Week 5 Assessment

The due date for submitting this assignment has passed. Due on 2020-03-04, 23:59 IST.

As per our records you have not submitted this assignment.

1) For a pulse injection of mass $M$ into a fluid with diffusion coefficient $D$ in three dimensions, the concentration at a distance $r$ from the location of the injection after time $t$ is,

- $\frac{M}{2\sqrt{Dt}}\exp(-r^2/(4Dt))$
- $\frac{M}{\sqrt{2Dt}}\exp(-r^2/(4Dt))$
- $\frac{M}{2Dt}\exp(-r^2/(4Dt))$
- $\frac{M}{8(Dt)^{3/2}}\exp(-r^2/(4Dt))$

No, the answer is incorrect.

Score: 0

Accepted Answers:

- $\frac{M}{8(Dt)^{3/2}}\exp(-r^2/(4Dt))$

2) For Question 1, at a fixed distance $r$ from the location of injection, when the concentration is measured as a function of time, the concentration is...
Conservation equations.

Diffusive transport I.

Diffusive transport II.

Forced convection.

variables for transport in a finite domain.

(unti?unit=54&lesson=56)

Unidirectional transport:
Separation of variables for transport in a finite domain continued.
(unti?unit=54&lesson=57)

Unidirectional transport:
Separation of variables for transport in a finite domain continued.
(unti?unit=54&lesson=58)

Unidirectional transport:
Separation of variables for transport in a finite domain continued.
(unti?unit=54&lesson=59)

Unidirectional transport:
Balance laws in cylindrical coordinates.
Heat transfer across the wall of a pipe. (unti?unit=54&lesson=60)

Quiz : Week 5 Assessment (assessment?name=114)

1) The value of the maximum concentration in Question 1 is,

- proportional to \( (M/r) \)
- proportional to \( (M/r^2) \)
- proportional to \( (M/r^3) \)
- Not applicable

No, the answer is incorrect.
Score: 0
Accepted Answers:
proportional to \( (M/r) \)
proportional to \( (M/r^3) \)

2) Consider the solution for the transient heat conduction in a channel of height \( L \), where the fluid and the top and bottom walls are at initial temperature \( T_0 \), and the temperature of the bottom wall is instantaneously increased to \( T_1 \), as shown in figure 1. Here, the red line is the initial temperature profile, the blue line is the final temperature profile. For this configuration, we had derived the solution for the transient temperature profile as,

\[
T = T_0 + (T_1 - T_0) \left( 1 - \frac{z}{L} \right) - \sum_{n=1}^{\infty} \frac{2(T_1 - T_0)}{n\pi} \sin(n\pi z/L) \exp(-((n\pi/L)^2\alpha)t)
\]

where \( \alpha \) is the thermal diffusivity of the fluid. If we approximate the solution for the transient temperature field by neglecting all terms \( n \geq 3 \) in the solution and retaining only the \( n = 1 \) and \( n = 2 \), what is the maximum error in the temperature due to the neglect of the term \( n = 3 \) at time \( t \)?

\[
T = T_0, \; z = L
\]

At \( t = 0 \), \( T = T_0 \)

\[
T = T_1, \; z = 0
\]

Figure 1:
Forced & natural convection.

Natural convection.

Transport in turbulent flows.

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\[
\frac{2(T_1 - T_0)}{3\pi} \\
\frac{2(T_1 - T_0)}{3\pi} \exp(-9\pi^2 at/L^2) \\
\frac{2(T_1 - T_0)}{3\pi} \sin(3\pi z/L) \\
\frac{2(T_1 - T_0)}{3\pi} \sin(3\pi z/L) \exp(-9\pi^2 at/L^2)
\]

No, the answer is incorrect. Score: 0
Accepted Answers:
\[
\frac{2(T_1 - T_0)}{3\pi} \exp(-9\pi^2 at/L^2)
\]

5) At what time does the error due to the neglect of the term \( n = 3 \) in Question 4 equal 0.01 \((T_1 - T_0)\)?

