Professional Engineers
Ontario

Confirmatory Exam Program Requirements
Chemical Engineering

Chemical Engineering Technical Exams. You must choose three of your four exams from the Chemical Engineering Technical Exam list. Two of these exams must be from Group A and one from Group B listed below.

The following restrictions apply:

If you choose 16-Chem-A2 or 16-Chem-A3, **do not** choose 16-Chem-B1

If you choose 16-Chem-A6, **do not** choose 16-Chem-B3

Chemical Engineering Technical Exams			
Group A		**Group B**	
16-Chem-A1	Process Balances and Chemical Thermodynamics	16-Chem-B1	Transport Phenomena
16-Chem-A2	Unit Operations and Separation Processes	16-Chem-B2	Environmental Engineering
16-Chem-A3	Heat and Mass Transfer	16-Chem-B3	Simulation, Modelling, and Optimization
16-Chem-A4	Chemical Reactor Engineering	16-Chem-B4	Biochemical Engineering
16-Chem-A5	Chemical Plant Design and Economics	16-Chem-B5	Pulp and Paper Technology
16-Chem-A6	Process Dynamics and Control	16-Chem-B6	Petroleum Refining and Petrochemicals
		16-Chem-B7	Extractive Metallurgy
		16-Chem-B8	Polymer Engineering
		16-Chem-B9	Advanced Materials
		16-Chem-B10	Life Cycle Assessment (LCA)
		16-Chem-B11	Nuclear and Nuclear Chemical Processes
		16-Chem-B12	Corrosion and Oxidation
		16-Chem-B13	Ceramic Materials
		16-Chem-B14	Nanomaterials

Complementary Studies. You must also choose one exam from the Complementary Studies below.

Complementary Studies	
11-CS-1	Engineering Economics
11-CS-2	Engineering in Society – Health & Safety
11-CS-3	Sustainability, Engineering and the Environment
11-CS-4	Engineering Management

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PEO'S TECHNICAL EXAMINATION PROGRAMS

WHY A TECHNICAL EXAM PROGRAM?

The academic requirement for licensing as a professional engineer in Ontario is a bachelor's degree in engineering from an accredited program at a Canadian university or its equivalent.

The Canadian Engineering Accreditation Board (CEAB) accredits undergraduate engineering degree programs on behalf of the provincial/territorial engineering associations/order, including PEO.

Applicants who do not hold a bachelor's degree in engineering from a CEAB-accredited program may be required to pursue either PEO's *Confirmatory or Specific* exam program to demonstrate that they possess the equivalent academic background for licensing purposes.

PEO's TECHNICAL EXAM PROGRAMS

Confirmatory Exam Program (CEP). Applicants whose undergraduate Bachelor's engineering degree was obtained via a program that appears to be similar to the respective CEAB-accredited program are usually assigned a Confirmatory Exam Program, which consists of four exams. The intent is to give the applicant an opportunity to demonstrate that s/he has an academic preparation that is deemed to be equivalent to that of a graduate of a CEAB-accredited program.

Specific Exam Program (SEP). If PEO's assessment reveals that an applicant's academic qualifications are below the established Canadian standard, s/he will be assigned a Specific Exam Program aimed to remedy identified deficiencies for licensing purposes. A Specific Exam Program may consist of Basic Studies exams, discipline-specific exams, Complementary Studies exams and a thesis.

Basic Studies exams are a prerequisite and must be addressed first; PEO will re-evaluate the applicant's file following the successful completion of all Basic Studies exams and may modify the original exam program, and advise the applicant of the options available to address any outstanding exams.

TIME LIMITS FOR WRITING EXAMS

PEO's technical exams are offered twice annually (in May and December).

Applicants must write at least one exam within two academic years following the date of receipt of their exam program notification. Once the exam program is commenced, the applicant must write at least one exam each academic year or the file will be closed. All exam programs must be successfully completed within eight academic years of the date that the applicant was notified of his/her exam program. ("Academic Year" means the period starting September 1 in a year and ending August 31 in the following year.)

HAVING THE FILE CLOSED

An application file will be closed if any one of the following conditions applies:

- not completing all exam requirements within the specified time limit;
- not writing at least one exam in each academic year after writing the first exam;
- failing the same exam on three attempts;
- failing a total of five exams;
- failing two Basic Studies exams; or
- failing to write a failed exam within one academic year for CEP.

PERFORMANCE STANDARDS

The pass mark for all PEO exams is 50%.

