MIT Academy of Engineering (An Autonomous Institute)	COURSE SYLLABI (2016 - 2020)				
SCHOOL OF MECHANICAL & CIVIL ENGINEERING			W.E.F.	:	2019-20
B Tech Mechanical Engineering			COURSE NAME	:	Computational Fluid Dynamics
			COURSE CODE	:	ME421
			COURSE CREDITS	:	4
RELEASE DATE	:	01/01/2019	REVISION NO.	:	0.0

TEACHING SCHEME :		EVALUATION SCHEME :					
LECTURE	PRACTICAL	THEORY			PRACTICAL	PRESENTATION/ DEMONSTRATION	TOTAL
		ICE	ECE	IA			
3	2	30	40	30	25	25	150

PRE-REQUISITE:

1. ME 212 : Fluid Mechanics
2. ME 303 : Heat Transfer
3. AS201: Engineering Mathematics

COURSE OBJECTIVES:

1. ME421.CEO.1: Model fluid / heat transfer problems and apply fundamental conservation principles.
2. ME421.CEO.2: Discretize the governing equations by Finite Difference Method and Finite volume Method.
3. ME421.CEO.3 Develop software skills for conduction, convection and fluid dynamics problems.
4. ME421.CEO.4 Solve basic convection and diffusion equations and understands the role in fluid flow and heat transfer.

COURSE OUTCOMES:

The students after completion of the course will be able to

1. ME421.CO.1: Explain and calculate the governing equations for fluid flow;
2. ME421.CO.2: Apply finite difference and finite volume methods to fluid flow problems
3. ME421.CO.3: Analyze and model fluid flow and heat transfer problems
4. ME421.CO.4: Generate high quality grids and interpret the correctness of numerical results with physics.

5. ME421.CO.5: Use a CFD tool effectively for practical problems and research.

THEORY:		
Unit I	**BASIC CONCEPTS OF CFD**	**8 Hours**
Review of FM and HT, Concept of substantial derivative, divergence and curl of velocity, Definition and overview of CFD, need, Advantages of CFD, Numerical vs Analytical vs Experimental, Applications of CFD, CFD methodology, grid independence, Verification and validation		
Unit II	**GOVERNING EQUATIONS : MASS, MOMENTUM & ENERGY**	**8 Hours**
Reynold's Transport Theorem, Navier Stokes equation, Derivation and physical interpretation of governing equations (conservation of mass, momentum and energy) in differential form, Mathematical behavior of partial differential equations – Elliptical, parabolic and Hyperbolic,Boundary conditions – Dirichlet, Neuuman, Robbins, Initial Conditions.		
Unit III	**DISCRETIZATION METHODS & SOLUTION TO CONDUCTION EQUATION**	**6 Hours**
Introduction to FEA, FDM and FVM, Solution of two dimensional steady and unsteady heat conduction equation using finite volume method (Implicit and Explicit), Stability Criteria.		
Unit IV	**SOLUTION TO ADVECTION EQUATION**	**8 Hours**
Solution of two dimensional steady and unsteady heat advection equation using finite volume method (Implicit and Explicit) with Dirichlet BC, Stability Criteria, Introduction to first order upwind, CD, second order upwind and QUICK convection schemes.		
Unit V	**SOLUTION TO CONVECTION-DIFFUSION EQUATION**	**6 Hours**
Solution of two dimensional steady and unsteady heat convection-diffusion equation for slug flow using finite volume method (Implicit and Explicit), Stability Criteria, 1-D transient convection-diffusion system, Peclet Number		
Unit VI	**CALCULATION OF THE FLOW FIELD**	**6 Hours**
Representation of the pressure gradient term, staggered grids, Pressure and Velocity Correction, SIMPLE Algorithm, SIMPLER Algorithm, PISO Algorithm		

PRACTICAL: Perform any six practicals from 1 to 6 using any commercial software.		
Practical No. 1	**Laminar flow through the pipe**	**4 Hours**
Steady state fluid flow analysis of flow through pipe under laminar flow conditions.		
Practical No. 2	**Temperature distribution in a pipe flow.**	**6 Hours**
Convection steady state heat transfer analysis of flow through pipe under laminar flow conditions.		
Practical No. 3	**Steady state temperature distribution in a rectangular plate**	**4 Hours**
2D Conduction steady state heat transfer analysis in rectangular solids		
Practical No. 4	**Unsteady state temperature distribution in a rectangular plate**	**4 Hours**

2D Conduction unsteady state heat transfer analysis in rectangular solids		
Practical No. 5	**Natural convection**	**4 Hours**
Natural convection steady state heat transfer analysis		
Practical No. 6	**Pin Fin**	**4 Hours**
Experimental and numerical analysis of pin fin apparatus.		
Practical No. 7	**CFD Analysis of external flow**	**4 Hours**
Forced convection steady state heat transfer analysis for external flow over circular cylinder or airfoil (NACA 0012)		
Practical No. 8	**Mini Project**	**6 Hours**
Students should take a problem of their choice and verify the CFD solution with experimental data / research paper.		

TEXT BOOK:

1. John D Anderson: Computational Fluid Dynamics- The Basics with Applications, McGraw-Hill
2. Atul Sharma, Introduction to Computational Fluid Dynamics: Development, Application and Analysis, Wiley
3. Suhas V. Patankar, Numerical Heat Transfer and Fluid Flow, Hemisphere Publishing Corporation
4. A. W. Date, Introduction to Computational Fluid Dynamics, Cambridge Univ. Press, USA.
5. H. Versteeg, and W.Malalasekara, An Introduction to Computational Fluid Dynamics: The Finite Volume Method, Pearson.

REFERENCES:

1. H. Tennekes and J. L. Lumley, A First Course in Turbulence, MIT Press.
2. David C. Wilcox, Turbulence Modeling for CFD, DCW Industries.
3. H. Schlichting and K. Gersten, Boundary-Layer Theory, Springer.
4. T. J. Chung, Computational Fluid Dynamics, Cambridge University Press.
5. J. Tu, G.-H. Yeoh and C. Liu: Computational Fluid Dynamics: A practical approach, Elsevier.