Name: Enrolment No:	UPES

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, December 2018

Course: Advanced Fluid Mechanics and Heat Transfer **Semester: I**
Programme: M.TECH CFD
Time: 03 hrs. **Max. Marks: 100**
Instructions:
Heat and Mass Transfer data book can be used

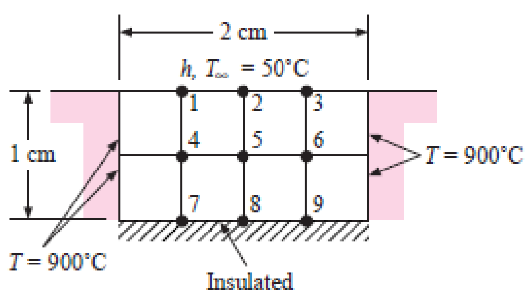
SECTION A

S. No.		Marks	CO
Q 1	Express the equation for net radiation exchange between a small isothermal surface and large isothermal surface?	**4**	**CO2**
Q 2	Why is the one-dimensional heat-flow assumption important in the analysis of fins? Define fin efficiency. Why is the insulated-tip solution important for the fin problems?	**4**	**CO1**
Q 3	What advantages does the effectiveness- NTU method have over the LMTD method? Why is a counter flow exchanger more effective than a parallel flow exchanger?	**4**	**CO2**
Q 4	Define Pressure head, velocity head, and elevation head for a stream and express them for a fluid stream? Does the amount of mass entering a control volume have to be equal to the amount of mass leaving during an unsteady flow process?	**4**	**CO1**
Q 5	Obtain the relevant stream function for the following velocity components of steady, incompressible flow $u = \frac{-Cx}{y},\ v = c\ln xy$	**4**	**CO2**

SECTION B

Q 6	A 1.0 kw heater is constructed of a glass plate with an electrically conducting film which produces a constant heat flux. The plate is 60 by 60 cm and placed in an airstream at 27^0 C, 1 atm with u_∞=5 m/s. Calculate the average temperature difference along the plate and the temperature difference at the trailing edge.	**10**	**CO2**

Q 7	An aluminium fin is attached to a transistor that generates heat at the rate of 300 mW. The fin has a total surface area of 9.0 cm^2 and is exposed to surrounding air at 27^0C. The contact conductance between transistor and fin is 0.9×10^{-4} $m^2.^0C/W$, and the contact area is 0.5 cm^2. Estimate the temperature of the transistor, assuming the fin is uniform in temperature.	**10**	**CO4**
Q 8	Drive Momentum conservation equation in Cartesian coordinate system and explain the nature various forces accounted?	**10**	**CO3**
Q 9	The minimum fresh air requirement of a residential building is specified to be 0.35 air changes per hour that is 35 % of the entire air contained in a residence should be replaced by fresh outdoor air every hour. If the ventilation required of 2.7 m high, 200 m^2 residences is to be met entirely by a fan, determine the flow capacity in L/min of the fan that needs to be installed. Also determine the minimum diameter of the duct if the average air velocity is not exceeded 5m/s (OR) A fan is to be selected to cool a computer case whose dimensions are 12 cm × 40 cm× 40 cm. half of the volume in the case is expected to be filled with components and the other half to be air space. A 5 cm diameter hole is available at the back of the case for the insulation of the fan that is to replace the air in the void spaces of the case once every second. Small low power fan motor combined units are available in the market and their efficiency is estimated to be 30 percent. Determine a.) The wattage of the fan motor unit to be purchased and b) The pressure difference across the fan. Take the air density to be 1.20 kg/m^3	**10**	**CO3**
	SECTION-C		
Q 10	A liquid flows down an inclined plane surface in a steady, fully developed laminar film of thickness h simply the continuity and Navier-Stokes equations to model this flow field. Obtain expressions for the liquid velocity profile, the shear stress distribution, the volume flow rate, and the average velocity. Relate the liquid film thickness to the volume flow rate per unit depth of surface normal to the flow. Calculate the volume flow rate in a film of water h=1 mm thick, flowing on a surface b=1 m wide, inclined at $\theta=15^0$ to the horizontal.		**CO4**
Q 11	The temperature distribution across a wall 1 m thick at a certain instant of time is	**20**	**CO5**

