

# MECHANICAL ENGINEERING EXAMINATIONS SYLLABUS

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## MECHANICAL ENGINEERING EXAMINATIONS

### GROUP A

#### COMPULSORY EXAMINATIONS (6 Required)

##### **07-Mec-A1 Applied Thermodynamics and Heat Transfer**

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.

##### **07-Mec-A2 Kinematics and Dynamics of Machines**

Kinematic and Dynamic Analysis: Graphical and analytical methods for kinematic analysis of planar and spatial mechanisms and elementary body motion in space, static and dynamic force analyses of mechanisms, gyroscopic forces, dynamics of rotating machinery, cam and gear mechanisms and specifications.

Vibration Analysis: Free and forced vibration of undamped and damped lumped single and multi degrees of freedom systems with, analytical and numerical techniques of solution, viscous damping, vibrational isolation, vibration measurement and control.

##### **07-Mec-A3 System Analysis and Control**

Open-loop and feedback control. Laws governing mechanical, electrical, fluid, and thermal control components. Mathematical models of mechanical, hydraulic, pneumatic, electrical and control devices. Block diagrams, transfer functions, response of servomechanisms to typical input signals (step function, impulse, harmonic), frequency response, Bode diagram, stability analysis, and stability criteria.

Improvement of system response by introduction of simple elements in the control circuit. Regulation of physical process: proportional, integral, and derivative control. Theory of linear controller design.

##### **07-Mec-A4 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.

### **07-Mec-A5 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.

### **07-Mec-A6 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.

### **07-Mec-A7 Advanced Strength of Materials**

Stress-Strain Analysis: Stress and strain, transformations, principal stresses, graphical representation by Mohr's circles of biaxial and triaxial cases, generalized Hooke's law including thermal strains, equations of equilibrium and compatibility, plane strain and plane stress problems. Failure theories and limit analysis. Euler critical loads for columns, curved beams, thick-walled cylinders and rotating disks, contact stresses, strain gauges and their application, stress concentrations, introductory fracture mechanics.

Energy Methods: Strain energy principles, virtual work, Castigliano's theorem. Applications to cases of axial, bending, and torsional loadings. Applications to statically indeterminate problems.

**GROUP B**  
**ELECTIVE EXAMINATIONS (3 REQUIRED)**

**07-Mec-B1    Advanced Machine Design**

Stress analysis and design of machine elements under conditions of: shock, impact, inertial forces, initial and residual stresses, corrosion environments, wear, elevated temperatures (creep), and low temperatures (brittle fracture). Hydrodynamic lubrication. Applications to the design of: journal bearings, power screws, clutches, brakes, couplings, and linkages. Introduction to probabilistic methods in mechanical design.

**07-Mec-B2    Environmental Control in Buildings**

Heating, ventilating, and air conditioning: Psychrometrics, heating load, cooling load, comfort, ventilation, and room air distribution. Humidifying and dehumidifying, duct and fan design, piping and pump design. Heating, ventilating and cooling systems, and components. Refrigeration.

Noise control: Sound wave characteristics, measurement instruments. Sources of noise, absorption, and transmission. Free field and reverberant conditions. Noise control techniques in buildings.

Energy management technology: Energy usage in buildings, control systems and instrumentation, lighting systems operation, engineering/economic analysis principles, energy audit procedures.

**07-Mec-B3    Energy Conversion and Power Generation**

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.

**07-Mec-B4    Integrated Manufacturing Systems**

Production automation and the role of the computer in modern manufacturing systems via an comprehensive overview of applications of advanced technologies in manufacturing and their business impact on the competitive dimensions of cost, flexibility, quality and deliverability. Particular topics include: facility layout; cellular manufacturing; fundamentals of automation, numerical control programming, material handling and storage, automatically-guided vehicles, flexible manufacturing systems, group technology, programmable logic controllers, concurrent engineering, production planning and control, production activity control systems, automatic identification and data collection, lean and agile manufacturing, computer-aided process planning, forecasting, inventory management and control, quality control and inspection and inspection technologies.

## **07-Mec-B5 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.

## **07-Mec-B6 Advanced Fluid Mechanics**

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.

