



FOURTH CLASS (EDITION 3)

COURSE OUTLINE WITH OUTCOMES

The material in this series is aligned with the SOPEEC Fourth Class Syllabus, dated November 2017, and the IPECC Curriculum, November 2017.

PART A UNIT 1: Elementary Mechanics and Dynamics

Chapter 1 Introduction to Basic Mechanics

Learning Outcome

Apply basic terms and calculations used in the study of mechanics.

Learning Objectives

1. Define mass, force, acceleration, velocity, and weight.
2. Perform simple calculations involving force, pressure, work, power, and energy.

Chapter 2 Forces and Moments

Learning Outcome

Perform calculations involving forces and moments, and determine when a system of forces is in equilibrium.

Learning Objectives

1. Define the moment of a force and its units.
2. Determine the direction and calculate the magnitude of the moment of a force.

Chapter 3 Simple Machines

Learning Outcome

Perform calculations relating to mechanical advantage, velocity ratio and efficiency.

Learning Objectives

1. Define the term simple machine and apply to calculations of mechanical advantage, velocity ratio and efficiency of simple machines.

Chapter 4 Scalars and Vectors

Learning Outcome

Define and identify scalar and vector quantities and solve simple vector problems graphically.

Learning Objectives

1. Define scalar and vector quantities as they apply to drawing vector diagrams.



FOURTH CLASS (EDITION 3)

COURSE OUTLINE WITH OUTCOMES

Chapter 5 Linear Velocity and Acceleration

Learning Outcome

Solve simple problems involving linear velocity, time, and distance.

Learning Objectives

1. Solve distance, displacement, speed, and velocity problems.
2. Draw graphs of velocity as a function of time.
3. Define acceleration, state its units, and solve simple acceleration problems.
4. Apply mathematical formulae relating acceleration, velocity, distance and time to solve problems.

Chapter 6 Force, Work, Pressure, Power, and Energy

Learning Outcome

Perform calculations involving force, work, pressure, power, and energy.

Learning Objectives

1. Perform calculations involving force and work.
2. Perform calculations involving gauge, atmospheric, and absolute pressure.
3. Perform calculations involving power and different forms of mechanical energy.

Chapter 7 Friction

Learning Outcome

Solve problems involving friction.

Learning Objectives

1. Apply the laws governing the types of friction.
2. Apply the coefficient of friction to problems involving forces on a horizontal plane.

Chapter 8 Stress and Strain

Learning Outcome

Explain physical properties of materials and how their behaviour is affected when external forces are applied.

Learning Objectives

1. Describe the mechanical properties of materials, including elasticity, stiffness, plasticity, ductility, toughness, brittleness, and hardness.
2. Calculate stress including tensile, compressive, and shear stresses within rigid bodies due to external loads.
3. Calculate the strain of members under load.



FOURTH CLASS (EDITION 3) COURSE OUTLINE WITH OUTCOMES

Chapter 9 Power Transmission

Learning Outcome

Perform calculations pertaining to common power transmission systems.

Learning Objectives

1. Calculate pulley speeds, transmitted power, and efficiency of belt drive systems.
2. Calculate gear speeds for gear and chain drive systems.

PART A UNIT-2: Elementary Physical, Chemical, and Thermodynamic Principles

Chapter 1 Introduction to Matter and Chemistry

Learning Outcome

Identify basic types of matter, their properties, and the associated chemical principles.

Learning Objectives

1. Differentiate among the physical states of matter.
2. Differentiate between chemical and physical changes in matter.
3. Classify matter as either a type of mixture or a pure substance.
4. Describe the purpose and uses of the periodic table using the parts of an atom.
5. Describe the three main ways atoms bond together: covalent, ionic, and metallic bonding.
6. Discuss chemical equations and their purpose.
7. Perform simple stoichiometric calculations.
8. Demonstrate how unstable compounds are combined to make stable compounds.

Chapter 2 Introduction to Thermodynamics

Learning Outcome

Explain the principles and laws of thermodynamics.

Learning Objectives

1. Define the first two laws of thermodynamics.
2. Define heat and specific heat, and perform sensible heat calculations.
3. Describe the expansion of solids and liquids.



