Unit 7 - Week 5

Course outline

Assignment 5

The due date for submitting this assignment has passed.
As per our records you have not submitted this assignment.

Due on 2019-09-04, 23:59 IST.

1) Which among the following statements regarding the critical Reynolds number is/are correct? *1 point*

(A) Below the critical Reynolds number, the flow is always laminar irrespective of the level of disturbance.
(B) Above the critical Reynolds number, the flow is always turbulent.
(C) Above the critical Reynolds number, the flow may be laminar under highly controlled conditions.
(D) Below the critical Reynolds number, the flow may be turbulent.

a
b
c
d

No, the answer is incorrect.
Score: 0
Accepted Answers:
a
c

2) Consider the following statements: *1 point*

(I) The time averaged velocity components $(\bar{u}, \bar{v}, \bar{w})$ in a constant density turbulent flow satisfy the continuity equation in the same form as satisfied by the corresponding instantaneous quantities.
(II) The time averaged velocity components $(\bar{u}, \bar{v}, \bar{w})$ and pressure $(\bar{p})$ in a constant density turbulent flow satisfy the Navier-Stokes equations in the same form as satisfied by the corresponding instantaneous quantities.

(A) Both (I) and (II) are true.
(B) (I) is true, but (II) is false.
(C) (II) is true, but (I) is false.
(D) Both (I) and (II) are false.

a
b
c
d

No, the answer is incorrect.
Score: 0
Accepted Answers:
b

3) The vorticity transport equation for a constant density flow is given by *1 point*

$$\frac{D\vec{\Omega}}{Dt} = \nu\nabla^2\vec{\Omega} + \left(\vec{\Omega}\cdot\nabla\right)\vec{V}$$

Which term in the vorticity transport equation is related to vortex stretching in a viscous turbulent flow?

(A) $\frac{D\vec{\Omega}}{Dt}$
(B) $\nu\nabla^2\vec{\Omega}$
(C) $\left(\vec{\Omega}\cdot\nabla\right)\vec{V}$
(D) None of the above

a
b
c
d

No, the answer is incorrect.
Score: 0
Accepted Answers:
c

4) The time average of a turbulent function $f(x, y, z, t)$ is defined as *1 point*

$$\bar{f} = \lim_{T\to\infty}\frac{1}{2T}\int_{-T}^{T} f\,dt$$

Which among the following statements about the averaging period T is correct?

(A) T is significantly longer than the time period of turbulent fluctuations but smaller than the system time-scale.
(B) T is significantly longer than the system time-scale but smaller than the time period of turbulent fluctuations.
(C) T is significantly longer than the system time-scale as well as the time period of turbulent fluctuations.
(D) T is significantly smaller compared to the system time-scale as well as the time period of turbulent fluctuations.

a
b
c
d

No, the answer is incorrect.
Score: 0
Accepted Answers:
a

5) **Assertion (A):** The time average of the product of the velocity fluctuations $\overline{u'v'}$ in a stationary turbulence is zero. *1 point*
Reason (R): By definition the fluctuations have a zero mean:

$$\overline{u'} = \lim_{T\to\infty}\frac{1}{2T}\int_{-T}^{T}(u-\bar{u})\,dt = \bar{u}-\bar{u} = 0$$

Therefore the time average of the product of the fluctuations, $\overline{u'v'} = \overline{u'}\ \overline{v'} = 0$.

(A) Both A and R are true, and R is the correct explanation of A.
(B) Both A and R are true, but R is not the correct explanation of A.
(C) A is true, but R is false
(D) A is false, but R is true.
(E) Both A and R are false.

a
b
c
d
e

No, the answer is incorrect.
Score: 0
Accepted Answers:
e

6) Which among the following is the correct relationship between the Kolmogorov length scale, η and the Reynolds number based on the largest eddy scales, $Re_L = \frac{uL}{\nu}$? *1 point*

