APPROVED VERSION FOR DISTRIBUTION

PE 1st Class Curriculum

Curriculum Version: 2024.1

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This curriculum document is prepared by IPECC and is intended to elaborate on the information found in the SOPEEC / ACI syllabi.

The SOPEEC / ACI syllabi are the official governing document for SOPEEC examinations. To view the official SOPEEC / ACI syllabi, refer to the SOPEEC website, www.sopeec.org.

The curriculum documents are developed and approved by IPECC members as a reference document for SOPEEC examinations. These documents are posted on the IPECC website, www.ipecc-canada.ca.

Note that this curriculum document is designed to exactly mirror the layout of the syllabus. Any deviation from the list format and contents of the syllabus is considered an error that must be remedied by IPECC.

To this end, the syllabus statements are printed in this document as a series of colour-coded headers, with indents demarking the various list levels of the syllabus.

The only information that is ADDED by the curriculum document is the curriculum objectives. These are the displayed in WHITE cells, as the lowest list items. The curriculum objectives are numbered in order, with this order assigned by IPECC.

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EXAM PART A1
01. Applied Thermodynamics and Plant Cycles
Principles, terminologies, and advanced practical calculations involving:
a. Rankine and Brayton cycles applied to power plant systems.
01. Explain heat engines and their application to a steam power plant.
02. Explain the Rankine Cycle using a steam temperature-entropy diagram.
03. Explain the Rankine Cycle improvements that can be incorporated into a power plant.
04. Explain the Brayton Cycle and its application to a gas turbine.
05. Explain the Brayton Cycle using pressure-volume and temperature- entropy diagrams.
06. Explain the Brayton Cycle improvements that can be incorporated into a power plant.
b. Steady flow work, energy calculations for steam; calorimeters, steam turbine/condenser systems; steam nozzles.
01. Evaluate a Rankine Cycle power plant in terms of efficiency, work ratio, specific steam consumption, isentropic efficiency and efficiency ratio.
02. Evaluate a Brayton Cycle power plant in terms of temperatures, work output, and efficiency.
c. Constant pressure, constant temperature, adiabatic processes for steam.
01. Describe the basis for non-flow processes of vapours.
02. Explain the constant volume process for steam and calculate heat supplied, work done and internal energy.
03. Explain the constant pressure process for steam and calculate heat supplied, work done and internal energy.
04. Explain the constant temperature process for steam and calculate heat supplied and work done.
05. Calculate steam entropy given the steam conditions.
06. Explain the reversible adiabatic process for steam and calculate work done and internal energy.
d. Energy relationships in non-flow processes.
XX. Explained in curriculum objective for syllabus statement A1.01.c.
e. Energy relationships, energy balance in steady flow processes; potential, thermal, internal, mechanical; energy conversions; nozzle flow process; throttling; work in heat engines (air compressors, turbines.)
01. Describe the steady-flow energy equation and calculate the work done in a steady-flow process.
02. Calculate the power consumed in a steady-flow process.
03. Explain the principle of conservation of energy and supersaturation as they apply to a nozzle and calculate nozzle inlet and outlet velocities.
04. Calculate the initial dryness fraction of steam in a throttling process.
05. Determine, using a Mollier Chart, the quality, enthalpy, and entropy of steam entering a calorimeter.
06. Calculate energy transfer, work done, and power produced in a steam turbine.
07. Calculate the heat lost, surface area, required cooling water flow, and heat transfer coefficient in a steam condenser.
08. Define and calculate availability and effectiveness in the context of the steady-flow processes.

f. Pressure, volume, temperature relationships, and work done during isothermal, adiabatic, and polytropic expansion and compression processes for gases.
01. Review the behaviour of perfect gases.
02. Explain Joule's law and its significance.
03. Calculate the heat added or rejected by a mass of perfect gas under changing temperature and pressure conditions.
04. Explain the isothermal process using a pressure-volume diagram, and calculate heat rejected and work done using a perfect gas as the working fluid.
05. Explain the reversible adiabatic cycle using a pressure-volume diagram and calculate work done, final volume, and final temperature using a perfect gas as the working fluid.
06. Calculate work done in a polytropic cycle using a perfect gas as the working fluid.
07. Calculate the efficiency of a polytropic process using a perfect gas as the working fluid.
08. Explain the Gibbs-Dalton law and calculate the work done and heat flow per kilogram when a gas mixture is expanded.
g. Temperature, enthalpy, entropy characteristics, diagrams for steam; Temperature/Entropy chart use.
01. Explain the significance of a Temperature-Entropy diagram for steam.
02. Explain the significance of a Mollier chart for steam.
h. Enthalpy, entropy, quality calculations for steam.
XX. Explained in curriculum objective for syllabus statement A1.01.e.
i. Expansion and contraction of metals; affects on boiler components and piping systems.
01. Explain how boiler and piping design allows for thermal expansion and contraction.
02. Calculate the linear and volumetric expansion of a header or pipe, given internal temperature conditions.
j. Heat transfer by conduction; compound insulations; boiler component heat transfers; restricted heat transfer.
01. Calculate heat transfer by conduction.
02. Calculate the heat flow through a compound insulated wall.
03. Calculate the thickness of insulation required to maintain a given temperature gradient.
k. Refrigeration thermodynamics: capacity; performance; efficiency.
01. Explain the Carnot Cycle as it applies to refrigeration using temperature-entropy and pressure-enthalpy diagrams.
02. Calculate the Carnot coefficient of performance of a refrigeration system and a heat pump system.
03. Calculate the refrigerating effect of a refrigeration system.
04. Calculate the coefficient of performance of a refrigeration system and a heat pump system.
05. Demonstrate graphically, using temperature-enthalpy diagrams, the effect on refrigeration capacity of using a throttle valve in place of an expansion machine, of superheating at the compressor inlet, of undercooling the condensed refrigerant, and of using a flash chamber.
06. Calculate the mass flow of refrigerant in a system.
07. Calculate the swept volume of a compressor cylinder, given its volumetric efficiency.
08. Calculate the power requirement of a refrigerant compressor.
l. Specific heats of gases and vapours.
XX. Explained in curriculum objective for syllabus statement A1.01.f.

