Engineering Management Level (III/2) Academic Syllabi

Contents:

III/2 – Applied Mechanics

The candidate will know:

Statics

The conditions of equilibrium of a body subject to a system of both coplanar and non-coplanar forces and/or moments.

Apply conditions of equilibrium.

Pin jointed frameworks.

Centre of gravity and centroid.

Friction

The effects of static and dynamic friction on rigid bodies at rest and moving on an inclined plane with uniform velocity.

Kinematics

Linear, angular and relative motion.

Motion of projectiles and moving objects.

The concept of relative and absolute velocity.

Dynamics

Force and energy.

The laws of motion applied to rotational dynamics.

Simple harmonic motion.

Machines

The principles of simple machines.

Strength of Materials

The effects on a material caused by the application of external forces.

The effect of temperature change on materials.

Stresses in thin cylinders and thin rotating rims.

Cantilevers, simply supported beams and the stability of axially loaded columns.

Torsion of circular shafts.

Elastic strain energy.

Stresses on oblique planes.

The candidate will be able to:

Statics

Resolve forces applied obliquely into perpendicular components using vectors.
State and explain the Principle of Moments.

Describe the classification of the lever: as one of three orders; straight or cranked; simple or compound.

Describe concurrent non coplanar force systems and state the conditions for equilibrium of a rigid body subject to a number of non-concurrent coplanar and concurrent coplanar force systems.

Solve problems analytically and graphically on concurrent coplanar and non-coplanar force systems involving up to four forces in equilibrium; to include the static condition of crank and overhung connecting rod.

Explain how 3 non parallel coplanar forces must be concurrent for equilibrium.
Solve problems involving Equilibrium, Resultant and Equilibrant in concurrent coplanar force systems.

Define moments of mass, volume and area.

Explain the principle of Rapson's slide.

Describe stable, unstable and neutral equilibrium.

Determine the support reactions for simple frameworks subjected to a maximum of 3 vertically applied forces, by graphical and/or analytical methods.
Explain the terms Strut and Tie.

Explain what is meant by a pin joint, solve problems using Bow's Notation related to pin joints and also the magnitude and nature of the force in the members of a simple framework.

Determine the magnitude and nature of the force in simple frameworks by graphical methods.

Explain how a centre of gravity can be determined by taking moments of mass.

Explain how a centroid can be determined by taking moments of area.

Solve problems involving centroids for laminas made up of combinations of:

Rectangles, Circles, Triangles, Semi circles. (N.B. Centroid position for semicircle to be given).

Friction

State and explain the laws of dry friction.

Solve problems related to forces acting on a body resting on a frictionless plane inclined to the horizontal.

Resolve the components of gravitational force acting on a body that is on an inclined plane.

Distinguish between static and dynamic friction.

Describe the effects of lubrication in relation to friction.
State examples of useful and detrimental effects of friction applied to marine engineering.

Solve problems involved in holding or causing a body to ascend and descend an inclined plane at uniform speed by means of: a force acting parallel with the plane; a force acting horizontally; the least force; forces acting at any angle.

Solve problems involving wedges and cotters.

Solve problems involving: frictional force, normal reaction and coefficient of friction for bodies both at rest and moving up or down an inclined place with uniform velocity.

Solve problems involving work lost due to friction.

Kinematics

Identify the relationship between linear and angular motion.

Solve problems analytically and graphically relating to linear and angular motion.

Explain relative and absolute velocity.

Using vector diagrams, determine the relative velocity of connected bodies in simple mechanisms.

Solve by analytical and/or graphical methods;

- Problems involving the horizontal and vertical components of the motion of a projectile;
- Problems relating to relative and absolute velocity of unconnected bodies.
- Problems relating to the relative velocity between two coplanar linear velocities to include elapsed time and closest approach.

Dynamics

State Newton's laws of motion and explain the concept of inertia.

Solve problems involving momentum, impulse, energy, work done and power; to include impact of non-elastic bodies.

Solve problems in which bodies are hauled by a connected body or winch in ascent and/or descent of an inclined plane.

Solve problems relating to Potential Energy and Kinetic Energy of translation.

Sketch and explain work diagrams for both constant forces and uniformly varying forces.

Use work diagrams in relation to springs.

Solve problems relating to work done and power; to include power lost due to bearing friction.

Solve problems relating to the relationship between torque, angular acceleration and moment of inertia.

State the expressions for the moment of inertia of an annular disc and composite flywheels, comprising of plain and annular discs.

