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# Unit 4 - Week 3



## 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 $\mathbf{V} = CurlCurl(rA) + Curl(rB)$, $P = P_0 + \mu \frac{\partial}{\partial r}(r\nabla^2 A)$, 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 $\mathbf{V} = CurlCurl(rA) + Curl(rB)$, $P = P_0 + \mu \frac{\partial}{\partial r}(r\nabla^2 A)$ represent the velocity vector and pressure field corresponding to the Stokes equatio

If, on the boundary of the sphere, we have $\mathbf{V}.\vec{e_\theta} = U\vec{i}.\vec{e_\theta}$,
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 $\psi$ is a biharmonic function and $\psi_1$ and $\psi_2$ are two harmonic functions, then $\psi$ 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) *2 points*

Consider flow past an elliptic drop of major radius $a = 7$ cm and minor radius b $= 5$ cm with surfac[e tension i]s denoted by $\sigma$. Let the fluid outside and inside the elliptic drop incur a normal stress $\tau_{\rm rr}^{\rm e}$ and $\tau_{\rm rr}^{\rm i}$ respectivel[y.] If the viscosity ratio of inner fluid to the outer fluid of the elliptic drop is $\mu = 2$, then the normal str[ess balance] 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) *2 points*

Consider the steady state heat conduction equation inside a sphere (with azimuthal axi-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 filed 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) *2 points*

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

**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 $\lambda$ 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 $\mathbf{A} : \lim_{\sigma\to 0}\frac{1}{\sigma\sqrt{2\pi}}e^{-t^2/2\sigma^2}$, $\mathbf{B} : \lim_{\epsilon\to 0}\frac{1}{\pi}\frac{\epsilon}{t^2+\epsilon^2}$,

$\mathbf{C} : \lim_{\epsilon\to 0} b(x,\epsilon)$ 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 distrit

**(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

Previous Page End