B. MECH ENGG. FINAL YEAR, 2ND SEMESTER   EXAMINATION 2018

INTRODUCTION TO TURBULENCE

Time: **Three hours**   **Full Marks: 100**

Answer to all parts of a question must be together

NB: Assume any data, if not furnished, consistent with the problem.

1   **Answer any four (4) questions from this group**

a)   What do you mean by critical Reynolds number? Discuss four parameters which affect the critical Reynolds number.

b)   Discuss how turbulence affects the heat transfer citing the energy equation.

c)   Isentropic turbulence implies homogeneous turbulence' – comment   on this statement and explain if the homogenous turbulent field leads to isentropic turbulence.

d)   State two hypotheses of Kolmogorov with sketch of energy spectrum.

e)   What do you mean by skeweness coefficient and Kurtosis coefficient? State their values for Gaussian distribution. What does a negative skewness imply?

                                                                                          5 x 4

2   **Answer any one (1) from this group**

 a)   In a two-dimensional flow field,   x and y –components of velocity (i.e. u and v) (in m/s) are
      [1.0 1.1 1.2 1.07 0.99 0.97 0.96 0.99 1.0] and [0.05 -0.01 -0.03 -0.05 0.01 0.02 0.022 0.04 0.05]
      Find the value of k (turbulent kinetic energy), u_{rms}, $\overline{u'v'}$ 20

b)   i.   Find out the Kurtosis value for Gaussian distribution.
          ii. Derive the Reynolds-averaged X-momentum equation in a three dimensional flow.

                                                                                          12+8

3   **Answer any three (3) questions from this group**

a)   Discuss the turbulent boundary layer over flat plate with clear sketch showing different zones.

b)   Water flows through a 3 cm diameter tube, 20 m length at the rate of 720 kg/hr. The outside of the tube is heated so as to maintain uniform heat flux. The inlet and exit

                                                                              [Turn over

temperatures are 10^0 and 70^0 C respectively. What is the amount of heat flux to water? Estimate the surface temperature of the tube at the exit.
   The thermo-physical properties are: $\upsilon = 0.658 \times 10^{-6} \, m^2/s$, k = 0.631 W/mK and Pr = 4.32

c)   Estimate the Reynolds number for Kolmogorov scale eddies. Estimate the smallest length and velocity scale in the flow field produced by a mixer which can contain 2 Kg of water and requires 500 W. Take kinematic viscosity value as $10^{-6} \, m^2/s$

d)   What do you mean by correlation tensor? Provide the expression for correlation tensor for turbulent flow. Explain Eulerian auto-corealtion coefficient. Sketch the distribution of fluctuating u and v components for positive, negative and zero value of the coefficient.

                                                                        10 x 3

4   **Answer any two (2) questions from this group**

a)   Derive the PDF for a velocity function u = 10+ 3 sin (ωt). Sketch the PDF with labeling.

                                                                        12+3

b)   Write down the Reynolds averaged Navier-Stokes equation, energy equation and Reynolds stress term for a 3-D flow and hence explain the concept of turbulent viscosity. In this context, briefly explain k-ε model. What are the pros-and cons of this model?

                                                                        3+3+3+3+3

c)   Briefly explain the turbulent kinetic energy budget and show how it can be derived.

                                                                        6+9