Introduction:

Successful completion of this module is a prerequisite to undertaking a course in Simulated Electronic Navigation at the Operational level (SEN O) and at the Managerial level (SEN M).

Attendance

The course is 90 hours in length, including assignments and examinations. Students must be present at least 90% of the time. Failure to maintain at least 90% attendance will result in the student not being permitted to write the final examination.

Evaluation

1st Assignment	10% of final grade
Mid term Examination	30% of final grade
2nd Assignment	10% of final grade
Final Written Examination	50% of final grade

Students will be required to achieve a minimum pass mark of 60% in each of the assignments, the mid-term and final examinations. Students will not be permitted to sit the final examination unless they have achieved a minimum pass mark in the mid - term examination.

An overall combined average score of 70% in the midterm examination, assignments and final examination will be required to achieve a course pass mark and be issued an EXN 24.

*(Note * The information below does not apply to the online course.)*
The mid-term and final examinations are of three hours duration each. Student's cell phones, tablets or computers will not be allowed in the examination room during the examinations.

The mid-term exam consists of 25 multiple choice questions.

The final examination consists of a section of descriptive answers, including calculations and simple drawing exercises and a section of multiple-choice questions.

The examination is divided into three sections; they are:
20 multiple choice questions worth two marks each;
5 multiple choice questions worth four marks each
1 descriptive question on "Radar / ARPA" worth 20 marks; and
1 descriptive question on compasses worth 20 marks.

It should be noted that a number of new technologies and techniques are being introduced to the mariner in this course. It is strongly recommended that students review items covered each day, as homework, in order to be able to clearly understand the topics that have been covered. If a student is having difficulty it is advisable to ask questions early rather than wait until the day before an examination is undertaken.

Syllabus

The Transport Canada requirements for this course are:

	Subject	Knowledge Required
Competence		**Plan and conduct a passage and determine position**
1.	**Knowledge of Electronic systems of position fixing**	**Introduction to Hyperbolic Positioning Systems** Ability to describe, with reference to position fixing, the nature of a hyperbola; The principles of the hyperbolae being position lines and ability to draw a hyperbolic pattern; The causes of ambiguity and reduced accuracy in the baseline extension area; Method of ascertaining position. **Loran-C and eLoran** Knowledge of the Loran-C and eLoran system; Ability to draw block diagram of a Loran-C receiver, showing how time differences are measured; How ambiguity in position line is resolved; Why third-cycle matching is used; How the use of sky waves affects the measured time difference; Ability to describe typical radii of coverage areas; Ability to identify the LORAN chart and the additional information printed thereon; Switch on equipment, select chain and relate the time differences obtained to the correct station pair; Ability to recognise warnings which indicate that the system may be faulty; The basic operating principles of eLoran; The principal difference between eLoran and traditional Loran-C; The use of eLoran when satellite services are disrupted; Ability to describe the control, operating and monitoring systems of eLoran; The view mode and signal tracking of eLoran; The advantages and limitations of eLoran. **Global Navigation Satellite Systems** The principles of operation of global navigation satellite systems; The intended level of accuracy of the system. **GPS systems and DGPS systems** The basic principles of the GPS; Ability to describe the system configuration; Atomic clock signal information; The frequencies that are used; Ability to describe the C/A & P codes; How the basic line measurement is obtained; The Dilution of Precision (DOP); The various DOPs that are used; The various errors of GPS; Selective availability; What is WGS 84; Datum shifts;

1.	**Knowledge of Electronic systems of position fixing**	The advantages and limitation of GPS; The basic principle of Differential GPS; DGPS frequency; The limitation of the DGPS receiver; Ability to set-up and initialize a GPS/DGPS receiver. **GLONASS and GALILEO systems** The principle on which GLONASS works; The different satellite constellation configurations under GLONASS and GPS respectively; The advantage of the receiver capable of operating both GLONASS and GPS (combined GPS/GLONASS system receiver); The limitation of the GLONASS system receiver; The principles of Galileo as the European satellite navigation system; Ability to describe that Galileo comprises 30 medium earth orbit (MEO) satellites in 3 circular orbits; The satellite geometry and dual atomic clocks in the Galileo system; The limitations of Galileo system receiver.
Competence		**Plan and conduct a passage and determine position**
2.	**Knowledge of electronic depth sounding system and speed and distance measurement**	**Echo-sounder systems and logs** The principles of echo sounding: a) The principles of sound transmission in water; b) How an echo sounder uses sound to perform its functions. The components of an echo sounder: a) Identify the principal components; b) Ability to describe the function and operational maintenance of each principal component. Ability to demonstrate the setting up procedure for an echo sounder: a) Ability to list the controls found on an echo sounder; b) Ability to demonstrate the function of each control; c) Ability to prepare an echo sounder display for use. The use of the echo sounder data: a) Application of echo sounder data to general navigation; b) Application of echo sounder data to specific navigation. The errors and limitations of an echo sounder: a) List and describe the errors of an echo sounder; b) List and describe the limitations of an echo sounder; c) The causes of inaccuracies to instrument or scale error and their likely magnitude and measures that may be taken to eliminate them; d) Recognise the various types of false echo that may be observed, describe their formation and state the possible action to remove them from the trace; e) The potential error due to trim, heel and transducer separation; Name the different types of log. The need for a log; Ability to determine the speed of the vessel; Ability to determine the distance traveled by the vessel;