	given as $$T(x)=a+bx+cx^2$$ Where T is in degrees Celsius and x is in meters, while $a=900^0$ C, $b=-300^0$ C/m, and $c=-50^0$ C/m^2. A uniform heat generation, $q_{gen}=1000 W/m^3$, is present in the wall of area 10 m^2 having the properties $\rho=1600$ kg/m^3, k=40 W/m.K and $c_p=4$ kJ/kg K. (i). Determine the rate of heat transfer entering the wall x=0 and leaving the wall x=1 m (ii). determine the rate of change of energy storage in the wall (iii). Determine the time rate of temperature change at x=0, 0.25, and 0.5 m		
	(OR) A 1-by-2-cm ceramic strip [k=3.0 W/m.^{0}C, $\rho=1600$ kg/m^3, and c=0.8 kJ/kg.^{0}C] is embedded in a high thermal conductivity material as shown in the figure. So that the sides are maintained at a constant temperature of 900^0 C. The bottom surface of the ceramic is insulated, and the top surface is exposed to a convection and radiation environment at $T_\infty=50^0$ C, h=50 W/m^2 ^{0}C, and the radiation heat loss is calculated from $$q=\sigma A\epsilon(T^4-T_\infty^4)$$ Where A= surface Area, $\sigma=5.669\times10^{-8}$ W/m^2.^{0}K^4, $\epsilon=0.7$ Solve for the steady state temperature distribution of the nodes shown and the rate of heat loss. The radiation temperatures are in degree Kelvin 	**20**	

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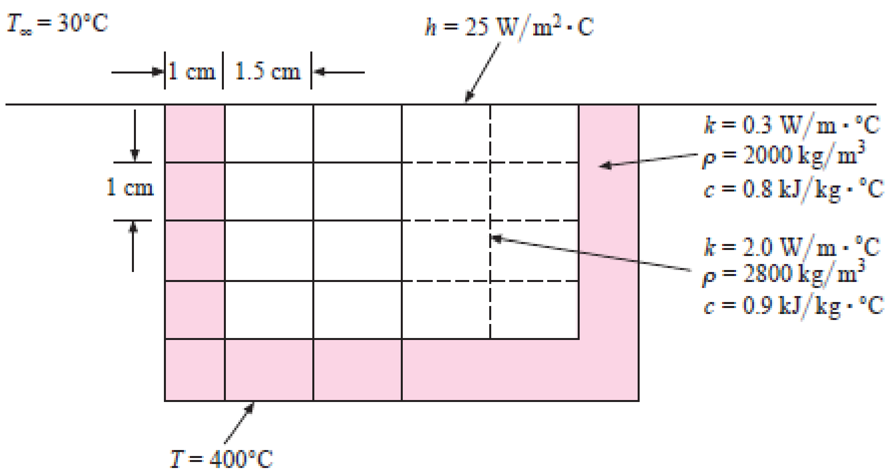
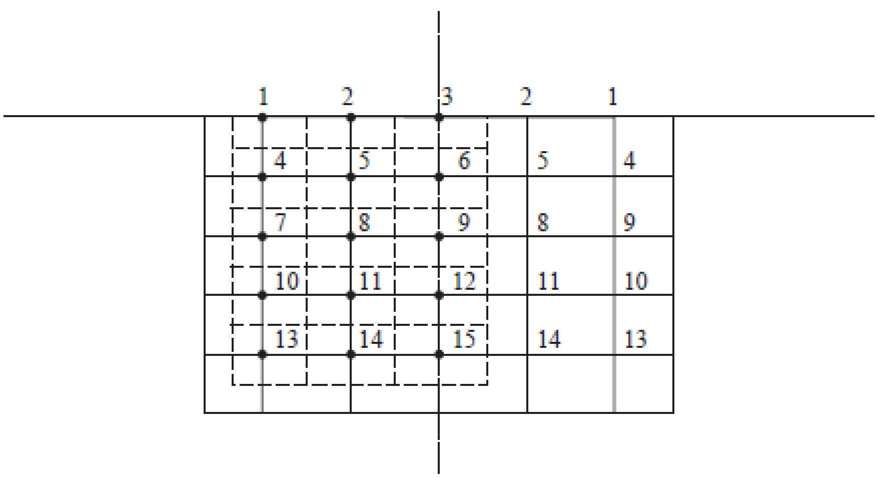
SECTION A

