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Courses » Modeling Transport Phenomena of Microparticles

Announcements **Course** Ask a Question Progress

Unit 3 - Week 2

Course outline

Week 2: Assignment

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

Due on 2017-02-08, 23:59 IST

Modeling Transport Phenomena of Micro-particles
Assignment 2

Note: Follow the notations used in the lectures. Symbols have their usual meanings.

1) The stream function $\psi(r,\theta)$ in spherical polar coordinate system is given by *2 points*

(a) $u_r = \frac{1}{r\sin\theta}\frac{\partial\psi}{\partial\theta},\ u_\theta = -\frac{1}{r\sin\theta}\frac{\partial\psi}{\partial r}$

(b) $u_r = \frac{1}{r^2\sin\theta}\frac{\partial\psi}{\partial\theta},\ u_\theta = -\frac{r}{\sin^2\theta}\frac{\partial\psi}{\partial r}$

(c) $u_r = \frac{1}{r^2\sin\theta}\frac{\partial\psi}{\partial\theta},\ u_\theta = -\frac{1}{r\sin\theta}\frac{\partial\psi}{\partial r}$

(d) $u_r = \frac{1}{r^2\sin\theta}\frac{\partial\psi}{\partial\theta},\ u_\theta = -\frac{1}{r\sin^2\theta}\frac{\partial\psi}{\partial r}$

No, the answer is incorrect.
Score: 0

Accepted Answers:
(c) $u_r = \frac{1}{r^2\sin\theta}\frac{\partial\psi}{\partial\theta},\ u_\theta = -\frac{1}{r\sin\theta}\frac{\partial\psi}{\partial r}$

2) *2 points*
The reduced from of the steady state Navier-Stokes equation (2D Cartesian) in terms of stream function is given by

(a) $\nu\nabla^4\psi - \nabla^2\psi = \frac{\partial(\psi,\nabla^2\psi)}{\partial(x,y)}$

(b) $\nu\nabla^4\psi - \nabla^2\psi = \frac{\partial(\psi,\nabla\psi)}{\partial(x,y)}$

(c) $\nu\nabla^4\psi = \frac{\partial(\psi,\nabla^2\psi)}{\partial(x,y)}$

(d) $\nu\nabla^4\psi - \frac{\partial}{\partial t}\nabla^2\psi = \frac{\partial(\psi,\nabla^2\psi)}{\partial(x,y)}$

No, the answer is incorrect.
Score: 0

Accepted Answers:
(c) $\nu\nabla^4\psi = \frac{\partial(\psi,\nabla^2\psi)}{\partial(x,y)}$

3) *4 points*
If the streamlines corresponding to a two-dimensional flow are represented by $\psi = x^2 - y^2$, then the resultant velocit direction at (2, 2) respectively are

(a) $2\sqrt{2}$, making an angle 60° to x − axis

(b) $2\sqrt{2}$, making an angle 45° to x − axis

(c) $4\sqrt{2}$, making an angle 45° to x − axis

(d) $4\sqrt{2}$, making an angle 60° to x − axis

No, the answer is incorrect.
Score: 0

Accepted Answers:

(c) $4\sqrt{2}$, making an angle 45° to $x-$ axis

4) *2 points*

Let a solid sphere of radius a be held fixed in a uniform stream U flowing steadily in the positive $x-$ direction. Let the fluid be incompressible viscous with viscosity μ. The corresponding Stokes drag when (in SI units) $a = 2$ m, $\mu = 2$ Ns/m^2, U = 7 m/s is given by

(a) 528 N

(b) 520 N

(c) 428 N

(d) 628 N

No, the answer is incorrect.
Score: 0

Accepted Answers:
(a) 528 N

5) *5 points*

Consider the following governing equations corresponding to a two-dimensional viscous incompressible flow in (r, θ) polar coordinates $\rho v_r \frac{\partial v_r}{\partial r} = -\frac{\partial p}{\partial r} + \mu\left(\nabla^2 v_r - \frac{v_r}{r^2}\right), 0 = -\frac{1}{r}\frac{\partial p}{\partial \theta} + \frac{2\mu}{r^2}\frac{\partial v_r}{\partial \theta}$, where $\nabla^2 \equiv \frac{\partial^2}{\partial r^2} + \frac{1}{r}\frac{\partial}{\partial r} + \frac{\partial^2}{\partial \theta^2}$.

If the radial velocity is given by $v_r = \frac{\mu}{\rho}\frac{1}{r} f(\theta)$ for any arbitrary function f that depends only θ, then the differential equation satisfied by f is

(a) $f'''(\theta) + 2f(\theta)f'(\theta) + 4f'(\theta) = 0$

(b) $f'''(\theta) + 2f(\theta)f''(\theta) + 4f'(\theta) = 0$

(c) $f'(\theta)^2 + 2f(\theta)f'(\theta) + 4f'(\theta) = 0$

(d) $f'''(\theta) + 2f(\theta)f'(\theta) + 4f''(\theta) = 0$

No, the answer is incorrect.
Score: 0

Accepted Answers:
(a) $f'''(\theta) + 2f(\theta)f'(\theta) + 4f'(\theta) = 0$

6) *5 points*

If $\vec{u}$, P and $\vec{\Omega}$ represent the velocity, pressure and vorticity respectively of a steady state Stokes flow, then the following relations hold