2.	**Knowledge of electronic depth sounding system and speed and distance measurement**	Ability to determine the log error; Ability to identify the information given by a log; Ability to identify the vessel's speed through the water; Ability to find the vessel's speed over the ground.
Competence		**Plan and conduct a passage and determine position**
3.	**Knowledge of the basic principle and the operational use of AIS and VDR system**	**AIS and VDR systems** The AIS Concepts and IMO standards; AIS Data, information and frequencies; AIS Ship Installation; AIS data overlays on ECDIS/ ARPA display; Ability to use the AIS at sea; The function and carriage requirements of VDR; Knowledge of VDR IMO standards; Knowledge of VDR types.
Competence		**Plan and conduct a passage and determine position**
4.	**Knowledge of ship's compass and steering system**	**Magnetism of the earth and ship deviation** The theory of magnetism as applied to ferromagnetic materials; Ability to describe a simple magnet, its poles and the law of attraction and repulsion; Ability to describe the magnetic field around a magnet; Ability to describe magnetic induction and differentiates between hard and soft iron; The meaning of the terms: intensity of magnetization, permeability, magnetic susceptibility (no mathematical formula required); Ability to describe the magnetic field of the earth; Definition of magnetic poles and magnetic equator; Definition of angle of dip; How the earth's total field can be split into horizontal and vertical components; Definition of magnetic variation and why it is a slowly changing quantity; Ability to describe the compass needle in relation with the horizontal components of the earth's field and the field due to the ship's magnetism; The effect of introducing a disturbing magnetic force into the vicinity of a compass needle; Ability to use a vector diagram to find the field at a point resulting from two given fields. **The Magnetic Compass** Ability to sketch and describe the construction and the composition of a liquid magnetic card; How the card is kept practically horizontal in all latitudes Ability to describe all the components elements of a magnetic compass; Ability to describe magnetic compass liquid; Definition of deviation;

4.	**Knowledge of ship's compass and steering system**	Ability to illustrate with sketches the deviation on various heading produced by permanent magnetism with a pole or poles lying in the plane of the compass card; How deviation chart is made; The precaution to be made around magnetic compass; Maintenance, error verification and compass adjustments. **The Gyro-Compass** The basic principle of a gyro-compass; Free gyroscope and its gimbal mounting; What is meant by gyroscopic inertia and precession; What is meant by tilt and drift; The apparent movement of the gyroscope on the earth's surface, given its position and initial latitude; How a free gyroscope can be made north-seeking by the use of gravity control and describe the resulting oscillation of the axis; The use of damping in azimuth and damping in tilt to cause settling of the axis; How control and damping can be achieved; Ability to describe a familiar gyro-compass with particular reference to: a) The method of support; b) Control and damping arrangement; c) The method of maintaining the heading indication in line with the axis of the gyro; d) The transmission of the heading to repeaters. The performance standard for heading control systems; Ability to describe the starting and stopping procedure for a gyrocompass; Ability to demonstrate the correct starting procedure; Ability to describe the correct stopping procedure; Ability to describe the set-up procedure for a gyrocompass repeater system; a) What are the various applications of gyrocompass repeaters: b) Describe the set-up procedure for each type; c) Describes how gyro heading input is supplied to radar installation. The alarms fitted to a gyro-compass; The operational checks and performance monitoring functions to be performed on a gyro-compass and repeaters; The checks required for a gyro-compass; The documentation necessary: a) The limitations of a gyro-compass; b) The effect of each limitation. **Fluxgate compass** Definition of singles axis and dual axis of a fluxgate compass; Ability to explain basic operation; Explain Transmitting Magnetic Compass; Solid state type. **Steering control system components** The principles of an automatic pilot system; The functions of the manual settings;