FOURTH CLASS (EDITION 3)

COURSE OUTLINE WITH OUTCOMES

Chapter 3 Introduction to Heat Transfer and Heat Exchangers

Learning Outcome

Explain the modes of heat transfer and the theory of heat exchanger operation.

Learning Objectives

1. Describe the three modes of heat transfer with reference to heat exchangers.
2. Discuss the general design and construction of typical heat exchangers.
3. Describe heat transfer fluids and how they affect the operation of a heat exchanger, including fouling, leakage, and vapour locking.
4. Describe heat exchanger inspection, maintenance, and operation, including placing them in service and removing them from service.

Chapter 4 Thermodynamics of Steam

Learning Outcome

Apply the thermodynamics principles through practical applications using the steam tables and the temperature-enthalpy chart.

Learning Objectives

1. Describe heat as it relates to steam, water, and ice.
2. Explain the various columns of the steam tables.
3. Explain the thermodynamic principles of steam, using the steam tables.

PART A UNIT-3: Introduction to Power Engineering and its Governance in Canada

Chapter 1 Introduction to Power Engineering

Learning Outcome

Describe the Power Engineer profession.

Learning Objectives

1. Describe steam, its uses and the basic steam cycle.
2. Describe the role and duties of a Power Engineer.
3. Describe how shift work affects sleep patterns, diet, and overall health.

Chapter 2 Jurisdictional Legislation for Power Engineers

Learning Outcome

Describe the application of Jurisdictional Acts and Regulations with respect to boilers and pressure vessels.

Learning Objectives

1. Describe how the Power Engineering profession is regulated in Canada.
2. Explain the purpose and scope of your Jurisdictional Act and Regulations pertaining to Power Engineering and Pressure Equipment.
3. Explain the purpose and intent of the Regulations governing Power Engineers and Pressure Welders.



FOURTH CLASS (EDITION 3) COURSE OUTLINE WITH OUTCOMES

Chapter 3 Codes and Standards for Power Engineers and Pressure Vessels

Learning Outcome

Describe the purpose of boiler and pressure vessel Codes and Standards.

Learning Objectives

1. Discuss the history of how codes and standards became necessary in the pressure equipment field.
2. Explain the content and use of the CSA B51 Boiler, Pressure Vessel, and Pressure Piping Code.
3. Explain the content and use of the CSA B52 Mechanical Refrigeration Code.
4. Explain the content and use of ASME Boiler and Pressure Vessel Code (ASME BPVC) Section I Power Boilers.
5. Explain the content and use of ASME BPVC Section VII - Recommended Guidelines for the Care of Power Boilers.
6. Explain the content and use of ASME BPVC Section IV - Rules for Construction of Heating Boilers.
7. Explain the content and use of ASME BPVC Section VI - Recommended Rules for Care and Operation of Heating Boilers.
8. Explain the purpose, intent, and limitation of ASME CSD-1 (Controls and Safety Devices) Standard.

PART A UNIT-4: Introduction to Plant and Fire Safety

Chapter 1 Introduction to Plant Safety

Learning Outcome

Describe general plant safety as it related to Power Engineers.

Learning Objectives

1. Discuss the cost and effects of workplace accidents.
2. Describe the basic hazards that may be in an energy plant, and the basic Personal Protective Equipment that may be required.
3. Define, give examples of, and describe common power house hazards.
4. Describe Industrial health and safety management system.
5. Describe Hazard Assessment and Control programs.

Chapter 2 Plant Safety Programs

Learning Outcome

Describe common safety programs generally applied in plants.

Learning Objectives

1. Describe common occupational health and safety (OH&S) programs found in most plants.
2. Describe industrial safety programs in which Power Engineers may require additional training.
3. Discuss safe work permits.
4. Describe methods of equipment isolation and lock out.



FOURTH CLASS (EDITION 3)

COURSE OUTLINE WITH OUTCOMES

Chapter 3 Handling of Dangerous Materials

Learning Outcome

Describe the policies and procedures for safe storage and handling of dangerous materials.

