



## **Confirmatory Exam Program Requirements Manufacturing Engineering**

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

<b>Manufacturing Engineering Technical Exams</b>		
<b>Group A</b>		<b>Group B</b>
08-Mfg-A1	Design and Manufacture of Machine Elements	08-Mfg-B1 Computer Aided Design and Computer-Assisted Manufacturing
08-Mfg-A2	Manufacturing Processes	08-Mfg-B2 Computer Integrated Manufacturing (CIM)
08-Mfg-A3	Production Management	08-Mfg-B3 System Analysis Simulation
08-Mfg-A4	Analysis and Design of Work	08-Mfg-B4 Product Design and Development
08-Mfg-A5	Facilities Planning	08-Mfg-B5 Engineering Materials
08-Mfg-A6	Quality Planning, Control and Assurance	08-Mfg-B6 Metrology
08-Mfg-A7	Electrical and Electronics Engineering	08-Mfg-B7 Logistics: Transportation Aspects
		08-Mfg-B8 Robot Mechanics
		08-Mfg-B9 Industrial Safety and Health
		08-Mfg-B10 Tooling, Jigs and Fixture Design
		08-Mfg-B11 Fluid Machinery
		08-Mfg-B12 Ergonomics

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

<b>Complementary Studies</b>	
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](mailto:orders@lb.ca), through the website [www.lb.ca](http://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](http://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](mailto:exams@peo.on.ca)

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## **MANUFACTURING ENGINEERING EXAMINATIONS**

### **INTRODUCTION**

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

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

**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.

## **GROUP A**

### **08-Mfg-A1 Design and Manufacture of Machine Elements**

Theory and methodology related to conceptual design; review of the methods used in stress analysis; simple design factor approach; variable loads; stress concentrations; bolts and bolted joints; welded joints; springs; shaft and bearing design; clutches, brakes, and braking systems.

The role and characterization of manufacturing technology within the manufacturing enterprise is also examined. Topics include an overview of the deformation process, joining processes, consolidation processes, material removal processes, material alteration processes; composites manufacturing, nano-and-microfabrication technologies rubber processing, glass working, coating processes, mechanical assembly, electronics packaging and assembly, and production lines; and process selection and planning; quality control systems.

### **08-Mfg-A2 Manufacturing Processes**

Fabricating characteristics of metals and plastics. Molding, forging, welding principles and operations, jigs and fixtures. Cold-forming and stamping, turning and related operations, other machining operations and related jigs and fixtures. Metrology. Numerical control machines and applications. Process quality control.

### **08-Mfg-A3 Production Management**

Production systems, including identification of technical, economic, social, human components and characteristics in the system. Forecasting techniques. Inventories, including role, measuring service level, inventory models and their application in distribution and manufacturing. Aggregate planning of production levels and inventories, including master plan, materials requirements planning (MRP), detailed scheduling and sequencing, assembly line balancing. Information and control systems for production operations. Project planning and control.

### **08-Mfg-A4 Analysis and Design of Work**

Methods of work analysis, including process analysis, activity charts, person machine charts, operation analysis, micromotion study, fundamental hand motions and film analysis. Principles of motion economy, method study, motion and time study, rating factor, performance factor, allowances and standard data. Pre-determined motion time systems. Work sampling. Wage payment. Motivation and work. Wage incentives. Job enrichment. Software available in the field of analysis and design of work.

### **08-Mfg-A5 Facilities Planning**

Strategic planning, site selection, product, process, schedule, activity relationship and space requirements, personnel requirements. Developing solutions, including material handling systems and equipment, layout and computer aided layout. Functions, including receiving and shipping, storage and warehousing, production, offices and services. Evaluating solutions, including deterministic and probabilistic models. Selection, implementation, and periodical review of the layout.