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EXAM PART A2
02. Principles of Applied & Fluid Mechanics
Principles, terminologies, and advanced practical calculations involving:
a. Work, power, and efficiencies of lifting machines.
01. Calculate velocity ratio, mechanical advantage, efficiency, effort, and maximum load for lifting machines.
02. Calculate velocity ratio, mechanical advantage, efficiency, effort, and maximum load of a differential pulley block.
03. Calculate velocity ratio, mechanical advantage, efficiency, effort, and maximum load of a worm gear and worm wheel.
04. Calculate velocity ratio, mechanical advantage, efficiency, effort, and maximum load of a worm-driven screw jack.
05. Calculate velocity ratio, mechanical advantage, efficiency, effort, and maximum load of a turnbuckle.
06. Calculate velocity ratio, mechanical advantage, efficiency, effort, and maximum load of a hydraulic jack.
b. Potential and kinetic energy; energy conservation.
01. Define potential and kinetic energy. Calculate the potential energy of a compressed spring.
02. Describe the behaviour of a spring-mass system and calculate the maximum compression of a spring caused by contact with a moving mass.
03. Describe the effect of friction losses on potential and kinetic energy.
c. Impulse and momentum; conservation of momentum; angular momentum.
01. Define linear momentum and calculate the coefficient of restitution.
02. Calculate the kinetic energy and velocity of an elastic head-on collision and an elastic collision not in a straight line.
03. Define angular momentum and calculate the changes in momentum of rotating shafts.
04. Calculate the kinetic energy and velocity of a rotating shaft.
05. Calculate the time required to change the rotational velocity of a shaft.
d. Centripetal force and acceleration; balancing rotating masses; stresses in flywheel; radius of gyration, simple harmonic motion.
01. Calculate the centripetal acceleration of a rotating body in uniform circular motion.
02. Calculate the centrifugal force on a rotating body in uniform circular motion.
03. Calculate the tension in an attachment cord for vertically revolving masses.
04. Calculate the speed and period of a conical pendulum.
05. Calculate the positions of balancing masses to equalize centrifugal forces.
06. Calculate the stress in a rotating flywheel rim.
07. Calculate the velocity, acceleration, and accelerating force of a reciprocating component such as a piston driving, or driven from, a crankshaft.
e. Torque, angular momentum, moments of inertia; centroids.
01. Calculate angular velocity given the angular momentum of a rotating shaft.
f. Torsion; shaft stresses; shaft power.
01. Calculate strain in a solid bar under torsion load.
02. Calculate the stress at a given radius in a solid shaft.
03. Calculate torsional stress and strain in a hollow shaft.
04. Calculate modulus of rigidity and torsional resilience for a solid shaft.

05. Calculate the power consumed by torque acting on a rigid body rotating about a fixed axis.
06. Calculate maximum and mean torque for solid and hollow shafts of circular cross section.
07. Calculate the deflection of a closely coiled helical spring.
g. Stress and strain; modulus of elasticity; Hooke s Law; restricted expansion; elastic strain energy.
01. Explain the behaviour of stress and strain in solids.
02. Calculate single and double shear stress in a solid bar subject to oblique loading.
03. Define the modulus of elasticity.
04. Calculate stress, strain, and the equivalent modulus of elasticity for a compound bar.
05. Calculate stress due to restricted thermal expansion.
06. Calculate the elastic strain energy of a solid bar.
07. Calculate the instantaneous compression and stress of a solid bar subjected to suddenly applied and shock loads.
08. Calculate stresses in pressure vessels due to internal pressure.
h. Shear forces and bending moments in beams; modulus of section; beam deflection.
01. Using the fundamental bending equation, calculate bending moment, moment of inertia, modulus of elasticity, radius of curvature, maximum stress, and location of neutral axis.
02. Compare the strengths of beams using the modulus of section.
03. Calculate the deflection of a beam under load.
i. Static fluid pressures and forces; liquid columns; hydraulics; manometers.
01. Calculate the relative density of a liquid mixture.
02. Calculate the pressure indicated by a manometer.
03. Calculate the energy transmitted by a pressurized liquid.
04. Calculate the pressure and force on the surfaces of a tank containing non-mixing liquids.
05. Calculate the position of the centre of pressure of a tank containing non-mixing liquids.
06. Explain Archimedes principle. Calculate the buoyant force of a submerged body and its relative density.
07. Calculate the tension and stress in the supporting member of a submerged solid body.
j. Buoyancy.
01. Calculate the density of a floating body, given the volume of liquid that it displaces.
k. Fluids in motion; equation of continuity; liquid energy; Bernoulli s Theorem; venturi and orifice flows; turbulent and laminar flow; Reynold s Number.
01. Explain the equation of continuity.
02. Calculate the fluid flow through a valve, given the valve diameter and lift.
03. Calculate flow through rectangular and triangular notches.
04. Calculate the total energy of a liquid in motion.
05. Calculate the pressure in a pipe given the cross-sectional area and liquid flow rate.
06. Calculate the diameter, velocity, and flow through an orifice given the coefficient of discharge.
07. Calculate flow through horizontal and vertical venturi given the discharge coefficient.
08. Compare the resistance to flow of various liquids due to their viscosity using the velocity gradient and coefficient of viscosity.
09. Explain the significance of steady and unsteady liquid flows with regard to Reynolds number.
10. Using Poiseuille s equation, calculate liquid flow in a pipe and the pressure required for the liquid flow to overcome viscosity.

11. Calculate the theoretical head imparted to water by a centrifugal pump.
12. Calculate the manometric head and efficiency, and power consumed by a centrifugal pump.
13. Calculate the power available from a hydraulic turbine.
l. Nozzle designs and flows.
01. Explain the design and significance of convergent and convergent-divergent nozzles and calculate the critical pressure of a steam nozzle.

