2021-2022	Mechanical Engineering	Year 3 - Sem. 5
MECA305	**Strength of Materials**	Mandatory
ECTS: **3**	*Coordinator:* Pr. Georges Challita	*Language:* English/French
Total hours: **39 h**	*Lectures:* Dr. Ibrahim Khoury, Pr. Georges Challita, Dr. Hilal Rida	

Description:

The actual course constitutes a backbone within the long chain of courses belonging to the Solid Mechanics Field dealing with components in static equilibrium. This course starts by developing the failure criteria and safety of ductile and brittle materials. Then, four types of internal efforts are discussed in details throughout four chapters: axial force, torsion, shear force and bending moment. For each type, calculation, sign convention, diagrams, generated stresses and displacements and their importance in design are detailed. The next chapter is devoted to the calculation of deflection in straight beams under bending, using several methods. This course ends by tackling the aspect of buckling in columns under compression emphasizing especially on Euler formulation for determination of the critical buckling load.

Learning outcomes:

- Predict failure of ductile and brittle materials under a known stress state,
- Determine the internal axial force developed in a member and plot the corresponding diagram,
- Calculate the normal stress and the axial displacement generated by an internal axial force,
- Solve statically indeterminate members under axial loading,
- Determine the internal torque developed in a shaft and plot the corresponding diagram,
- Calculate the shear stress and the twist angle generated by an internal torque,
- Solve statically indeterminate shafts under torsional loading,
- Determine the internal shear force developed in a beam and plot the corresponding diagram,
- Calculate the transverse shear stress generated by an internal shear force and study its variation throughout a cross-section,
- Determine the internal bending developed in a beam and plot the corresponding diagram for either simple bending, unsymmetrical bending or compound bending,
- Calculate the normal stress generated by an internal bending moment for any case of bending (simple, unsymmetrical, compound) and locate the neutral axis within a cross-section,
- Calculate the normal stress generated by an internal bending moment in curved beams,
- Calculate the factor of safety and design the size of a member subjected to a combined loading,
- Determine the expression(s) of transverse deflection and slopes in straight bent beams and then locate and calculate the maximum value of the deflection using either flexural formula, superposition principle or conjugate beam method,
- Understand the aspect of buckling of columns under compression and apply Euler's equations to find the value of the critical force for buckling,
- Predict the size of a column to avoid failure either by buckling or compression.

Content:

- Review of stress state, ductile and brittle materials. Failure criteria for ductile materials (Tresca, Von Mises, Von Mises-Henckey) and for brittle materials (Rankine, Mohr, Coulomb-Mohr). Concept of factor of safety.
- Determination of expressions of internal axial force developed in a member through its length applying the method of sections. Plot of axial force diagram. Calculation of normal stress and axial displacement produced by an internal axial force. Determination of supports axial reaction in indeterminate members using either method of superposition or displacement compatibility.
- Determination of expressions of internal torque developed in a shaft through its length applying the method of sections. Plot of torque diagram. Calculation of shear stress and twist angle produced by an internal torque. Determination of supports torsional reaction in indeterminate shafts using either method of superposition or displacement compatibility.
- Determination of expressions of internal shear force developed in a member through its length applying the method of sections. Plot of shear force diagram. Calculation of transverse shear stress produced by an internal shear force. Study of

variation of transverse shear throughout a cross-section in terms of the location of the loaded point within the section.

- Determination of expressions of internal bending developed in a member through its length applying the method of sections. Plot of bending moment diagrams. Calculation of normal stress produced by an internal bending moment for either simple bending, unsymmetrical bending or compound bending case. Calculation of the equation of neutral axis within a cross-section. Stresses in beams under combined loading, location of critical section, design for safety. Stresses in curved beams under bending such as hooks or eye bots.
- Flexural formula in straight beams. Integration of this formula to calculate the expressions of transverse deflection and slope developed in beams under bending. Elaboration of suitable boundary and continuity conditions to find the integration constants. Calculation of position and value of maximum deflection. Method of superposition for determination of deflection and slope. Method of conjugate beam for determination of deflection.
- Definition of buckling as instability or undesired aspect in a column under axial compression. Critical load in buckling and influencing parameters. Development and application of Euler's formulation for critical buckling load calculation for columns under different support conditions. Factor of safety in buckling. Secant formula to find normal stress in columns subjected to eccentric axial compressive load.

References:

- R.C. Hibbeler. Mechanics of Materials. 10th edition, Prentice Hall (Textbook).
- A.C.Ugural, S.K. Fenster. Advanced Mechanics of Materials and Applied Elasticity. 6th edition, Prentice Hall.
- R.R. Craig Jr., E.M. Taleff. Mechanics of Materials. 4th edition, Wiley.

Evaluation Method:

Assessment in the following areas will be converted to points, to compute your final grade in this course:

- Mid-Term
- Final Exam
- Attendance and Participation

Description :

Le cours actuel constitue un élément capital dans la longue chaîne de cours appartenant au domaine de la Mécanique des Solides traitant des composants en équilibre statique. Ce cours commence par développer les critères de rupture et la sécurité des matériaux ductiles et fragiles. Ensuite, quatre types d'efforts internes sont discutés en détail tout au long de quatre chapitres : l'effort normal, la torsion, l'effort tranchant et le moment fléchissant. Pour chaque type, le calcul, la convention de signe, les diagrammes, les contraintes et déplacements générés et leur importance dans la conception sont détaillés. Le chapitre suivant est consacré au calcul de la déflexion dans les poutres rectilignes en flexion, en utilisant plusieurs méthodes. Ce cours se termine en abordant l'aspect du flambement dans les colonnes sous compression en se basant particulièrement sur la formulation d'Euler pour la détermination de la charge critique de flambement.