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NPTEL

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Courses » Modeling Transport Phenomena of Microparticles

Announcements

Course

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Unit 4 - Week 3

Course outline

How to access the portal

Week 1

Week 2

Week 3

- Lecture 11: Solution of arbitrary Stokes flows
- Lecture 12: Mechanics of Swimming Microorganisms
- Lecture 13: Viscous flow past a spherical drop
- Lecture 14: Migration of a viscous drop under Marangoni effects
- Lecture 15: Singularities of Stokes flows
- Week 3: Lecture Material
- Quiz : Week 3: Assignment
- Week 3 Assignment Solution

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Week 3: Assignment

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

Due on 2017-02-15, 23:59 IST

Modeling Transport Phenomena of Micro-particles Week 3: Assignment 1

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

1) 2 points
If $\mathbf{V} = \text{CurlCurl}(rA) + \text{Curl}(rB)$, $P = P_0 + \mu \frac{\partial}{\partial r}(r\nabla^2 A)$, represent the velocity vector and pressure field corresponding to the Stokes equations, then A , B and P satisfy

- (a) $\nabla^2 A = 0, \nabla^2 B = 0, \nabla^4 P = 0$
- (b) $\nabla^2 A = 0, \nabla^4 B = 0, \nabla^2 P = 0$
- (c) $\nabla^4 A = 0, \nabla^2 B = 0, \nabla^2 P = 0$
- (d) $\nabla^4 A = 0, \nabla^4 B = 0, \nabla^4 P = 0$

No, the answer is incorrect.

Score: 0

Accepted Answers:

(c) $\nabla^4 A = 0, \nabla^2 B = 0, \nabla^2 P = 0$

2) 2 points
Consider Stokes flow past a sphere with an ambient velocity $U\vec{i}$. Let $\mathbf{V} = \text{CurlCurl}(rA) + \text{Curl}(rB)$, $P = P_0 + \mu \frac{\partial}{\partial r}(r\nabla^2 A)$ represent the velocity vector and pressure field corresponding to the Stokes equation

If, on the boundary of the sphere, we have $\mathbf{V} \cdot \vec{e}_\theta = U\vec{i} \cdot \vec{e}_\theta$, the corresponding reduced form is given by

- (a) $\frac{1}{r} \frac{\partial}{\partial \theta} \left(A + r \frac{\partial A}{\partial r} \right) + \csc \theta \frac{\partial B}{\partial \varphi} = U \cos \theta \cos \varphi$
- (b) $\frac{1}{r} \frac{\partial}{\partial \theta} \left(A + \frac{\partial A}{\partial r} \right) + \csc \theta \frac{\partial B}{\partial \varphi} = U \cos \theta$
- (c) $\frac{1}{r \sin \theta} \frac{\partial}{\partial \varphi} \left(A + r \frac{\partial A}{\partial r} \right) - \frac{\partial B}{\partial \theta} = U \cos \theta$
- (d) $\frac{1}{r \sin \theta} \frac{\partial}{\partial \varphi} \left(A + r \frac{\partial A}{\partial r} \right) - \frac{\partial B}{\partial \theta} = U \cos \theta \cos \varphi$

No, the answer is incorrect.

Score: 0

Accepted Answers:

(a) $\frac{1}{r} \frac{\partial}{\partial \theta} \left(A + r \frac{\partial A}{\partial r} \right) + \csc \theta \frac{\partial B}{\partial \varphi} = U \cos \theta \cos \varphi$

3) 2 points
If ψ is a biharmonic function and ψ_1 and ψ_2 are two harmonic functions, then ψ can be expressed as

-
- (a) $\psi = \psi_1 + \psi_2$
-
- (b) $\psi = \psi_1 + r\psi_2$
-
- (c) $\psi = \psi_1 + r^2\psi_2$
-
- (d) $\psi = \psi_1 + \frac{1}{r}\psi_2$

No, the answer is incorrect.

Score: 0

Accepted Answers:

(c) $\psi = \psi_1 + r^2\psi_2$

4)

Consider flow past an elliptic drop of major radius $a = 7$ cm and minor radius $b = 5$ cm with surface tension σ denoted by σ . Let the fluid outside and inside the elliptic drop incur a normal stress τ_{rr}^e and τ_{rr}^i respectively. If the viscosity ratio of inner fluid to the outer fluid of the elliptic drop is $\mu = 2$, then the normal stress jump at the boundary of the elliptic drop is given by

-
- (a) $\tau_{rr}^e - 2\tau_{rr}^i = \frac{1}{5}\sigma$
-
- (b) $\tau_{rr}^e - \tau_{rr}^i = \frac{1}{7}\sigma$
-
- (c) $\tau_{rr}^e - 2\tau_{rr}^i = \frac{2}{35}\sigma$
-
- (d) $\tau_{rr}^e - 2\tau_{rr}^i = \frac{12}{35}\sigma$

No, the answer is incorrect.