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EXAM PART A3
03. Applied Engineering Technologies
a. Metallurgy and metallography: in- depth knowledge of metals used in boilers, pressure vessels, piping, pumps, turbines, and ancillary equipment; metal structure; typical operational effects on metals in pressure equipment.
01. Describe the structure of metals.
02. Explain the nature and significance of phase changes in iron and steel due to temperature change.
03. Explain how alloying elements affect phase changes in steel and state the major alloying elements used in steel.
04. Explain the criteria for the assessment of materials.
05. Explain what creep is, and why it is important to monitor its effects on equipment.
06. Explain the methods of stress analysis.
07. Explain failure analysis.
i. Thermal and dynamic stresses.
01. Explain the effect of temperature on the tensile strength of steel.
b. Corrosion: Corrosion theory and mechanisms, in depth corrosion chemistry for boilers, pipelines, cooling towers and pressure vessels; types of corrosion (including flow accelerated; heat affected zone corrosion, etc.); monitoring techniques and equipment; interpretation of corrosion results; prevention strategies (e.g. cathodic protection.)
01. Explain atomic and molecular structures.
02. Explain the anodic and cathodic processes of corrosion.
03. Explain the electromotive force series and galvanic series.
04. Explain the effect of polarization.
05. Explain corrosion of single metals.
06. Explain the processes of crevice corrosion and pitting corrosion.
07. Explain the process of microbiologically influenced corrosion.
08. Explain the process of stress induced corrosion.
09. Explain the processes of erosion- corrosion.
10. Explain the impact of corrosion
11. Explain the agents of corrosion found in water
12. Explain the mechanisms and significance of magnetite formation and magnetite depletion on boiler tube surfaces.
13. Explain the mechanisms and significance of economizer and superheater corrosion.
14. Explain the mechanism, identification, and significance of flue-gas side corrosion of boiler components.
15. Explain the mechanism, identification, and significance of low temperature corrosion of boiler components.
16. Explain the relationship between boiler water chemistry and corrosion of copper alloys in feedwater systems.
17. Explain the mechanisms and significance of deaerator cracking and corrosion.
18. Describe the methods of monitoring and analyzing corrosion.
19. Explain the design, applications, and operation of cathodic protection systems.
20. Explain the use of protective coatings for corrosion control.
21. Describe the regulatory and safety requirements relating to corrosion monitoring.
22. Describe chemical control of corrosion.

23. Explain the corrosion characteristics and susceptibility of engineering materials and their selection for various purposes.
24. Describe the chemical, mechanical, and operational factors that are considered in controlling corrosion in steels.
25. Describe the chemical, mechanical, and operational factors that are considered in controlling corrosion in copper alloys.
26. Explain the risks and required precautions involved with chemical cleaning of boiler surfaces.
27. Explain the steps taken to reduce waterside and fireside corrosion during dry and wet storage of a boiler.
28. Explain the development, components, and management of a corrosion prevention program for cooling water systems, including the selection, application, and characteristics of biocides.
29. Explain the development, components, and management of a corrosion prevention program for piping and pressure vessels.
30. Explain the development, components, and management of a corrosion prevention program for rotating equipment.
c. Combustion: Fuel types, compositions, characteristics; low and high heat values; flame characteristics; boiler, fired-heater, and duct burner designs; burner design / operation vs. efficiency and emissions; effects of excess air; combustion troubleshooting; optimizing combustion; combustion and burner safety; combustion calculations for excess air, flue gas composition and analysis; combustion efficiency calculations; heat value calculations; staged combustion.
01. Explain the factors involved in the selection of primary and secondary fuel for a new installation.
02. Describe the fuel handling considerations and fuel burning characteristics for non-conventional solid fuels including municipal waste, petroleum coke, and biomass.
03. Compare the fuel burning characteristics of non-conventional gaseous fuels, including refinery gas, landfill gas, digester gas, carbon monoxide, liquid petroleum gases (LPGs), and acid gases.
04. Compare the fuel burning characteristics of black liquor.
05. Compare the physical properties and fuel burning characteristics of different grades of oil.
06. Describe the considerations for coal cleaning and blending.
07. Describe the purpose and process of coal gasification.
08. Differentiate between low heating value and high heating value fuels.
09. Describe the design and operational considerations for the use of low heating value fuels.
10. Explain the economic considerations for fuel selection for multifuel burners.
11. Describe the general criteria for effective burner design.
12. Describe the classes of burner designs, based on the fuel in use.
13. Compare the design strategies for mixing fuel and air including: co- flow, cross-flow, flow stream disruption, and entrainment.
14. Describe the design considerations for a duct burner.
15. Sketch a typical multi-nozzle duct burner layout.
16. Describe the relationship of burner selection to furnace design.
17. Describe the relationship between coal pulverizer selection and burner design. Describe burner design methods to reduce noise.

18. Explain the principle, significance, application, and design of staged combustion burners, including staged fuel flow and staged air flow burners.
19. Explain the inherent assumptions and factors considered when determining combustion efficiency.
20. Explain the methods and limitations for obtaining maximum efficiency from the combustion of gaseous fuels.
21. Explain the methods and limitations for obtaining maximum efficiency from the combustion of liquid fuels.
22. Explain the methods and limitations for obtaining maximum efficiency from the combustion of solid fuels.
23. Explain the economic and efficiency factors for fuel and burner management in real time operating conditions for a multifuel system.
24. Describe the use of electronic instruments to continuously monitor combustion efficiency.
25. Explain the significance of flame shape, colour, and temperature.
26. Explain the effect of excess air on combustion stability and boiler efficiency.
27. Explain the symptoms, significance, and corrective action for common combustion problems.
28. Describe the requirements for safe operation of a combustion system.
29. Compare the significance of burner safety devices for different fuel types.
30. Explain the cause and prevention of furnace explosions in boilers and fired heaters.
31. Describe the processes for dust reduction in coal handling systems.
32. Describe the procedures for dealing with coal bunker and pulverizer fires.
33. Explain the effect of excess air and combustion efficiency on emissions parameters.
34. Explain pre-treatment as a strategy for NOX reduction (fuel switching, additives, and fuel pre-treatment).
35. Explain combustion and operational modification as a strategy for NOX reduction (low NOX burners, staged combustion, water/steam injection, burners out of service, low excess air, and air preheat and furnace temperature reduction.
36. Explain process modification as a strategy for NOX reduction (reduced production, electrical heating, improved thermal efficiency and product switching).
37. Explain post treatment as a strategy for NOX reduction (SCR and SNCR).
38. Explain the effect on NOX emissions of boiler design, boiler condition and boiler loading characteristics.
39. Explain the reasons for and significance of flue gas recirculation.
d. Advanced water treatment chemistry: in-depth knowledge of pre-treatment and internal boiler chemistry (for all common treatment methods); selection of pre-treatment and internal treatment strategies/programs for various size boilers (including equilibrium phosphate, coordinated phosphate, all volatile treatment, oxygenated, cycle chemistry, etc.); potable water, dealing with water treatment contractors and consultants; cooling water treatment.
01. Describe the mechanisms of coagulation and flocculation.
02. Describe the chemical processes and reactions of oxidation of organic contaminants.
03. Describe the chemical processes and reactions of iron and manganese removal from raw water.
04. Describe the chemical processes and reactions in a lime-soda softener.
05. Describe the chemical processes and reactions in a sodium Zeolite softener.
06. Describe the chemical processes and reactions in a hydrogen Zeolite softener.