Confirmatory Exam Program. An applicant will be considered to have successfully completed the CEP if the average of the technical exam marks is at least 55% and a pass mark (at least 50%) was received on the Complementary Studies exam.

If an applicant fails two exams or fails the same exam twice in a CEP, s/he may be assigned a Failed-to-Confirm exam program, which may consist of additional exams in the Basic Studies, discipline-specific and Complementary Studies categories.

GOOD-PERFORMANCE REVIEW POLICY

Confirmatory Exam Program. To meet the "good-performance" review criterion, an applicant must have written two technical exams at the first sitting and achieved a minimum average of 65% with no mark below 60%.

After a second exam sitting, if an applicant has passed three technical exams with no mark below 60%, s/he may receive consideration for exemption from writing the Complementary Studies exam. If an applicant attempted two exams in the first sitting but failed one, s/he may still qualify for a "good-performance" review if s/he passes the failed exam with a mark of 70% or higher and achieves 60% or higher on the previously unwritten technical exam attempted at the second sitting.

Important: If an applicant has been assigned a **Directed Confirmatory Exam Program,** the good performance criteria are different; to be eligible, in addition to meeting the above criteria, all the directed exams must be addressed as well. Applicants are advised to contact the Exam Centre to discuss further.

Note:

- Good-Performance reviews are not applicable to Specific Exam Program and Failed-to-Confirm exam program applicants.

WHEN AND WHERE PEO EXAMS ARE OFFERED

PEO technical exams are held in May and December at 14 centres in Ontario. Exams are usually offered over a five-day period.

Registration packages to write are mailed in January for the May sitting and in July for the December sitting.

If the technical exam package is not received by the times indicated above, applicants should call the Exam Centre.

PROCUREMENT OF TEXTS AND OTHER MATERIALS FOR AN EXAM

To help in the procurement of all the suggested technical text books Contact customer service of Login Brothers at orders@lb.ca , through the website www.lb.ca or 1-800-665-1148 to assist you. It is recommended to always purchase the latest edition of any suggested textbook.

If an applicant does not have the current text listing or the text(s) is out of print, the applicant is advised to contact the Exam Centre (see below).

Recent written exams (i.e., reprints) are available on-line at PEO's website at www.peo.on.ca for free download. These past exams are available to provide the applicant with knowledge of the exam format, etc. The answers/solutions of past exams are not available at PEO.

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PEO'S TECHNICAL EXAMINATION PROGRAMS

EXAM FEES

All Exam Fees are non-refundable.

First Exam Fee	$700
Each Subsequent Exam Fee	$200
Submission of an Engineering Thesis	$360

COURSES-IN-LIEU

For all course(s)-in-lieu of PEO exam(s), applicants must get prior approval from PEO. A request must be in writing and should include a description of the proposed university calendar course and should be submitted at least two months in advance of the course's registration deadline.

Applicants must arrange for the official grade report(s) to be forwarded to the Licensing and Registration Department upon the completion of the course(s).

NOTE: ***Courses-in-lieu are not acceptable for:***

- ***Basic Exams,***
- ***Confirmatory Exams,***
- ***Directed Confirmatory Exams,***
- ***Failed exams***

EXAM CENTRES

Exams are offered annually in May and December at the following centres in Ontario:

Belleville	London	Sudbury
Chalk River	Ottawa	Thunder Bay
Hamilton	Peterborough	Toronto
Kingston	Sarnia	Windsor
Kirkland Lake	St. Catharines	

The timetable information and exact location of exams are posted on PEO's website early in April to applicants writing exams in May, and early in November for those writing in December.

Applicants living inside Ontario must write at an Ontario centre. One of the centres listed may be selected. Applicants living outside Ontario may make special arrangements to write outside Ontario or Canada. Call the Exam Centre for further instructions if special arrangements are required.

ADDITIONAL INFORMATION

Order of exams. Basic Studies exams are a prerequisite and must be written first. Following the successful completion of all Basic Studies exams, applicants may write the remaining exams in any order. However, it is recommended that exams in less-advanced subjects be written first. Passing an exam in an advanced subject does not merit credit for a less-advanced subject.

English Language Skills. An acceptable level of English–both written and spoken–is required to practise engineering and to successfully complete PEO exams. If an applicant needs to improve English language skills, s/he should contact one of the many English as a Second Language Programs run by schools and community organizations throughout Ontario.