Explain the concept of radius of gyration in relation to a thin rim type flywheel.
Solve problems relating to kinetic energy of rotation.

Solve problems involving connected masses passing over frictionless light pulleys, including inclined planes.

Solve problems involving masses connected to separate ropes on stepped flywheels, including inertia and friction.

Solve problems on the concept of fluctuation of speed and energy.

Solve problems involving combinations of translational and rotational motion.

Define angular momentum and state the conservation of angular momentum.

Calculate the rate of change of angular momentum and angular impulse.
Solve problems on the torque to overcome friction on a thrust collar bearing.

Solve problems involving torque and power transmitted by single flat plate and cone friction clutches.

Solve problems involving centripetal and centrifugal forces on a body moving in a circular path with uniform angular velocity.
Solve problems relating to simple harmonic motion with reference to crankshafts, piston speeds and cams

Machines

Describe the concepts of simple lifting machines, in relation to wheel and axle, differential wheel and axle, rope pulley blocks, differential rope pulley blocks, chain blocks, screw jack, Warwick screw, worm and wheel mechanisms, and hydraulic jacks.

Determine the law of a machine.

Solve problems relating to Effort, Load, Mechanical advantage (MA), Velocity or Movement ratio (VR) and Efficiency for the above machines.

Describe the transmission of power and torque through simple and compound gear systems.

Solve problems involving speed ratio, power and torque transmitted for a gear system.

Explain power transmission via belt drives.

Determine the torque transmitted in terms of belt tensions.

Solve problems involving: speed ratios, power and torque transmitted for a belt drive system.

Strength of Materials

Draw and explain load/extension graph from experimental data and from it obtain: E, UTS yield stress, limit of proportionality, % area reduction, and % elongation, elastic limit, ultimate load and breaking load and indicate a cup and cone fracture.

Explain how a material subjected to a direct force experiences both direct and shear stresses on an oblique plane.

Define 'Factor of Safety' and state features to be considered when deciding upon its value.

Explain the term proof stress and how it is obtained from a stress/strain graph.

Solve problems involving the shear stress in simple components e.g. jointed stays.

Determine the direct and shear stresses on an oblique plane of a material subjected to axial force and mutually perpendicular forces (or stresses).

Show that the maximum shear stress occurs on a 45° plane.

Explain the concept of complementary shear stress.

Determine the direct and shear stresses on an oblique plane of a material subjected to axial force and mutually perpendicular forces (or stresses), including applied shear stress.

Solve problems involving simple, stepped and compound bars subjected to axial loading.

Determine the linear expansion of components subjected to a temperature change.

Determine the linear strain and thermal stresses in single and compound components when expansion or contraction is restricted.
Determine the stresses set up in simple and stepped bars subjected to linear thermal strain.
Calculate Hoop Stress and Longitudinal stress in thin cylinders.
Solve problems involving direct and shear stresses on oblique seams of thin cylinders.

Calculate the Hoop Stress in a thin rotating rim.

Explain the relationship between Shear Force and Bending Moment and the need for a sign convention when dealing with each.

Explain the slope and deflection of loaded beams and calculate the SF and BM at any point along a given beam.

Solve problems using bending theory, together with the concepts of BM diagrams for beams with square, rectangular, circular and annulus sections subjected to combinations of point loads and uniformly distributed loading together, sketch the SF and BM diagrams for the standard cases: cantilever with point load at free end; simply supported beam with UDL along total length; cantilever with UDL along total length; simply supported with an offset bracketed load; loading case of uniformly varying distributed loading.

Show that the Neutral Axis of the section passes through the centroid.
Determine maximum bending moment and point(s) of contra-flexure from BM diagram.

Explain the concept of combined bending and direct stresses.

Describe how eccentric and inclined loading can induce both bending and direct stresses and solve problems involving sections symmetrical and non-symmetrical about their NA.

Explain the concept of buckling and define the term ‘slenderness ratio'.
Solve problems using given Euler equation.

Differentiate between maximum torque and mean torque.

Define torsional stiffness and determine the shear force in shaft coupling bolts given the transmitted torque.

Solve problems regarding torsion in relation to uniform and stepped shafts of solid and/or hollow section and to shaft and pulley arrangements.

Define strain energy and resilience.
Solve problems relating to components subjected to gradually applied and impact loading.

Solve problems involving conversion of PE and/or KE into strain energy to determine the maximum instantaneous stress and deformation.

Solve problems relating to the strain energy of a helical spring in terms of linear deflection, torque and axial load.