4.	**Knowledge of ship's compass and steering system**	The procedures for change-over from automatic to manual steering and vice-versa; What is meant by an adaptive automatic pilot and how it functions; The course monitor and off-course alarm; The operation of the course recorder log; The other alarms fitted to the system; The regulation regarding the use of the automatic pilot; The recommendation on performance standards for automatic pilots.
Competence:		**Use of RADAR and ARPA to maintain safety of navigation**
5.	**Knowledge of the basic theory and operation of a marine Radar System**	**Fundamental principles of a radar system** The principles of range and bearing measurement; The function and siting of component. **Radiation hazard and precautions and safe distance** The importance of not storing radar spares nearer to magnetic compasses than the specified safe distance; The safety precaution necessary in the vicinity of open equipment and the radiation hazard near antennae and open waveguides. **Recognize that radar consists of computer components** The main components of a computer system: input device, output device, printed circuit board, Central Processing Unit (CPU), Memory; Relate computer processing to radar: Analogue and digital concepts, analogue to digital converter, Auto-tuning, Auto-clutter, Trails, manual plotting, Image expansion and image averaging. **Characteristics of radar sets and factors affecting performance** The relationship between maximum range and pulse recurrence frequency; The relationship between detection range and transmitted energy (power and pulse length); The relationship between minimum range and pulse length; The effects on bearing and range accuracy of beam width, heading marker error, centring error, yawing, parallax, variable range marker and gyro error; The effects on bearing discrimination beam width, spot size, plan position indicator tube size, pulse length, gain; The difference between x-band radar and S-band radar (Frequencies, antennas); Advantages and disadvantages of X-band and S-band Radar; **Factors external to the radar set affecting detection** Ability to use the equation for the distance to the radar horizon and ability to explain the relationship between antenna location and detection ranges; The effect of variations in refraction on radar detection range (super refraction, sub refraction, surface duct, elevated duct); The effect of precipitation on radar detection ranges (rain, hail, snow fog); Ability to identify blind areas and shadow areas, permanent blind and shadow sectors and their relationship to the antenna location;

5.	**Knowledge of the basic theory and operation of a marine Radar System**	How characteristics of targets influence their detection range (aspect, shape, composition, size); How clutter may mask targets (sea clutter and rain clutter). **Factor which might cause faulty interpretation of the radar picture** Relative motion and true motion presentation; The cause and effect of interference; The cause and effect of side echoes; The cause and effect of indirect echoes; The cause and effect of multiple echoes; The cause and effect of second trace echoes; The effect on radar performance of power lines and bridge crossing rivers and estuaries; The effect of the ship in seaway; The effect of ship in ice covered waters. **IMO Performance standards for radar equipment** The performances standards contained in Res. 477(XII), annexe 4, Recommendation on performance Standards for Radar equipment as amended by IMO resolution MSC.64 (67) Annex 4; Required accuracy (range and bearing measurement); Required discrimination (range and bearing); Carriage requirement for radar as mentioned in the Navigation Safety regulation SOR/2005-134.
6.	**Knowledge of the set up and the operation of Radar in accordance with manufacturer's instructions.**	**Set up and maintain optimum radar display** Ability to operate main controls (Power, antenna); Ability to operate transmitter controls (Standby/transit, pulse length, PRF); Ability to adjust receiver controls to give an optimal picture (tuning, gain, linear/logarithmic gain, sensitivity time control, fast time control); Ability to adjust display controls (brilliance, illumination, focus, shift, range selector, range rings, VRM, EBL, mechanical cursor, heading marker, anti-clutter); The presentation of: Head-up, Course-up, North-up, relative motion mode, True motion mode; The function of each radar display control; The operation of radar in high speed Craft (ref. High Speed Craft Code); Routine radar checks; The periodic operational checks to be performed by the radar operator; The purpose and the contents of radar logs.
7.	**Knowledge of an ARPA System**	**ARPA systems display characteristics** Different display characteristics: Vectors, graphics, digital read-out, PPC, PAD; Different ways in which targets may be acquired; The sensors that supply ARPA input data; The processing of the input data; The ARPA output displays.

7.	**Knowledge of an ARPA System**	**IMO performance standards for ARPA** IMO performance standards for ARPA as mentioned inside IMO Resolution A.823(19), Annex, *Recommendation on Performance Standards for Automatic Radar Plotting Aids (ARPAs);* The requirements for acquisition and tracking targets; The requirements for accuracy of ARPA; Operational warning required; Which data which should be available in alphanumeric form; The effects of sensor errors for ARPA equipment complying with IMO performance standards; Performance standards for gyro and log inputs; The performance standards for range and bearing accuracy and discrimination of radar; Knowledge of ARPA IMO symbols; Carriage requirement for ARPA as mentioned in the Navigation Safety regulation SOR/2005-134. **Acquisition of targets principles** The criteria for target acquisition; The criteria for automatic selection of targets given in the set's instruction manual; The criteria to be used for manual acquisition targets**;** The maximum number of targets which may be acquired; Appropriate use of suppression of target acquisition over certain areas. **ARPA tracking capabilities and limitations** Target tracking by ARPA; How targets are lost and alarm activated; Common circumstances leading to target swop; The effect of target swop on displayed data. **ARPA processing delays** The delay in the display of processed ARPA data after target acquisition; Delay in the display of new data when the target ship manoeuvres.