Learning Objectives

1. Discuss the WHMIS system.
2. Discuss the essential components required in the WHMIS systems.
3. Describe the safe handling and use of gas cylinders in an energy plant (power plant).
4. Discuss the safe handling of Hydrocarbons.

Chapter 4 Plant Fire Safety

Learning Outcome

Explain fire safety in an industrial plant.

Learning Objectives

1. Discuss the theory, terminology, and the life safety issues associated with fires.
2. Explain the five classes of fires, and describe the types of fire extinguishing media and how they act on these fires.
3. Explain fire prevention.
4. Discuss fire prevention methods for the five types of fires.

Chapter 5 Fire Extinguishing Methods and Equipment

Learning Outcome

Describe typical fire extinguishing equipment and its operation in plant environments.

Learning Objectives

1. Describe the construction and operation of various types of portable fire extinguishers.
2. Discuss the inspection and maintenance requirements of portable fire extinguishers.
3. Describe the types, layout, and operation of standpipe and sprinkler systems.
4. Discuss the maintenance requirements of standpipe and sprinkler system components.
5. Describe the purpose, operation, and maintenance of fire pumps.



FOURTH CLASS (EDITION 3)

COURSE OUTLINE WITH OUTCOMES

PART A UNIT-5: Introduction to Plant Operations and the Environment

Chapter 1 Introduction to the Environment

Learning Outcome

Identify environmental considerations and how they relate to an operating plant.

Learning Objectives

1. Describe four important Biogeochemical Cycles that operate within the environment.
2. Describe typical interdependencies seen among elements within an “ecosystem.”
3. List the types of impacts that operating facilities can have on the environment.
4. Describe the alert processes related to environmental problems of plants.
5. Explain the importance of “attitude” in limiting environmental impacts of plants.
6. Describe the long-term environmental impacts after the decommissioning and abandonment of plants.

Chapter 2 Gas and Noise Emissions

Learning Outcome

Explain how gas and noise emissions affect plant operations.

Learning Objectives

1. Identify the sources and effects of common gases and vapours that have an adverse environmental impact.
2. Identify the common greenhouse and acid rain causing gases and describe their effects.
3. Describe the common methods for monitoring and reducing gaseous pollutants.
4. Describe the effects of noise pollution and methods of identifying, measuring, and controlling it.

Chapter 3 Liquid and Solid Emissions

Learning Outcome

Explain how liquid and solid emissions affect plant operation.

Learning Objectives

1. Describe the sources and effects of solid pollutants from energy plants.
2. Describe the theory of operation of separators/collectors and monitoring of flue gas particulates.
3. Describe the disposal methods of solid waste from energy plants.
4. List sources and effects of liquid and thermal pollution.
5. Describe the preventive measures that can be taken to prevent liquid and thermal pollution.
6. Describe methods of liquid waste disposal.



FOURTH CLASS (EDITION 3)

COURSE OUTLINE WITH OUTCOMES

PART A UNIT-6: Elements of Material Science and Welding Technology

Chapter 1 Energy Plant Construction and Operation Materials

Learning Outcome

Describe the mechanical properties of engineering materials used in engineering.

Learning Objectives

1. Describe the mechanical properties of materials.
2. Describe the various types of ferrous materials.
3. Describe the various types of non-ferrous materials.

Chapter 2 Introduction to Welding

Learning Outcome

Describe welding processes relevant to the plant and Power Engineering.

Learning Objectives

1. Describe non-fusion welding process, equipment used, and methods.
2. Describe forge and oxy-fuel fusion welding processes and cutting processes.
3. Describe metal arc welding processes.
4. Describe heat treatment of welds.
5. Describe the types of weld joints used in pressure vessel construction.
6. Describe the additional construction components required for pressure vessels to ensure structural integrity and “access”.

Chapter 3 Boiler and Pressure Vessel Inspection

Learning Outcome

Describe inspection processes and testing methods for welds and materials.

Learning Objectives

1. Describe common weld defects.
2. Describe the process of Visual Testing of welds.
3. Describe the process of Penetrant Testing for detecting weld or material defects.
4. Describe the process of radiographic weld testing.
5. Describe the process of ultrasonic weld testing.