Penalties. Using notes or other aids in an exam where these are not allowed is strictly forbidden. Applicants caught doing so will have their paper confiscated and risk having their licence application withdrawn.

Exam Results. Exam results are normally mailed within 45 working days following writing of the exam. No results will be given over the telephone or in person at PEO office. Exam papers will not be returned to applicants and answers are not available. Failed exams are automatically re-read. However, applicants may request a formal re-read of an exam paper. A non-refundable fee of $330 is charged in the event a formal re-read is requested by an applicant. Requests for a re-read must be received within 30 days after an applicant has been notified of the exam mark.

Reapplying After A File Has Been Closed. If a file has been closed, an applicant may reapply with the understanding that the regulations and policies in effect at the time of the new application will be enforced.

An application for licence fee and all other associated fees will be required.

If a file was closed for poor academic performance, the applicant may be required to show that s/he has taken course(s) in the subject(s) covered by any failed exam(s).

All recorded failed exams from a previous application must be successfully addressed before an applicant will be allowed to pursue the new program.

WORKING IN ENGINEERING BEFORE LICENSURE

Applicants may work in engineering provided a licensed professional engineer takes responsibility for the work. It is illegal to use the title "professional engineer" or any variation thereof (project engineer, systems engineer, etc.) as an occupational or business title that might lead to the belief that a person is a licensed professional engineer.

NEED MORE INFORMATION?

For more information about licensing/registration requirements, please contact:
Licensing and Registration Department
Professional Engineers Ontario
40 Sheppard Avenue West, Suite 101
Toronto, ON M2N 6K9
Tel: (416) 224-1100 / 1-800-339-3716
Fax: (416) 224-8168 / 1-800-268-0496
http://www.peo.on.ca

PEO'S *CONFIRMATORY* EXAMINATION PROGRAM

Confirmatory Exam Program (CEP)
PEO's ***Confirmatory Exam Program*** (CEP) consists of three technical exams in the applicant's engineering discipline and a *Complementary Studies* exam.

- This program must be completed within eight academic years following the date of receipt of the exam program notification. ("Academic Year" means the period starting September 1 in a year and ending August 31 in the following year.)
- Applicants will have successfully completed the *Confirmatory Exam Program* if the average of their three technical exams is at least 55% with no mark below 50% and they achieve a pass (50%) on the *Complementary Studies* exam.
- To qualify for the good performance review, applicants must address all the directed exams, if the applicant is assigned a *Directed Confirmatory Exam Program*

Good-Performance review for CEP applicants may be warranted as follows:

- Applicants who pass any two technical exams at their first sitting, with a minimum average of 65% and with no mark below 60%, may be exempted from completing the remaining exams in the *Confirmatory Exam Program.*
- Applicants who complete three technical exams in two sittings with no mark below 60% may be exempted from the *Complementary Studies* exam.
- Applicants who fail one technical exam and achieve a mark of 70% or higher on the failed exam on their second attempt, and 60% or higher on a previously unwritten technical exam attempted at the same sitting, may be exempted from completing the remaining exams in their *Confirmatory Exam Program.*

A ***Failed-to-Confirm*** Exam Program for CEP applicants, consisting of additional exam(s), will be assigned to applicants who do not confirm their engineering knowledge via their *Confirmatory Exam Program.* At least one of the following will apply:

- Applicants who do not achieve an average mark of at least 55% on the three technical exams will be assigned a *Failed-to-Confirm* Exam Program and one additional technical exam will be assigned.
- Applicants, who failed the same exam twice or failed two different exams will be assigned a *Failed-to-Confirm* Exam Program where an additional exam will be assigned for each exam failure. They must also pass the failed exams.

Please note: For applicants who are assigned a ***Failed-to-Confirm*** Exam Program, their engineering experience does not begin until after the academic requirements for licencing are met, and they will be required to demonstrate 48 months of engineering experience from that time.

A ***file will be closed*** under the following circumstances:

- If there is loss of contact (no active mailing address), the applicant's file will be closed.
- Applicants who do not attempt any exams within two academic years after notification of their exam program will have their file closed.
- Once an exam program commences, applicants must write at least one exam each academic year or their file will be closed even if the applicant has successfully passed exams in the past.
- Applicants who fail a technical/Complementary Studies exam on their first sitting must pass the failed exam within one academic year or their file will be closed.