**08-Mfg-A6 Quality Planning, Control, and Assurance**

Basic concepts: planning, measurement, control, and improvement of quality. Economics of quality. Strategic planning of quality. Total quality management. Quality function organization. Motivation for quality. Statistical tools: tests, regression analysis, design and analysis of planned experiments, Taguchi methods, control charts for variables and attributes, capability analysis, acceptance sampling: single, multiple, sequential, MIL STD105 E, MIL STD 414, elements of reliability. Quality assurance: ISO/QS 9000, suppliers, audits, quality manual, certification.

**08-Mfg-A7 Electrical and Electronics Engineering**

Introduction to analogue and digital semiconductor devices. Transistor amplifiers and switches. Power semiconductor devices, rectifiers, dc power supplies and voltage regulation. Operational amplifiers and application circuits. Combinational and sequential digital logic circuits. Practical approach to electronic instrumentation, measurement systems and transducers. DC circuits, Single phase and polyphase circuits Magnetic circuits and transformers (ideal and practical), DC machines: motors and generators. AC machines: induction motors, synchronous motors, and alternators. Power factor correction.

**GROUP B**

**08-Mfg-B1 Computer Aided Design and Computer-Assisted Manufacturing**

Fundamental concepts in design and manufacturing automation strategies, high volume discrete parts production systems, numerical control manufacturing systems, computer aided manufacturing (CAM), support systems for manufacturing, group technology, and flexible manufacturing systems.

**08-Mfg-B2 Computer Integrated Manufacturing (CIM)**

Computerization in manufacturing. Manufacturing information systems. Hierarchical control. Just-in-time in the context of CIM. CIM Architecture: Networking OSI, LANS, WANS, MAP. Current technologies: operating systems, case technologies, artificial intelligence, databases. Product Information Management: CAD positioning; Design File Management; Hardware & software; Product Data Models; component, specifications, symbols. Typical Product Information Standards: PDES, IGES, EDIF; Data For Human Consumption. Case Studies.

**08-Mfg-B3 Systems Simulation**

Computer simulation of systems. Design of simulation models of discrete systems. Statistical foundations and methodology. Generation of random variates. Design of simulation experiments. Simulation programming languages. Applications: the analysis and design of systems for production, and distribution. Model validation. Simulation output analysis. Use of software.

**08-Mfg-B4 Product Design and Development**

Modern tools and methods for creative product design and development involving product research, establishment of design parameters, experimentation, development of conceptual alternatives, visualization, evaluation, revision, optimization and presentation. Particular topics include: The engineering design process, development processes and organizations, product planning, identifying customers needs, product specifications, concept generation, concept selection, prototyping, robust design, concept testing,

product architecture, industrial design, design for manufacturing, patents and intellectual property, product development economics, and managing projects.

#### **08-Mfg-B5      Engineering Materials**

Working properties of steel, aluminum, magnesium, and titanium light alloys, superalloys and metal matrix composites. High temperature materials, metallic foams and other cellular materials, precursor derived ceramics, corrosion of materials, intermetallics, multicomponent alloys, biomedical materials, polymeric composites as structural materials, ultrafine and nano structured materials. Microscale and nanoscale mechanisms responsible for their unique properties, such as molecular mobility and phase transitions. Working properties of polymers, shape memory alloys, piezoelectric materials, electrorheological fluids, magnetostrictive materials, and fibre-reinforced composites. Selection of materials.

Testing of engineering materials. Emphasis on those used in aircraft, high-speed ground transportation vehicles, underwater, and space applications.

#### **08-Mfg-B6      Metrology**

The language and systems of measurement. Standards and measuring units system. Calibration and traceability and . Optical, pneumatic, electronic and mechanical measuring instruments and related methods. Coordinate metrology and mathematical concepts of dimensional metrology. Measuring errors analysis, their sources and propagation. Uncertainty in physical measurements. Precision and surface engineering. Applications of computers in metrological work and the interfacing of digital measuring equipment.