## **07-Mec-B7 Aero and Space Flight**

Atmospheric characteristics relating to flight; measurement of air speed. Prediction of 2-D lift and drag using momentum and pressure methods; boundary layers and friction drags; dimensional analysis and wind tunnel measurements pertaining to lift and drag; induced drag and total airplane drag. Propulsion systems: turbo-fan and propeller/engine combinations; propulsion efficiency; thrust/power characteristics. Airplane performance; climb rate, time of climb, ceiling, generalized power required curve; range-payload characteristics; turns, take off, and landing; flight performance including stall, structural, and gust envelopes. Static stability and control. Re-entry and launch issues for space flight.

## **07-Mec-B8 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, electro-rheological 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.

Design and Analysis of Structures: Torsion of shells and box beams. Bending of thin-walled beams with open and closed sections. Flexural axis, shear lag, effects of stringers and booms. Pressure cabin problems, introduction to dynamic loading, normal modes, response to gust and landing loads. Aeroelastic effects, flutter and divergence.

## **07-Mec-B9 Advanced Engineering Structures**

Materials and mechanics issues. Constitutive models for macroscale representation of the material response to mechanical load, temperature changes, electric field, etc. High and low temperature problems. Strength theories for triaxial cases, stress concentration, fatigue analysis and endurance limit, plastic behaviour, residual stresses, creep and stress relaxation. Fatigue and crack propagation. Design and analysis of structures: torsion of shells and box beams. Bending of thin-walled beams with open and closed sections. Flexural axis, shear lag, effects of stringers and booms. Pressure cabin problems, introduction to dynamic loading, normal modes, response to gust and landing loads. Aeroelastic effects, flutter and divergence.

## **07-Mec-B10 Finite Element Analysis**

Linear static analysis: basic concepts, shape functions, bar and beam elements, direct and energy-based formulations, simple coordinate transformations, element assembly, boundary conditions, equation solution. Planar model formulations, work equivalent loads. Isoparametric element formulation: Jacobian matrix, numerical integration, stress averaging. Modeling, common errors, convergence, and accuracy issues. Introductory 3D solids, solids of revolution, plates and shells. Thermal analysis: matrix formulation, steady state and transient response. Introductory nonlinear modeling and procedures: simple material nonlinearity, stress stiffening, contact interfaces.

## **07-Mec-B11 Acoustics and Noise Control**

Function of hearing system, acquired deafness, acoustics standards and recommendations. Basic principles and calculations of acoustics phenomenon. Instrumentation about noise measurement, frequency-analysis sound meter. Acoustics reflection and transmission, characterization and selection of acoustics materials. Room acoustics, preventive calculation of noise level in rooms. Sound propagation in conduits, muffler design. Noise analysis and application of noise reduction techniques.

## **07-Mec-B12 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.

## **07-Mec-B13 Biomechanics (04-Bio-A4)**

The musculoskeletal system; general characteristics and classification of tissues and joints. Elastic and viscoelastic mechanical characterization of biological tissues including bone, cartilage, ligament and tendon. Principles of viscoelastic and the rate sensitivity of biological materials. The stress-strain-time or constitutive equations for soft connective tissue components. Biomechanics and clinical problems in orthopaedics. Modelling and force analysis of musculoskeletal systems. Passive and active kinematics. Mechanical properties of biological and commonly used biomedical engineering materials.

# The Association of Professional Engineers and Geoscientists of British Columbia

## 2007 MECHANICAL ENGINEERING SYLLABUS

### Checklist for Self Evaluation

(Not required for candidates who are assigned confirmatory exams)

Name: \_\_\_\_\_

Exam Number	Exam Name	Applicants Self-Evaluation - Course Equivalent	For Office Use Only
<b><i>Basic Studies (All Required)</i></b>			
04-BS-1	Mathematics		
04-BS-3	Statics and Dynamics		
04-BS-6	Mechanics of Materials		
04-BS-7	Mechanics of Fluids		
04-BS-10	Thermodynamics		
04-BS-11	Properties of Materials		
<b><i>Basic Studies (2 required)</i></b>			
04-BS-2	Probability and Statistics		
04-BS-4	Electric Circuits and Power		
04-BS-5	Advanced Mathematics		
04-BS-8	Digital Logic Circuits		
04-BS-9	Basic Electromagnetics		
04-BS-15	Engineering Graphics and Design Process		
04-BS-16	Discrete Mathematics		
<b><i>Group A (6 required)</i></b>			
07-Mec-A1	Applied Thermodynamics and Heat Transfer		
07 -Mec-A2	Kinematics and Dynamics of Machines		