III/2 –Electro Technology

The candidate will know:

Resistive Direct Current (DC) Circuits.

DC Transient Circuits.

Construction and operation of 3 Phase Synchronous Alternating Current (AC) Generators.

Balanced and unbalanced 3 Phase AC Circuits.

Construction and operation of 3 Phase AC Motors.

Construction and operation of AC Transformers.

AC distribution load sharing.

Use of electronics in marine applications.

The candidate will be able to:

Resistive Direct Current (DC) Circuits.

Solve problems using Ohm's and Kirchhoff's laws involving a maximum of two unknowns for the following:

- Radial feeders
- Ring mains
- Double-fed systems using dissimilar voltages

DC Transient Circuits

Solve problems in relation to growth and decay of electrical quantities of series connected RC circuits during charging and discharging.

Solve problems in relation to growth and decay of electrical quantities of series connected RL circuits during switch on and/or switch off using a steady DC supply.

Construction and operation of 3 Phase Synchronous Alternating Current (AC) Generators:

Sketch the waveform diagram of three phase voltages.

Apply the relationship between frequency, number of poles and speed.

Describe the constructional details of the following: Stator, rotor (cylindrical and salient), methods of excitation, terminal box and cooling arrangements.

Calculate the EMF value of a generator.

Explain the need for Automatic Voltage Regulation describing the different methods of excitation

Determine the terminal voltage for varying loads and power factors.
Explain generator protection required for single and parallel operation.

Explain insulated and earth neutral systems.

<u>Balanced and unbalanced 3 Phase AC Circuits</u>:

Solve problems for balanced star and/or delta connected three phase AC loads comprising RLC elements in relation to: Phase voltages and line voltages, Phase currents and line currents, Power factor and Power factor correction.

Sketch 3 phase voltage and current diagrams.

Solve problems on unbalanced three phase AC loads in relation to the magnitude and angular orientation of the neutral conductor current.

<u>Construction and operation of 3 Phase AC Motors</u>:

Describe the construction of the different types of 3 phase AC motor.

Explain the operating principles of 3 phase AC motors, including torque/slip curves.

Solve problems on: Slip, Frequency of rotor EMF, Synchronous speed, Rotor speed, Stator losses, Rotor copper losses, Output and input power, Motor torque, Motor current and Efficiency.

Describe starting and speed control methods of a 3 phase AC motor.

Solve problems relating to synchronous motors being used for power factor correction.

<u>Construction and operation of AC Transformers</u>:

Explain the principles of operation of single phase transformer.

Describe the construction of single phase transformer.

Solve problems on the application of transformer EMF equation, ratios of transformers, and

VA ratings of transformers.

Sketch and explain ideal and practical transformer phasor diagrams.

Solve problems involving transformer phasor diagrams.

Solve problems involving transformer losses and efficiency.

Explain, and identify applications of, 3 phase transformer connections (star/delta, star/star, delta/delta, and delta/star) and standard identification of connections.

Describe the principle of operation of an autotransformer including applications and circuit diagrams.

Solve problems on autotransformers, involving voltages, turns ratio, and tapping points.
Describe the function of instrument transformers including applications and circuit diagrams.

AC distribution load sharing:

Solve problems relating to: active power, reactive power, apparent power, power factor, power factor correction.

Use of electronics in marine applications:

Explain the operation of a p-n junction diode in forward and reverse bias conditions, including characteristic curves.

Sketch and describe the circuit diagram and input and output waveforms for full-wave and half-wave rectifiers, including smoothing.

Determine mean dc rectified voltage for half and full wave single phase circuits given ac input supply and vice versa.

Explain the operation of pnp and npn bi-polar transistors in common base, common emitter and common collector connections.

Sketch the circuit diagram for a bipolar transistor used as a switch and explain its action, with reference to marine applications.

Sketch the circuit diagram for a bipolar transistor small signal amplifier and explain its action, with reference to marine applications.

Calculate the current flow in a transistor switching circuit used for control or alarm purposes. Explain the photo-electric effect and its application to photo-diodes and identify a use of the photo-diode in a marine application.

Describe the construction, characteristics and operation of a thyristor, including bias voltage polarities necessary for "turn-on", necessary conditions for "turn-off" and identify applications.

Sketch a thyristor circuit using variable phase shift control, showing typical load current and voltage.

Describe the construction, characteristics, operation and application of a zener diode

Sketch a basic dc stabiliser circuit and calculate values of: voltage, current and power, under change of load and supply voltage.