(A) $\frac{\eta}{L} \sim Re_L^{-1/4}$
(B) $\frac{\eta}{L} \sim Re_L^{-1/2}$
(C) $\frac{\eta}{L} \sim Re_L^{-3/4}$
(D) $\frac{\eta}{L} \sim Re_L^{-2/3}$

a
b
c
d

No, the answer is incorrect.
Score: 0
Accepted Answers:
c

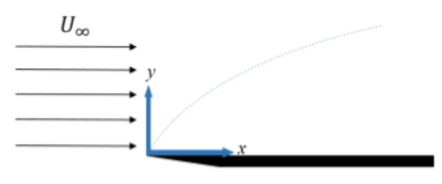
7) In a wall bounded turbulent flow, the streamwise velocity is non-dimensionalized as $u^+ = \frac{\bar{u}}{u_\tau}$, where $u_\tau = \sqrt{\frac{\tau_w}{\rho}}$, τ_w denotes the wall shear stress, ρ is the fluid density and the coordinate normal to the wall is non-dimensinalized as $y^+ = \frac{u_\tau y}{\nu}$. *1 point*
Which among the following expressions correctly represents the dimensionless velocity profile within the viscous sublayer just adjacent to the solid wall in a wall bounded turbulent flow?

(A) $u^+ = \ln(1+y^+)$
(B) $u^+ = \exp(y^+) - 1$
(C) $u^+ = 1 - \exp(-y^+)$
(D) $u^+ = y^+$

a
b
c
d

No, the answer is incorrect.
Score: 0
Accepted Answers:
d

8) Consider laminar boundary layer flow of a Newtonian fluid of density ρ and dynamic viscosity μ over a flat plate of length L as shown in the figure below. *1 point*



The velocity of the uniform free stream is U_∞. Assume the boundary layer theory to be valid over the entire length of the plate. Which among the following scaling relations between the non-dimensional boundary layer thickness and the Reynolds number, $Re_L = \frac{\rho U_\infty L}{\mu}$ is correct?

(A) $\frac{\delta}{L} \sim Re_L^{1/2}$
(B) $\frac{\delta}{L} \sim Re_L^{-1/2}$
(C) $\frac{\delta}{L} \sim Re_L^{-1}$
(D) $\frac{\delta}{L} \sim Re_L^{-2}$

a
b
c
d

No, the answer is incorrect.
Score: 0
Accepted Answers:
b

9) Consider a steady, two-dimensional, incompressible flow over a flat plate at zero angle of incidence with respect to the uniform free stream. The boundary layer thickness is 2 mm at a location where the local Reynolds number is 1000. If the free stream velocity of the flow alone is increased by a factor of 4, then the boundary layer thickness at the same location, in mm will be *1 point*

(A) 1
(B) 0.5
(C) 8
(D) 4

a
b
c
d

No, the answer is incorrect.
Score: 0
Accepted Answers:
a

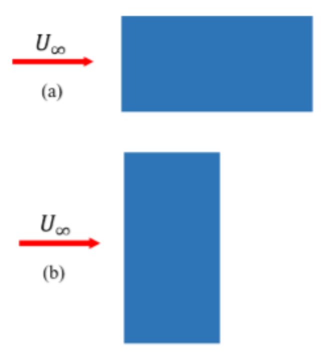
10) Consider laminar flow of water over a flat plate of length 1 m. If the boundary layer thickness at a distance of 0.2 m from the leading edge of the plate is 6 mm, the boundary layer thickness (in mm), at a distance of 0.8 m from the leading edge will be *1 point*

(A) 1.5
(B) 3
(C) 12
(D) 24

a
b
c
d

No, the answer is incorrect.
Score: 0
Accepted Answers:
c

11) One dimension of a thin rectangular flat plate is twice the other. Air at uniform speed flows parallel to the plate, and a laminar boundary layer forms on both sides of the plate. Consider the cases shown in the figure below. *1 point*



In case (a), the long dimension is oriented parallel to the wind and in case (b), the short dimension is oriented parallel to the wind. Assume the boundary layer to be laminar over the entire length of the plate for both the cases and the boundary layer theory to be valid. Let F_a be the magnitude of the drag force on the plate for case (a). Then the drag force on the plate for case (b) is

(A) $\frac{F_a}{\sqrt{2}}$
(B) $\sqrt{2}F_a$
(C) $\frac{F_a}{2}$
(D) Cannot be determined

a
b
c
d

No, the answer is incorrect.
Score: 0
Accepted Answers:
b