07. Describe the chemical processes and reactions in a demineralizer.
08. Describe the chemical processes and reactions in a dealkalizer.
09. Describe the mechanisms of membrane technology, including chemical and mechanical cleaning methods and clean-in-place design.
10. Describe the chemical processes and mechanisms of electrodialysis (ED) and electrodeionization (EDI.)
11. Describe the chemical processes and reactions of oxygen scavenging and metal passivation.
12. Describe the methods by which silica is removed from feedwater and condensate.
13. Explain the principles, reactions, and control of chelation.
14. Explain the principles, reactions, and control of a coordinated phosphate program.
15. Explain the phenomenon of phosphate hideout.
16. Explain the principles, reactions, and control of a congruent phosphate program.
17. Explain the principles, reactions, and control of an equilibrium phosphate program.
18. Explain the principles, reactions, and control of an all-volatile treatment program.
19. Explain the principles, reactions, and control of a polymer treatment program.
20. Explain the principles, reactions, and control of an oxygenated water treatment program.
21. Describe the mechanism of sludge conditioning.
22. Describe the mechanism of antifoam conditioning.
23. Describe the chemical processes and reactions of condensate treatment, including corrosion prevention, deaeration, and polishing.
24. Explain the financial management of the costs and benefits of water treatment.
25. Apply raw water analysis to the selection of a water treatment system.
26. Explain monitoring and control of cycle chemistry.
27. Describe the troubleshooting process when a cycle chemistry parameter deviates from the acceptable range.
28. Describe the selection and maintenance of resins for zeolite, demineralizer, dealkalizer, and condensate polisher service.
29. Describe the procedures and interpretation for tube deposit analyses.
30. Explain the inspection procedure for internal boiler components in relation to water treatment.
31. Describe a typical maintenance program for components of water treatment systems, including: water filters, clarifiers and lime-soda softeners, sodium zeolite softeners, demineralizers, mixed bed and condensate polishers, reverse osmosis units, microfiltration, electrodialysis and electrodeionization units, and deaerators.
32. Describe the selection, responsibilities, and management of water treatment consultants.
33. Describe the regulatory requirements for potable water quality and monitoring.
34. Describe the parameters and interpretation of potable water analyses.
35. Describe the selection and mechanism of oxidation agents.
36. Describe the mechanism of ultraviolet sterilization.
37. Explain the components and management of a cooling water treatment program.
38. Describe the use and chemistry of biocides in cooling water.
39. Describe the use and chemistry of corrosion inhibitors in cooling water.
40. Explain the use of chelants in cooling water.
41. Explain the use of threshold scale inhibitors in cooling water.
42. Explain the use of surfactants, dispersants, and biodispersants in cooling water.

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EXAM PART A4
04. Power Plant Operators
a. Energy Management practices; energy recovery systems (power factor correction; synchronous compensation; uninterruptible power supplies; distributed generation; emergency power; peak load reduction;) controllable losses; computerized performance management systems (data dumping, spreadsheets, and performance databases.)
01. Explain the concept of energy management and identify the operational factors that are included in an energy management program.
02. Describe the significance, components, responsibilities, and procedure of an energy audit.
03. Explain the significance and application of power factor management, including the effects of: capacitor banks, synchronous motors, inductive and resistive loads, transformers, voltage regulation for synchronous generators, and synchronous compensators.
04. Calculate capacitor ratings required for power factor correction.
05. Explain, using a sketch, the purpose, applications, design, and operation of a static uninterruptible power supply (UPS).
06. Explain the concept and significance of distributed generation, including the design implications for electrical distribution systems.
07. Describe the benefits of UPS in a distributed generation system, including the use of UPS as a bridge between utility and internal power.
08. Explain the benefits of motor- generator sets, internal combustion engines, and microturbines in a distributed generation system.
09. Explain the design, operating principle, and benefits of a fuel cell in a distributed generation system.
10. Explain the purpose, components, and operation of emergency power systems, including the physical interconnection between emergency power and main power.
11. Explain the concept, significance, and management of peak load reduction, including utility contract obligations and use of internal generation.
12. Explain the concept and principles of generation load dispatch including contract obligations.
b. Factors, components, calculations, and strategies/procedures for testing, maintaining and maximizing power plant efficiencies: boiler efficiency. gas turbine and combined cycle efficiency, including turbine inlet cooling. power generation efficiencies. overall plant/cycle efficiencies.
01. Describe methods used to maximize efficiency of steam power plants and minimize energy losses.
02. Calculate boiler gross efficiency using input-output method and heat loss method.
03. Calculate turbine performance and efficiency.
04. Calculate the condensate savings and heat gained through improvements in condenser efficiency.
05. Describe the components and significant parameters of a typical computerized plant performance management system, including a program to reduce controllable losses.
06. Describe the efficiencies of a simple cycle gas turbine and various cycle improvements that can be made.
07. Describe the design, layout, and advantages of a gas turbine / steam turbine combined cycle plant.
08. Explain the total energy concept as it applies to a power plant.