III/2 – Naval Architecture

The candidate will know:

Hydrostatics

Resultant hydrostatic force on an area immersed at any depth in a liquid.

Centre of Pressure of an area immersed at any depth in a liquid.

Archimedes Principle.

Stability and Trim

Principles of flotation.

Simpson’s Rules.

Procedures for determining transverse stability.

Procedures for determining longitudinal stability (trim).

Ship Stresses

Methods of evaluating shear forces and bending moments on ships of simple geometric form.

Ship Resistance

Factors involved in the resistance to motion and the power required for a ship at any given speed.

Methods of estimating power and fuel consumption.

Propellers and Rudders

Propeller terminology and the relationships between engine power and the propeller performance.

Principles of propeller cavitation.

Types of rudders and the effect on the stability of the vessel when helm is applied.

The candidate will be able to:

Hydrostatics

Solves problems relating to the resultant thrust and centre of pressure for immersed areas (rectangular, circular, triangular and trapezoidal) positioned vertically and inclined, including when the free surface is subject to a gas pressure.

Calculate the resultant thrust and centre of pressure for a vertical rectangular area wetted by two immiscible liquid, including when the free surface is subject to a gas pressure.

Solve problems relating to Archimedes Principle for bodies floating in and descending vertically through a liquid.

Stability and Trim

Calculate displacement, buoyancy, TPC, KB, KM data of different ship forms for construction and use of hydrostatic curves.

Use Simpson’s Rules or other appropriate method to calculate area, first moment of area and second moment of area used in calculating ships displacement, stability and trim.

Calculate the position of the centre of gravity of a ship under any condition of loading.

Describe the different types of stability and their effect on the ship.
Calculate measures of stability for different load conditions for small angles of heel including the use of the wall sided formula.

Describe the effect of free surface liquids on transverse stability and solves problems involving free surface effect

Describe the inclining experiment and solve problems relating to the inclining experiment.

Use cross curves of stability to determine stability at large angles of heel for varying load conditions.

Describe the effects of the change of form on stability.
Calculate change of trim and end draughts of a ship due to the movement, addition or removal of small masses

Use hydrostatic curves or data to calculate change of trim and end draughts for large mass changes.

Describe and calculate the change of transverse stability due to dry docking.
Solve problems on the change of stability and trim due to bilging.

Ship Stresses

Construct load, shear force and bending moment diagrams for vessels of simple geometric form and load conditions.

Solve problems of load, SF and BM for vessels of simple geometric form and load conditions.

Ship Resistance

Describe and calculate the components of resistance to motion and power required for a ship at any given speed.

Calculate approximate power using Admiralty Coefficient.

Calculate the variation in daily fuel consumption with speed and the fuel requirements for a given voyage.

Propellers and Rudders

Describe propeller terminology and solve problems involving true and apparent slip, thrust, torque and efficiency.

Describe the relationships between powers measured at points between the ship's engines and the propeller making use of thrust deduction factor, hull efficiency, propeller efficiency, transmission efficiency, mechanical efficiency, propulsive coefficient and quasi propulsive coefficient.

Describe the phenomenon of propeller cavitation, its causes, effects and methods of reduction.

Distinguish between unbalanced, balanced and semi-balanced rudders and calculate the principal forces acting on the ship and rudder when helm is applied.

Solve problems involving heeling of a ship due to rudder helm being applied.

Reading List.

Muckle W Naval Architecture for Marine Engineers (revised by D A Taylor) Butterworth ISBN 0713667346
Rawson KJ and Tupper EC – Basic Ship Theory Vols 1 & 2 (Butterworth – Heinemann Ltd, 2001) 0750653965 & 0750653973
Stokoe E A — Reed’s Naval Architecture for Marine Engineers (Adlard Coles Nautical, 2003) ISBN: 0713667346
Taylor D — Merchant Ship Construction (IMarEST, 1998) ISBN: 1902536002

III/2 – Applied Heat

The candidate will know:

Individual and sequences of thermodynamic processes;

Heat engine cycles;

Single and multistage reciprocating compressors;

Combustion of solid, liquid and gaseous fuels by mass and by volume.

Heat transfer through thick cylinders, spheres, heat exchangers and insulated systems;

Hydrodynamics;

Two phase steam systems and steam cycles;

Steam flow through a nozzle;

Steam turbines;

Two phase refrigeration and heat pump cycles.

The candidate will be able to:

Individual and sequences of thermodynamic processes.