#### **08-Mfg-B7      Logistics: Transportation Aspects**

Introduction to transportation engineering, and transport planning and economics. Modelling of transportation and warehousing problems. Characteristics of transportation systems: rail, highway, airway, waterway, and pipeline. The rural and intercity transport system in Canada; cost and tariffs. Network analysis; the transport planning process. Logistics and competitiveness: evaluation of transportation projects and systems, urban transportation analysis and prediction, traffic studies, highway and intercity capacity, characteristics of traffic flow, traffic control principles, and economics.

#### **08-Mfg-B8      Robot Mechanics**

Robot components (sensors, actuators, and end effectors, and their selection criteria); basic categories of robots (serial and parallel manipulators, mobile robots); mobility/constraint analysis; workspace analysis; rigid body kinematics (homogeneous transformation, angle and axis of rotation, Euler angles, cylindrical and spherical coordinates); manipulator kinematics and motion trajectories (displacement and velocity analyses, differential relations, Jacobian matrix); non-redundant and redundant sensing/actuation of manipulators; manipulator statics (force and stiffness); singularities; and manipulator dynamics.

#### **08-Mfg-B9      Industrial Safety and Health**

Fundamentals of systems safety. Safety and accident prevention — causes and models. Safety in product and process design. Fault-tree analysis and risk assessment. Occupational diseases, stress, fatigue. Health, safety and the physical environment. Engineering methods of controlling chemical hazards, safety and the physical environment: engineering methods of controlling chemical and physical hazards. Code and regulations for worker safety and health.

### **08-Mfg-B10 Tooling, Jigs and Fixture Design**

Types of jigs and fixtures and their applications. Concepts of referencing, locating and planes of movement. Design characteristics for locating, clamping, assembling, machining and operational devices. Templates, vices, angle-plate, boxes and channels, Designing around the human element. Modular work holding, welding fixtures and manipulators, machining and assembly fixtures. Tooling for conventional machining and numerically controlled machines, setup devices. Tooling, jigs and fixtures for high quality production. Tool materials. Considerations for design economics.

### **08-Mfg-B11 Fluid Machinery**

Dimensional analysis and similitude. Performance characteristics. Specific speed and machine selection, idealized velocity diagram. System characteristics and operating point and matching a pump to a piping system. System regulation, momentum and energy transfer, thermodynamic analysis, and efficiency definitions. Two-dimensional cascade analysis and performance. Application to pumps, fans, compressors, and turbines. Performance limits due to unsteady flow stalling and cavitation.

### **08-Mfg-B12 Ergonomics**

Basic human abilities and characteristics, including vision and hearing. Psychomotor characteristics. Anthropometry: static and dynamic human body dimensions and muscle strength. Environmental factors, including illumination, atmospheric conditions, noise, and vibration. Ergonomic work design, including layout of equipment, manual work aids, design of seating, and person-machine interfaces: instruments, controls, and software.

## **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.

## MANUFACTURING ENGINEERING – SUGGESTED TEXT LIST

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### 08-Mfg-A1 Design and Manufacture of Machine Elements

Juvinall, Robert C., and Kurt M. Mershek, Fundamentals of Machine Component Design, 4th Edition. Wiley, 2005. ISBN: 0-471-66177-5.

Groover, Mikell P., Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, 3<sup>rd</sup> Edition. Wiley, 2006. ISBN: 0-471-74485-9.

### 08-Mfg-A2 - Manufacturing Processes

Kalpakjian, Serope, Manufacturing Processes for Engineering Materials, 3<sup>rd</sup> Edition, Addison Wesley Longman Inc., 1997. ISBN # 0-201-82370-5

E.P. DeGarmo, J.T. Black, and R.A. Kohser, Materials and Processes in Manufacturing, 6<sup>th</sup> edition. MacMillan, 1984.

### 08-Mfg-A3 - Production Management

Stephenson, J. Williams, Production Operations Management, 6<sup>th</sup> Ed., CD Rom On-Line Card, McGraw Hill. ISBN 007 2359587

Stevenson & Hojati, Operations Management, 2<sup>nd</sup> Edition, McGraw-Hill Publishing Co. ISBN# 0-07-091189-4, 2004

### 08-Mfg-A4- Analysis and Design of Work

Ralph M. Barnes, Motion and Time Study Design and Measurement of Work, 7<sup>th</sup> Edition. John Wiley and Sons Inc.