(a) $\nabla^2\vec{u} = 0, \nabla^2 P = 0, \nabla^2\vec{\Omega} = 0$

(b) $\nabla^4\vec{u} = 0, \nabla^2 P = 0, \nabla^2\vec{\Omega} = 0$

(c) $\nabla^2\vec{u} = 0, \nabla^2 P = 0, \nabla^4\vec{\Omega} = 0$

(d) $\nabla^4\vec{u} = 0, \nabla^2 P = 0, \nabla^4\vec{\Omega} = 0$

No, the answer is incorrect.
Score: 0

Accepted Answers:
(b) $\nabla^4\vec{u} = 0, \nabla^2 P = 0, \nabla^2\vec{\Omega} = 0$

7) *5 points*

For a specific geometry, let us consider the following simplified Navier-Stokes equations $0 = -\frac{\partial p}{\partial r} + \rho\omega^2 r$, $0 = -\frac{1}{\rho}\frac{\partial p}{\partial \theta}, 0 = -\frac{\partial p}{\partial z} - \rho g$. Integrate these to obtain the corresponding pressure. If this pressure satisfies $p(r, z) = 0$ a $= (0, h)$ then we have

(a) $p = \frac{\rho w^2 r^2}{2} - \rho g z + \rho g h$

(b) $p = \frac{\rho w r^2}{2} - \rho g z + \rho g h$

(c) $p = \frac{\rho w^2 r}{2} - \rho g z + \rho g h$

(d) $p = \frac{\rho w^2 r^2}{2} + \rho g z - \rho g h$

No, the answer is incorrect.
Score: 0

Accepted Answers:
(a) $p = \frac{\rho w^2 r^2}{2} - \rho g z + \rho g h$

8) *3 points*

The velocity components in case of an axi-symmetric flow are given in (r, θ, z) cylindrical co-ordinates as $u_r = \frac{r^2 z}{3}$, $u_z = -\frac{r z^2}{2}$. Then, the corresponding stream function is given by

(a) $\psi = -\frac{r^2 z^2}{6}$

(b) $\psi = -\frac{r^3 z^3}{6}$

(c) $\psi = -\frac{r^3 z^2}{6}$

(d) $\psi = -\frac{r^3 z^2}{4}$

No, the answer is incorrect.
Score: 0

Accepted Answers:
(c) $\psi = -\frac{r^3 z^2}{6}$

9) *4 points*

Consider a two dimensional flow through a narrow passage of length L and width H, where $\epsilon = H/L << 1$. In order to non-dimensionalize the Navier-Stokes equations governing the flow inside the passage, the following dimensionless variables are used: $x' = \frac{x}{L}, y' = \frac{y}{\epsilon L}, t' = \frac{Ut}{L}, u' = \frac{u}{U}, v' = \frac{v}{\epsilon U}, p' = \frac{p}{P_a}$.

If the corresponding x-momentum equation is given by $\alpha\left(\frac{\partial u'}{\partial t'} + u'\frac{\partial u'}{\partial x'} + v'\frac{\partial u'}{\partial y'}\right) = -\frac{1}{\Lambda}\frac{\partial p'}{\partial x'} + \beta\frac{\partial^2 u'}{\partial x'^2} + \gamma\frac{\partial^2 u'}{\partial y'^2}$,

then the parameters α, β, γ and Λ are given by

(a) $\alpha = \epsilon Re, \beta = \epsilon^2, \gamma = 1, \Lambda = \frac{\mu U}{\epsilon^2 P_a L}$

(b) $\alpha = \epsilon^2 Re, \beta = \epsilon^2, \gamma = 1, \Lambda = \frac{\mu U}{\epsilon^2 P_a L}$

(c) $\alpha = \epsilon^2 Re, \beta = \epsilon^2, \gamma = \epsilon^2, \Lambda = \frac{\mu U}{\epsilon^2 P_a L}$

(d) $\alpha = \epsilon^2 Re, \beta = \epsilon^2, \gamma = 1, \Lambda = \frac{\mu U}{P_a L}$

No, the answer is incorrect.
Score: 0

Accepted Answers:
(b) $\alpha = \epsilon^2 Re, \beta = \epsilon^2, \gamma = 1, \Lambda = \frac{\mu U}{\epsilon^2 P_a L}$

10) *3 points*

Consider an incompressible Newtonian fluid between two parallel disks of radius R, separated by a distance $H(R \gg$
The upper disk is subjected to a velocity $' - V'$ in $z-$ direction and the lower disk is stationary. If the flow is assumed
to be axi-symmetric, then the following holds

(a) v_r is substantial but $\frac{\partial v_z}{\partial z}$ is negligible

(b) v_r is substantial but $\frac{\partial v_z}{\partial r}$ is negligible

(c) v_r is substantial and $\frac{\partial v_z}{\partial r}$ is substantial

(d) v_z is substantial but $\frac{\partial v_z}{\partial z}$ is negligible

No, the answer is incorrect.
Score: 0

Accepted Answers:
(b) v_r is substantial but $\frac{\partial v_z}{\partial r}$ is negligible

Previous Page End