09. Describe different methods for waste heat recovery and the resultant improvement of efficiency.
10. Compare the inherent efficiencies of Once-Through Steam Generators (OTSG) with Heat Recovery Steam Generators (HRSG).
11. Calculate the steam generated and efficiency of a combined cycle plant, given system data.
c. Power Plant construction practices: major factors, approaches, components in the design and construction process for a power (or process) plant; include new plant vs. expansion; equipment/system modifications; role of the chief engineer before and during construction; receiving/acceptance procedures for new vessels; tying into existing plant.
01. Describe the general criteria, including economics, which must be considered in determining the need for additional facilities and in deciding between new plant construction and existing plant expansion.
02. Describe the general criteria to be considered in the design of a new plant.
03. Describe the regulatory permitting processes for a construction project, including environmental feasibility study.
04. Describe a quality assurance /quality control (QA/QC) program for pressure equipment, including the process for accepting, receiving, and approving new and used vessels.
05. Describe the major considerations and steps involved in the construction of a new plant, from design to completion.
06. Explain the control processes for a construction project, including the role of the chief power engineer and regulatory inspectors.
07. Explain the components and management of a construction health and safety program.
08. Explain the process of coordinating plant expansion activities with the operation of the existing plant, including tie-in of the old and new facilities.
09. Interpret, in detail, the information provided in construction drawings.
d. Commissioning and de- commissioning practices: outlines and specific procedures for commissioning new equipment, including boilers and auxiliaries, steam and gas turbines, piping systems, large pumps; start-up sequences; performance contracts for new plants/equipment; re-commissioning after major outages; de-commissioning.
01. Explain the sequence for commissioning a new plant.
02. Explain the detailed procedures for commissioning a boiler.
03. Explain the detailed procedures for commissioning a steam turbine.
04. Explain the detailed procedures for commissioning a gas turbine.
05. Explain the detailed procedures for commissioning a piping system.
06. Explain the detailed procedures for commissioning a large fan.
07. Describe the content and significance of a performance contract/guarantee for new equipment or a new plant.
08. Explain the specific procedures for re-commissioning a plant after a major outage.
09. Explain the obligations and liabilities of de-commissioning a plant, including regulatory requirements.
10. Explain the specific procedures for de-commissioning a plant.
e. Retrofitting: purposes, practices in redesign of existing boilers, turbines, and ancillary equipment; approval, design processes.
01. Explain the considerations that are used to determine whether replacement, re-powering, retrofitting, or upgrading should be undertaken.

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02. Explain the regulatory requirements for modifications to equipment and systems, including pressure equipment, electrical systems, and environmental impact.
03. Explain the overall process and responsibilities when modifying or retrofitting plant systems.
04. Describe the benefits of control system retrofitting with smart instrumentation.
05. Describe the retrofitting methods used to improve boiler efficiency and capacity including superheater upgrades, economizer upgrades, combustion system upgrades, improved air heater seals, improved waterwall design, environmental enhancements, and control upgrades.
06. Describe the retrofitting methods used to improve steam turbine efficiency including improved turbine blades and diaphragms, turbine stage additions, and improved blade tip sealing.
07. Describe the retrofitting methods used to improve gas turbine efficiency including upgrading inlet guide vanes, improved seals, tighter clearances, improved combustion liners, improved turbine blades and vanes, thermal barrier coatings, compressor blade coatings, compressor stage additions, and compressor supercharging.

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EXAM PART B1
05. Legislation and Codes for Industrial Equipment
Familiarity with all applicable Codes and Standards applicable to the Chief Power/Operating Engineer, particularly the application and authority of each Code to vessel operation and repair, including the following:
a. Local and National Jurisdictional Codes, Acts and Regulations regarding boilers and pressure vessels: design, registration, operation, fees; engineer regulations; specific procedures of the chief engineer in applying the Acts and Regulations.
01. Describe the typical duties of the chief engineer as set out in boiler and pressure vessel legislation.
02. Describe the legal foundation for the boiler and pressure vessel legislation.
03. Define statutory delegation of powers as they apply to the Boiler and Pressure Vessels Act.
04. Describe the authority that safety officers (inspectors) have within their jurisdiction.
05. Determine what the offences and penalties are under the act and the appeal process.
06. Describe the typical regulations under the Boiler and Pressure Vessels Act.
07. Describe the typical codes and standards referenced by the Boiler and Pressure Vessels Act.
b. ASME, Section I Power Boilers
01. Describe the organization of ASME Section I and its application.
i. includes thickness and pressure calculations, using Code paragraphs, for cylindrical components, heads, headers, tubing, power piping, compensations for openings, stayed surfaces, ligaments, stay bolts, furnaces; safety valves sizes and capacities.
01. Calculate the required thickness or maximum allowable working pressure of a cylindrical shell.
02. Calculate the required thickness or maximum allowable working pressure of a seamless, unstayed dished head, flat head, and formed head.
03. Calculate the maximum dimensions of openings, and the strength of compensation required for reinforcement of openings in cylindrical shells, headers, or heads.
04. Calculate the requirements for braced surfaces and support stays.
05. Calculate the required tubesheet thickness and maximum allowable working pressure for firetube and watertube boilers.
06. Calculate required wall thicknesses of plain circular furnaces, circular flues, Adamson ring reinforced and corrugated furnaces.
07. Calculate the required size and capacity of pressure relief valves.
c. ASME, Section VIII Pressure Vessels
01. Describe the organization of ASME Section VIII Division 1 and its application
i. includes design calculations for shells, heads, covers, opening reinforcements, and stayed surfaces.
01. Calculate the required thickness or maximum allowable working pressure of a cylindrical shell in a pressure vessel.
02. Calculate the required thickness or maximum allowable working pressure of a seamless dished head, flat head, and formed head in a pressure vessel.
03. Calculate the reinforcement requirements of openings in a pressure vessel.
04. Calculate the reinforcement requirements of openings in a pressure vessel using the ligament efficiency method

05. Calculate the required dimensions and locations of staybolts, and braced surfaces in a pressure vessel.
06. Calculate the required size and capacity of safety valves and safety relief valves for a pressure vessel.
d. ASME, Section IX Welding.
01. Explain the significance of ASME Section IX.
e. CSA Standard B.51 Construction and Inspection of Boilers and Pressure Vessels.
01. Describe the content and requirements of CSA B51.
02. Explain the role and interactions of regulatory authorities and the Chief Engineer with regard to CSA B51 and B52.
f. CSA Standard B.52 Mechanical Refrigeration Code.
01. Describe the content and requirements of CSA B52.
g. Power and Process Piping: ANSI B31.1 and B31.3.
01. Explain the significance and applications of ASME B31.1 Power Piping.
02. Describe the general content of ASME B31.1 Power Piping.
03. Explain the significance and applications of ASME B31.3 Process Piping.
04. Describe the general content of ASME B31.3 Process Piping.
h. API 510, 570 Pressure Vessel Inspection Codes.
01. Explain the significance and applications of API 510 Pressure Vessel Inspection Code: Maintenance Inspection, Rating, Repair, and Alteration.
02. Describe the general content of API 510 Pressure Vessel Inspection Code: Maintenance Inspection, Rating, Repair, and Alteration.
03. Explain the significance and applications of API 570 Inspection, Repair, Alteration and Re-rating of In-service Piping Systems.
04. Describe the general content of API 570 Piping Code: In-service Inspection, Rating, and Alteration of Piping Systems.
05. Explain the role and responsibilities of the chief engineer with regard to the ASME B31.1 and B31.3 Codes and the API 510 and 570 Codes.

