Course details and Program modality for Web-enabled MTech in Aerospace Engineering with specialization in Ammunition Technology at IIT Madras

Introduction

The Web-enabled MTech program *matches* the regular and fully residential program **totally** in its *requirements* and *rigor*. The student, while working, takes courses at IIT M on the Web in the evenings which are held in an interactive mode in virtual classrooms.

Lectures will be delivered on a high-speed dedicated video link between 5 and 7 pm. A typical course will meet about 150 minutes every week and spend another 50-100 minutes on problem solving, Q&A etc.

The degrees awarded are identical to the degrees awarded to the regular students at IIT M in a residential mode. The details of the degrees awarded and the course-plan (such as core and additional courses for each degree) are contained in Annexure I & 2.

Program Module

This letter of Acceptance of Offer is applicable to the online M.Tech Program in Aerospace Engineering at IIT Madras for the batch commencing in the academic year __________.

i) Program Title : **M.Tech in Aerospace Engineering with Specialisation in Ammunition Technology**
ii) Duration : 3 years
iii) Semester : Three sessions a year (Trimester scheme)
iv) Program Courses : Core courses (six) – I year
Additional courses (five) – II year
Project work – III year
v) Program Schedule : Batch commencing August ____________
vi) Program Mode : Online
vii) Course details and program modality are detailed in **Annexure-I** and syllabi of courses in **Annexure 2**
viii) Attendance of the participants to be recorded during the program.
ix) After completion of the program, a Degree Certificate to be awarded to successful students by IIT Madras.

Annexure-1

Program Schedule

- Program to begin in August along with the other MTech programs
- Three sessions (trimesters) in a year with each session lasting for about 16 weeks
- Maximum of two courses per trimester
- The number of lecture hours per course will be as dictated by the credit requirements.
- The videos of lectures are made available to the students for offline viewing.

- Course examination will be conducted at online/at designated centers decided by IITM and answer papers will be evaluated by IITM
- Grading policies as per IITM MTech ordinances
- First two years for course work (11 courses over 6 trimesters). Last year for the project

Infrastructure Required

- High bandwidth internet connection of at least 2 Mbps per active class to be provided at all the centers where the candidates are present.

Eligibility of the candidates: IIT Madras will have a test/interview on basic mathematics, fluid mechanics, strength of materials and thermodynamics to select the students. The candidates should possess Bachelor's degree in Aerospace/Civil/Chemical/Computer Science/Electrical/Mechanical/Metallurgical/Naval Architecture OR Master's degree in Physics/Mathematics/Chemistry. The applications of the candidates should be forwarded and routed through the parent industry/defense unit.

Project Work

- Both IIT M and the parent industry/defense unit will work together in selecting the appropriate student projects of interest/ relevance to unit and fine-tuning the scope of the project work.
- Project work will be carried out at industry/unit under the guidance of the someone whose academic qualification shall be MTech or higher.
- If IIT M guidance is required, separate costing need to be evaluated depending on the facility usage and consultancy time of the mentor.
- Project will be of one year duration and the student, and the guide(s) will have frequent virtual meetings for remote guidance, evaluation, and criticism.
- Guides are to be finalized no later than the end of the fourth trimester. This will ensure that some preliminary work (like literature review) can be started in the sixth trimester itself.
- There will be two progress review meetings, one each at the end of seventh and eighth trimesters. Final project evaluation will be at the end of 9th trimester (end of 3rd year).

Lab Courses: students will spend up to 2 weeks at IITM if lab course is required.

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Credit System at IIT M and expected efforts in the programme

- At IIT M, the courses are counted in terms of credits. Each credit implies 14 periods (50 min each) of effort (typically one period per week over 14 weeks), including evaluation.
- "**L**" implies lecture given by the faculty; "**T**" implies tutorials or problem solving; "**E**" implies extended tutorials under supervision of the teaching assistants; "**P**" implies lab/ practical; "**O**" implies effort expected from the students outside the class hours revising the material, working out additional problems etc. "**C**" is the sum total of all credits.
- Ex: Basic mathematics course in Annexure I is 3-1-1-0-6-11 credits, which means there will be 3 lectures a week, 2 tutorial periods a week and in addition, students are

expected to spend 6 periods (5 hrs) preparing for the material every week for this course.

