



Confirmatory Exam Program Requirements Nuclear Engineering

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

Nuclear Engineering Technical Exams			
Group A		Group B	
08-Nuc-A1	Introduction to Nuclear Physics and Nuclear Engineering	08-Nuc-B1	Nuclear Shielding
08-Nuc-A2	Nuclear Reactor Analysis	08-Nuc-B2	Radiation Protection
08-Nuc-A3	Nuclear Reactor Design	08-Nuc-B3	Fuel Management / Fuel Design
08-Nuc-A4	Reactor Safety and FMEA	08-Nuc-B4	Waste Management
08-Nuc-A5	Nuclear Detection and Instrumentation	08-Nuc-B5	Nuclear Plant Chemistry
08-Nuc-A6	Nuclear Power Plant Systems and Operation	08-Nuc-B6	Nuclear Materials
08-Nuc-A7	Process Dynamics and Control (16-Chem-A6)	08-Nuc-B7	Reactor Control
		08-Nuc-B8	Applied Thermodynamics and Heat Transfer (16-Mec-A1)
		08-Nuc-B9	Energy Conversion and Power Generation (16-Mec-B3)
		08-Nuc-B10	Fluid Machinery (16-Mec-B6)
		08-Nuc-B11	Power Systems and Machines (16-Elec-A6)
		08-Nuc-B12	Power Systems Engineering (16-Elec-B7)

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



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.



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

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NUCLEAR ENGINEERING EXAMINATIONS

INTRODUCTION

Each discipline examination syllabus is divided into two examination categories: compulsory and elective. A full set of Nuclear Engineering examinations consists of nineteen, 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 Examination 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-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-9 Basic Electromagnetics

Introduction to the basic electromagnetic principles upon which electrical engineering is based (laws in both integral and differential form). Classical development of electrostatics and magnetostatics leading to Maxwell's equations. Application of electromagnetic theory to calculation of d-c circuit parameters, study of plane wave transmission in various media.

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-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

08-Nuc-A1 Introduction to Nuclear Physics and Nuclear Engineering

Basic nuclear structure; nuclear properties; the force between nucleons; nuclear models; radioactive decay; alpha decay; beta decay; gamma decay; nuclear reactions; nuclear fission; nuclear fusion; concepts of reactivity and criticality; radiation interaction with matter; elements of energy production by fission processes and their control; introduction to nuclear reactor design; the CANDU reactor; LWR reactors; fast breeders, the nuclear fuel cycle.

08-Nuc-A2 Nuclear Reactor Analysis

Introduction to nuclear energy; nuclear physics and chain reactions; reactor statics and kinetics; multi-group analysis; core composition changes; numerical methods; miscellaneous topics.

08-Nuc-A3 Nuclear Reactor Design

Advanced overview of multi-disciplinary areas in nuclear engineering; past, present and future reactor types; energy generation and conversion; heat transfer and transport in a nuclear reactor; power system thermodynamic cycles including the Rankine and Brayton cycle; characteristics and performance of nuclear fuels; thermal margins and safety limits; aging and degradation mechanisms of core structural materials; structural integrity of components.

08-Nuc-A4 Reactor Safety and FMEA (Failure Mode and Effects Analysis)

Nuclear reactor safety design and analysis principles and practice. Probability theory, failure rates, availability, reliability, test frequencies, passive and active systems, and deterministic and probabilistic evaluation for simple systems. Historical and philosophical basis for nuclear safety, safety criteria, grouping and separation, diversity, independence, initiating events, fault trees and event trees, safety analysis.

08-Nuc-A5 Nuclear Detection and Instrumentation

Industrial monitoring and detection; diagnostic equipment installation; thermal measurement techniques; pressure measurement techniques; flow measurement; level measurement; radiation measurements; environmental assessment and measurement; void fraction; quality and humidity measurement; chemical composition measurement; measurement reliability; and safety systems.