Score: 0

Accepted Answers:

(d) $\tau_{rr}^e - 2\tau_{rr}^i = \frac{12}{35}\sigma$

5)

Consider the steady state heat conduction equation inside a sphere (with azimuthal axis-symmetry).

Seek a solution of the form $T(r, \theta) = \sum_{n=0}^{\infty} \left(a_n r^n + \frac{b_n}{r^{n+1}} \right) P_n(\cos \theta)$.

If the far field temperature is given by $T(r, \theta) \sim T_{\infty} + T_{\infty} r^2 (3 \cos^2 \theta - 1)$, then

-
- (a) $a_0 = T_{\infty}, a_1 = T_{\infty}, a_2 = 2T_{\infty}, a_n = 0 \forall n \geq 3$
-
- (b) $a_0 = T_{\infty}, a_1 = 0, a_2 = 2T_{\infty}, a_n = 0 \forall n \geq 3$
-
- (c) $a_0 = 0, a_1 = T_{\infty}, a_2 = 2T_{\infty}, a_n = 0 \forall n \geq 3$
-
- (d) $a_0 = T_{\infty}, a_1 = 0, a_n = 0 \forall n \geq 2$

No, the answer is incorrect.

Score: 0

Accepted Answers:

(b) $a_0 = T_{\infty}, a_1 = 0, a_2 = 2T_{\infty}, a_n = 0 \forall n \geq 3$

6)

Consider the following function $\psi(t) = \begin{cases} t^2, & 0 \leq t < 5 \\ 0, & 5 \leq t < 10 \\ 6t, & 10 \leq t. \end{cases}$

If $\psi(t) = f_1(t)H(t-0) + f_2(t)H(t-5) + f_3(t)H(t-10)$, then

-
- (a) $f_1(t) = -t^2, f_2(t) = -t^2, f_3(t) = 6t$
-
- (b) $f_1(t) = t^2, f_2(t) = -t^2, f_3(t) = 6$
-
- (c) $f_1(t) = t^2, f_2(t) = -t^2, f_3(t) = 6t$
-
- (d) $f_1(t) = -t^2, f_2(t) = -t^2, f_3(t) = -6t$



2 points

2 points

2 points

No, the answer is incorrect.

Score: 0

Accepted Answers:

(c) $f_1(t) = t^2, f_2(t) = -t^2, f_3(t) = 6t$

7)

2 points

Consider a deformable spherical drop $r = (1 + \epsilon \cos \theta)$. On the boundary of the deformable spherical dro

if we have $-P_c + \left(\frac{1}{r^4} + \frac{1}{r^2}\right)U_c \cos \theta = \frac{2\lambda}{r}$, where λ is a constant,

then the equation of the deformable drop is

- (a) $r \sim \left(1 + \frac{U_c}{\lambda} \cos \theta\right)$
- (b) $r \sim \left(1 - U_c \lambda \cos \theta\right)$
- (c) $r \sim \left(1 + U_c \lambda \cos \theta\right)$
- (d) $\sim \left(1 - \frac{U_c}{\lambda} \cos \theta\right)$

No, the answer is incorrect.

Score: 0

Accepted Answers:

(d) $\sim \left(1 - \frac{U_c}{\lambda} \cos \theta\right)$

8) Let $g(x)$ be a function defined by $g(x) = 1 + x + x^2, x \in \mathbb{R}$.

2 points

Then the value of the integral $\int_{-\infty}^{\infty} g(x)\delta(x-2)$ is equal to

- (a) 7
- (b) 3
- (c) 1
- (d) 2

No, the answer is incorrect.

Score: 0

Accepted Answers:

(a) 7

9) The fundamental solution of the Laplace equation in 3D coordinate system is given by

2 points

- (a) $\frac{1}{4\pi r}$
- (b) $\frac{1}{2\pi} \ln r$
- (c) $\frac{r}{2\pi}$
- (d) $\frac{1}{2\pi} r \ln r$

No, the answer is incorrect.

Score: 0

Accepted Answers:

(a) $\frac{1}{4\pi r}$

10)

2 points

Consider the following functions **A** : $\lim_{\sigma \rightarrow 0} \frac{1}{\sigma\sqrt{2\pi}} e^{-t^2/2\sigma^2}$, **B** : $\lim_{\epsilon \rightarrow 0} \frac{1}{\pi} \frac{\epsilon}{t^2 + \epsilon^2}$,

C : $\lim_{\epsilon \rightarrow 0} b(x, \epsilon)$ where $b(x, \epsilon) = \begin{cases} 0, & |x| > \frac{\epsilon}{2} \\ \frac{1}{\epsilon}, & |x| < \frac{\epsilon}{2} \end{cases}$. Then which of the above represent Dirac delta distrib

- (a) Only **A** and **B** but not **C**

- (b) Only **A** and **C** but not **B**
- (c) Only **B** and **C** but not **A**
- (d) **A**, **B** and **C** all of them

No, the answer is incorrect.
Score: 0

Accepted Answers:
(d) A, B and C all of them



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