- Consequently, in each of the three trimesters, the student is taking 21 credits and hence is expected to spend 21 periods (17.5 hours) per week on the two courses.

Project Work in Year III

- Project work is worth 85 credits and hence each student is expected to put in 85*14*5/6 = about 1000 hours of work on the project.
- Since project work will be carried out in 3rd year, it amounts to about 20 hours per week for the project.
- Students are expected to finalize their guide by the end of the fifth trimester. This will ensure that some preliminary work (like literature review) can be started in the sixth trimester itself.

Detailed Curriculum and Credits for the program:

Year	Session	Course Name	Lecture	Tutorial	Extended Tut.	Afternoon Lab	Time to be spent outside class	Credits
I	1	Mathematics for Aero. Engineers	3	1	1	0	6	11
I	1	Aerodynamics & A/C performance	3	1	0	0	6	10
I	2	Compressible Fluid flows	3	1	0	0	6	10
I	2	Aerospace Structures	3	1	1	0	6	11
I	3	Aerospace Propulsion	3	1	0	0	6	10
I	3	Flight Mechanics	4	1	0	0	7	12
		Core theory Credits:	**19**	**6**	**2**	**0**	**37**	**64**
II	4 to 6	Additional courses (**Any 5**)	15	0	0	0	30	45
III		**Project**	0	0	0	0	88	88
		Total Credits:	**34**	**6**	**2**	**0**	**155**	**197**

Annexure -2

MTech Courses and syllabi

Core (introductory) subjects:

1. AS5010 - Aerodynamics and Aircraft Performance

Course Content:

Aerodynamics: Governing equations for fluid flows; incompressible flow and Bernoulli's equation; stream function and velocity potential; source, sink and doublet; non-lifting flow past a circular cylinder; circulation; lifting flow past a circular cylinder; Kutta-Joukowski theorem; flow past an airfoil: Kutta condition and Kelvin's starting vortex; thin airfoil theory; compressibility correction; finite wings: tip vortices, downwash and induced drag; Prandtl's lifting line theory; propeller theory. Aircraft Performance: Standard atmosphere; parts of an airplane; drag-divergence; area-rule; drag polar; steady flight: climb, range, endurance; accelerated flight; V-n diagram; takeoff and landing

2. AS5011 - Compressible Fluid Flows

Course Content:

Fluid Mechanics: Classification of fluid flow; Eulerian and Lagrangian viewpoints; streamlines, streaklines and pathlines; velocity gradient tensor; governing equations of fluid flow; Cauchy stress; boundary layers; Couette flow. Compressible Flows: Review of thermodynamics; isentropic flow relations; compressibility, speed of sound and Mach number; 1-D steady flow: adiabatic, frictionless flow with normal shock – Hugoniot curve, Fanno flow, Rayleigh flows; 2-D steady flows: flows with oblique shock, θ-β-M curve, Prandtl- Meyer expansion fans; 1-D unsteady flows: moving shock waves, shock tube; flow through CD nozzles: area-Mach relation, choked flow, underexpanded and over expanded nozzles; linearized subsonic and supersonic flows – Prandtl-Glauert relations

3. AS5020 - Aerospace Propulsion

Course Content: Classification of airbreathing engines, efficiencies of air breathing engines, engine performance of turbojet, turboprop, turbo shaft, turbofan and ramjet engines, thrust augmentation of turbojets and turbofan engines. Aerothermodynamics of non-rotating propulsion components such as intakes, combustor and nozzle. Basics of moving components (fans, compressors and turbines). Thrust equation and specific impulse, efficiencies of non-airbreathing engines vehicle acceleration, drag, gravity losses, multi-staging of rockets. Classification of chemical rockets, brief description of electrical rockets. Performance of solid, liquid and hybrid propellant rockets. Brief description of various components of solid, liquid and hybrid propellant rockets.