\[
t = (0.0034 \frac{L^2}{\alpha})
\]

\[
t = (0.01 \frac{L^2}{\alpha})
\]

\[
t = (0.034 \frac{L^2}{\alpha})
\]

\[
t = (0.1 \frac{L^2}{\alpha})
\]

No, the answer is incorrect. Score: 0
Accepted Answers:
\[
t = (0.034 \frac{L^2}{\alpha})
\]

6) In Question 4, if \( k \) is the thermal conductivity of the fluid, what is the heat flux from the surface at \( z = 0 \)?

\[
\frac{k(T_1 - T_0)}{L}
\]

\[
\frac{k(T_1 - T_0)}{L} \left(1 + 2 \sum_n \sin(n\pi z/L)\right)
\]

\[
\frac{k(T_1 - T_0)}{L} \left(1 + 2 \sum_n \exp(-n\pi/L)^2 at\right)
\]

\[
\frac{k(T_1 - T_0)}{L} \left(1 + 2 \sum_n \exp(-n\pi/L)^2 at \sin(n\pi z/L)\right)
\]
No, the answer is incorrect.
Score: 0
Accepted Answers:
\[ \frac{k(T_1 - T_0)}{L} \left( 1 + 2 \sum_n \exp(-n\pi/L)^2 at) \right) \]

7) Consider a fluid of thermal diffusivity \( \alpha \) in a channel of height \( L \) along the \( z \) direction, unbounded in the \( x \) and \( y \) directions, bounded by two walls at \( z = 0 \) and \( z = L \), as shown in figure 2. The wall at \( z = 0 \) is insulating, so that the flux is zero at this wall. The wall at \( z = L \), as well as the fluid in the region \( 0 < z < L \) are initially at temperature \( T_0 \). At \( t = 0 \), the temperature of the fluid at \( z = L \) is instantaneously increased to \( T_1 \). Use the separation of variables procedure to determine the temperature in the fluid. What is the temperature in the channel for \( t \to \infty \), which satisfies the heat conduction equation at steady state, and the boundary conditions?

\[ T = T_1 \quad z=L \]

At \( t=0 \), \( T = T_0 \)

Zero flux \( z=0 \)

Figure 2:

\[ T = T_0 + (T_1 - T_0)(z/L) \]
\[ T = T_0 + (T_1 - T_0)((L - z)/L) \]
\[ T = T_0 \]
\[ T = T_1 \]

No, the answer is incorrect.
Score: 0
Accepted Answers:
\[ T = T_1 \]

8) Which of the following is the correct schematic for the evolution of the temperature with time in \( 1 \) point Question 7? The red line shows the initial temperature, the blue line shows the final temperature, and the dashed arrow shows the direction of the change in the profile as time increases.
9) If the difference between the instantaneous temperature and the steady state temperature in Question 7 is expressed as,

\[ T(t) - T_s = \sum_{n=0}^{\infty} A_n \Phi_n(z, t) \]

where \( n \) is an integer, what is the correct set of basis functions \( \Phi_n \)?

- \( \sin(n\pi z/L) \exp(-(n\pi/L)^2 a t) \)
- \( \cos(n\pi z/L) \exp(-(n\pi/L)^2 a t) \)
- \( \sin((n + (1/2))\pi z/L) \exp(-((n + (1/2))\pi/L)^2 a t) \)
- \( \cos((n + (1/2))\pi z/L) \exp(-((n + (1/2))\pi/L)^2 a t) \)

No, the answer is incorrect.
Score: 0
10) In the solution
\[ T(t) - T_s = \sum_{n=0}^{\infty} A_n \Phi_n(z, t) \]

in Question 9, what is the value of \( A_n \)?

- \( \frac{2}{n\pi} (T_1 - T_0) \)
- \( \frac{2}{(n + 1/2)\pi} (T_1 - T_0) \)
- \( \frac{2(-1)^n}{n\pi} (T_1 - T_0) \)
- \( \frac{2(-1)^n}{(n + 1/2)\pi} (T_1 - T_0) \)

No, the answer is incorrect.
Score: 0

Accepted Answers:
\( \frac{2(-1)^n}{(n + 1/2)\pi} (T_1 - T_0) \)