Define and apply the fundamental properties of thermodynamics to a process.

State Boyle's Law, Charles' Law, ideal gas law and the combination law.

State the Equation of State.

State and apply the relationship between pressure, volume and temperature for polytropic and adiabatic processes.

Determine graphically and analytically the polytropic index ‘n'.

Explain a reversible process.

Define Isentropic as a reversible adiabatic process and identify the difference between Isentropic and non-reversible adiabatic processes.

Define a reversible process carried out with an ideal gas for the following:

- Constant volume process;
- Constant pressure process;

- Isothermal process;
- Isentropic or adiabatic or constant heat process;
- Polytropic process.

Represent each of, or combination of each of the thermodynamics processes listed above on p-V and T-s diagrams.

Explain the concept of entropy as a thermodynamic property of a perfect gas.

Solve problems relating to the heat energy transfer, work energy transfer and

change of entropy associated with the thermodynamic processes.

State Avogadro's Law.

Define kg - mol and apply it in the Equation of State.

Define "Molar Volume" and state its value at Standard Temperature and Pressure (S.T.P.)

Solve problems relating to Avogadro's Law and the Universal Gas Constant.

<u>Heat engine cycles.</u>

Apply the principles and concepts of heat engine cycles.
Explain the 2nd law of thermodynamics and relate this to the heat engine.

Identify the sequence of thermodynamic processes associated with the Carnot Cycle with reference to a heat engine.

Determine the thermal efficiency of a Carnot Cycle.

Apply Carnot's principle to show that no cycle can be more efficient without contravening the 2nd law.

Identify and sketch the sequence of thermodynamic processes associated with each of the ideal engine cycles on p – V and T –s diagrams. i.e. Otto, Diesel, Dual

Combustion and Joule cycles.

Define air standard efficiency.

Solve problems involving thermal efficiency, indicated mean effective pressure and net work done for ideal engine cycles.

Identify the practical counterparts of ideal engine cycles.

Identify and sketch the simple ideal and actual open and closed gas turbine cycles on p – V and T –s diagrams.

Identify the effects on the simple ideal and actual open and closed gas turbine cycles on p – V and T –s diagrams of each of, or combination of, the following:

- Two stage compressors;
- Multi stage turbines;
- Reheat;
- Optional heat exchanger (recuperator).

Define heat exchanger "Effectiveness" and "Thermal Ratio".

Solve problems associated with the simple ideal and actual open and closed gas turbine cycles in relation to thermal efficiency, work ratio, work compatibility and net work done.

Single and multistage reciprocating compressors

Define each of the following:

- Clearance volume;
- Induced volume;
- 'Free air' delivery for an air compressor;
- Volumetric efficiency based on 'free air' and actual air conditions.

Sketch the ideal p-V diagram for a compressor with and without clearance volume and explain how the actual cycle for a single stage compressor differs from the theoretical cycle.

State the effect of compressive index on net indicated work transfer.

Relate ideal (isothermal) and actual (polytropic) compression cycles.

Explain multi-stage compression and identify the advantages of same.

Define conditions of minimum work as applicable to multi-stage compression.

Explain the effects on multi-stage compression when minimum work does not apply.

Distinguish between indicated and input power requirements.

Determine heat transfer during compression and interstage cooling.

State the significance of Clearance Ratio.
Solve problems involving work input, mechanical efficiency and heat balance across single and multi-stage compressors.

Combustion of solid, liquid and gaseous fuels by mass and by volume.

Explain the combustion of solid, liquid and gaseous fuels by mass and by volume in terms of air requirements, excess air and products of combustion.

Explain the chemistry definitions: Atom, Molecule, Compound, Atomic Mass and Molecular Mass.

State the equations of combustion by mass.

State the equations of combustion by volume for gaseous fuels.

Determine the stoichiometric and actual air requirements.

Apply Avogadro's Hypothesis to exhaust and flue gas analysis.

Determine total flue gas and dry flue gas analysis by mass and by volume.

Determine air supply from flue gas analysis.

Determine the proportional gravimetric constituents of a fuel from flue gas analysis.

Identify the exhaust products resulting from insufficient air supply and determine C burned to CO and CO burned to CO_2.

Apply Dalton's law and Gibbs-Dalton law to stoichiometric and other mixtures of gaseous fuels and air.

Determine the mean molecular mass of a mixture of gases and the specific gas constant for the mixture.

Determine the "dew point" of water vapour from flue gas analysis.

Determine heat carried away in flue gases.