4. AS5030 - Aerospace Structures

Course Content: Determination of loads acting on major airplane components (wing, fuselage, tails). Analysis of wings. Shear centre. Bending and torsion of closed and open tubes. Multi-cell tubes. Columns and beam-columns. Bending and buckling of plates and sheet stringer combination. Analysis of fuselage. Learn about the main aircraft structural components, to introduce the concept of semi- monocoque construction in aircraft, discuss different loads acting on an aircraft, concept of airworthiness and generation of a safety-flight envelope (known as 'V-n' diagram). Modelling the components in terms of 1-D or 2-D structural elements. Analysis of thin-walled open and closed section beams under bending, shear and torsional loads. Bending and buckling of plates and sheet-stiffener combination. Structural idealization of wings and fuselage and preliminary analysis

5. AS5040 - Flight Mechanics
Course Content:
Review of rigid body dynamics: Derivation of full six degree of freedom equations of motion (translational, angular, and kinematic). Various reference axis systems – earth-fixed, body, stability, and wind axes. Equations of angular motions: Airplane pitch dynamics and longitudinal stability –trim, neutral point, static margin. Treatment of spacecraft attitude dynamics –disturbance torques, spin stabilization. Overview of satellite attitude determination and control techniques. Aircraft flight dynamics: Linearization of equations of motion about a steady flight condition. Aerodynamic derivatives. Aircraft dynamic modes and stability. Introduction to lateral and directional stability. Basics of orbital mechanics: Two body motion. Motion in elliptic, hyperbolic, and parabolic orbits. Keplerian orbital elements. Orbital maneuvers and transfer orbits.

6. AS6520 - Mathematics for Aerospace Engineers
Course Content: Linear Algebra including matrices, solution of linear system of equations, Eigenvalues and eigenvectors, Cayley-Hamilton Theorem. Analytic functions. Cauchy-Riemann equations and application to potential theory, Line integral, Cauchy integral theorem, Taylor' and Laurent' series, Residue theorem and applications. Conformal mapping and applications, Fourier Series, Laplace Transforms. Vector and Tensor Calculus, Review of first and higher order ODEs, Classification of PDEs, Laplace equation, heat and wave equations, classical and approximate solution techniques with applications to problems in aerospace engineering. Review of basic Probability theory, Random variables, discrete and continuous distributions.

Additional Courses: (Any five)

1. AS 6080- Theory of interior and intermediate ballistics
Introduction to fundamentals: Thermodynamics, thermochemistry, combustion, Use of CEA software. Introductory concepts of ballistics: .Guns and projectiles: Types and classification, interior, intermediate, exterior and terminal ballistics, ballistic terminology. Analytical formulation of interior ballistic phenomena: Gunpowder combustion and projectile motion – Lagrangian approach – pressure travel curves, interior ballistic trajectories during burning – effect of parameters – types of propellant, chamber and barrel configurations, sensitivity and efficiency analysis. Extension of interior ballistic theory to high-velocity weapons. Design of ammunition: construction of propellant charges, cartridge case, structural analysis of the shell -full bore and sub-caliber-sabot – prediction of stresses and failure, design of buttress threads and barrel. Intermediate ballistics: primary, secondary blasts and other flow interfaces, projectile-flow interactions, analytical prediction of projectile aerodynamic characteristics. Gun dynamics: Recoil, flow through muzzle brakes, measurement of projectile travel near the start of motion, in-bore velocity and acceleration measurement.