If you have any questions concerning the above listed, please contact the Exam Centre
416-840-1097, 1057, 1096, 1095 or 1(**800) 339-3716** 1097, 1057, 1096, 1095
e-mail: exams@peo.on.ca

Last Revision: May 2019

PEO CHEMICAL ENGINEERING EXAMINATIONS

INTRODUCTION

Each discipline examination syllabus is divided into two examination categories: compulsory and elective. A full set of Chemical Engineering examinations consists of eighteen, three-hour examination papers and an engineering report. Candidates will be assigned examinations based on an assessment of their academic background. Examinations from discipline syllabi other than those specific to the candidates' discipline may be assigned at the discretion of PEO's Academic Requirement Committee.

Information on examination scheduling, textbooks, materials provided or required, and whether the examinations are open or closed book, will be provided by PEO's examinations Centre.

BASIC STUDIES

04-BS-1 Mathematics
Calculus, Vector, and Linear Algebra: Applications involving matrix algebra, determinants, eigenvalues; first and second order linear ordinary differential equations, Laplace transforms. Vector algebra; vector functions and operations; orthogonal curvilinear coordinates; applications of partial derivatives, Lagrange multipliers, multiple integrals, line and surface integrals; integral theorems (Gauss,Green, Stokes). Power series.

04-BS-2 Probability and Statistics
Concepts of probability, events and populations, probability theorems, concept of a random variable, continuous and discrete random variables, probability distributions, distributions of functions of a random variable, sampling and statistical estimation theory, hypothesis testing, simple regression analysis.

04-BS-3 Statics and Dynamics
Force vectors in two- and three-dimensions, equilibrium of a particle in two- and three-dimensions; moments and couples; equilibrium of rigid bodies in two- and three-dimensions; centroids, centres of gravity; second moment of area, moment of inertia; truss, frame and cable static analysis; friction. Planar kinematics of particles and rigid bodies; planar kinetics of particles and rigid bodies; work and energy, impulse, and momentum of particles and rigid bodies.

04-BS-4 Electric Circuits and Power
Basic laws, current, voltage, power; DC circuits, network theorems, network analysis; simple transients, AC circuits. Impedance concept, resonance; use and application of phasors and complex algebra in steady-state response; simple magnetic circuits; basic concepts and performance characteristics of transformers; an introduction to diodes and transistors; rectification and filtering; simple logic circuits.

04-BS-5 Advanced Mathematics
Series Solutions of Differential Equations: Series solutions of ordinary differential equations, boundary value problems and orthogonal functions, Fourier series.
Numerical Methods: Use of computers for numerical solution of engineering problems, including techniques involving library subroutines and spreadsheets. Approximations and errors, interpolation, systems of linear and non-linear algebraic equations, curve fitting, numerical integration and differentiation, and ordinary differential equations.

04-BS-6 Mechanics of Materials
Definitions of normal stress, shearing stress, normal strain, shearing strain; shear force and bending moment diagrams; members subjected to axial loading; members subjected to torsional loading; compound stresses, Mohr's circle; deformation of flexural and torsional members; failure theories; elastic and inelastic strength criteria; columns.

04-BS-7 Mechanics of Fluids
Fluid characteristics, dimensions and units, flow properties, and fluid properties; the fundamentals of fluid statics, engineering applications of fluid statics; the one-dimensional equations of continuity, momentum, and energy; laminar and turbulent flow, flow separation, drag and lift on immersed objects; wall friction and minor losses in closed conduit flow; flow of incompressible and compressible fluids in pipes; dimensional analysis and similitude; flow measurement methods.

04-BS-10 Thermodynamics
Thermodynamic states of simple systems; the laws of thermodynamics; equilibrium, PVT and other thermodynamic diagrams; equation of state; compressibility charts and steam tables; calculation of property changes; enthalpy; applications of thermodynamics, cycles, reversibility; thermodynamics of phase changes, Gibbs phase rule, gas-vapour mixtures.

04-BS-11 Properties of Materials
Properties of materials for mechanical, thermal and electrical applications. Atomic bonding, solid solutions, crystallization. Equilibrium phase diagrams, applications to steel and aluminium alloys, heat treatments. Structure and special properties of polymers and ceramic materials. General characteristics of metallic composites, polymeric composites and concrete. Introduction to materials in hostile environments: corrosion, creep at high temperature, refractory materials, subnormal temperature brittle fracture.

