Professional Engineers
Ontario

Confirmatory Exam Program Requirements
Software Engineering

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

Software Engineering Technical Exams			
Group A		**Group B**	
19-Soft-A1	Algorithms & Data Structures	19-Soft-B1	Advanced Software Design
19-Soft-A2	Computer Architecture and Operating Systems	19-Soft-B2	User Interface
		19-Soft-B3	Security
19- Soft-A3	Software Design	19-Soft-B4	Dependable Systems
19-Soft-A4	Real Time Systems	19-Soft-B5	Software Modeling & Verification (Formal Methods)
19-Soft-A5	Requirements and Specifications		
19-Soft-A6	Software Quality Assurance	19-Soft-B6	Software Project Management
19-Soft-A7	Software Development Process	19-Soft-B7	Reverse Engineering, Maintenance & Evolution
		19-Soft-B8	Distributed Systems
		19-Soft-B9	Parallel Computing
		19-Soft-B10	Networking and Communications
		19-Soft-B11	Process Control Systems
		19-Soft-B12	Engineering Computation: Numerics
		19-Soft-B13	Performance Analysis & Simulation
		19-Soft-B14	Safety Critical Systems
		19-Soft-B15	Artificial Intelligence
		19-Soft-B17	Programming Languages, Semantics and Implementation
		19-Soft-B18	Data Visualization

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

Professional Engineers
Ontario

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.

Professional Engineers
Ontario

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'S *CONFIRMATORY* EXAMINATION PROGRAM

Confirmatory Exam Program (CEP)

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- 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 technical/Complementary Studies exam twice, failed two technical exams or failed one technical exam and a Complementary Studies exam will be assigned a *Failed-to-Confirm* Exam Program where an additional technical/Complementary Studies exam will be assigned for each exam failed. They must also pass the failed exams.

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e-mail: exams@peo.on.ca

Last Revision: August 2017

SOFTWARE ENGINEERING EXAMINATIONS

INTRODUCTION

Each discipline examination syllabus is divided into two examination categories: compulsory and elective. A full set of Software Engineering examinations consists of eighteen, three-hour examination papers. 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-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-8 Digital Logic Circuits
Boolean algebra, encoders, decoders, shift registers, and asynchronous and synchronous counters together with timing considerations. Design of asynchronous circuits, synchronous sequential circuits, and finite state machines. Karnaugh mapping techniques, and state tables and diagrams. Introduction to programmable logic.

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, crystallisation. 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-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

19-Soft-A1 Algorithms & Data Structures

Fundamental data structures and their associated algorithms. Stacks and queues, trees, tables, lists, arrays, strings, sets; files and access methods. B-trees, multi-key organizations. Searching. Sorting. Algorithm design techniques, such as divide and conquer, the greedy method, balancing, dynamic programming. Algorithms related to set operations, Graphs, graph algorithms: depth-first and breadth-first search, minimum spanning tree, shortest path. Empirical and theoretical measures of the efficiency of algorithms. Complexity analysis. Hard problems, NP-completeness, and intractable problems.

19-Soft-A2 Computer Architecture and Operating Systems

Computer Architecture basics, including Boolean algebra, gates, combinational and sequential logic, machine-level representation of data; machine organization, assembly/machine language programming; memory organization, caches, heaps, stacks; serial and parallel I/O, interrupts, bus protocols, and direct-memory access (DMA). Operating System basics, including concurrency, process scheduling, memory management; protection, access, and authentication; linking and loading; virtual machines.

19-Soft-A3 Software Design

Role of software design activity. Software design quality attributes: correctness, reliability, maintainability, portability, robustness. Software design principles: separation of concerns, abstraction, information hiding. Static and dynamic typing. Mutable and immutable types. Modularity and decomposition. Function-oriented design. Object-oriented design. Subtyping. Components. Interface design. Module level design. Notations: UML and other notations. Basic concepts of design patterns. Introduction to testing: unit tests, blackbox vs. grey box testing, test coverage.