2. AS 6090 - Theory of exterior and terminal ballistics
Introductory concepts: Trajectories- vacuum, simple air (Flat fire)-Wind effects. Point mass trajectory, 6-DoF trajectory, modified point mass trajectory. Linearized aero-ballistics: pitching and yawing motions, Gyroscopic and dynamic stabilities, Yaw of repose, Roll resonance, Mass asymmetries, Lateral throw-off: Static and dynamic imbalances, Swerve motion: Aerodynamic jump, drift of spinning bodies and slender bodies Non-linear aero-ballistics. Terminal ballistics: Introduction to penetration theories, penetration on concrete, soils, ceramics and composites, pentation from various projectiles, Chemical and kinetic energy projectiles. Armors: Rolled Homogeneous armors and explosive reactive armor.

3. AS 6095 - Design of Ammunition

Overview of ammunition types and applications, History and evolution of ammunition design, ammunition Types: Fixed ammunition, separable ammunition, separate-loaded ammunition, Internal, external, and terminal ballistics, kinetic energy and penetration, fragmentation, and lethality, Propellants and Explosives, Types of firearms and their components, Explosives and their properties, Guns and Barrels, Mechanics of gun operation, Consistency, and accuracy. Design of propellant: Types of propellants and their characteristics, Chemical reactions and combustion processes, Design considerations and safety principles, case designs Projectile design: full caliber and sub-caliber projectiles: aerodynamic, stability, structural and material considerations in interior, intermediate exterior, and terminal phases. Barrel and muzzle brake design: Rifled and smooth bore, Gun & barrel dynamics: estimation of forces and moments, material considerations, autofrettage process, barrel coating. Fusing and Timing: Types of fuses and their functions, Design of electronic and mechanical timing devices, Safety, and arming mechanisms Testing and Evaluation: Laboratory testing procedures and protocols, Field testing and evaluation of ammunition, Quality control and manufacturing considerations, Ethical and legal considerations, Future ammunition.

4. Multiphase Flows

Course Contents: Introduction-classification of multiphase flows-multiphase aerospace flows- Interface flows-liquid-gas , liquid-solid, gas-solid flows- flow through porous media. Governing equations, Eulerian-Lagrangian and eulerian-eulerian formulations-mass, momentum and energy exchange terms-dilute and dense two-phase flows-phase change- sharp and diffuse interface methods-incompressible and compressible multi-phase flows-compressible multi-fluid formulations-stiffened gas equation of state Applications-interior ballistics of guns-chamber and nozzle flows-two-phase losses-delivered specific impulse in solid propulsion systems-particle impingement-slag accumulation-granular propellant /explosives/pyrotechnique combustion-fluidization-stratification in cryogenic tanks- water hammer-cavitation, vaporization and condensation-injector flows and atomization.

5. Advanced Materials and their Processing Methods

Course Contents: Classification of materials, metals, alloys and ceramics, composites, polymers & their properties, Mechanical features of advanced materials in different sectors, processing methods: Conventional (casting, forging etc.) and Non-conventional fabrication techniques, Testing methods for advanced materials, Introduction to nano-technology.

6. Measurement and Testing Methods

Course Contents: Measurement and importance of measurement from industrial perspective, Classification of measurement system, Conventional measurement methods - Sensors and transducers: Pressure, force, temperature, displacement and acceleration; strain gages and extensometer; electrical resistance strain gages - measurement principle, error analysis and applications, Optical visualization techniques in flow systems, LDV, PIV, Hotwire anemometer, Optical microscope, Electron Microscope, Laser based systems, Surface profilers, SEM, AFM; digital image correlation.

7. Manufacturing Processes in Modern Industries:

Course Contents: Materials In modern Industries, Types of fabrication, Casting of complicated designs, forming (roll, high velocity hydro forming, high energy rate forming electromagnetic forming etc.), Welding and Forging techniques, Adv. techniques of material processing (STEM, EJT, ECG etc.), Micro-machining, Additive Manufacturing (3-D printing).