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| **Name:**<br><br>**Enrolment No:** | UPES<br>UNIVERSITY WITH A PURPOSE |

**UNIVERSITY OF PETROLEUM AND ENERGY STUDIES**
**End Semester Examination, December 2019**

**Course: Advanced Fluid Mechanics and Heat Transfer** **Semester: I**
**Program: M.TECH CFD** **Time 03 hrs.**
**Course Code: ASEG 7019** **Max. Marks: 100**
**No.of pages:03**
**Instructions: Heat Transfer Data Book is allowed**

**SECTION A**

| S. No. | Answer All the Question in the following section | **Marks** | **CO** |
|---|---|---|---|
| Q 1 | What is the Reynolds number of water at $30^0$ C flowing at 0.30 m/s through a 5 mm diameter tube? If the pipe is now heated at what mean water temperature will the flow transition to turbulence. Assume the velocity of the flow remains constant. | **5** | **CO3** |
| Q 2 | Explain the concept of Fluid as a continuum. Viscosity in Fluids, Newtonian and Non Newtonian Fluids ? | **5** | **CO1** |
| Q 3 | What is meant by subcooled and saturated boiling? Distinguish between nucleate and film boiling | **5** | **CO2** |
| Q 4 | How does thermal radiation differ from other types of electromagnetic radiation? Define irradiation and radiosity? | **5** | **CO1** |

**SECTION B**
**Answer all the Questions and Q 8 has Internal Choice**

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| Q 5 | A steel tube having k=46 W/m.ºC has an inside diameter of 3.0 cm and a tube wall thickness of 2 mm. A fluid flows on the inside of the tube producing a convection coefficient of 1500 $W/m^2$.ºC on the inside surface, while a second fluid flows across the outside of the tube producing a convection coefficient of 197 $W/m^2$.ºC on the outside tube surface. The inside fluid temperature is 223 ºC while the outside fluid temperature is 57 ºC. Calculate the heat lost by the tube per meter of length. | **10** | **CO2** |
| Q 6 | A speedboat on hydrofoils is moving at 20 m/s in a fresh water lake. Each hydrofoil is 3 m below the surface. Assuming as an approximation, frictionless, incompressible flow, find the stagnation pressure gauge at the front of each hydrofoil. At one point | **10** | **CO1** |

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| | on a hydrofoil, the pressure is -75 kPa. Calculate the speed of the water relative to the hydrofoil at this point and the absolute water speed. | | |
| Q 7 | Derive and expression for the heat transfer in a laminar boundary layer on a flat plate under the condition $u=u_\infty$=constant Assume that the temperature distribution is given by the cubic parabola relation. $$\frac{\theta}{\theta_\infty}=\frac{T-T_w}{T_\infty-T_w}=\frac{3}{2}\frac{y}{\partial_t}-\frac{1}{2}\left(\frac{y}{\partial_t}\right)^3$$ This solution approximates the condition observed in the flow of a liquid meter over a flat plate? | **10** | **CO2** |
| Q 8 | Water from a stationary nozzle impinges on a moving vane with turning angle θ= $120^0$. The vane moves away from the nozzle with constant speed U=20 m/s, and receives a jet that leaves the nozzle with speed V =50 m/s. The nozzle has an exit area of 0.008 $m^2$. Find the force that must be applied to maintain the vane speed constant<br>OR<br>A tank of 0.1 $m^3$ volume is connected to a high-pressure airline; both line and tank are initially at a uniform temperature of $20^0$ C. The initial tank gage pressure is 100 kPa. The absolute line pressure is 2.0 MPa; the line is large enough so that its temperature and pressure may be assumed constant. The tank temperature is monitored by a fast response thermocouple. At the instant after the valve is opened, the tank temperature rises at the rate of $0.05^o$ C/s. Determine the instantaneous flow rate of air into the tank if heat transfer is neglected. | **10** | **CO3** |
| | **SECTION-C**<br>**Answer all the Questions and Q 10 has Internal Choice** | | |
| Q 9 | Consider a long solid tube, insulated at the outer radius $r_2$ and cooled at the inner radius $r_1$, with uniform heat generation q($W/m^3$) within the solid.<br>a. Obtain the general solution for the temperature distribution in the tube<br>b. In a practical application a limit would be placed on the maximum temperature that is permissible at the insulated surface ($r=r_2$). Specifying this limit as $T_{s,2}$, Identify approximate boundary conditions that could be used to determine the arbitrary constants appearing in the general solution. | **20** | **CO5** |

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<td>Determine these constants and the corresponding form if the temperature distribution.<br>c. If the coolant is available at a temperature $T_{\infty}$, Obtain an expression for the convection coefficient that would have to be maintained at the inner surface to allow for operation at prescribed values of $T_{s,2}$ and q.</td>
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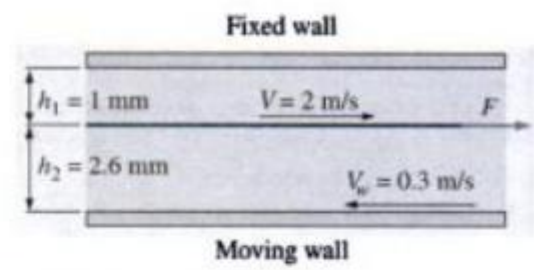
<tr>
<td rowspan="2">Q 10</td>
<td>A thin 40 cm × 40-cm flat plate is pulled at 2 m/s horizontally through a 3.6 mm thick oil layer sandwiched between two plates, one stationary and the other moving at a constant velocity of 0.3 m/s, as shown in the figure. The dynamic viscosity of oil is 0.027 Pa.s. Assuming the velocity in each oil layer to vary linearly. Solve the Naiver-Stokes equation for the velocity profile between the plates.<br>a. Plot the velocity profile and find the location where the oil velocity is zero.<br>b. Determine the force that needs to be applied on the plate to maintain this motion.<br>
<br>(OR)</td>
<td rowspan="2">20</td>
<td rowspan="2">CO4</td>
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<td>The engine cylinder of a motor cycle is constructed of 2024-T6 aluminum alloy and is of height H=0.15 m and outside diameter D=50 mm. Under typical operating conditions the outer surface of the cylinder is at a temperature of 500 K and is exposed to ambient air at 300 K with a convention coefficient of 50 $W/m^2$ K. Annular fins are integrally cast with the cylinder to increase heat transfer to the surroundings. Consider five such fins, which are of thickness t=6 mm, length L=20 mm, and equally spaced. What is the increase in heat transfer due to use of the fins?</td>
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