19-Soft-A4 Real-Time Systems

Definition and characteristics of real-time systems. Hard and soft real-time systems. Dynamic responses of simple physical processes. Designing real-time systems (requirements, design methods, implementation, testing, human-computer interaction). Reliability and fault tolerance. Exceptions and exception handling. Concurrency, synchronization, communication and resource control. Scheduling (cyclic executive, rate monotonic and deadline priority, priority ceiling protocols). Real-time operating systems. Simple embedded systems.

19-Soft-A5 Requirements and Specifications

Elicitation sources and techniques. Modelling paradigms, including information modelling, behavioural modelling, domain modelling, functional modelling, constraint modelling. Quality requirements (e.g., performance, usability, reliability, maintainability); expressing quality requirements so that they are testable. Prioritization, trade-off analysis, negotiation, risk analysis, and impact analysis. Requirements management, consistency management, interaction analysis, traceability. Requirements documentation (e.g., use cases) and specification languages. Validation, reviews and inspections, prototyping, validating non-functional requirements. Acceptance test design.

19-Soft-A6 Software Quality Assurance

Validation and verification concepts, software lifecycle and application of validation and verification, software quality assurance processes. Definitions of software product quality, quality characteristics, engineering quality definitions, specifications. Definition and classifications of software defects, fitness for use and customer quality definitions. Software costs, quality costs and economics. Reviews, walkthroughs and inspections. Unit (Module/Package) level testing, subsystem/integration testing, regression testing, state based testing, traditional functional testing, logical testing/analysis, OO testing considerations (polymorphism and inheritance). Safety/failure analysis and testing.

19-Soft-A7 Software Development Process

Software life cycles. Software process models. Control and life-cycle management of correct, reliable, maintainable and cost-effective software. Software documentation. Project management tools. Risk management. Communication and collaboration. Cause and effects of project failure. Cost estimation and scheduling. Factors influencing productivity and success. Productivity metrics. Configuration management. Defect management.

GROUP B

19-Soft-B1 Advanced Software Design

Software design paradigms: object-oriented, service-oriented, component-based, agent-based, functional programming, client-server (including protocols such as REST), virtualization. Distributed component-based frameworks and systems. Design patterns. Model-driven design of software. Software architecture. Architecture representation.

19-Soft-B2 User interface

Psychological principles of human-computer interaction. Evaluation of user interfaces. Usability engineering. Task analysis, user-centered design and prototyping. Conceptual models and metaphors. Software design rationale. Design of windows, menus and commands. Voice and natural language I/O. Response time and feedback. Colour, icons and sound. Internationalization and localization. User interface architectures and APIs. Case studies and project.

19-Soft-B3 Security

Security risks, threats, and vulnerabilities. Confidentiality, integrity, and privacy. Cryptography, access control, assurance, accountability. Engineering of secure systems, architectural approaches (e.g., confinement, virtual machines, trusted computing). Analysis techniques (e.g., static analysis and testing, model checking). Implications on human interface design and usability.

19-Soft-B4 Dependable systems

Software and hardware faults. Faults, latent faults and failures. Characterization of failure functions, probability distribution of failures, failure intensity function. Software reliability definition and measures. MTTF, MTBF, MTTR, availability, maintainability. Hardware reliability and software reliability. Techniques for prediction of remaining faults, including fault injection, classification tree analysis, code coverage. General lifecycle techniques for producing reliable software, including defect prevention, early defect detection and removal; design for robustness; use of process measurements; stabilization of requirements, design, code and test artifacts. Active and Passive fault detection. N-version programming, forward and backward check-pointing, recovery blocks, and arbitration techniques. Fault handling and correction, exceptions, fault tolerance. Survivability, critical functions and degraded modes of operation. Data integrity protection.

19-Soft-B5 Software Modeling & Verification (Formal Methods)

Mathematical modelling of software, including topics such as programming logics, process algebras, model based specification, object constraint languages, and algebraic specification. Mathematical reasoning using such models, including proofs of program correctness. Tools for static checking of the correctness of software relative to its specification.