04-BS-12 Organic Chemistry
Principles of organic chemistry developed around the concepts of structure and functional groups. The main classes of organic compounds. Properties of pure substances. Introduction to molecular structure, bond types, properties, synthesis and reactions, reaction mechanisms, as a means of systematizing organic reactions.

04-BS-13 Biology
Cellular reproduction, growth, and differentiation; metabolism and bioenergetics of living cells; cell structure and function related to the material properties of plant and animal tissues; introductory microbiology — characteristics and classification of microorganisms; interactions of microorganisms with man in the natural world; kinetics and mathematical models of microbial growth; engineered biological systems such as bio-reactors, bio-instrumentation, and waste treatment systems.

04-BS-14 Geology
The structure of the earth, plate tectonics, earthquakes and igneous activity. Minerals and rocks including their formation, identification, basic properties, and classification. Processes of weathering, erosion, transport, and deposition of geological materials and their results of significance to engineering. Occurrence, flow, and quality of groundwater. Introductory aspects of structural geology including faulting, folding, and the overall formation of discontinuities and their effect on the engineering properties of rock masses. Aerial photography and geological maps.

04-BS-15 Engineering Graphics and Design Process
Engineering drawing: Orthographic sketching. Standard orthographic projection. Principal views, selection and positioning of views. Visualization. Conventions and practices. First and second auxiliary views. Basic descriptive geometry. Section views, types, hatching conventions. Basic dimensioning requirements. Tolerance for fits and geometry control. Detail drawings and assembly drawings, other drawings and documents used in an engineering organization. Bill of materials. Fasteners and welds.
Design process and methods. Project management & teamwork. Requirements and function analysis in design. Conceptual design and testing. Concept evaluation design factors such as: cost, quality, manufacturability, safety, etc. Systems modelling & design detail.

04-BS-16 Discrete Mathematics
Logic: propositional equivalences, predicates and quantifiers, sets, set operations, functions, sequences and summations, the growth of functions. Algorithms: complexity of algorithms, the integers and division, matrices. Methods of proof: mathematical induction, recursive definition. Basics of counting: pigeonhole principle, permutations and combinations, discrete probability. Recurrence relations: inclusion-exclusion. Relations and their properties: representing relations, equivalence relations. Introduction to graphs: graph terminology, representing graphs and graph isomorphism, connectivity, Euler and Hamilton paths. Introduction to sorting.

GROUP A

16-Chem-A1 Process Balances and Chemical Thermodynamics
The analysis of industrial and chemical processes; mass conservation and energy conservation; thermochemistry; properties of pure substances; properties of solutions; energy and the first law of thermodynamics; the second law of thermodynamics and entropy; applications of the laws of thermodynamics to problems in the behaviour of fluids, flow processes, power cycles, refrigeration and heat pumps, phase equilibria and chemical reaction equilibria.

16-Chem-A2 Unit Operations and Separation Processes *(formerly Mechanical and Thermal operations)*
Incompressible and compressible fluid flow. Flow through packed beds, fluidization. Particle size distribution. Mechanical operations such as mixing and blending, filtration and sedimentation. Thermal operations such as evaporation and crystallization. Application of equilibrium theory and rate considerations for absorption, adsorption, distillation, drying, extraction, membrane separation, leaching.

16-Chem-A3 Heat and Mass Transfer
Theory and practice of conductive, convective, and radiative heat transfer; design of heat exchangers; heat transfer involving phase change. Diffusion and permeability; mass transfer through stagnant and moving films; the concept of equilibrium stages; estimation and use of overall heat and mass transfer coefficients in the design of process equipment.

16-Chem-A4 Chemical Reactor Engineering
Application of the principles of chemical kinetics and other rate phenomena to the design of chemical reactors. Dynamics in chemical systems, including chemical kinetics, catalysis and transport processes. Theory of idealized isothermal reactors including batch, plug flow, and continuous stirred tank reactors for single and multiple reactions. Residence time distributions and their effect on conversion. Simple adiabatic and non-isothermal reactors with homogeneous and heterogeneous reactions; thermal run-away reactions.

16-Chem-A5 Chemical Plant Design and Economics
Structure of chemical process systems and systematic methods for capital and operating cost calculations. Economic factors in design, economic balances, capital and operating cost estimation techniques, assessment of alternative investments and replacements, and application of compound interest calculations. Simple optimization theory. Evaluation of process alternatives. Equipment and materials selection. Factors such as energy, safety, hygiene, and environmental protection. Familiarity with computer process simulation. Intrinsically safe design. Risk analysis. The use of heuristics in design of chemical processes.