07-Mec-A3	System Analysis and Control		
07-Mec-A4	Design and Manufacture of Machine Elements		
07-Mec-A5	Electrical and Electronics Engineering		
07-Mec-A6	Fluid Machinery		

**Group B (3 Required)**

07-Mec-B1	Advanced Machine Design		
07-Mec-B2	Environmental Control in Buildings		
07-Mec-B3	Energy Conversion and Power Generation		
07-Mec-B4	Integrated Manufacturing Systems		
07-Mec-B5	Product Design and Development		
07-Mec-B6	Advanced Fluid Mechanics		
07-Mec-B7	Aero and Space Flight		
07-Mec-B8	Engineering Materials		
07-Mec-B9	Advanced Engineering Structures		
07-Mec- B10	Finite Element Analysis		
07-Mec -B11	Acoustics and Noise Control		
07 – Mec -B12	Robot Mechanics		
07-Mec-B13	Biomechanics (04-Bio-A4)		

**Complementary Studies (All Required)**

98-CS-1	Engineering Economics		
98-CS-2	Engineering in Society - Health, Safety, and the Environment		

98-CS-3	Management Concepts for Engineers		
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## SUGGESTED TEXT 2007 CCPE - MECHANICAL SYLLABUS

\*\* Note to candidates, the listed textbooks below are only suggested. The list does not define or limit the syllabus.

### **07-MEC-A1 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.

### **07-MEC-A2 KINEMATICS AND DYNAMICS OF MACHINES**

Inman, D.J., Engineering Vibrations, 2<sup>nd</sup> Edition. Prentice-Hall, 2000, ISBN 978-0137261420.

Waldron, K.J., and Kinzel, G.L., Kinematics, Dynamics and Design of Machinery. John Wiley & Sons, 2004, ISBN 0471244171

### **07-MEC-A3 SYSTEM ANALYSIS AND CONTROL**

Bissell, C.C., Control Engineering, 2<sup>nd</sup> Edition. Taylor & Francis, 1996, ISBN 978-0412577109.

Franklin, Feedback Control of Dynamic Systems, 2006. ISBN 978-0131499324.

### **07-MEC-A4 DESIGN AND MANUFACTURE OF MACHINE ELEMENTS**

Juvinall, Robert C., and Kurt M. Mershek, Fundamentals of Machine Component Design, 4<sup>th</sup> 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.

### **07-MEC-A5 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.

### **07-MEC-A6 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.

#### **07-MEC-A7 ADVANCED STRENGTH OF MATERIALS**

Ugural, Ansel, & Saul Fenster, Advanced Strength & Applied Elasticity, 4<sup>th</sup> Edition. Prentice Hall Englewood Cliffs New Jersey 07632 2003.

Budynas, R.G., Advanced Strength & Applied Stress Analysis, 2<sup>nd</sup> Edition. McGraw-Hill, 1998.

Boresi, A.P., and R.J. Schmidt, Advanced Mechanics of Materials, 6<sup>th</sup> Edition. John Wiley & Sons, 2003.

#### **07-MEC-B1 ADVANCED MACHINE DESIGN**

Shigley and Mischke, Mechanical Engineering Design, 5<sup>th</sup> edition (metric/english edition) McGraw Hill. ISBN 0-07-056899-5.

#### **07-MEC-B2 ENVIRONMENTAL CONTROL IN BUILDINGS**

F.C. McQuinston & G.D. Parker, Heating, Ventilating, & Air Conditioning – Analysis & Design, 5<sup>th</sup> edition. John Wiley & Sons, 1994. ISBN # 0471-581070.