S. No.		Marks	CO
Q 1	Define thermal conductivity and Discuss the mechanism of thermal conduction in gases and solids, Name some good conductors of heat; some poor conductors?	**4**	**CO1**
Q 2	What is the basic procedure in setting up a numerical solution to a two-dimensional conduction problem? How one-dimensional transient solutions may be used for solution of two and three-dimensional problems.	**4**	**CO2**
Q 3	Explain the reason for higher heat transfer rates experienced in dropwise condensation than in film condensation? How is the Reynolds number defined for film condensation?	**4**	**CO2**
Q 4	Explain the cause of viscosity in liquids and gases? How do they vary in liquids and gasses with change in temperature? Consider two identical small glass balls dropped into two identical containers, on filled with water and the other with oil. Which ball will reach the bottom of the container first? Why?	**4**	**CO1**
Q 5	Write the momentum equation for steady one-dimensional flow for the case of no external force and explain the physical significance? Describe body forces and surface forces, and explain how the net forces acting on a control volume is determined?	**4**	**CO2**

SECTION B			
Q 6	Air at 27^0C and 1 atm flows over a flat plate at a speed of 2 m/s. Calculate the boundary-layer thickness at distance of 20 and 40 cm from the leading edge of the plate. Calculate the mass flow which enters the boundary layer between x=20 cm and x=40 cm. The viscosity of air at 27^0C is 1.85×10^{-5}kg/m.s. Assume unit depth in the z direction.	**10**	**CO2**
Q 7	Derive steady state heat conduction equation using Cartesian coordinate system; also express one dimensional heat flow with heat generation?	**10**	**CO4**
Q 8	Water enters a tank of diameter D_T steadily at a mass flow rate of $m_{in.}$ An Orifice at the bottom with diameter D_0 allows water to escape. The orifice has a rounded entrance, so the frictional losses are negligible. If the tank is initially empty, a). Determine the maximum height that the water will reach in the tank and b) obtain a relation for water height z as a function of time.	**10**	**CO3**
Q 9	The 2-D Velocity field for an incompressible, Newtonian fluid is described by the relation given below $$V=\left(12xy^2-6x^3\right)\hat{i}+\left(18x^2y-4y^3\right)\hat{j}$$ Where the velocity has units of m/s where x and y are in meters. Determine the stress σ_{xx}, σ_{yy} and τ_{xy} at the point x=0.8 m, y=-0.78 m. if the pressure at this point is 12.6 kpa and the fluid is lubricating oil at 16^0 C. Show that stress in the fluid element and consider the viscosity as 1.46 N.s/m^2.	**10**	**CO3**
	(OR) Consider two dimensional, steady, incompressible flow through the plane converging channel. The velocity on the horizontal centerline is given by $\vec{V}=V_1\left(1+\frac{x}{L}\right)\hat{i}$ Find an expression for the acceleration of a particle moving along the centerline using (a). The Eulerian approach and (b). the Lagrangian approach. Evaluate the acceleration when the particle is at the beginning and at the end of the channel.		
SECTION-C			

Q 10	Consider steady, incompressible, laminar flow of a Newtonian fluid in the narrow gap between two infinite parallel plates. The top plate is moving at speed V, and the bottom plate is stationary. The distance between those plates is H, and gravity acts in the negative z-direction. There is no applied pressure other than hydrostatic pressure due to gravity. Calculate the velocity and pressure fields, and estimate the shear force per unit area acting on the bottom plate?		**CO4**
Q 11	A composite material is embedded in a high thermal conductivity material maintained at 400^0 C as shown. The upper surface is exposed to a convection environment at 30^0 C with h=25 W/m^2. K. Determine the temperature distribution and heat loss from the supper surface for steady state.  	**20**	**CO5**
	(OR) The bulk thermal conductivity of a Nano fluid containing uniformly dispersed, non-contacting spherical nanoparticles may be approximated by	**20**	

	$k_{nf}=\left[\frac{k_p+2k_{bf}+2\varphi(k_p-k_{bf})}{k_p+2k_{bf}-\varphi(k_p-k_{bf})}\right]k_{bf}$ Where φ is the volume fraction of the nanoparticles, and k_{bf}, k_p, and k_{nf} are the thermal conductivities of the base fluid, particle, and Nano fluid, respectively. Likewise, the dynamic viscosity may be approximated as $\mu_{nf}=\mu_{bf}(1+2.5\varphi)$ Determine the value of k_{nf}, ρ_{nf}, $c_{p,nf}$, μ_{nf}, and α_{nf} for a mixture of water and Al_2O_3 nano-particles at a temperature of T=300 K and a particle volume fraction of φ=0.05. The thermo-physical properties of the particle are k_p=36.0 W/m.K, ρ=3970 kg/m^3, and $c_{p,p}$=0.765 kJ/kg .K.		