### 08-Mfg-A5- Facilities Planning

Meyers, F.E. & Stephens, M,P, Manufacturing Facilities Design and Material Handling, Edition 3, 2005, ISBN 0-13-112535-4

Muther,R,J & Wheeler,J,D, Simplified Systematic Layout Planning, ISBN 0-933684-09-6

S. Heragu, Facilities Design, PWS Publishing Company (20 Park Plaza; Boston MA 02116-4324), 1997. ISBN # 0-534-95183-X

D.R. Sule, Manufacturing Facilities. PWS-Kent Publishing, Boston.

J.A. Tompkins and J.A. White, Facilities Planning. John Wiley and Sons Inc.

### 08-Mfg-A6 - Quality Planning, Control, and Assurance

J.M. Juran and F.M. Gryna, Quality Planning and Analysis, latest edition. McGraw-Hill.

D.C. Montgomery, Introduction to Statistical Quality Control, latest edition. John Wiley and Sons (NOTE: Exclude Chapters 10 and 15.)

### 08-Mfg-A7 Electrical and Electronics Engineering

Edminister, J. A., and M. Nahvi, Electric Circuits, 4<sup>th</sup> Edition. Schaum's Outlines, 2003. Nasar, S.,

Electric Machines and Electromechanics, 2<sup>nd</sup> Edition. Schaum's Outlines, 1998

Rizzoni, G., Principles and Applications of Electrical Engineering, 5<sup>th</sup> edition. McGraw Hill, 2007.

## **MANUFACTURING ENGINEERING – SUGGESTED TEXT LIST**

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### **08-Mfg-B1 - Computer Aided Design and Computer-Assisted Manufacturing**

M.P. Groover, Automation, Production Systems and Computer-Integrated Manufacturing, latest edition. Prentice-Hall, 1987. ISBN # 0-13-054652-6025.

### **08-Mfg-B2 - Computer Integrated Manufacturing (CIM)**

Reinhold, Blume, Dillmann, Computer Integrated Manufacturing Technology and Systems, latest edition. Marcel Dekker, Inc. ISBN # 0-8247-7403-5.

### **08-Mfg-B3 - Systems Simulation**

A.M. Low and W.D. Kelton, Simulation, Modelling and Analysis, 2<sup>nd</sup> edition. McGraw-Hill Inc., 1991.

C.D. Pegden, R.E. Shannon, and R.P. Sadowski, Instruction to Simulation Using Siman. McGraw-Hill Inc., 1990.

### **08-Mfg-B4 Product Design and Development**

Collier, D.A. & Evans, J.R., Operations Management, Goods, Services and Value Chains, Edition 2, Illustrated, Thomson-Delmar Publishing, 2007 ISBN 0-324-36077-0

Ulrich, Karl T. & Steven D. Eppinger, Product Design and Development, 4<sup>th</sup> Edition. McGraw Hill, 2008. ISBN: 13 9780073101422.

Boothroyd, G., W.A. Knight & Peter Dewhurst, Product Design for Manufacture and Assembly, 2<sup>nd</sup> Edition. Marcel Dekker Inc. 2002. ISBN-10: 082470584X.

#### ***Supplementary Texts:***

Ullman, David G., The Mechanical Design Process, 3<sup>rd</sup> Edition. McGraw Hill, 2003. ISBN: 0072373385.

### **08-Mfg-B5 Engineering Materials**

#### ***Prime Text:***

Ashby, Michael and D.R.H. Jones, Engineering Materials 1: An Introduction to Properties, Applications and Design, 3<sup>rd</sup> Edition. Butterworth-Heinemann, 2005. ISBN-10: 0750663804.

Ashby, Michael and D.R.H. Jones, Engineering Materials 2: An Introduction to Microstructures, Processing and Design, 3<sup>rd</sup> Edition. Butterworth-Heinemann, 2005. ISBN-10: 0750663812.