Heat transfer through thick cylinders, spheres, heat exchangers and insulated systems

Explain the modes of heat transfer by conduction, convection and radiation.

State Fourier's Law for conductive heat transfer through single planar walls.

State Fourier’s equation for conductive heat transfer through composite walls of a maximum of three layers.

State and apply expressions for heat transfer through thick cylinders, single and double lagged pipes, spheres and hemispherical ends of cylinders.

Explain the principles of heat transfer through boundary layers and apply thermal conductance coefficients.

Determine the overall heat transfer coefficient "U" for composite flat plates and composite lagged pipe systems, using thermal conductivity and surface heat transfer coefficient.

Solve problems involving heat transfer rate, thermal conductance, surface heat transfer coefficient, thermal conductivity and interface temperature for composite planar, cylindrical and spherical systems.

Apply principles of heat transfer to heat exchangers.

Determine heat transfer of gas to air and gas to water heat exchangers.

Solve problems involving heat exchangers using "log mean temp difference".

Hydrodynamics;

Explain the concepts of energy related to the steady flow motion of liquids.

Explain the volumetric and mass flow rates of liquids and state the continuity equation.

Explain the concept of coefficient of velocity (C_V), coefficient of contraction (C_C), and coefficient of discharge (C_d) for a sharp edged orifice.

Identify the various forms of energy possessed by a liquid in motion and state the expression for these in terms of energy and equivalent head.

Apply the principle of the conservation of energy and the Bernoulli expression.

Explain the effect of friction related to flow problems and how this is included with the Bernoulli statement.

Apply the above to a venturi meter.

Explain the concept of the coefficient of discharge, c_d, with reference to a venturi meter.

Solve problems using the principle of the conservation of energy and the Bernoulli expression to: parallel and tapering pipes, venturi meters positioned horizontally, vertically and inclined; both frictionless and systems with friction to be included.

State D'Arcy's formula for friction losses in pipelines.

Explain 'equivalent length' of pipes to allow for energy losses at bends and valves.

Solve problems related to friction loss in pipes, bends and valves.

Solve problems related to changes in momentum of liquids in motion.

State that force is equal to the rate of change of momentum.

Apply an expression for the instantaneous pressure rise due to rapid valve closure.

Determine the resultant force on pipe bends due to change of momentum.

Determine the power of a hydraulic jet.

Solve problems related to the impact of jets on stationary flat plates and moving plates positioned perpendicular and inclined to jet.

Explain the principles of a centrifugal pump.

Determine impeller width for constant and variable radial flow velocity through an impeller.

Determine volumetric flow rate through an impeller.

Determine the work done on the fluid passing through a centrifugal pump.

Apply the expression for manometric head and determine manometric efficiency.

Solve problems involving: impeller speed, blade angles, fluid velocity, pump efficiency, capacity and power for shockless flow.

Two phase steam systems and steam cycles

Explain the concept of steam generation and identify steam terms in relation to change of state.

Determine the mass of a given volume of saturated, dry or superheated vapour.

State that an operation following the law pV^n = a constant is a hyperbolic operation when the working fluid is a vapour.

Calculate changes in the enthalpy and internal energy of a vapour during constant pressure and constant volume operation.

Calculate the final condition of the vapour after an operation to the law pV^n = a constant.

Explain the concepts of throttling.

Explain the concepts of entropy of liquid, vapour and super-heated steam and demonstrate their evaluation from steam tables and given formulae.

Explain the construction and demonstrate the use of h-s and T-s charts.

Explain the isentropic expansion of steam and demonstrate this process on h-s and T-s diagrams.

Explain the Carnot Vapour Cycle and modifications resulting in the basic Rankine Cycle.

Explain the improvements to the basic Rankine cycle from super-heating, reheating and feed heating.

Sketch the Carnot, basic Rankine and modified Rankine Cycles on two property diagrams.

Identify and apply an expression for thermal efficiency when operating on the above cycles.

Determine the heat energy distribution in a boiler plant and compile a heat balance account.

Determine feed pump work and relate this to plant thermal efficiency.

Explain bled steam feed heating and determine the heat transfer by steam and feed water through multi-stage contact and surface feed heating systems.

State Dalton's Law of partial pressures and demonstrate its application to partial volumes, steam/air mixtures in condensers and associated plant.

Apply thermodynamic properties of water and steam to solve problems on mixtures, evaporators and steam generators, including interpolation of tables and use of h–s, p–V and T–s diagrams and charts.