16-Chem-A6 Process Dynamics and Control
Concept of transfer functions. Response of simple chemical processes to step, ramp, and sinusoidal inputs. Transient response of interacting elements in series. Frequency response analysis of simple systems. On-off control, cascade control, ratio control, proportional, integral, derivative, and combinations of these control actions, single-input/single-output control and multiple-input/multiple-output control. Closed-loop response. Feedback and feedforward control. Controller tuning and algorithms. Simple stability analysis. Dynamics and control of common chemical process units such as heat exchangers, simple reactors, and agitated vessels. Hardware implementation, analog and digital, of simple control algorithms and designs.

GROUP B

16-Chem-B1 Transport Phenomena
The application of integral and differential techniques for solving problems involving mass, energy and/or momentum transport through solids and within fluids. Steady and unsteady state processes. Molecular transport. Convective transfer of heat and mass involving laminar and turbulent fluid flows.

16-Chem-B2 Environmental Engineering
Engineering aspects of air and water pollution abatement and effluent treatment. Characterization of water contaminants and their measurement, biological oxygen demand, sedimentation, flotation, aeration, and activated sludge processes, pH control, ion exchange, oxidation-reduction, electrodialysis, reverse osmosis. Sources and dispersion of atmospheric pollutants. Control methods for particulates, gases, and vapours. Photochemical reactions, noxious pollutants, and odour control. Contaminated soil remediation. Measurement techniques.

16-Chem-B3 Simulation, Modelling, and Optimization
The analysis and modelling of chemical processes using either a mechanistic or an empirical input/output approach. Subsystem modelling to reduce complex processes to simpler component parts. Linearization of non-linear processes. Optimization methods; direct search, climbing and elimination techniques, linear and non-linear programming.

16-Chem-B4 Biochemical Engineering
Basic microbiology and chemistry of cells, biochemical kinetics, enzymes, metabolic pathways, energetics, transport phenomena and reactor design as applied to biochemical reactors, scale-up, fermentation technology.

16-Chem-B5 Pulp and Paper Technology
Papermaking raw materials: wood anatomy and chemistry. Pulping processes: mechanical pulping, chemi-thermo-mechanical processes, chemical pulping (sulphite, Kraft). Pulp treatment: refining and bleaching. Papermaking equipment and processes. Environmental protection. Structure and properties of paper and paperboard.

16-Chem-B6 Petroleum Refining and Petrochemicals
The composition and classification of petroleum. Crude oil evaluation in relation to product quality. Refinery products: properties, specifications, and testing. The petroleum refinery: crude oil distillation, catalytic cracking, alkylation, hydrogen production, catalytic reforming, hydrotreating, amine processes, sulphur production, isomerization, polymerization, oxygen compounds. Lubricating oil and asphalt manufacturing. Synthesis of primary products; ethylene, methanol, glycols, aromatics.

16-Chem-B7 Extractive Metallurgy
Thermodynamics and reaction kinetics of extractive metallurgical processes. Electrolytic reduction of molten salts. Metal refining processes. Heat transfer, mass transfer, and materials preparation in the metallurgical industry. Comparison of processes. Equipment selection and operation.

16-Chem-B8 Polymer Engineering
Basic polymer structures and characterization of polymer physical, chemical, and mechanical properties. Polymerization reactions and kinetics; chain formation and co-polymerization. Polymerization processes: bulk, suspension, solution, and emulsion polymerizations. Polymer flow behaviour describing non-Newtonian and visco-elastic effects. Polymer processing including extrusion, moulding and film production. Polymer systems: additives, blends, composites, and fibre reinforcement.

16-Chem-B9 Advanced Materials
Properties, production of and uses of composites, engineered plastics, biopolymers, special coatings, and nanostuctured materials with emphasis on structure property relationships.

16-Chem-B10 Life Cycle Assessment (LCA)
Concepts of life cycle assessment. Applications to energy utilization, environment, sustainable development and process analysis and optimisation.

16-Chem-B11 Nuclear and Nuclear Chemical Processes
The properties of actinides; radioactivity; processes of mining, refining and enrichment of uranium; reactor materials and design; reprocessing chemistry; waste management.

16-Chem-B12 Corrosion and Oxidation
Basic corrosion theory. Electrochemical corrosion theory. Metallurgical cells. Environmental cells. Stress assisted corrosion. Materials selection. Protective coatings. Corrosion inhibitors. Cathodic and anodic protection. Oxidation.