19-Soft-B6 Software Project Management

Software development lifecycles (sequential, iterative, spiral, agile). Managing software costs: size and effort estimation. Managing risks. Managing software quality. Managing software assets (configuration management, open source software and related IP issues). Software development governance, in particular in regulated environments. Software production and deployment.

19-Soft-B7 Reverse Engineering, Maintenance & Evolution

Software maintenance: corrective, perfective, and adaptive. Techniques for reverse engineering software architecture and design, for the purpose of program comprehension. System and process re-engineering (technical and business). Refactoring. Migration (technical and business). Impact analysis. Release and configuration management. Models of software evolution (theories, laws). Relationship among evolving entities (e.g., assumptions, requirements, architecture, design, code, test suites). Legacy systems. Technical debt.

19-Soft-B8 Distributed Systems

Characteristics of distributed systems. Networked vs. centralized systems. Fundamental concepts and mechanisms. Architectural concepts of distributing an application over several platforms. Overview of network configurations and topologies. Client-server systems. Process synchronization and inter-process communications. Principles of fault tolerance. Transaction processing techniques. Distributed file systems. Operating systems for distributed architectures. Cloud computing. Security.

19-Soft-B9 Parallel Computing

Models of parallel computation. Superscalar architecture. Shared memory parallel machines. Interconnection networks and their topological properties. Massively parallel computers. Hypercube architectures. Performance measurement for parallel algorithms. Parallel evaluation of expressions. Parallel searching and data structures. Parallel algebraic and geometric processing.

19-Soft-B10 Networking and Communications

Data communications, including signals, modulation, and reception. Channel models and channel capacity. Error detecting and correcting codes. Bit error rate. Data transmission protocols, including half/full duplex, asynchronous/synchronous, point-to-point/multidrop. Character sets, switching alternatives, including circuit and packet. Layered network architecture. Data link and network layer protocols. Transport protocols. Local and wide area networks. Elements of queuing theory. Network performance measures (queue length, delay and throughput). Standards and the standardization process.

19-Soft-B11 Process Control Systems

Discrete time models of continuous physical phenomena. Z-transform and transfer functions. Time domain and frequency domain response of first, second and higher order systems. Stability and feedback compensation. Steady state error and proportional, integral and derivative (PID) control. Compensator design using Nyquist criterion and frequency domain

design. Sampling theorem, aliasing, anti-aliasing filtering. Design of digital controllers. Software implementation of digital controllers. Computer control interfacing.

19-Soft-B12 Engineering Computation: Numerics

Representation of numbers and floating-point round-off. Caveats of computations with floating point. Linear systems: direct and iterative methods, conditioning, structured systems. Zeros of functions. Quadrature. Data-fitting methods. Ordinary differential equations: initial value problems, predictor-corrector, boundary value problems, systems of ODEs. Simple partial differential equations. Continuous optimization.

19-Soft-B13 Performance Analysis & Simulation

Basic techniques of system performance evaluation. Specific topics include: measurement methods and tools, experimental design and analysis, modeling (including queuing and network of queuing systems), discrete event simulation, verification and validation of simulation models, analysis of simulation output, statistical methods (comparing systems using sample data, hypothesis testing and confidence measures).

19-Soft-B14 Safety Critical Systems

Safety and hazard analysis. Use of software in safety related systems. Legal and ethical considerations. Risk analysis techniques: FMEA, HAZOP, FTA, ETA. Safety integrity levels and safety cases, use of GSN (Goal Structuring Notation). Software reliability. Distinction between safety and reliability of systems. Achievement of software reliability by fault prevention and fault tolerance. Software design aspects for safety and fault tolerance. Human factors in design for safety. Choice of programming language, safe subsets. Formal methods, algebraic, model and process based specification, formal specification languages, refinement proofs, verification proofs, STAMP/STPA techniques. Fault tolerance, redundancy and common mode failures, N-version programming and recovery blocks. Safety related standards. Certification.

