SECOND ENGINEER REG III/2
MARINE ELECTRO-TECHNOLOGY

LIST OF TOPICS

A Electric and Electronic Components
B Electric Circuit Principles
C Electromagnetism
D Electrical Machines

The expected learning outcome is that the student:

A Electric and Electronic Components

1. Understands the physical construction and characteristics of basic components.

   1.1 Compares the characteristics of conductors, semi-conductors and insulators in terms of the Electron Theory.

   1.2 Defines the basic quantities of electricity,eg charge, current, emf, potential difference, energy and power.

   1.3 Describes resistance, inductance and capacitance in terms of physical dimensions and materials.

   1.4 Solves numerical problems relating R, L and C to their physical parameters.

   1.5 Appreciates how temperature affects conductors, semi-conductors and insulators.

   1.6 Defines temperature coefficient of resistance at O˚C (α_0) and also at a stated temperature (α_t).

   1.7 Calculates change in conductor resistance using the temperature coefficients in 1.6.

   1.8 Draws and labels the principal parts of a lead acid cell.

   1.9 Describes (without using chemical formulae) the action of charge and discharge on the components of the cell.

   1.10 Explains how the state of charge of a lead acid cell may be measured using a hydrometer.

   1.11 Draws and labels the principal parts of an alkaline cell, Nickel iron or nickel cadmium.

1.12 Explains how the state of charge may be assessed for alkaline cells.

1.13 Compares lead acid and alkaline cells on the basis of:

(a) voltage per cell;
(b) performance under poor conditions of charge/discharge;
(c) retention of charge;
(d) effect of temperature;
(e) mechanical strength;
(f) weight;
(g) cost.

1.14 States that the capacity of a battery is measured in ampere hours at a given rate.

1.15 Solves problems on efficiency of batteries in terms of ampere-hours and watt-hours.

1.16 Solves problems involving batteries in series and in parallel combinations including internal resistance and current in a connected load.

1.17 Draws a simple charging circuit from a dc supply.

1.18 Measures the state of charge of a battery before and after carrying out the charging procedure.

1.19 States the two common types of semi conductor material as germanium and silicon.

1.20 Explains the formation of 'p' type and 'n' type semi conductor materials referring to the doping process.

1.21 Draws a p-n junction in forward and reverse bias modes and indicates electron flow and conventional current flow in the junction and in the external circuit.

1.22 Obtains the static characteristic curves for forward and reverse biasing of the pn junction from test results.

1.23 States the need for rectification of alternating voltages.

1.24 Explains and draws circuit diagrams to show how rectification of an ac single phase supply is obtained using:

one diode; two diodes and centre tapped transformer; and bridge connected diodes.

1.25 Draws the input and output waveforms for the rectifier circuits in 1.24.

1.26 Explains the formation of a pnp and npn alloy junction transistor.

1.27 Draws a circuit diagram showing pnp and npn transistors connected in the common emitter mode.

1.28 Draws and explains a circuit diagram illustrating the use of a transistor as a switch.

1.29 Draws and explains a circuit diagram illustrating the use of a transistor as an alternating small signal amplifier.

1.30 Describes the photo-electric effect and its application to photo-diodes.

1.31 State some marine applications of 1.28 and 1.30.

B Electric Circuit Principles

2. Understands the operation of simple linear dc and ac electrical circuits and solves related problems.

2.1 States Ohms Law.

2.2 Solves problems on 2.1.

2.3 States Kirchhoffs Current Law.

2.4 States Kirchhoffs Voltage Law.

2.5 Describes a series circuit configuration using a variety of components and finds the equivalent resistance.

2.6 Describes a parallel circuit configuration using a variety of components and finds the equivalent resistance.

2.7 Solves problems on series/parallel circuits.

2.8 Solves problems on power and energy in dc resistive circuits.

2.9 Solves problems using Kirchhoffs laws by application of simultaneous equations (two unknowns only).

2.10 Explains the principle of the Wheatstone.bridge and derives the balance equation.

2.11 Solves problems related to 2.10.

2.12 Defines an alternating emf in terms of its maximum value, rms level, periodic time, frequency and its time equation.