08-Nuc-A6 Nuclear Power Plant Systems and Operation

Reactor power plant systems and operation; science fundamentals; equipment and systems principles relevant to reactors, overall unit control.

08-Nuc-A7 Process Dynamics and Control (16-Chem-A6)

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

08-Nuc-B1 Nuclear Shielding

Radiation sources; characteristics and utilization of various radiation detectors; statistics of radiation counting; radiation spectroscopy with scintillation detector; semi-conductor detectors; identification and measurement of source strength, spectrum and geometry; shielding requirements for various types of radiation; shielding materials for equipment and processes employing radiation; radiation heating; radiation damage; measuring the effectiveness of various shielding materials; shielding for the transportation of radioactive materials; calculation and design of shielding for industrial and power plant applications; shielding requirements for spent fuel storage.

08-Nuc-B2 Radiation Protection

Dose limitation; dosimetric quantities for individuals and populations; dose limits; tissues at risk; internal doses and the compartment model; derived air concentrations and annual limit on intake; metabolic models for respiratory system and GI tract, radiation safety at nuclear reactors, particle accelerators, irradiators, X-Ray installations and laboratories; pathway analysis; derived emission limits; environmental monitoring, sample collection and preparation, and sources of radiation; atmospheric transport; cost-benefit analysis; radon dosimetry, measurement, and limits; derivation of limits for laboratory contamination.

08-Nuc-B3 Fuel Management / Fuel Design

Nuclear fuel cycles from mining to ultimate disposal of the spent fuel; enrichment and reprocessing techniques; operational and economical evaluation; disposal of nuclear waste and the overall fuel cycle costs; burn-up calculations; in-core and out-of-core fuel management for CANDU Pressurized Heavy Water Reactors (PHWR) and Light Water Reactors (LWR); fuel management for thorium-fuelled CANDU reactors and other advanced fuels such as MOX containing plutonium from discarded nuclear warheads, and DUPIC (Direct Use of PWR fuel in CANDU reactors); fuel management optimization.

08-Nuc-B4 Waste Management

Physical and chemical properties of irradiated fuel and approaches to storage and disposal; nature and distribution of radionuclides; chemical and physical properties of the Zircaloy fuel cladding before and after in-reactor exposure; principles behind pool and dry storage including the design of storage containers and the chemical and corrosion processes that could influence their long-term integrity; possible permanent disposal scenarios developed internationally; the properties of engineered barriers within the geological site.

08-Nuc-B5 Nuclear Plant Chemistry

Corrosion and crud formation; heavy water chemistry; heavy water production and up-keep; moderator and heat transport system chemistry; purification systems to remove particulates, contaminants and chemicals added to control reactivity; decontamination; steam generator, condenser and feedwater chemistry; pH and pD control in power plants; online and offline control of process chemistry; metallurgical problems in nuclear power plants; metallurgical techniques for irradiated materials.

08-Nuc-B6 Nuclear Materials

Irradiation effects on material properties, including neutrons, charged particles and gamma radiation; activation products; selection of materials for nuclear applications; radiation induced damage in materials; neutronic, thermal and structural considerations; material properties of nuclear fuels and fuel cladding; pressure vessel and pressure tube material behaviour; moderator, coolant and steam generator material properties; materials suitable for reactivity control device and shielding; materials used for long term storage of radioactive waste and spent fuel; activation analysis of materials using a neutron source.

08-Nuc-B7 Reactor Control

Control theory and application to nuclear power plants; use of indicators and alarms; role of the operator, man-machine interface; use of computers in reactor control; in-core and out-of-core measurement of neutron flux, spatial flux control, start-up instrumentation, failed fuel detection and location; reactivity control methods, mechanisms and algorithms; reactor shutdown methods, mechanisms and systems; loss of reactor control; temperature, pressure and flow measurements; heat transport system pressure and inventory control.