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EXAM PART B2
06. Safety, Loss, and Environmental Program Management
a. Components and administration of a loss control program; loss control standards.
01. Explain the purpose, benefits, and typical components of a loss control program.
02. Explain the process of developing a comprehensive loss control program, including the typical responsibilities and accountabilities of the program.
03. Describe the tools and techniques used to develop a positive attitude towards the components of a loss control program.
04. Describe the tools and techniques used to develop safety awareness in consumers.
b. Implementation and management of a complete plant safety program: safety attitude and motivation techniques; incident investigation & reporting; emergency response programs; work with occupational health and safety committee; safe work permits, safe work procedures and planning.
01. Explain the ultimate responsibility and requirement, in the work place, to enforce all relevant safety legislation and regulations, and to respond to regulatory directives.
02. Describe the legal and ethical obligations of managers, supervisors, and employees to personnel safety.
03. Explain the significance, components, and applications of Canada Labour Occupational Health and Safety legislation.
04. Explain the authority, significance, components, and applications of provincial safety regulations, including the role and interactions of the provincial safety inspectors with plant staff.
05. Explain the requirements for safety compliance training.
06. Explain right to refuse work legislation and its legal implications.
07. Explain the authority, significance, and applications of the Workers' Compensation Board regulations, including the role and interactions of the Board with plant staff.
08. Describe the function of, and roles and responsibilities for, a worksite health and safety committee.
09. Identify the components and explain the management of a comprehensive safe work program.
10. Explain the components and management of a safety training program.
11. Explain the significance and procedure for safe work planning.
12. Explain the significance and procedure for safe work permits, including lockouts.
13. Explain the significance and procedure for confined space entry.
14. Explain the significance and procedure for hot work.
15. Explain the significance and procedure for excavations.
16. Explain the significance and procedure for working at heights.
17. Explain the significance and components of a contractor safety program.
18. Explain the components and management of a safety audit program, including roles and responsibilities.
19. Explain the purpose, components, and procedure for a hazard and operability study.
c. Safety Legislation in the workplace: identify Labour Canada, Workers Compensation Board, and provincial legislation; legalities; responsibilities to enforce.
01. Explain the ultimate responsibility and requirements to enforce all relevant environmental legislation and regulations and to respond to regulatory directives.

02. Explain the authority, significance, components, and applications of provincial environmental legislation and regulations, including the role and interactions of the provincial inspectors with plant staff.
03. Explain the significance and process of identifying and working with typical stakeholders for environmental programs the Environmental Impact Assessment (EIA) process.
04. Explain typical compliance requirements for an environmental monitoring program, including equipment calibration and uptime requirements.
d. Risk Assessment and Risk Management Techniques including; Safety Audits (components, procedures, analysis, follow-up; working with safety inspectors) and HAZOP (hazardous operability.)
01. Explain the process of hazard identification, risk assessment, and mitigation.
e. Insurance programs; factors affecting insurance rates; insurance inspection procedures; working with insurance inspectors.
01. Describe the factors affecting insurance rates and the authority, role, and interaction of insurance inspectors with plant staff.
f. Environmental Legislation: identify/explain all applicable legislation (provincial and federal); legalities, responsibilities.
01. Explain the authority, significance, components, and applications of federal environmental legislation and regulations, including the role and interactions of the federal environmental inspectors with plant staff.
g. Environmental Permits: components of, including understanding of all terminology and units.
01. Explain the components and development of an environmental audit program.
h. Environmental Audits: components, procedures, analysis, follow-up; working with environmental inspectors.
01. Explain the procedure for an environmental audit including the roles and responsibilities for performing and responding to the audit.
i. Environmental reporting procedures: routine reports and exceedences; spill cleanup and containment.
01. Describe requirements for environmental routine, excursion, and exceedance reporting.
02. Explain the compliance tests for Continuous Emission Monitoring Systems (CEMS) and the significance and procedures for Relative Accuracy Test Audits (RATA).
03. Explain the responsibilities and procedures for spill containment and cleanup.
j. Environmental Management Systems, including ISO 14000 series; purpose, components and influence.
01. Explain the purpose, significance, and components of an Environmental Management System.
02. Describe the ISO 14000 - 14002 standards for an Environmental Management System.
k. Disposal and Reclamation: procedures and practices, including waste manifests.
01. Explain the significance, procedures, and regulatory requirements of waste segregation and disposal.
02. Identify waste streams that require special disposal procedures, including recognition of hazardous wastes.
03. Explain the significance and general requirements of hazardous waste transportation.
04. Explain the significance and general components of Transportation of Dangerous Goods Acts.

