1. Which of the following flows is likely to be turbulent:

(a) Flow in a circular pipe at a Reynolds number of 2000  
(b) Flow over a sphere at a Reynolds number of 5000  
(c) Flow over a flat plate at a Reynolds number of 10000  
(d) None of the above  
**Comment:** The transition Re are about 2100, 200000 and 500000, respectively for a, b and c.

2. Which of these are characteristics describe turbulent flows:

(a) wholly unpredictable  
(b) always fluctuating  
(c) high diffusivity  
(d) do not obey Navier-Stokes equations

3. Which of the following statements is correct about the time interval for time-averaging of Navier Stokes equations:

(a) it should be as large as possible  
(b) it should be much larger than the time period of the smallest wave number associated with turbulence  
(c) it should be much smaller than the time period of the largest wave number associated with turbulence  
(d) it should be much larger than the time period of the largest wave number associated with turbulence

4. Which of the following statements is true about the turbulence closure problem:

(a) It does not arise  
(b) It refers to the case of a mathematical problem in which there are too many equations and too few variables  
(c) It arises only when do direct numerical simulation of turbulence  
(d) None of the above

5. Turbulent kinetic energy is defined as (here <…> indicates time averaging):

(a) \( \frac{\mu}{\rho} \langle u'_m u'_n \rangle \)  
(b) \( \frac{\mu}{\rho} u'_m u'_m \)  
(c) \( \frac{\partial u'_m}{\partial x_n} \partial u'_n / \partial x_m \)  
(d) \( \langle u'_m u'_m \rangle \)

6. The units of turbulent kinetic energy dissipation rate are:

(a) \( \text{m}^2/\text{s}^3 \)  
(b) \( \text{m}^2/\text{s}^3 \)  
(c) \( \text{J} \)  
(d) \( \text{J/s} \)

7. Which of the following statements is true about eddy viscosity:

(a) It is dimensionless.  
(b) It is isotropic.  
(c) It varies across the cross-section of a pipe even in fully developed flow.  
(d) None of the above.

8. Which of the following statements is true about Reynolds stresses?
(a) They are dimensionless.  (b) They are constant for a given Reynolds number. (c) They are constant across the cross-section of a pipe in fully developed flow although individual stresses are different. (d) None of the above.

9. We are solving the case of steady, fully developed turbulent flow between two infinitely long and wide parallel plates using the mixing length turbulence model. For this case, the number of differential equations that we need to solve is (a) 1 (b) 2 (c) 3 (d) 4.

10. We are solving the case of steady, fully developed turbulent flow between two infinitely long and wide parallel plates using the k-ε turbulence model. For this case, the number of differential equations that we need to solve is (a) 4 (b) 3 (c) 2 (d) 1.