Steam flow through a nozzle

Define a nozzle and give practical applications of where nozzles are used in steam turbines.

Explain the use of steam as a working fluid and its behaviour during flow through nozzles under equilibrium conditions.

Explain that increase in K.E. at nozzle exit is proportional to the enthalpy drop.

Apply steady flow energy equation to flow through steam nozzles and determine throat and exit velocities.

Identify the differences between isentropic and actual enthalpy drop in nozzles and define nozzle efficiency.

State reasons for change of nozzle form and use of convergent and convergent/divergent sections.

Determine critical pressure ratio for nozzle flow from given formulae.

Solve problems on nozzles with regards to mass flow rates and flow areas.

Steam turbines

Sketch combined velocity diagrams and determine the power developed in a single stage impulse turbine and a single stage reaction turbine.

Draw the vector diagram for inlet and outlet steam velocities over a turbine blade for shockless flow.

Combine the inlet and outlet diagrams to form a single diagram and identify on said diagrams each of the following:

- Velocity of whirl;
- Effect of blade friction (blade velocity coefficient);
- Absolute inlet and exit velocities;
- Relative inlet and outlet velocities;
- Fixed and moving blade inlet and exit angles.

Draw the combined velocity diagram for a single stage reaction turbine.

Explain degree of reaction and state that 50% reaction is usual and refers to a Parsons turbine.

Explain compounding arrangements for simple turbines.

Construct blade velocity diagrams for simple impulse turbine.

Define kinetic or friction losses and leaving losses.

Construct blade velocity diagrams for a Curtis stage.

Construct blade velocity diagram for a reaction turbine pair.

Define mean blade height and blade speed ratio.

Solve problems by use of velocity diagrams and/or mathematical means for single and two stage impulse and reaction turbines relating to power produced, diagram efficiency, mean blade height and axial thrust.

Two phase refrigeration and heat pump cycles

Identify the physical operating requirements of a typical refrigerant.

Explain the concept of a reversed heat engine cycle and its application to refrigerating plant and heat pumps.

Explain the basic vapour compression refrigeration cycle.

Apply the use of thermodynamic tables, including the interpolation of values, to solving problems.

Apply the concepts of entropy and its evaluation from tables and from given formulae.

Draw the reversed Carnot cycle and vapour compression cycle on p-h and T-s axes.

Explain the effect of superheating at evaporator outlet and undercooling at condenser outlet on cycle performance and relate said effects to p-h and T–s diagrams.

State the relationship between mass flow rate of refrigerant, refrigerating effect and cooling load.

Define Coefficient of Performance (COP) for a heat pump and a refrigeration plant.

Apply expressions for COP of actual plant and compare to COP of plant working on reversed Carnot cycle.
Define volumetric efficiency of a compressor and explain its effect on cylinder dimensions.

Solve problems on refrigeration and heat pump cycles relating to isentropic efficiency, mechanical efficiency, cooling/heating load, refrigerating effect and coefficient of performance.

Explain the application of intermediate liquid cooling and flash chambers.

Reading List:

Eastop T. D., McConkey A. (1993) *Applied Thermodynamics for Engineering Technologists*. 5th Edition. Harlow: Pearson. ISBN: 978-0582091931

Çengel Y. A., Boles M. A. (2014) *Thermodynamics: An Engineering Approach*. 8th Edition. New York: McGraw Hill. **ISBN:** 9789814595292
Kroos K., Potter M. C. (2014) *Thermodynamics for Engineers* SI Edition. Toronto Nelson (Engineering). ISBN: 978-1133112877

Rogers G., Mayhew Y. (1995) *Thermodynamic and Transport Properties of Fluids (SI Units)*. 5th Edition. Oxford: Blackwell. ISBN: 978-0631197034

III/2 – Mathematics

The candidate will know:

The rules of Algebra
Logarithms,
Complex numbers
Graphs
Trigonometry
Binary, Hexadecimal Number systems and Logic
Calculus: Differentiation
Calculus: Integration

The candidate will be able to:

The rules of Algebra

Solve problems related to fractional, negative and zero indices.

Solve problems related to addition, subtraction and product of indices.

Solve problems involving the multiplication and division of polynomial expressions by binomial expressions.

Factorise expressions which have one factor consisting of one term only.

Factorise expressions of four terms which can be expressed as the product of two binomials.

Factorise expressions of the type $ax^2 + bx + c$, where a, b and c have numerical values, including when a is equal to 1 and when a is not equal to 1.

Factorise trinomials which form a perfect square.