05. Describe the purpose, significance, requirements, and general process of land reclamation.

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EXAM PART B3
07. Inspection, Maintenance and Repair Practices
a. Project management skills: identify and apply project management techniques to plant maintenance; managing maintenance contractors; long term service agreements.
01. Define a project, the role of project management, and the makeup of the project stakeholders.
02. Identify the roles and responsibilities of a typical project team.
03. Explain in detail the project planning step.
04. Describe the common tools that are used for project planning and management, including Work Breakdown Structure (WBS), Critical Path Method (CPM), and Gantt charts.
05. Explain in detail the project execution step, including control processes.
06. Explain in detail the project completion step, including assessment and reporting.
b. Predictive and preventive maintenance programs: components and management of; strategic/operational maintenance planning; run-to-failure, etc.; maintenance optimization.
01. Describe how equipment is managed through the concept of asset management.
02. Explain the purpose, components, and management of a maintenance program including preventive, predictive, and corrective maintenance approaches.
03. Explain the concepts and importance of reliability centred maintenance (RCM) in developing a maintenance program.
04. Describe the major steps in performing an RCM analysis.
05. Provide an example of how RCM is applied.
06. Describe how maintenance can be optimized.
07. Describe how a plant turnaround is planned and effectively executed.
08. Explain the concept, process, and benefits of outsourcing maintenance.
09. Explain the setting up and management of short-term maintenance contracts and long- term service agreements.
10. Explain the purpose and process of maintenance planning and scheduling.
c. Root Cause Analysis: purpose, procedure.
01. Explain the purpose and process of root cause failure analysis (RCFA).
d. National Board requirements for owner inspection and quality control programs: components of a quality control program for vessel repairs; scope, authorities, interaction with jurisdictional inspectors, records and reporting procedures.
01. Explain the National Board of Boiler Inspectors (NBBI) requirements for owner inspection and quality control programs.
02. Describe in detail the components of owner inspection and quality control programs, including roles and responsibilities, records, and reporting procedures.
03. Describe the roles, responsibilities, and personnel qualifications regarding repairs to boilers.
e. Boiler repairs: procedures for typical repairs to boiler parts, including cracks, ruptured tubes, etc. (step-by-step management of such repairs); safety valve maintenance.
01. Explain the detailed procedure for repairs to cracks in boiler parts, including drums and headers.
02. Explain the detailed procedure for repairs to ruptured boiler tubes.
03. Explain the management, responsibilities, and procedures for safety valve repairs.
04. Describe the management roles, responsibilities, and qualifications regarding repairs to pressure vessels and pressure piping.

f. Pressure vessel inspection and repair procedures (other than boiler) including cracks, corrosion etc.
01. Explain the concept of fitness for service.
02. Describe in detail a typical pressure vessel inspection, identifying common problem areas.
03. Describe in detail a typical pressure piping inspection, identifying common problem areas.
g. Pressure vessel repair: repair procedures for pressure vessels, including cracks, corrosion, etc.
01. Explain the detailed procedure for typical repairs to cracks in pressure vessels.
02. Explain the methods and detailed procedures for typical repairs to corrosion in pressure vessels.
h. Pressure and power piping repairs: procedures for typical repairs to power plant piping.
01. Explain the detailed procedure for typical repairs to cracks in pressure piping.
02. Explain the methods and detailed procedures for typical repairs to corrosion in pressure piping.
i. Non-destructive examination: describe, in depth, the selection, equipment, applications, procedures, and interpretation of the results for the non-destructive examination methods (dye penetrant, magnetic particle, eddy current, radiographic, ultrasonic, electro-magnetic acoustic transducer); manage contracts and interpret results with non-destructive examination contractors; ASME Code, Section V; identify / explain inspection techniques as per Code.
01. Explain the significance and application of ASME Section V.
02. Describe the process of radiographic examination.
03. Describe the process of ultrasonic examination.
04. Describe the process of dye penetrant examination.
05. Describe the process of magnetic particle examination.
06. Describe the process of eddy current examination.
07. Describe the process of acoustic emission examination.
08. Explain the selection, management, and control of a non-destructive examination contractor.
j. Typical monitoring, inspection, and overhaul procedure for a large steam turbine, gas turbine, large multi-stage pump, and large alternator.
01. Explain the typical maintenance problems of a large steam turbine.
02. Explain the procedures for inspection and overhaul of a large steam turbine.
03. Explain the typical maintenance problems of a gas turbine.
04. Explain the procedures for inspection and overhaul of a gas turbine.
05. Explain the typical maintenance problems of a large multi-stage pump.
06. Explain the procedures for inspection and overhaul of a large multi-stage pump.
07. Explain the typical maintenance problems of a large generator.
08. Explain the procedures for inspection and overhaul of a large generator.
k. Rotating equipment monitoring including turbovisory monitoring (overall expansion, differential expansion, differential temperature, critical speed, oil whip, oil whirl, eccentricity) and vibration analysis (vibration theory, measurement, interpretation of results).
01. Describe the purpose, importance and types of rotating equipment monitoring.
02. Explain the concept and significance of turbine thermal expansion, the general principles and placement of measuring devices, and the procedures to control.
03. Explain the concept and significance of turbine differential expansion, the general principle and placement of measuring devices, and the procedures to control.

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04. Explain the concept and significance of turbine eccentricity, the general principle and placement of measuring devices, and the procedures to control.
05. Explain the concept of vibration, including typical causes, effects, and locations of vibration in rotating equipment and how it is measured.
06. Explain the concept and significance of turbine critical speed.
l. Oil analysis: purpose, theory and interpretation of oil analyses including lube oil and transmission oil.
01. Explain the concept and significance of oil whirl, oil whip, and steam whirl, and the design and operational considerations to counter oil whirl.
02. Describe common oil problems and their effects on rotating equipment and a typical oil sampling and testing program.

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EXAM PART B4
08. Business & Workforce Management
a. Budgets: techniques in preparation, control, and reporting; components of plant and department (utilities/power plant) budgets; zero- based budgeting (advantages & disadvantages.)
01. Explain budget development, control, and reporting processes.
02. Explain typical types of budgets and their significance, including revenue, expense, capital expenditure, and production budgets.
03. Explain the components of plant and department budgets.
b. Balance sheet and bottom-line accounting: knowledge / significance of terminology (e.g. dual entry, credits, debits, revenue, expenses, liabilities, assets, balance sheet, income statements, cash flow); financial statements; accruals.
01. Explain the concept and significance of the following accounting terms: accounting cycle, dual entry accounting, debits and credits, accrual accounting, revenue and expenses, assets and liabilities, and debt and equity.
02. Explain the concept and significance of financial statements, including Income Statement, Balance Sheet, Statement of Retained Earnings and Cash Flow Statement.
c. Inventory management techniques, such as: automated and computerized inventory systems; max / min; just in time.
01. Describe the components and use of a typical automated inventory system.
02. Explain the purpose and operation of typical inventory management systems, including fixed-point, fixed- interval, max/min, ABC, Just In Time (JIT), and Economic Order Quantity (EOQ.)
03. Explain the concepts and significance of periodic and perpetual inventory systems, Last In First Out (LIFO) and First In First Out (FIFO).
04. Describe the role of a supplier and the use of strategic partnerships in an inventory management system.
d. Cost benefit and financial analysis calculations; net present value and internal rate of return models; return on investment.
01. Explain the significance of a cost / benefit analysis.
02. Explain the time value of money concept and calculate the Net Present Value (NPV) and Internal Rate of Return (IRR) of a proposed investment.
03. Calculate the Return on Investment (ROI) of a proposed investment.
04. Explain depreciation, including straight-line and declining balance depreciation, and the concept and significance of Capital Cost Allowance (CCA).
e. Contracts: types of and control of; legalities of contracts; torts, legal and ethical liability, due diligence; force majeure.
01. Define and explain the legal significance of contract, offer, and acceptance.
02. Explain the significance of contract documentation, and the rights and obligations of a contactor and contractee.
03. Compare contract types, including: fixed price; cost plus/shared risk; fixed price/cost plus incentive; bonus/penalty; time/material; product/service/resource; and enforceable/unenforceable contracts.
04. Describe methods of discharging a contract, including: agreement, performance, impossibility, operation of law, breach, failure to perform and specific performance.
05. Explain tort and its legal significance; the three basic types of torts, including: intentional, fault-based or negligent, and strict liability, the distinction between legal and ethical liability,