19-Soft-B15 Artificial Intelligence

Artificial intelligence; definition and applications. Problem solving: search, adversarial search and constraint solving. Knowledge and Reasoning: agents, logic, planning, knowledge representation. Uncertainty: probabilistic computation and reasoning, decision problems. Learning: from examples, learning models, reinforcement learning, neural networks, deep learning. Communication: natural language processing, perception, robotics.

19-Soft-B17 Programming Languages, semantics and implementation

Programming paradigms (procedural, object-oriented, logic and functional). Structuring features (modules, objects, inheritance, polymorphism). Explicit examples from a variety of languages. Abstract syntax. Type systems. Interpretation, compilation, code generation, code transformation, code analysis. Structure and components of compilers. Run-time support. Code optimization.

19-Soft-B18 Data Visualization

Data abstractions. Task abstractions. Data analysis and data mining. Pattern discovery. Human visual system, perception. Visual presentations, visual design. Chart types. Maps and networks. Data visualization tools.

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.

NOTE: Please feel free to use the most recent edition of textbooks referenced in this list
NOTA : Utilisez l'édition la plus récente des manuels cités dans cette liste.

19-Soft-A1 Algorithms & Data Structures

Adam Drozdek, *Data Structures and Algorithms in C++*, Fourth Edition, Cengage Learning, 2013.

19-Soft-A2 Computer Architecture and Operating Systems

David A. Patterson, John L. Hennessy, Morgan Kaufman, *Computer Organization & Design*, 1998.
David A. Patterson, John L. Hennessy, *Computer Organization and Design MIPS Edition: The Hardware/Software Interface*, 2013 edition.
Saltzer and Kaashoek, *Principles of Computer System Design: An Introduction.*

19-Soft-A3 Software Design

Carlo Ghezzi, Mehdi Jazayeri, Dino Mandrioli, *Fundamentals of Software Engineering,* Second Edition, Pearson 2003, ISBN 0-13-305699-6.
Shari Lawrence Pfleeger, Joanne M. Atlee, *Software Engineering,* Third Edition, Pearson 2006, ISBN 0-13-146913-4.
Robert C. Martin, *Agile Software Development, Principles, Patterns, and Practices,* Prentice Hall, 2002.

19-Soft-A4 Real Time Systems

A. Burns, Andy Wellings, *Real-Time Systems and Programming Languages: Ada, Real-Time Java and C/Real-Time POSIX* Addison –Wesely, 2009 ISBN-13: 978-0321417459.
Giorgio Buttazzo, *Hard Real-Time Computing Systems,* Springer ISBN 978-1-4614-0676-1

19-Soft-A5 Requirements and Specifications

Shari Lawrence Pfleeger, Joanne M. Atlee, *Software Engineering,* Third Edition, Pearson 2006, ISBN 0-13-146913-4.
Karl E. Wiegers, *Software Requirements,* Microsoft Press, 1999.

19-Soft-A6 Software Quality Assurance

Daniel Galin, *Software Quality Assurance: From Theory to Implementation*, Pearson, 2003, ISBN-13: 978-0201709452.

19-Soft-A7 Software Development Process

Shari Lawrence Pfleeger, Joanne M. Atlee, *Software Engineering,* Third Edition, Pearson 2006, ISBN 0-13-146913-4.

Carlo Ghezzi, Mehdi Jazayeri, Dino Mandrioli, *Fundamentals of Software Engineering,* Second Edition, Pearson 2003, ISBN 0-13-305699-6.

19-Soft-B1 Advanced Software Design

Bass, L., Clements, P., & Kazman, R., *Software Architecture in Practice*, Third edition, 2012, Reading, MA: Addison-Wesley.
Gorton, I., *Essential Software Architecture,* Second Edition, 2006, Berlin: Springer.
Bernd Bruegge, Allen H. Dutoit, *Object-Oriented Software Engineering*, Second Edition, Pearson 2004.
Joshua Bloch, *Effective java*, Addison-Wesley, ISBN-13: 978-0134685991.