#### ***Supplementary Texts:***

Courtney, Thomas H., Mechanical Behavior of Materials, 2<sup>nd</sup> Edition. Waveland Pr. Inc., 2005. ISBN-10: 1577664256.

Ashby, Michael, Materials Selection in Mechanical Design, 3<sup>rd</sup> Edition. Butterworth-Heinemann, 2005. ISBN-10: 0750661682.

### **08-Mfg-B6 Metrology**

Bosch, John A., Coordinate Measuring Machines and Systems, Marcel Dekker 1995, ISBN-10: 0824795814, ISBN-13: 978-0824795818

Dotson, Connie, Fundamentals of Dimensional Metrology, Edition 5, Illustrated, Thomson-Delmar Publishing, 2006, ISBN13 - 978-1-4180-2062-0



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### **08-Mfg-B7 - Logistics: Transportation Aspects**

Supply Chain Management: Strategy, Planning, and Operation (By Sunil Chopra and Peter Meindl) -  
Part V : Designing and Planning Transportation Networks  
ISBN-10: 0132743957

Transportation: A Supply Chain Perspective (By John J. Coyle)  
Part III - Chapters 9,10,11,13,13,14  
ISBN-10: 032478919

### **08-Mfg-B8 Robot Mechanics**

Paul, R.P., Robot Manipulators - Mathematics, Programming and Control, MIT Press, 1981. ISBN 026216082X (out of print, but could be borrowed from libraries)

Craig, J.J., Introduction to Robotics: Mechanism and Control, Addison-Wesley Publishing Co., 2005. ISBN 0201543613

### **08-Mfg-B9 - Industrial Safety and Health**

Occupational Health and Safety Act Regulation for Industrial Establishment. 880 Bay St. Toronto, Ontario. M7B 1N8. Tel.: 416-326-5300, 1-800 668-9938.

Willie Harruner, Occupational Safety Management and Engineering, latest edition. Prentice-Hall. ISBN 0-13-629437-5.

### **08-Mfg-B10 Tooling, Jigs, and Fixture Design**

Edward G. Hoffman, Jig and Fixture Design, Edition 5, Illustrated, Cengage Learning, 2003, ISBN 1401811078, 9781401811075

### **08-Mfg-B11 Fluid Machinery**

Dixon, S.L., Fluid Mechanics and Thermodynamics of Turbomachinery, 5<sup>th</sup> Edition. Butterworth-Heinemann, 2005.

Finnemore, E.J. & J.B. Franzini, Fluid Mechanics with Engineering Applications, 10<sup>th</sup> Edition. McGraw-Hill, 2002.

### **08-Mfg-B12 - Ergonomics**

R.S. Bridger, Introduction to Ergonomic. McGraw-Hill, ISBN 0-07-007741-X.

Kodak Ergonomics Group, Ergonomic Design for People at Work, Volumes I and II. Van Nostrand Reinhold Co. Ltd.

*Updated: February 2014*



**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, 2<sup>nd</sup> 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 5<sup>th</sup> 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

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04-BS-15	Engineering Graphics and Design Process

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08-Mfg-A3	Production Management
08-Mfg-A4	Analysis and Design of Work
08-Mfg-A5	Facilities Planning
08-Mfg-A6	Quality Planning, Control and Assurance
08-Mfg-A7	Electrical and Electronics Engineering

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08-Mfg-B2	Computer Integrated Manufacturing (CIM)
08-Mfg-B3	System Analysis Simulation
08-Mfg-B4	Product Design and Development
08-Mfg-B5	Engineering Materials
08-Mfg-B6	Metrology
08-Mfg-B7	Logistics: Transportation Aspects
08-Mfg-B8	Robot Mechanics
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08-Mfg-B10	Tooling, Jigs and Fixture Design
08-Mfg-B11	Fluid Machinery
08-Mfg-B12	Ergonomics

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

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