Factorises the difference of two squares.

Solve problems involving the addition and subtraction of algebraic fractions limited to polynomials no greater than binomial expressions.

Solve problems involving the multiplication and division of algebraic fractions limited to polynomials no greater than binomial expressions.

Simplify and solve linear equations.

Solve problems on the transposition of algebraic expressions.

Develop linear equations consistent with data provided in a question, and finds the solution to these equations.

Solve linear simultaneous equations of two unknowns by the method of substitution and by the method of elimination.

Solve linear simultaneous equations of three unknowns.

Develop linear simultaneous equations of two unknowns consistent with data provided in a question, and finds the solution to those equations.

Solve quadratic equations that factorise.

Solve quadratic equations using the general formula.

Solve simultaneous equations of two unknowns consisting of linear and quadratic equations.

Solve problems involving direct variation, inverse variation and constant of variation.

Logarithms

(not directly examinable but such knowledge will be assumed).

Use the laws of logarithms to evaluate powers etc.

Evaluate expressions involving natural logarithms.

Complex numbers

Add, subtract, multiply and divide using complex numbers.

Plot Polar and rectangular co-ordinates.

Convert polar to rectangular and vice-versa.

Explain vectors in terms of polar and rectangular.

Solve arithmetic operations involving vector quantities (without drawings).

Graphs

Solve graphically problems of the form $pV^n = C$, where n is unknown.

Solve graphically two simultaneous equations plotted on the same axis

Solve graphically a quadratic equation.

Solve graphically simultaneous quadratic equations

Solve equations by graphical addition.

Solve graphic problems of trigometric form no more complex than $y = a \sin mx + b \cos nx$, and finds the solution of simultaneous equations involving such graphs.

Solve graphical problems of the form $y = a \tan mx$.

Trigonometry

Defines Sine, Cosine, Tangent, Secant, Cosecant, Cotangent and the relationships between them.

Read values of Sin, Cos, Tan, Sec, Cosec and Cot for any angle between 0' and 90'.

Determine an angle from tables knowing its sin, cos, tan, sec, cosec or cot.

Determine values of sin, etc, for angles 90' - 360' and also is able to obtain an angle (00 - 360') knowing its sin, etc.

Solve any triangle for any side or angle using Pythagoras, Sine and Cosine rules.

Binary, Hexadecimal Number systems and Logic

Solve problems on addition, subtraction, multiplication and division using binary and hexadecimal numbers.

Solve problems using logical NOT, AND, OR, XOR, NAND & NOR logical operations on binary numbers

Calculus: Differentiation

Determine the derivative of multinomial algebraic expressions.

Determine the 2nd derivative of multinomial algebraic expressions

Determines the 1st derivative of functions involving sinx, cosx and lnx.

Determine velocity from displacement-time functions and acceleration from velocity-time functions.

Determine the max and/or min volumes for given functions.

Calculus: Integration

Determines the integrals of multinomial algebraic expressions (ax^n where $n \neq -1$).

Determines the integrals of multinomial algebraic expressions (ax^n where $n \neq -1$), including limits.

Determines the integrals of functions involving sinx and cosx.
Determines areas and volumes by integration given the law of the boundary curve and limits.

Solves problems relating the area under the curve, given by $pV^n = C$.

III/2 Engineering, Systems and Ship’s Drawings Syllabus

The candidate will know:

Mechanical Assembly Drawings

Piping Systems Drawings

Hydraulic & Pneumatic Systems Drawings

Electrical Systems Drawings

Ships Construction Drawings

The candidate will be able to:

Mechanical Assembly Drawings

Identify the component parts of an assembly

Determine the correct disassembly / assembly sequence of the assembled components

Explain the operation of the assembled components.

Determine the consequence of making any alterations or adjustments to the components of the assembly.

Piping Systems Drawings

Identify the system components

Explain the operation of the component parts of the system

Explain the operation of the system as a whole

Identify the cause of a malfunction from evidence provided

Hydraulic and Pneumatic System Drawings

Identify the system components

Explain the operation of the component parts of the system

Explain the operation of the system as a whole

Identify the cause of a malfunction from evidence provided

Electrical Power Systems and Control Systems Drawings

Identify the system components

Explain the operation of the component parts of the system

Explain the operation of the system as a whole

Identify the cause of a malfunction from evidence provided

Ships Construction Drawings

Explain frame numbering

Identify the component parts of the assembly

Identify plate specification from a shell expansion plan

Use a docking plan