08-Nuc-B8 Applied Thermodynamics and Heat Transfer (16-Mec-A1)

Thermodynamics: Review of the fundamental laws of thermodynamics, introductory psychrometry and analysis of the ideal gas compressor cycle, Rankine cycle, Otto cycle, Diesel cycle, Brayton cycle and the vapour compression refrigeration cycle.

Heat Transfer: Application of the principles of steady and transient conduction heat transfer, natural and forced convection heat transfer and radiation heat transfer. Thermal analysis of heat exchangers.

08-Nuc-B9 Energy Conversion and Power Generation (16-Mec-B3)

Fuel sources and characteristics: hydrocarbon fuels, nuclear fission, fusion fuels and fuel cells. Fuel reserves. Applications of steam and gas cycles for large-scale commercial power generation; theory and practice of fossil boilers, nuclear reactors, steam and gas turbines, hydroturbines, and fuel cells. Methods of improving conversion efficiency of power generation systems. Energy storage methods and limitations. Renewable energy methods: wind, solar heating and photovoltaics, hydroelectric, geothermal, ocean thermal energy conversion, waves. Safety, environmental and emissions, economic, and social issues.

08-Nuc-B10 Fluid Machinery (16-Mec-B6)

Review of basic concepts; elementary two-dimensional potential flow, vorticity and circulation, onedimensional compressible flow of an inviscid perfect gas, isentropic flow through nozzles, shock waves, frictional compressible flow in conduits, equations of viscous flow, laminar and turbulent boundary layers. Bernoulli's equation and Navier-Stokes equations. Dimensional analysis and similitude.

08-Nuc-B11 Power Systems and Machines (16-Elec-A6)

Magnetic circuits and transformers. Wye and delta connected three-phase systems. Generation, transmission, and distribution of electric power. Three-phase transformers. AC and DC machines. Three-phase synchronous machines and three phase induction motors.

08-Nuc-B12 Power Systems Engineering (16-Elec-B7)

Power system representation and analysis. Components: power transmission lines, transformers, synchronous machines. Distribution: power flow, operations, and control. Fault analysis and power system protection. System stability.

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.

08-Nuc-A1 Introduction to Nuclear Physics and Nuclear Engineering

LaMarsh, J.R. and Baralta, "Introduction to Nuclear Engineering", 3rd Edition", Prentice-Hall

08-Nuc-A3 Nuclear Reactor Design

El Wakil, M.M., Nuclear Energy Conversion, American Nuclear Society, 1992, Third Printing- Chapters 1 to 12, ISBN: 0-89448-015-4

J.R. Lamarsh and A.J. Baratta, Introduction to Nuclear Engineering, Third Edition, Prentice Hall, 2001, Chapter 8, ISBN_ 0-201-82498-1

Donald R. Olander, Fundamental Aspects of Nuclear Reactor Fuel Elements, US Department of Energy, Washington DC, 1976, TID-26711-P1 (Out of Print, possibly available at Georgia Tech Bookstore)

For reactor materials: J.T.A. Roberts, Structural Materials in Nuclear Power Systems, Plenum Press, N.Y. (1981)

Glasstone and Sesonke, Nuclear Reactor Engineering, 4th Edition, Chapman & Hall, 1994

Tong and Weisman, Thermal Analysis of Pressurized Water Reactors, American Nuclear Society, 1979

Lahey and Moody, The Thermal-Hydraulics of a Boiling Water Nuclear Reactor, American Nuclear Society, 1977

Todreas and Kazimi, Nuclear Systems, Vol. 1, Hemisphere Publishing, 1990

08-Nuc-A5 Nuclear Detection and Instrumentation

J. P. Holman, Experimental Methods for Engineers, 8th Edition, ISBN-10: 0073529303
ISBN-13: 978-0073529301

Also, foundation books about NPP systems, detectors, instruments will help.

08-Nuc-A6 Nuclear Power Plant Systems and Operation

Bereznai, G.T. in the form of a course pack that contains interactive CD, text and simulation. It is available from the McMaster and the UOIT Book stores under the title "Nuclear Power Plant Systems and Operation".