19-Soft-B2 User interface

J. Tidwell, O'Reilly, *Designing Interfaces: Patterns for Effective Interaction Design,* ISBN-13: 978-1449379704.
J. Johnson, Morgan Kauffman, *Designing with the Mind in Mind: Simple Guide to Understanding User Interface Design Guidelines*, ISBN-13: 978-0124079144.

19-Soft-B3 Security

R. J. Anderson, *Security Engineering: A Guide to Building Dependable Distributed Systems,* Second Edition, Wiley, 2008.

19-Soft-B4 Dependable systems

Nancy G. Leveson, *Engineering a Safer World: Systems Thinking Applied to Safety,* 2012, MIT Press, ISBN-13: 978-0262016629.

19-Soft-B5 Software Modeling & Verification (Formal Methods)

V. S. Alagar and K. Periyasamy, Springer-Verlag, *Specification of Software Systems,* 1998, ISBN 0-387-98430-5.

19-Soft-B6 Software Project Management

Not available at this time.

19-Soft-B7 Reverse Engineering, Maintenance & Evolution

Not available at this time.

19-Soft-B8 Distributed Systems

Not available at this time.

19-Soft-B9 Parallel Computing

Not available at this time.

19-Soft-B10 Networking and Communications

B. P. Lathi and Z. Ding, *Modern Digital and Analog Communication Systems*, Fifth edition, Oxford University Press, 2018.
B. A. Forouzan, *Data Communications and Networking*, Fifth edition, McGraw-Hill, 2013.
A. Leon-Garcia and I. Widjaja, *Communication Networks: Fundamental Concepts and Key Architectures*, McGraw-Hill, 2004.
D. Bertsekas and R. Gallager, *Data Networks*, Second edition, Upper Saddle River, NJ: Prentice Hall, 1991.

19-Soft-B11 Process Control Systems

Not available at this time.

19-Soft-B12 Engineering Computation: Numerics

Laurene V. Fausett, *Numerical Methods,* Pearson, 2003.

Singiresu S. Rao, *Applied Numerical Methods for Engineers and Scientists,* Prentice Hall, 2002.

19-Soft-B13 Performance Analysis & Simulation

Mor Harchol-Balter, *Performance Modeling and Design of Computer Systems: Queueing Theory in Action,* Cambridge University Press, 2013, ISBN: 9781107027503.

19-Soft-B14 Safety Critical Systems

Nancy Leveson, *Engineering a safer world*, MIT Press, 2012.
Clifton Ericsson, *Software safety primer*, CreateSpace, 2013.

19-Soft-B15 Artificial Intelligence

Peter Norvig and Stuart J. Russell, *Artificial Intelligence: A Modern Approach*, Pearson, ISBN: 0-13-604259-7.

19-Soft-B17 Programming Languages, semantics and implementation

Benjamin C. Pierce, *Types and Programming Languages,* MIT Press, ISBN 0-262-16209-1.
Daniel P. Friedman and Mitch Wand, *Essentials of Programming Languages*, MIT Press, Third Edition, ISBN-13: 978-0262062794.
Robert Harper, *Practical Foundations for Programming Languages*, Cambridge University Press, Second Edition, ISBN: 9781107150300.

Keith Cooper and Linda Torczon, Morgan Kaufmann, *Engineering: A Compiler*, ISBN-13: 978-0120884780.

19-Soft-B18 Data Visualization

Tamara Munzner, *Visualization Analysis and Design,* CRC Press, 2014, ISBN-13: 978-1466508910.

11-CS-1 Engineering Economics

Primary Text
Fraser, Niall; Jewkes, Elizabeth; Bernhardt, Irwin and Tajima, May. Global Engineering Economics: Financial Decision Making for Engineers. Fourth edition, Pearson Education Canada, 2008. ISBN: 978-0132071611.