Jennings, Environmental Engineering, International Test Book Co.; Carrier & Trane System Manuals; ASHRAE Handbooks; ASHRAE Environmental Control Principles & Education Supplement to ASHRAE Handbook Fundamentals Volume.

#### **07-MEC-B3 ENERGY CONVERSION AND POWER GENERATION**

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

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

#### **07-MEC-B4 INTEGRATED MANUFACTURING SYSTEMS**

Groover, Mikell P., Automation, Production Systems, and Computer-integrated Manufacturing, 2<sup>nd</sup> Edition. Prentice Hall, 2001. ISBN-10: 0130889784.

#### **07-MEC-B5 PRODUCT DESIGN AND DEVELOPMENT**

##### *Prime Texts:*

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.

#### **07-MEC-B6 ADVANCED FLUID MECHANICS**

White, F.M., Fluid Mechanics, 6<sup>th</sup> Edition. McGraw-Hill, 2006.

### **07-MEC-B7 AERO AND SPACE FLIGHT**

Anderson, J.D., Introduction to Flight, 4<sup>th</sup> edition. McGraw Hill, 2000, ISBN 007109282X.

Barnes W. McCormick Aerodynamics, Aeronautics & Flight Mechanics 2<sup>nd</sup> Edition. Wiley, 1995.

### **07-MEC-B8 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.

### **07-MEC-B9 ADVANCED ENGINEERING STRUCTURES**

#### *Prime Text:*

Dowling, Norman E., Mechanical Behavior of Materials, 3<sup>rd</sup> Edition. Prentice Hall, 2006. ISBN-10: 0131863125.

Megson, T.H.G., Aircraft Structures for Engineering Students, 3<sup>rd</sup> Edition. Butterworth-Heinemann, 1999. ISBN-10: 0340705884.

#### *Supplementary Texts:*

LeMaitre, J., Handbook of Materials Behavior Models. 3 vol. Set. Elsevier, 2001. ISBN 0-12-443341-3.

Bruhn, E.F., Analysis and Design of Flight Vehicle Structures. Jacobs Pub, 1973. ISBN-10: 0961523409.

Reddy, J.N., Mechanics of Laminated composite Plates and Shells: Theory and Analysis, 2<sup>nd</sup> Edition. CRC Press, 2003. ISBN: 0849315921.

Dutton, Stuart, Donald Kelly, and Alan A. Baker (Editors), Composite Materials for Aircraft Structures, 2<sup>nd</sup> Edition. American Institute of Aeronautics & Ast., 2004. ISBN-10: 1563475405.

### **07-MEC-B10 FINITE ELEMENT ANALYSIS**

Cook, R.D., Finite Element Modeling for Stress Analysis. John Wiley & Sons, Toronto, 1995.

Frank L. Stasa, Applied Finite Elements for Engineers, Holt, Reinhart, 1985, ISBN #0-03-062737-0.

Logan, A First Course in Finite Element Method, P.W.S. Engineering, 2<sup>nd</sup> edition, 1992.  
W. Bickford, A First Course in Finite Element Method, Irwin, 1990.

## **07-MEC-B11 ACOUSTICS AND NOISE CONTROL**

### *Prime Text:*

Barron, Randall F., Industrial Noise Control and Acoustics. Marcel Dekker, 2002. ISBN 0-8247-0701-X

### *Supplementary Texts:*

Bell, Lewis H. and Douglas H. Bell, Industrial Noise Control: Fundamentals and Applications, 2<sup>nd</sup> Edition, Marcel Dekker, 1993. ISBN 0-8247-9028-6

Irwin, J.D., Industrial Noise and Vibration Control. Prentice-Hall, 1979. ISBN 0-13-461574-3

Wilson, Charles E., Noise Control: Measurement, Analysis, and Control of Sound and Vibration. Krieger, 1994. ISBN 0-89464-879-9

## **07-MEC-B12 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

## **07-MEC-B13 BIOMECHANICS (04-BIO-A4)**

Berger, S.A., W. Goldsmith and E.R. Lewis, Introduction to Bioengineering. Oxford University Press, 2000.

Nordin, Margareta and Victor H. Frankel, Basic Biomechanics of the Musculoskeletal System. Lippincott Williams&Wilkins, 3rd edition, 2001.