SCHEME OF COURSE WORK:

Course Details:

Course Title	Computational Fluid Dynamics Lab					
Course Code	19ME2208	**LTPC**	**0**	**0**	**3**	**1.5**
Program	M.Tech.					
Specialization	Thermal Engineering					
Semester	I					
Prerequisites	Engineering Thermodynamics and Thermal Engineering					
Course to which is a prerequisite	NA					

Course Outcomes:

CO1	Solve steady state and transient heat conduction problems using a software package
CO2	Solve heat transfer problems in fins and duct flow using a CFD software
CO3	Analyze natural convection problems using a CFD package
CO4	Solve diffusion problems using FVM
CO5	Apply central and upwind methods to convection-diffusion problems

Program Outcomes:

PO Code	**Program Outcome (PO)**
PO1	exhibit in-depth knowledge in thermal engineering specialization
PO2	think critically and analyse complex engineering problems to make creative advances in theory and practice
PO3	solve problem, think originally and arrive at feasible and optimal solutions with due consideration to public health and safety of environment
PO4	use research methodologies, techniques and tools, and will contribute to the development of technological knowledge
PO5	apply appropriate techniques, modern engineering tools to perform modeling of complex engineering problems with knowing the limitations
PO6	understand group dynamics, contribute to collaborative multidisciplinary scientific research
PO7	demonstrate knowledge and understanding of engineering and management principles and apply the same with due consideration to economical and financial factors
PO8	communicate complex engineering problems with the engineering community and society, write and present technical reports effectively
PO9	engage in life-long learning with a high level of enthusiasm and commitment to improve knowledge and competence continuously
PO10	exhibit professional and intellectual integrity, ethics of research and scholarship and will realize the responsibility towards the community
PO11	examine critically the outcomes of actions and make corrective measures

Course Outcome Vs Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	S	S	S				M			
CO2	S	S	S	S	S				M			
CO3	S	S	S	S	S				M			
CO4	S	S	S	S	S				M			
CO5	S	S	S	S	S				M			

S - Strongly correlated, M - Moderately correlated, Blank - No correlation

Assessment Methods:
Assignment/Quiz/Seminar/Case Study, Mid term exam and End term examination.

Teaching-Learning and Evaluation

Week	Title of the Experiment	CO	Sample Questions	Teaching-Learning Strategy	Assessment method & Schedule
1	Introduction to ANSYS WORKBENCH, ANSYS FLUENT			Lecture and Practice on ANSYS FLUENT	No evaluation, Practice session
2	Steady state one-dimensional heat conduction in a composite wall	CO1	Consider a furnace wall with three layers: 15 cm thick inside layer of firebrick, 7 cm thick middle layer of insulating brick and 12 cm thick outside layer of red brick. The furnace operates at 850^{o}C and it is anticipated that the outside of this composite wall can be maintained at 45^{o}C by the circulation of air. Assuming close bonding of layers at their interfaces calculate the interfaces temperature and heat conduction rate using ANSYS Steady Sate Thermal. Cross-section of the wall is considered as 4 m x 2.2 m. Thermal conductivities for firebrick is equal to 1.24 W/m^{o}C, insulating brick 0.15 W/m^{o}C and red brick 0.82 W/m^{o}C. Also find the heat conduction rate and interfaces temperatures by analytical formulae.	Lecture and Practice on ANSYS FLUENT	Day to Day Evaluation and Record Submission, Mid term exam (week 9)
3	Transient one dimensional heat conduction in a slab	CO1	A slab (60 cm x 60 cm) of aluminium (ρ = 2725 kg/m^3, k = 212 W/m^{2}K, C_p = 910 J/kgK) 12 cm thick is originally in a temperature of 520^{o}C. It is suddenly immersed in a liquid at 105^{o}C resulting in a heat transfer coefficient 1225 W/m^{2}K. Determine the temperature at the centreline and the surface 1 minute after the immersion using ANSYS Transient Thermal. Also, calculate the total thermal energy removed per unit area of the slab during this period.	Lecture and Practice on ANSYS FLUENT	Day to Day Evaluation and Record Submission, Mid term exam (week 9)
4	Heat transfer from a circular fin.	CO2	A steel rod (k = 32W/m˚C) of 1.2 cm diameter and 7.5 cm long protrudes from a wall which is maintained at 125˚C. The rod is insulated at its tip and is exposed to an environment with convection heat transfer coefficient, h = 60 W/m2.˚C and	Lecture and Practice on ANSYS FLUENT	Day to Day Evaluation and Record Submission,