2.13 States that e = E MAX sin 2reft volts.

2.14 Explains that the resultant current will also be sinusoidal and represented by i = I MAX sin 21-rft ampers.

2.15 Solves problems related to 2.13 and 2.14.

2.16 Draws the wave forms for above and indicates peak value; peak to peak value; periodic time; frequency.

2.17 Explains terms, mean value, rms value and form factor with reference to a sine wave.

2.18 Calculates the rms value, mean value and form factor of sinusoidal and non-sinusoidal wave forms.

2.19 Explains the term phasor quantity.

2.20 Explains how phasors may be used to represent sinusoidal quantities.

2.21 Solves graphical problems involving addition and subtraction of ac voltages and currents using phasor method.

2.22 Sketches the current, voltage and power waveform patterns of a pure:

(a) resistor;
(b) inductor;
(c) capacitor;

when connected to a sinusoidal supply.

2.23 Draws phasor diagrams for pure resistive, inductive and capacitive circuits and distinguishes between in phase, lagging and leading currents.

2.24 Defines and calculates inductive reactance and capacitive reactance.

2.25 Constructs and uses phasor diagrams for R-L, R-C and R-L-C series circuits.

2.26 Sketches and uses impedance triangles for the series circuits in 2.25.

2.27 Defines phase angle and active and reactive components.

2.28 Resolves phasor quantities into active,and reactive components eg I cos 0 and I sin 0.

2.29 Solves circuit problems using circuit elements connected as in 2.28.

2.30 Constructs a diagram in terms of active power, apparent power and reactive power.

2.31 Defines power factor as the ratio of active power to apparent power.

2.32 Solves problems related to 2.30 and 2.31.

2.33 Measures and notes value of V, I and P in an R-C and R-L series ac circuit.

2.34 Draws a phascr diagram from the results in 2.33 and calculates the power factor and capacitance/inductance of the circuit.

C Electromagnetism

3. Understands the principles of magnetism and electromagnetic induction.

3.1 Explains the terms magnetic polarity, magnetic field, magnetic flux, magnetic flux density.

3.2 States that a current carrying conductor produces a magnetic field.

3.3 Draws the magnetic field pattern for a straight conductor, loop and a solenoid carrying current.

3.4 Determines the polarity of fields in 3.3 using corkscrew rule, right-hand gripping rule, end rule as appropriate.

3.5 Explains the terms magnetomotive force and magnetic field strength.

3.6 Explains the effect of introducing a magnetic material into a magnetic field.

3.7 States the units of flux and flux density.

3.8 Explains the use of magnetic screening.

3.9 Explains the term reluctance and states the advantages and disadvantages of leaving air gaps in magnetic circuits.

3.10 States that $S = \frac{F}{\Phi}$

3.11 Explains the terms

(a) absolute permeability;
(b) permeability of free space;
(c) relative permeability.

3.12 States that $B = \mu_0 \mu_r H$ and explains that μ_r is not a constant.

3.13 Draws the B-H curve for a non magnetic material.

3.14 Draws the B-H curve for a typical ferromagnetic material.

3.15 States that different ferromagnetic materials will give different B-H curves.

3.16 Solves problems on simple non composite magnetic circuits to include the use of graphs.

3.17 Solves problems on composite magnetic circuits (to include air gap) and the effect of fringing and leakage.

3.18 States that a current carrying conductor in a magnetic field has a force exerted on it.

3.19 Determines the direction of the force in 3.18.

3.20 States that the magnitude of the force is given by

$F = BIl$ newton and $F = \frac{aB^2}{2\mu_0}$ newton.

