**CARLETON UNIVERSITY**
**Dept. of Mechanical and Aerospace Engineering**
**Course Outline**

**Lightweight Structures: Eng. 88.563W(MCG5381)**

# MECH 5603 [0.5 credit] (MCG 5381)

## Lightweight Structures

Structural behaviour. Fundamentals of basic elasticity. Energy methods of structural analysis. Bending, shear, and torsion of open and closed multicell structures. Bending of plates. Structural idealization and its effects on open and closed sections. Structural stability.

**Introduction and Fundamentals:** structural systems and components; load classifications; review of general stress analysis (stresses and strains, principal stresses and strains); governing equations of elasticity (stress equilibrium eqs., stress-strain relationships, compatibility, boundary conditions); solution of problems in elasticity.

**Review of Energy Methods:** principle of virtual displacements; principle of virtual forces; linear elastic structural systems; application of Energy Methods (Raleigh-Ritz method, unit displacement method, Castigliano's $1^{st}$ Theorem, principle of stationary total complementary potential energy, unit force method); Castigliano's $2^{nd}$ Theorem.

**Bending and Shear of Closed and Open Thin-Walled Sections:** pure bending; general bending theory; displacements; thin-walled sections; shear in open thin-walled sections; shear in closed thin-walled sections (shear flow, warping distribution); shear effects on bending.

**Torsion of Closed and Open Thin-Walled Sections:** solid sections (Prandtl stress function); membrane analogy; open thin-walled sections; closed thin-walled sections; multicell thin-walled sections.

**Structural Idealization:** Monocoque and semi-monocoque construction; bending of idealized open and closed sections; shear and torsion in idealized open and closed sections; multicell idealized sections , shear-lag effects.

**Thin Rectangular Plates:** pure bending; bending and twisting; distributed transverse loads; combined bending and in-plane loading; energy methods.

**Structural Stability:** classical approaches to Euler buckling; critical review of stability concepts (kinetic vs. static approach); beam-columns; buckling of thin plates; local instability; instability of stiffened panels.

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**References:**


1. D.J. Peery, and J.J. Azar; *Aircraft Structures,* 2nd edition; McGraw-Hill, 1982
2. T.H.G. Megson; *Aircraft Structures,* 2nd edition; Halstead Press, 1990
3. Howard D. Curtis; *Aircraft Structural Analysis,* Irwin, a Times Higher Education Group, Inc. Company, 1997
4. R.M. Rivello; *Theory and Analysis of Flight Structures,* McGraw-Hill, 1969
5. E.F. Bruhn; *Analysis and Design of Flight Structures,* Tri-State Offset, 1973
6. S.P. Timoshenko, J.N. Goodier; *Theory of Elasticity,* 3rd edition, McGraw-Hill, 1970
7. J.R. Vinson; *The Behaviour of Thin-Walled Structures,* Kluwer Academic Publishers, 1989
8. Z.P. Bazant and L. Celdon; *Stability of Structures,* Oxford University Press, 1991



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| Assessment: | Assignments/Project | 30% |
| | Final Exam | 70% |
| Total | | 100% |

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