TOTAL EXAMINATION PROGRAM

PEO Syllabus of Examinations, 2008 Edition

NUCLEAR ENGINEERING

PROFESSIONAL EXAMS – SPECIFIC TO NUCLEAR ENGINEERING

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.

(23-CHEM-A6)

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.

(22-MEC-A1)

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.

(22-MEC-B3)

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.

(22-MEC-A6)

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

Review of basic concepts; elementary two-dimensional potential flow, vorticity and circulation, one-dimensional 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.

(22-ELEC-A6)

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.

(22-ELEC-B7)

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.

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 Antomatic Process Control, John Wiley, second edition, 1997.

08-Nuc-B1 Nuclear Shielding

Reactor Shielding for Nuclear Engineers, by N.M. Schaeffer

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 Lerning, 2002.
Grainger, John and William Stevenson Jr., Power System Analysis. McGraw Hill, 1994.

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