3.21 Solves problems related to 3.20.

3.22 States that the ampere is defined on the basis of the force between two current carrying conductors.

3.23 States Faraday's law of electromagnetic induction.

3.24 States Lenz's Law.

3.25 States that the magnitude of the emf induced in a coil is determined by:

(a) the number of turns;
(b) the rate of change of flux cutting the coil and

$$e = \frac{N\Delta\Phi}{\Delta t} \text{ volts.}$$

3.26 Explains that other factors, principally the material of the coil core, also determine the value of induced emf.

3.27 Solves problems related to 3.25.

3.28 States that an emf can be self induced in a coil.

3.29 States that $e = \frac{L\Delta_i}{\Delta t}$ volts.

3.30 Defines the unit of self inductance.

3.31 States that $L = N\frac{\Delta\Phi}{\Delta I}$ and $L = \frac{N^2}{S}$

3.32 Solves problems related to 3.29, 3.31.

3.33 Shows that the energy stored in the magnetic field of a current carrying coil is given by $\frac{1}{2}L^2$ joules.

3.34 States that changing magnetic flux emanating from one circuit can induce an emf in another.

3.35 States that the effect in 3.34 is called mutual inductance.

3.36 Defines the unit of mutual inductance.

3.37 States that the emf of mutual inductance is given by $e = M\frac{\Delta_i}{\Delta_t}$ and $M = k\sqrt{L_1}L_2$

3.38 States examples of mutual inductance effect eg transformer, engine ignition coil.

3.39 Solves problems related to 3.37.

3.40 States that a conductor moved in and at right angles to a magnetic field will have an emf induced between its ends and determines its direction.

3.41 States that the magnitude of the emf will be determined by $E = Blv$ volts.

3.42 Solves problems related to 3.41.

D Electrical Machines

4. Understands the principles and applications of dc and ac motors and generators.

4.1 States that:

(a) motors convert electrical energy into mechanical energy;

(b) generators convert mechanical energy into electrical energy.

4.2 Explains using simple sketches the action of a single loop dc generator and motor.

4.3 Describes the function of a commutator.

4.4 Labels on a given diagram the essential parts of a dc machine.

4.5 Sketch circuits for shunt, series and compound wound dc machines.

4.6 Relates the emf induced in the armature of a dc generator to the expression $E = 2Z\Phi n\frac{p}{A}$ volts A

4.7 Solves problems related to 4.6.

4.8 Solves dc generator circuit problems using $V = E - I_A R_A$

4.9 Obtains the load characteristics of shunt and compound dc generators.

4.10 Relates the 'back emf' (E_b) induced in the armature of a dc motor to the expression $E_b = 2Z\Phi n\frac{p}{A}$ volts.

4.11 Solves dc motor circuit problems using $V = E_b + I_a R_a$.

4.12 Explains the need for starting resistance for a dc motor.

4.13 Explains the method of speed control for a dc motor using variation of armature voltage and field methods.

4.14 Explains that for a dc machine $E \alpha \Phi n$ and $E \alpha Ia \Phi$

4.15 Solves problems using

$$\frac{E_1}{E_2} = \frac{\Phi_1}{\Phi_2} \times \frac{n_1}{n_2} \text{ and } \frac{T_1}{T_2} = \frac{Ia_1}{Ia_2} \times \frac{\Phi_1}{\Phi_2}$$

4.16 Recognises the power losses which occur in dc machines.

4.17 Obtains the load characteristics (T/Ia) of shunt, series and compound dc motors.

4.18 Explains the basic operation of an ac generator.

4.19 Labels on a given diagram the essential parts of a 3 phase, ac generator of both salient and cylindrical rotor construction.

4.20 Explains how to safely synchronise an incoming 3 phase ac generator to live busbars using lamps and/or synchroscope and voltmeters.

4.21 Obtains the load characteristics of a 3 phase ac generator under various power factor conditions.

4.22 Explains the basic principle of operation of the 3 phase single cage ac induction motor.

4.23 Describes with sketches the construction of the 3 phase single cage ac induction motor.

4.24 Obtains the load characteristic (T/n) of a 3 phase ac single cage induction motor.

4.25 States typical marine applications for the motors in 4.17 and 4.23 and generators.