FOURTH CLASS (EDITION 3) COURSE OUTLINE WITH OUTCOMES

PART A UNIT-7: Introductory Fluid Handling Technology

Chapter 1 Introduction to Energy Plant Piping Systems

Learning Outcome

Discuss the basic types of piping, piping connections, supports, and drainage devices used in industry.

Learning Objectives

1. State the applications for the most common materials and identify the sizes of commercial pipe.
2. Describe methods of connection for screwed, flanged, and welded pipe; identify fittings and their markings.
3. Describe methods and devices used to allow for pipe expansion and support.
4. Explain the methods used to promote good drainage of steam pipes, including the installation and maintenance of steam traps, to reduce the effects of water hammer.
5. Explain the requirements, materials, and methods for insulating pipe.

Chapter 2 Introduction to Energy Plant Valves

Learning Outcome

Discuss the design and uses of the valve designs most commonly used in industry and on boilers.

Learning Objectives

1. Describe standard valve designs.
2. Describe design and operation of specialized boiler valves.
3. Describe a typical steam pressure reducing station, and the design and operation of steam system pressure-reducing valves.
4. Discuss valve details, including materials of construction and identification markings.
5. Describe typical valve maintenance requirements.

UNIT A-8: Basic Concepts in Electrotechnology

Chapter 1 Basic Electricity

Learning Outcome

Apply the concepts of basic electricity while performing simple calculations using voltage, current, resistance, and power.

Learning Objectives

1. Describe the atomic structure of matter and its relationship to electricity.
2. Describe basic electrical circuits.
3. State Ohm's Law and apply it to single-resistor circuits.
4. Apply Ohm's Law to series resistance circuits.
5. Apply Ohm's Law to parallel resistance circuits.
6. Explain electrical conductors and insulators using examples.
7. Explain the factors that affect resistance mathematically.
8. Calculate the power developed in an electrical circuit.



FOURTH CLASS (EDITION 3)

COURSE OUTLINE WITH OUTCOMES

Chapter 2 Magnetism and Electromagnetism

Learning Outcome

Describe the basic principles of magnetism.

Learning Objectives

1. Describe magnetism and the relationship between magnetism and electricity.
2. Describe the relationship between electricity and magnetism in an electrical generator.
3. Describe the relationship between electricity and magnetism in an electric motor.

Chapter 3 Electrical Metering Devices

Learning Outcome

Describe the design and application of electrical metering devices.

Learning Objectives

1. Describe electrical meters and their uses.
2. Describe how voltage, current, and resistance are measured in an electric circuit.
3. Describe the construction and operation of a kilowatt hour meter.

Chapter 4 Motors and Generators

Learning Outcome

Describe the operating principles of the various types of AC and DC motors and generators.

Learning Objectives

1. Describe the construction and operation of DC generators and motors.
2. Describe the construction and operation of AC generators (alternators) and motors.
3. Interpret the information on a motor nameplate.
4. Perform basic calculations relating to power factor and power factor correction.

Chapter 5 Transformers

Learning Outcome

Describe the operating principles of electrical transformers.

Learning Objectives

1. Describe the principle of operation of transformers.
2. Perform basic transformer calculations as they relate to the construction and operation of single-phase transformers.
3. Describe the construction and operation of three-phase transformers.
4. Discuss special transformer types and their applications.
5. Discuss transformer cooling, safety, and maintenance.



FOURTH CLASS (EDITION 3)

COURSE OUTLINE WITH OUTCOMES

Chapter 6 Electrical Distribution Circuits

Learning Outcome

Describe an electrical distribution system.

Learning Objectives

1. List and describe the standard types of electrical voltage systems.
2. Interpret electrical single-line diagrams and circuit symbols.
3. Describe the major components of an electrical distribution system.
4. Describe the function and operation of fuses and circuit breakers.
5. Describe the function and operation of alternate power supply system equipment.

Part A UNIT-9: Energy Plant Instrumentation and Controls

Chapter 1 Introduction to Energy Plant Controls and Instrumentation

Learning Outcome

Describe the overall purpose and function of plant instrumentation systems.

Learning Objectives

1. Describe the concept and basic components of a control loop.
2. Describe the various means by which control signals are transmitted, and the function of transducers.
3. List and describe the types of instruments that are not control loop components.