16-Chem-B13 Ceramic Materials
Bonding in ceramics. Ceramic structures. Effect of chemical forces and structure on physical properties. Defects in ceramics. Diffusion and electrical conductivity. Phase equilibria. Sintering and grain growth. Mechanical properties: fast fracture, creep, slow crack growth and fatigue. Thermal stresses and thermal properties. Dielectric properties.

16-Chem-B14 Nanomaterials
Physical chemistry of solid surfaces, zero, one and two dimensional nanostructures, special nanomaterials, nanostructures fabricated by different physical techniques. Characterization and properties of nanomaterials in electronics, biology, catalysis, quantum devices, energy and environment.

COMPLEMENTARY STUDIES

11-CS-1 Engineering Economics
Basic concepts of engineering economics through understanding of the theoretical and conceptual financial project analysis. Types and applications of engineering economic decisions. Capital, cash flow, and the time value of money concepts. Nominal and effective interest rates when considering loans, mortgages, and bonds. The application of present worth analysis, annual equivalent analysis and rate of return analysis in evaluating independent projects, comparing mutually exclusive projects, analyzing lease vs. buy alternatives and making decisions. After-tax financial analysis requiring an understanding of capital cost allowance (depreciation) and corporate income tax. Understanding methods of financing and capital budgeting. Break-even, sensitivity and risk analyses.

11-CS-2 Engineering in Society – Health and Safety
The duties and legal responsibilities for which engineers are accountable; safety laws and regulations; and a basic knowledge of potential hazards and their control: biological hazards – bacteria, viruses; chemical hazards - gases, liquids and dusts; fire and explosion hazards; physical hazards – noise, radiation, temperature extremes; safety hazards – equipment operation; workplace conditions - equity standards, human behaviour, capabilities, and limitations; managing safety and health through risk management, safety analyses, and safety plans and programs; practices and procedures to improve safety. The roles and social responsibilities of an engineer from a professional ethics point of view, as applied in the context of Canadian values. The integration of ethics into engineering practice, and its effect on public safety and trust.

11-CS-3 Sustainability, Engineering and the Environment
Basic knowledge of soil, water and air quality engineering: soil and water interaction, water supply issues, human activities and their interaction on soil, air and water resources. Fundamentals of: soil erosion, water quality, atmospheric pollution (carbon and nitrogen cycle), climate change, risk assessment. Basic knowledge of renewable energy sources: solar, photovoltaic, wireless electricity, thermal, wind, geothermal, and biofuels. **Introduction to** renewable materials engineering; nano materials, new material cycles. Eco-product development, and product life cycle assessment; recycling technologies; reuse of products; design for disassembly, recycling, e-waste, and reverse manufacturing. Consumption patterns; transportation;

environmental communication; consumer awareness. Optimized energy and resources management. Sustainable methods: sustainability indicators; life cycle assessment; regulatory aspects of environmental management, ecological planning.

11-CS-4 Engineering Management

Introduction to management principles and their impact upon social and economic aspects of engineering practice. Engineering management knowledge topics including: market research, assessment and forecasting; strategic planning; risk and change management; product, service and process development; engineering projects and process management; financial resource management; marketing, sales and communications management; leadership and organizational management; professional responsibility. New paradigms and innovative business models, including: sustainable production, products, service systems and consumption; best practices and practical examples of successful implementations of sustainable scientific and engineering solutions.

3.2 ENGINEERING REPORT

Upon passing the examination(s) assigned by PEO's Academic Requirements Committee, a candidate may be required to write an Engineering Report. The report must demonstrate the candidate's ability to present an engineering problem, observation, or idea, and to analyze it logically and accurately using engineering principles, and to draw conclusions or make recommendations. The work must include acceptable technical content involving engineering analysis, design, development, or research. The report must also demonstrate a satisfactory level of writing and graphical skills, thus the quality of the presentation will be a factor in determining the acceptability of the report.

The report itself need not prove originality of ideas, but the candidate should demonstrate his/her ability to appreciate, present, differentiate between and draw conclusions from observations and ideas. The definition of a "report" is flexible and could also include discussion and judgement of opposed theories or methods, or a description of a novel technique or process and a discussion of the practicality of its application. The key consideration is that the report address a new issue, and not repeat the coverage of the particular subject available in textbooks. It is the current state of the art, the novel or the contentious that is expected to be explored in the report.