<table>
<tr><td></td><td></td><td></td><td>surrounding temperature, Ta = 32˚C. Calculate fin temperature at its tip end and rate of heat dissipation using ANSYS Steady Thermal.</td><td></td><td>Mid term exam (week 9)</td></tr>
<tr><td>5</td><td>Parallel flow heat exchanger</td><td>CO2</td><td>Hot oil enters a parallel flow heat exchanger at a temperature of 100^{o}C through its centre pipe. Water at 30^{o}C enters through annulus of the heat exchanger. Considering d_o = 1.5 cm, d_i = 1 cm, D_o = 2.54 cm and D_i = 2 cm, L = 1 m, calculate outlet temperatures of hot oil and water from the heat exchanger using ANSYS FLUENT.</td><td>Lecture and Practice on ANSYS FLUENT</td><td>Day to Day Evaluation and Record Submission, Mid term exam (week 9)</td></tr>
<tr><td>6</td><td>Counter flow heat exchanger</td><td>CO2</td><td>Hot oil enters a counter flow heat exchanger at a temperature of 100^{o}C through its centre pipe. Water at 30^{o}C enters through annulus of the heat exchanger. Considering d_o = 1.5 cm, d_i = 1 cm, D_o = 2.54 cm and D_i = 2 cm, L = 1 m, calculate outlet temperatures of hot oil and water from the heat exchanger using ANSYS FLUENT.</td><td>Lecture and Practice on ANSYS FLUENT</td><td>Day to Day Evaluation and Record Submission, Mid term exam (week 9)`</td></tr>
<tr><td>7</td><td>Natural convection heat transfer</td><td>CO3</td><td>A thin plate (Aluminium) is maintained at a constant temperature of 315 K and placed in static ambient air at a temperature of 300 K. Consider the length of the pipe as 5 cm and accelerating due to gravity is acting in negative Y-direction. Assuming the flow of air over the plate is due to natural convection obtain pressure, velocity and temperature variations for the plate using ANSYS FLUENT.</td><td>Lecture and Practice on ANSYS FLUENT</td><td>Day to Day Evaluation and Record Submission, Mid term exam (week 9)</td></tr>
<tr><td>8</td><td>Revision of Cycle 1</td><td></td><td></td><td></td><td></td></tr>
<tr><td>9</td><td>Mid Term Examination</td><td></td><td></td><td></td><td></td></tr>
<tr><td>10</td><td>Transient 1-D heat conduction in a slab by Crank-Nicolson implicit method by FDM discretization</td><td>CO1</td><td>Consider 1D transient heat conduction through a metal rod (□ = 82.4 x 10^{-6} m^2/s) of length 32 cm. Two extreme ends of the rod maintained at constant temperatures of 125^{o}C and 25^{o}C respectively. At the initial instant of time, temperature at its internal nodes is given as follows.
<table>
<tr><td>Node</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td></tr>
<tr><td>Temp (^{o}C)</td><td>100</td><td>95</td><td>90</td><td>85</td><td>80</td><td>76</td><td>74</td><td>70</td><td>67</td></tr>
</table></td><td>Lecture and Practice on ANSYS FLUENT</td><td>Day to Day Evaluation and Record Submission, Mid term exam (week 18)</td></tr>
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			Assume, number of divisions along the *x* direction is 10 and time interval is 2 sec. Determine, the variation of temperature in the rod for a time of 20 sec with a computer code using FDM discretization.		
11	Steady state 1-D heat transfer in an insulated rod with heat generation by FVM discretization	CO1	Consider one dimensional steady state heat conduction through a metal rod with constant temperatures (110^{o}C and 25^{o}C) on its ends. Heat generation within the metal rod is 12 kW/m^{3}C. Thermal conductivity of metal rod is 115 W/mK. Length of the metal rod is 12.5 cm. Diameter of the rod is 1.25 cm. Determine temperature distribution within the rod using FVM with 4 divisions of control volumes along the length of the rod.	Lecture and Practice on ANSYS FLUENT	Day to Day Evaluation and Record Submission, Mid term exam (week 18)
12	Steady state 1-D heat transfer in a cylindrical fin by FVM discretization	CO1	A fin (diameter 1 cm) is attached to heating surface at 100^{o}C. The fin exposed to atmosphere where air with 30^{o}C is moving at an external heat transfer coefficient of 52 W/m^2.^{o}C. Assuming the end of the fin as is insulated and length of the fin as 10 cm Determine temperature distribution within the rod using FVM with 4 divisions of control volumes along the length of the rod.	Lecture and Practice on ANSYS FLUENT	Day to Day Evaluation and Record Submission, Mid term exam (week 18)
13	One-dimensional heat transfer by convection-diffusion by FVM discretization. Use central differencing scheme in discretization	CO4	Air (ρ = 1.2 kg.m^{-3}, μ = 2.2 x 10^{-5} kg.m^{-1}s^{-1}) at a velocity of 1.2 m/s and temperature 25^{o}C is allowed to flow over a flat plate of 20 cm length and unit width. Plate is subjected to constant temperature of 100^{o}C. Using FVM discretization solve the GDE for velocity and temperature distributions.	Lecture and Practice on ANSYS FLUENT	Day to Day Evaluation and Record Submission, Mid term exam (week 18)
14	One-dimensional heat transfer by convection-diffusion by FVM discretization. Use upwind differencing scheme in discretisation	CO4	Air (ρ = 1.2 kg.m^{-3}, μ = 2.2 x 10^{-5} kg.m^{-1}s^{-1}) at a velocity of 1.2 m/s and temperature 25^{o}C is allowed to flow over a flat plate of 20 cm length and unit width. Plate is subjected to constant temperature of 100^{o}C. Using FVM discretization solve the GDE for velocity and temperature distributions.	Lecture and Practice on ANSYS FLUENT	Day to Day Evaluation and Record Submission, Mid term exam (week 18)
15	Solve three simultaneous algebraic equations by Gaussian elimination method	CO5	Solve the following three simultaneous equations by Gaussian elimination method using computer code in C^{++}. x–2y+2z = 6; 2x+3y–4z = 5 and 3x+2y+z = 4	Lecture and Practice on ANSYS FLUENT	Day to Day Evaluation and Record Submission,

					Mid term exam (week 18)
16	Revision of Cycle 2				
17	Revision of Cycle 1,2				
18	Mid Term Examination-II				
19-20	End Term Examination				