Course Number	:	ME517
Course Name	:	Advanced Analytical Techniques for Engineers
Credits	:	3-1-0-4
Prerequisites	:	None
Intended for	:	UG/MTech/MS/PhD in engineering streams.
Distribution	:	core for M.Tech students in Fluid and Thermal Engineering
Semester	:	Odd/Even

1: Preamble: The present course is proposed as a core course in Fluid and Thermal Engineering (FTE) MTech program to develop a strong background in analytical (mathematical) techniques that are required in the various other core and elective courses in the program. The courses, which will benefit from the course on analytical techniques include, but are not limited to, advanced fluid dynamics, convective heat transfer, conduction and radiation, advanced thermodynamics, and computational fluid dynamics.

2: Course modules with quantitative lecture hours:

- Integral Transforms: Fourier transform for solution of ODEs and PDEs, Laplace transform for solution of ODEs and PDEs. [6hrs]
- Partial Differential Equations: solution of linear PDEs including special cases of heat conduction equation and Navier--Stokes equation, solution of PDEs in cylindrical and spherical coordinate systems. [10hrs]
- First-order integral equations: Fredholm, Volterra and Wiener-Hopf equation, power series solution for integral equations, integral equations as a generalization of eigenvalue equations and connection to inverse problems [6hrs]
- Tensors: Einstein notation, tensor transformations, tensor fields and tensor calculus, integral theorems. [6hrs]
- Complex analysis: functions of a complex variable, limits and continuity, analytic functions, complex exponents, contour integrals, Cauchy integral formula, complex series, Chauchy's residue theorem, singularity, zeros and poles, improper integrals in Fourier analysis, application to plane fluid flow and signal processing. [8hrs]
- Linear Algebra: spaces and subspaces, positive definiteness and singular value decomposition (best basis), transformations and change of basis, pseudoinverse, eigenvalues and eigenvectors, introduction to multigrid, Krylov subspaces and conjugate gradients methods for solving large linear systems. [10 hrs]

- Statistical Methods: probability, random variables, discrete and continuous probability distributions, autocorrelation and cross correlation, Monte-Carlo method for the solution of diffusion equation, radiative transfer equation and collimated beam radiation problem; linear regression and curve fitting. [10 hrs]

3: Text Books:

1. B. Dasgupta, Applied Mathematical Methods, Pearson Education, 2006.
2. Sheldon M Ross, Probability and Statistics for Engineers and Scientists, 5/e, Academic Press, 2014.

4: References:

1. M D. Greenberg, Advanced Engineering Mathematics, 2nd Edition, Pearson India, 2007.
2. E. Kreyszig, Advanced Engineering Mathematics, John Wiley and Sons, International 10th Revised Edition, 2015.
3. G. Strang, Linear Algebra and Its Applications, Thomson, Brooks/Cole, 2006
4. P. V. O'Neil, Advanced Engineering Mathematics, CENGAGE Learning,, 2011.
5. R. L. Thomas and G. B. Finney, Calculus and Analytic Geometry, 11/e Addition-Wisley Reading, 2010.
6. M. L. Boas, Mathematical Methods in the Physical Sciences, 3rd Ed, Wiley India, 2009.
7. A. D. Polyanin and A. V. Manzhirov, Handbook of Integral Equations, Second Edition, Chapman & Hall/CRC Press, Boca Raton, 2008.

5: Similarity Content Declaration with Existing Course

S.N	Course Code	Similarity Content	Approx. % of Content
1.	MA522	solution of linear PDEs	15%
2.	MA512	Spaces and subspaces, transformations and change of basis, eigenvalues and eigenvectors,	10%
3.	MA524, EE534	Probability, Random Variables, Discrete and Continuous Probability Distributions	10%

6: Justification for new course proposal if cumulative similarity content is > 30 %

The cumulative similarity content is more than 30%, which is expected for a course on mathematical techniques. Various postgraduate mathematics courses overlap with this course, however, the overlap does not exceed 10% with any one course. The present course is proposed as a core course in Fluid and Thermal Engineering (FTE) MTech program to develop a strong background in analytical techniques that are required in the various other

core and elective courses in the program and it cannot be therefore replaced by multiple mathematics courses. Moreover, there are topics which are not covered in any course available at IIT Mandi presently.