Additional Resources
Sonyi, Andrew; Fenton, Robert and White, John. Principles of Engineering Economics Analysis. Canadian edition, Wall & Emerson Inc., 2000. ISBN: 978-0921332497.

Web Resources
Key words: engineering economics, cost engineering, financial analysis

Organizations: International Cost Engineering Council, Association of Cost Engineers, Association for the Advancement of Cost Engineering

11-CS-2 Engineering in Society – Health & Safety

Primary Text
Brauer, Roger L. Safety and Health for Engineers. Second edition, John Wiley & Sons Inc., 2006. ISBN: 978-0471286325.

Web Resources
Key words: health and safety, public safety, engineering ethics

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

11-CS-3 Sustainability, Engineering and the Environment

Mihelcic, J.R. and Zimmerman, J.B. (2014) *Environmental Engineering: Fundamentals, Sustainability, Design, 2nd edition.* John Wiley & Sons, Hoboken, NJ.

Berg, L., Hager, M.C., Goodman, L. and Baydack, R. (2010) *Visualizing the Environment* (Canadian Edition). John Wiley & Sons, Hoboken, NJ. (Chapters 10, 11)

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

Additional Resources
The Report of the Brundtland Commission ("Our Common Future")
1972 Stockholm Report of the United Nations Conference on the Human Environment
1992 United Nations international Earth Summit in Rio de Janeiro

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

11-CS-4 Engineering Management

Primary Text
American Society for Mechanical Engineers. Guide to the Engineering Management Body of Knowledge. American Society for Mechanical Engineers, 2010. ISBN: 978-0791802991

Additional Resources
Gray, Clifford F. and Larson, Erik W. Project Management: The Managerial Process. Canadian 5th edition. Irwin/McGraw-Hill, 2011. ISBN: 978-0073403342

aussi disponible en français :
Gray, Clifford F. et Larson, Erik W. Management du projet. Chenelière McGraw-Hill, 2006. ISBN: 978-2765104537

Web Resources
Key words: engineering management, financial management, strategic management, resource management, operations management

Organizations: American Society for Mechanical Engineers (ASME), Canadian Society for Engineering Management, Project Management Institute, American Society for Engineering Management

Updated: October 2014

SOFTWARE ENGINEERING

INTRODUCTION

A full set of Software Engineering examinations consists of the following, three-hour examination papers. 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.

BASIC STUDIES EXAMINATIONS

04-BS-1	Mathematics
04-BS-2	Probability and Statistics
04-BS-4	Electric Circuits and Power
04-BS-5	Advanced Mathematics
04-BS-6	Mechanics of Materials
04-BS-7	Mechanics of Fluids
04-BS-8	Digital Logic Circuits
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-16	Discrete Mathematics

PROFESSIONAL EXAMS – SPECIFIC TO SOFTWARE ENGINEERING

GROUP A

19-Soft-A1	Algorithms & Data Structures
19-Soft-A2	Computing Architecture and Operating Systems
19-Soft-A3	Software Design
19-Soft-A4	Real Time Systems
19-Soft-A5	Requirements and Specifications
19-Soft-A6	Software Quality Assurance
19-Soft-A7	Software Development Process

GROUP B

19-Soft-B1	Advanced Software Design
19-Soft-B2	User interface
19-Soft-B3	Security
19-Soft-B4	Dependable Systems
19-Soft-B5	Software Modeling & Verification (Formal Methods)
19-Soft-B6	Software Project Management
19-Soft-B7	Reverse Engineering, Maintenance & Evolution
19-Soft-B8	Distributed Systems
19-Soft-B9	Parallel Computing
19-Soft-B10	Networking and Communications
19-Soft-B11	Process Control Systems
19-Soft-B12	Engineering Computation: Numerics
19-Soft-B13	Performance Analysis & Simulation
19-Soft-B14	Safety Critical Systems
19-Soft-B15	Artificial Intelligence
19-Soft-B17	Programming Languages, Semantics and Implementation
19-Soft-B18	Data Visualization

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