Chapter 2 Introduction to Process Measurement

Learning Outcome

Describe the construction and operation of common devices used to measure pressure, level, flow, temperature, humidity, and composition.

Learning Objectives

1. Describe the types of pressure sensing and measuring devices.
2. Describe the types of level sensing and measuring devices.
3. Describe the types of flow sensing and measuring devices.
4. Describe the types of temperature sensing and measuring devices.
5. Describe the types of humidity sensing and measuring devices.
6. Describe the types of gas sensing and measuring devices.



FOURTH CLASS (EDITION 3)

COURSE OUTLINE WITH OUTCOMES

Chapter 3 Basic Control and Instrumentation Components

Learning Outcome

Describe the basic types and functions of transmitters, recorders, controllers, and control actuators.

Learning Objectives

1. Describe the construction and operational principles of instrumentation transmitters.
2. Describe the construction and operational principles of instrumentation indicators and recorders.
3. Describe the construction and operational principles of instrumentation controllers.
4. Describe the construction and operational principles of final control elements.

Chapter 4 Introduction to Programmable Controllers

Learning Outcome

Describe the operation of programming controls for boilers, including applicable testing and maintenance procedures.

Learning Objectives

1. Discuss how programmable controllers work and how they act as sequencers for equipment.
2. Describe applications of programmable controllers.
3. Explain the HMI (human machine interface) and purpose of touchscreen displays, functions, and alarm handling.

Chapter 5 Electronic Control Systems and Computer Applications

Learning Outcome

Describe the design and operation of electronic control systems.

Learning Objectives

1. Discuss electronic process control systems.
2. Describe computers and how they operate within control systems.
3. Describe the applications of computerized control systems and plant computers.

Chapter 6 Electrical Control Systems

Learning Outcome

Describe the design and operation of electrical control systems.

Learning Objectives

1. Describe the basic construction and operation of various electric control system components.
2. Describe the function of control devices in electric control systems.
3. Explain the operating sequence of basic electric control circuits.



FOURTH CLASS (EDITION 3)

COURSE OUTLINE WITH OUTCOMES

PART A UNIT-10: Fundamental Industrial Communication Skills

Chapter 1 Energy Plant Sketching

Learning Outcome

Create engineering equipment sketches.

Learning Objectives

1. Create sketches using center lines and dimensioning.
2. Recognize standard views of an object.
3. Recognize cross-hatching methods in sectional drawings.
4. Identify common symbols and lines used in plant system trace drawings.
5. Complete a plant line tracing.

Chapter 2 Plant Diagrams and Drawings

Learning Outcome

Identify common types of diagrams used in plants.

Learning Objectives

1. Explain the layout of plant diagrams.
2. Explain the use of process flow diagrams (PFDs).
3. Explain the use of piping and instrumentation diagrams (P&IDs).
4. Explain the use of general arrangement, block plans and equipment diagrams.

Chapter 3 Plant Communications

Learning Outcome

Describe the types and proper usage of plant communication systems.

Learning Objectives

1. Discuss effective written and verbal communication skills, including the use of two-way radios.
2. Describe the legal documentation requirements for Power Engineers, including log books and log sheets.
3. Discuss the elements of Maintenance Management Systems, including work requests, and work orders.
4. Discuss the purpose, revision, and control of Standard Operating Procedures.
5. Discuss updating procedures for piping and instrumentation diagrams.



FOURTH CLASS (EDITION 3)

COURSE OUTLINE WITH OUTCOMES

PART A UNIT-11: Introduction to Boiler Designs

Chapter 1 Introduction to Boilers

Learning Outcome

Describe the historical development of boilers, boiler design, components, and configuration.

Learning Objectives

1. Describe the history of boiler applications, boiler design, and modern boiler improvements.
2. Describe packaged boilers.
3. Describe the construction of shop-assembled and field-erected boilers.
4. Describe components and design aspects common to all boiler vessels.

Chapter 2 Firetube Boilers

Learning Outcome

Describe the design, components, and characteristics of firetube boilers.