08-Nuc-A7 Process Dynamics and Control

D.E. Seborg, T.F. Edgar, D.A. Mellichamp, Process Dynamics and Control. John Wiley, second edition, 2003.

T. Marlin, Process Control, Designing Processes and Control Systems for Dynamic Performance, second edition. McGraw-Hill, 2000.

B.W. Bequette, Process Control: Modeling, Design and Simulation. Prentice Hall, 2003.

C.A. Smith, A.B. Corripio, Principles and Practice of Automatic Process Control, John Wiley, second edition, 1997.

08-Nuc-B2, Radiation Protection

Essentials of Radiation Biology and protection. ISBN 0766813304 latest edition.

08-Nuc-B8 Applied Thermodynamics and Heat Transfer

Moran, M.J., H.N. Shapiro, B.R. Munson and D.P. DeWitt, Introduction to Thermal Systems Engineering: Thermodynamics, Fluid Mechanics, and Heat Transfer. John Wiley and Sons, 2002.

08-Nuc-B9 Energy Conversion and Power Generation

Weston, K.C., Energy Conversion, West Publishing Co., 1992. (available as an online ebook at <http://onlinebooks.library.upenn.edu/webbin/book/lookupid?key=olbp33597>)

Khartchenko, Nikolai, Advanced Energy Systems, Crc Press Llc, 1998. ISBN #1560326115.

08-Nuc-B10 Advanced Fluid Mechanics

White, F.M., Fluid Mechanics, 6th Edition. McGraw-Hill, 2006.

08-Nuc-B11 Power Systems and Machines

Chapman, Stephen, Electric Machinery and Power System Fundamentals, McGraw Hill, 2001.

Wildi, Theodore, Electrical Machines, Drives, and Power Systems, 6th Edition, Prentice Hall, 2005.

08-Nuc-B12 Power Systems Engineering

Glover, J. Duncan, and Mulukutla Sarma, Power System Analysis and Design, 3rd Edition. Thomson Learning, 2002.

Grainger, John and William Stevenson Jr., Power System Analysis, McGraw Hill, 1994.

Updated: July 2019

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

NUCLEAR ENGINEERING

INTRODUCTION

A full set of Nuclear Engineering examinations consists of the following, 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.

BASIC STUDIES EXAMINATIONS

04-BS-1	Mathematics
04-BS-2	Probability and Statistics
04-BS-3	Statics and Dynamics
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-9	Basic Electromagnetics
04-BS-10	Thermodynamics
04-BS-11	Properties of Materials
04-BS-15	Engineering Graphics and Design Process
04-BS-16	Discrete Mathematics

PROFESSIONAL EXAMS – SPECIFIC TO NUCLEAR ENGINEERING

GROUP A

08-Nuc-A1	Introduction to Nuclear Physics and Nuclear Engineering
08-Nuc-A2	Nuclear Reactor Analysis
08-Nuc-A3	Nuclear Reactor Design
08-Nuc-A4	Reactor Safety and FMEA (Failure Mode and Effects Analysis)
08-Nuc-A5	Nuclear Detection and Instrumentation
08-Nuc-A6	Nuclear Power Plant Systems and Operation
08-Nuc-A7	Process Dynamics and Control

GROUP B

08-Nuc-B1	Nuclear Shielding
08-Nuc-B2	Radiation Protection
08-Nuc-B3	Fuel Management / Fuel Design
08-Nuc-B4	Waste Management
08-Nuc-B5	Nuclear Plant Chemistry
08-Nuc-B6	Nuclear Materials
08-Nuc-B7	Reactor Control
08-Nuc-B8	Applied Thermodynamics and Heat Transfer
08-Nuc-B9	Energy Conversion and Power Generation
08-Nuc-B10	Fluid Machinery
08-Nuc-B11	Power Systems and Machines
08-Nuc-B12	Power Systems Engineering

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
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