06. Explain due diligence and its legal and ethical significance.
07. Explain force majeure and its legal significance.
08. Explain what is involved in issuing and then completing a tendering process.
f. Ethics and social responsibilities.
01. Explain the content and significance of a typical code of ethics of a professional association.
02. Explain the importance and application of ethical practices in the work place.
g. Problem solving and decision making techniques/models.
01. Explain the importance and application of a structured decision making process.
02. Describe the eight steps in a rational decision making process.
03. Compare analytic, conceptual, directive, and behavioural decision making styles.
04. Explain the advantages and disadvantages of group decision making.
05. Describe the common methods of group decision making, including brainstorming, storyboarding, nominal group technique (NGT), and the Delphi technique.
06. Apply a problem solving and decision making approach to a typical plant case study.
h. Leadership: styles, responsibilities; establishing and communicating plant/department goals; motivational models; communication practices; conflict resolution.
01. Explain leadership responsibilities and the significance of an effective leadership style.
02. Explain the managerial grid and its significance.
03. Explain situational leadership and its significance.
04. Compare the concept and significance of traditional objective setting and management by objectives (MBO).
05. Compare methods of communicating goals and objectives.
06. Explain the motivation process. Compare the basic models of individual motivation, including the hierarchy of needs, motivation hygiene theory, goal-setting theory, reinforcement theory, equity theory, and expectancy theory.
07. Explain the concept and significance of the social styles matrix.
i. Labour Relations: internal and external; legislation; working with union and non-union workforces; recognizing & enforcing special workforce legislation; contract / term employees; contingent workforce; human resource and capacity planning; conflict resolution techniques.
01. Explain management's right and responsibilities in the enforcement of federal and provincial labour legislation.
02. Compare management interactions between union and non-union work forces.
03. Explain the concept, preparation, and tactics of collective bargaining, including the use of a problem- solving approach.
04. Explain the concepts, significance, roles, and responsibilities during conciliation, arbitration, strike or lockout.
05. Compare the benefits and significance of permanent and contingent employees.
06. Explain the purpose and process of human resource planning and capacity planning.
07. Explain the facilitation of labour relations with a contractor's workforce.
08. Explain the concept and significance of homeostasis.
09. Explain the significance and effects of conflict in an organization.
10. Describe interpersonal and intergroup conflict.
11. Explain the lose/lose, lose/win, win/lose and win/win outcomes of conflict.
12. Explain assertiveness and cooperativeness and their significance.
13. Compare avoiding, accommodating, forcing, collaborating and compromising as conflict resolution strategies.

14. Explain the stages in assertive behaviour for conflict resolution.
15. Describe the concept, significance, responsibilities, and typical steps and tactics of a grievance process.
16. Explain the process of labour/management conflict resolution.
j. Benchmarking: purposes, practices and techniques.
01. Explain the purposes and processes of benchmarking.
k. Public relations: communication practices; typical areas of public concern.
01. Compare linear, interactive, and transactive communications and their significance.
02. Explain the common communication shortcuts and their significance including selectivity, assumed similarity, stereotyping, and the halo effect.
03. Describe the typical public stakeholders for an organization s business, and the typical communication processes used in dealing with the public.
04. Explain the public concerns that an organization must address, and the appropriate communication methods used in addressing them.
l. Recruitment, hiring, and interviewing techniques (including behavioral descriptive interviewing.)
01. Explain the purpose and components of a human resource management process.
02. Explain the legal and ethical constraints on recruitment and selection.
03. Explain the types and processes of pre-employment testing.
04. Explain the purpose, procedure, and limitations of typical interviewing techniques, including behavioural descriptive interviews.
05. Explain the significance and components of a training and development program including training standards, roles, and responsibilities.
06. Explain the significance and components of an orientation process.
07. Explain the purpose and process of a needs assessment and gap analysis.
08. Explain the purpose and process of competency profiling.
m. Workforce development techniques: employee orientation; needs assessment; gap analysis; competency profiles; training methods and standards; performance management.
01. Explain the significance and selection of typical training methods and their relationship to learning styles.
02. Explain the significance of progression and cross-training methods.
03. Explain the purpose and components of a performance management program, including coaching.
04. Explain typical models of performance reviews.
05. Explain the process of corrective and progressive discipline.
n. change management techniques; psychology of change; promoting and managing workplace change; the manager s role as a change agent.
01. Describe the types of changes that occur in the workplace, the relationship between workplace change and employee attitude, the psychological costs and benefits of change, and management's role and responsibilities.
02. Describe the three types of resistance to change (logical, psychological, and sociological), the potential benefits of resistance to change, and the three basic steps to overcome resistance (unfreezing, changing, and refreezing).
03. Explain the typical strategies used to build support for change, including; use of group forces, leadership for change, participation, shared rewards, negotiation, employee security, and communication.

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o. Plant management structures and organization; inter-departmental relationships and responsibilities, workforce styles (promoting teamwork; elements of teamwork and self-directed work teams; supervised work teams.)
01. Compare the design and benefits of typical organizational structures, including: scalar, functional, tall/flat and matrix.
02. Explain the concept and significance of organizational culture.
03. Explain the significance of a team- based organizational structure and methods to develop and promote teamwork.
04. Compare the significance, benefits, and limitations of supervised and self-directed work teams.
05. Describe the characteristics and functioning of a successful work team.
06. Explain the concept and significance of cross-functional work teams.