Learning Objectives

1. Differentiate the Scotch Boiler from the other firetube boilers, and describe its development history.
2. Describe circulation patterns in firetube boilers.
3. Discuss construction details of firetube boilers.

Chapter 3 Watertube Boilers

Learning Outcome

Describe the design, components, and characteristics of watertube boilers.

Learning Objectives

1. Describe the design and operating principles of watertube boilers.
2. Describe watertube boiler components.
3. Explain the design and application of packaged watertube boilers.
4. Describe the design, construction, and components of large-scale steam generating units.

Chapter 4 Electric Boilers

Learning Outcome

Explain the general design and application of electric boilers.

Learning Objectives

1. Discuss the advantages and disadvantages of electric boilers.
2. Describe the construction and operating principle of electric boilers.



FOURTH CLASS (EDITION 3)

COURSE OUTLINE WITH OUTCOMES

Chapter 5 Special Boiler Designs for Heating Plants

Learning Outcome

Describe the special design considerations of boilers used in heating plants.

Learning Objectives

1. Describe the design of watertube and coil tube heating boilers.
2. Describe cast iron boilers and vertical firetube boilers.
3. Describe the construction and application of firetube heating boiler designs.

Chapter 6 Differences between Power and Heating Boilers

Learning Outcome

Differentiate between ASME Section I and ASME Section IV boilers.

Learning Objectives

1. Discuss the differences between power boiler and heating boiler design and installation.
2. Discuss the differences between power boiler and heating boiler operation.

PART A UNIT-12: Elements of Boiler Systems

Chapter 1 Combustion

Learning Outcome

Discuss the basic theory of combustion, and the equipment used to provide proper combustion conditions within a boiler.

Learning Objectives

1. Discuss combustion, combustion equations, and the relationship between theoretical and excess air.
2. Discuss the characteristics of solid, liquid, and gaseous fuels.
3. Explain the effects of fuels and combustion on refractory materials.

Chapter 2 Fuel Delivery and Firing Systems

Learning Outcome

Describe common fuel systems found in boiler systems.

Learning Objectives

1. Describe solid fuel delivery systems.
2. Describe the main types of solid fuel firing systems.
3. Describe gaseous fuel delivery systems.
4. Describe the main types of gaseous fuel firing systems.
5. Describe liquid fuel delivery systems.
6. Describe the main types liquid fuel firing systems.
7. Describe flue gas analysis and its relationship to boiler efficiency.



FOURTH CLASS (EDITION 3)

COURSE OUTLINE WITH OUTCOMES

Chapter 3 Draft

Learning Outcome

Describe basic concepts and equipment used to supply combustion air to boiler furnaces.

Learning Objectives

1. Describe the various air streams that deliver combustion air to a furnace.
2. Relate differential pressure to the creation of draft.
3. Describe forced, induced, and balanced mechanical draft.
4. Discuss common methods of controlling combustion airflow.
5. Discuss common methods of measuring furnace pressures.

Chapter 4 Feedwater Systems

Learning Outcome

Describe feedwater systems used with boilers.

Learning Objectives

1. Describe the overall layout of feedwater, condensate, and make-up water systems.
2. Describe the valves used in feedwater systems.
3. Describe the control strategies for single-element, two-element, and three-element boiler feedwater systems.
4. Describe methods of supplying feedwater to steam heating boilers.
5. Explain the operation of condensate receiver make-up water controls.
6. Describe the return of condensate, and the supply of feedwater to high-pressure boilers.

Chapter 5 Blowoff and Blowdown Systems

Learning Outcome

Describe the equipment, operation, and purpose of boiler blowoff and blowdown systems.

Learning Objectives

1. Describe blowoff, blowoff equipment and blowoff procedures.
2. Describe continuous blowdown, blowdown equipment, and blowdown procedures.
3. Describe the maintenance and repair of blowoff systems.

Chapter 6 Boiler Fireside Cleaning Systems

Learning Outcome

Describe types of boiler fireside cleaning equipment, their purpose, and their operation.

Learning Objectives

1. Describe common options for in-service fireside cleaning.
2. Describe the construction and operation of retractable soot blowers.
3. Describe the construction and operation of stationary soot blowers.
4. Describe falling shot cleaning methods.