While no rigid rules of format are specified, it is recommended that the report be suitably subdivided and include:

a) A title page and date
b) A signed declaration of authorship
c) A table of contents
d) A summary of the report and its conclusions
e) Technical content including analysis, design, development or research
f) Conclusions and/or recommendations
g) A list of the technical literature cited
h) A list of acknowledgements, contributors, reviewers and sources of information

The report should be about 5,000 words long, not including tables and graphs. Diagrams, illustrations, etc. should be clearly and properly identified. It is preferable to locate graphs, diagrams, etc. necessary for the understanding of the text at the place where reference to them is made.

2016 PEO CHEMICAL ENGINEERING EXAMINATIONS TEXTBOOKS REFERENCE LIST

NOTE: Please feel free to use the most recent edition of textbooks referenced in this list

16-Chem-A1 Process Balances and Chemical Thermodynamics

J.M. Smith, H.C. Van Ness, M.M. Abbott, Introduction to Chemical Engineering Thermodynamics, latest edition. McGraw-Hill.

R.W. Felder, R.W. Rousseau, Elementary Principles of Chemical Processes, latest edition. John Wiley.

16-Chem-A2 Unit Operations and Separation Processes (formerly Mechanical and Thermal Operations)

C.J. Geankoplis, Transport Processes and Unit Operations, latest edition. Prentice Hall.

W.L. McCabe, J.C. Smith, P. Harriott, Unit Operations of Chemical Engineering, latest edition. McGraw-Hill.

F.P. Incropera, D.P. DeWitt, Fundamentals of Heat and Mass Transfer, latest edition. John Wiley.

16-Chem-A3 Heat and Mass Transfer

R.E. Treybal, Mass Transfer Operations, latest edition. McGraw-Hill.

P.H. Wankat, Equilibrium Staged Separations. Elsevier.

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Web Resources
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Primary Text
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Organizations: Canadian Society of Safety Engineering (CSSE), Canadian Centre for Occupational Health and Safety (CCOHS), Health Canada, National Academy of Engineering Center for Engineering, Ethics and Society

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Wimmer, W. and Kauffman, Joanne. Handbook of Sustainable Engineering. First edition, Springer Publishing, 2011. ISBN: 978-1-4020-8939-8.

Additional Resources
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1972 Stockholm Report of the United Nations Conference on the Human Environment
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Web Resources
Key words: Sustainability; Sustainable engineering; Energy, Engineering and the Environment

Organizations: Environment Canada, Natural Resources Canada, Organisation for Economic Co-operation and Development (OECD) sustainable development

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Primary Text
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Additional Resources
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04-BS-3	Statics and Dynamics
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04-BS-5	Advanced Mathematics
04-BS-6	Mechanics of Materials
04-BS-7	Mechanics of Fluids
04-BS-10	Thermodynamics
04-BS-11	Properties of Materials
04-BS-12	Organic Chemistry
04-BS-13	Biology
04-BS-14	Geology
04-BS-15	Engineering Graphics and Design Process

PROFESSIONAL EXAMS – SPECIFIC TO CHEMICAL ENGINEERING

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16-Chem-A1	Process Balances and Chemical Thermodynamics
16-Chem-A2	Unit Operations and Separation Processes
16-Chem-A3	Heat and Mass Transfer
16-Chem-A4	Chemical Reactor Engineering
16-Chem-A5	Chemical Plant Design and Economics
16-Chem-A6	Process Dynamics and Control

GROUP B

16-Chem-B1	Transport Phenomena
16-Chem-B2	Environmental Engineering
16-Chem-B3	Simulation, Modelling, and Optimization
16-Chem-B4	Biochemical Engineering
16-Chem-B5	Pulp and Paper Technology
16-Chem-B6	Petroleum Refining and Petrochemicals
16-Chem-B7	Extractive Metallurgy
16-Chem-B8	Polymer Engineering
16-Chem-B9	Advanced Materials
16-Chem-B10	Life Cycle Assessment (LCA)
16-Chem-B11	Nuclear and Nuclear Chemical Processes
16-Chem-B12	Corrosion and Oxidation
16-Chem-B13	Ceramic Materials
16-Chem-B14	Nanomaterials

COMPLEMENTARY STUDIES

11-CS-1	Engineering Economics
11-CS-2	Engineering in Society – Health & Safety
11-CS-3	Sustainability, Engineering and the Environment
11-CS-4	Engineering Management

3.2	Engineering Report