeam sonar transmit and receive beam forming and steering. Distinguish between physical and electronic beam forming techniques.
- Compare and contracts beamforming and phase differencing multibeam systems
- With the help of diagrams explain the dependence of depth coverage and uncertainty on:
    - Bandwidth
    - beam-width
    - beam elevation angle
    - depth
    - ping rate
    - sound speed uncertainty
    - vessel attitude
    - vessel motion (speed, heave, roll, pitch, heading and yaw)

- Describe vessel motion compensation techniques for: speed, heave, roll, pitch, heading and yaw.
- Explain the effects on depth and position uncertainty from:
    - errors in sensor locations and alignments within the vessel reference frame
    - sound velocity
    - vessel motion
    - timing
- What is a "patch test" and why is it performed?
- With the use of diagrams, describe the four main errors that a “patch test” is designed to address. Make sure you include where, how and why the patch test lines are run.
- Compare and contract shallow water and deep water multibeam systems

4. Sidescan Sonar

- Explain the effect on sidescan sonar performance from:
    - Frequency
    - beam angle
    - resolution (along track and across track)
    - gain
    - towing speed
    - Deployment (deep tow, shallow tow, pole mount)
    - Height above the bottom

- Describe sonar signatures from
    - debris from wrecks
    - pipelines
    - gas
    - fish
    - fresh water

5. Water Levels and Flow

- Describe in detail the tide generating forces and how they interact
- Describe the major harmonic constituents
- Define different tidal levels.
- Describe the four basic tidal regimes and describe how they are categorized
- Explain the principles of four types of water level measurement devices.
- Describe the relation between streams and tides
- Describe methods for measuring tidal streams and currents, including log ship, pole and current meters
- Describe the temporal and spatial effects on water level caused by:
    - atmospheric pressure
    - wind
    - seiches
    - precipitation

6. Vertical Positioning

- With the help of a diagram, describe the various vertical datums used in hydrographic operations, including tidal, geodetic and ellipsoidal.
- Describe a method for establishing the separation between an ellipsoid and chart datum.
- Describe the field observations and procedures necessary for establishing the elevation of a tide gauge from a benchmark.
- List the vessel motion and orientation parameters and describe how they are measured.
- Explain the principles of inertial roll and pitch sensors

7. Understanding Principles and Technology

- Compare and contrast singlebeam, multibeam and sidescan sonar systems. Under what circumstances would you use a singlebeam and side scan sonar as opposed to a multibeam system?

- Describe the quality control procedures you would follow prior to a hydrographic survey, during the survey and at the end of the survey.

- Describe the multibeam processing workflow from data collection to a final bathymetric surface.

8. Hydrographic Surveys

- Describe the basic survey "orders" as defined in the "S-44 IHO, 5th Edition, Standards for Hydrographic Surveying". Include:
    - horizontal and vertical uncertainties for soundings
    - minimum object detection size
    - bottom coverage

- Write out the basic equation used to define the allowable vertical uncertainty as per the "S-44 IHO, 5th Edition, Standards for Hydrographic Surveying."

- Describe the purposes of nautical charting surveys including all essential data collection necessary to ensure safety of navigation

- Describe how you would conduct a hydrographic survey for a pipeline river crossing.

- Describe how you would conduct pre-dredge and post-dredge hydrographic surveys.