1) Numerical methods are preferred over analytical methods because

Statement 1: Partial differential equations are not always linear and cannot be accurately linearized.
Statement 2: The computational domain can have complex geometry and material parameters.
Statement 3: Boundary conditions required can be time-dependent or mixed.
Statement 4: Results obtained using numerical methods are always more accurate than the analytical methods.

- Only statement 1 is correct, but not others.
- Only statement 2 is correct, but not others.
- Only statement 3 is correct, but not others.
- Only statement 4 is correct, but not others.
- Statements 2, 3 and 4 are correct, but not 1.
- Statements 1, 3 and 4 are correct, but not 2.
- Statements 1, 2 and 3 are correct, but not 4.
- Statements 1 and 2 are correct, but not 3 and 4.
- Statements 2 and 3 are correct, but not 1 and 4.
- Statements 3 and 4 are correct, but not 1 and 2.
- Statements 1 and 3 are correct, but not 2 and 4.

Accepted Answers:

Statements 1, 2 and 3 are correct, but not 4.

2) The difference schemes for \( \frac{\partial f(x)}{\partial x} \bigg|_{x=x_o} \) are

Statement 1: \( FD = \frac{f(x_o) - f(x_o - \Delta x)}{\Delta x} \) and \( BD = \frac{f(x_o + \Delta x) - f(x_o)}{\Delta x} \)

Statement 2: \( CD = \frac{f(x_o + \Delta x) - f(x_o - \Delta x)}{2\Delta x} \) and \( FD = \frac{f(x_o + \Delta x) - f(x_o)}{\Delta x} \)

Statement 3: \( BD = \frac{f(x_o) - f(x_o + \Delta x)}{\Delta x} \) and \( CD = \frac{f(x_o + \Delta x) - f(x_o - \Delta x)}{2\Delta x} \)

Statement 4: \( CD = \frac{f(x_o + \Delta x) - f(x_o)}{\Delta x} \) and \( FD = \frac{f(x_o + \Delta x) + f(x_o)}{2\Delta x} \) and \( BD = \frac{f(x_o) - f(x_o + \Delta x)}{\Delta x} \)

- Only statement 1 is correct, but not others.
- Only statement 2 is correct, but not others.
Only statement 3 is correct, but not others.
Only statement 4 is correct, but not others.
Statements 1 and 2 are correct, but not others.
Statements 1 and 3 are correct, but not others.
Statements 1 and 4 are correct, but not others.
Statements 2 and 3 are correct, but not others.
Statements 2 and 4 are correct, but not others.
Statements 3 and 4 are correct, but not others.

**Accepted Answers:**

Only statement 2 is correct, but not others.

3) For a differencing scheme to be stable

- The numerical domain of influence and physical domain of influence should be equal.
- The physical domain of influence should contain the numerical domain of influence.
- The numerical domain of influence should contain the physical domain of influence.
- It depends upon the type of numerical problem.

**Accepted Answers:**

The numerical domain of influence should contain the physical domain of influence.

4) Which of the following correctly represents 2nd order $\Phi_{xx}$ forward difference scheme, where $O(n)$ is order of truncation?

$$\frac{\Phi_{i+2} - 2\Phi_{i+1} + \Phi_i}{2(\Delta x)} ; O(\Delta x)^2$$

- $\frac{\Phi_{i+1} - 2\Phi_i + \Phi_{i-1}}{(\Delta x)^2} ; O(\Delta x)^3$
- $\frac{\Phi_{i+2} - 2\Phi_{i+1} + \Phi_i}{(\Delta x)^2} ; O(\Delta x)^2$
- $\frac{\Phi_{i+1} - 2\Phi_i + \Phi_{i-1}}{(\Delta x)^2} ; O(\Delta x)^2$

**Accepted Answers:**

$$\frac{\Phi_{i+2} - 2\Phi_{i+1} + \Phi_i}{(\Delta x)^2} ; O(\Delta x)^2$$

5) Which of the following correctly represents 2nd order $(\Phi_{xx})$ backward difference scheme, where $O(n)$ is order of truncation?

$$\frac{\Phi_{i-2} - 2\Phi_{i-1} + \Phi_i}{\Delta x} ; O(\Delta x)^2$$

- $\frac{\Phi_{i-2} - 2\Phi_{i-1} + \Phi_i}{(\Delta x)^2} ; O(\Delta x)^2$
- $\frac{\Phi_{i-2} - 2\Phi_{i-1} + \Phi_i}{\Delta x} ; O(\Delta x)^4$
- $\frac{\Phi_{i-2} - 2\Phi_{i-1} + \Phi_i}{(\Delta x)^2} ; O(\Delta x)^4$

**Accepted Answers:**

$$\frac{\Phi_{i-2} - 2\Phi_{i-1} + \Phi_i}{\Delta x} ; O(\Delta x)^2$$
6) Which of the following correctly represents 2nd order central difference scheme, where \( O(n) \) is order of truncation?  

- \( \frac{\Phi_{i+1} - 2\Phi_i + \Phi_{i-1}}{(\Delta x)^2} ; O(\Delta x)^2 \)
- \( \frac{\Phi_{i+1} - 2\Phi_i + \Phi_{i-1}}{(\Delta x)^2} ; O(\Delta x)^2 \)
- \( \frac{\Phi_{i+1} - 2\Phi_i + \Phi_{i-1}}{(\Delta x)^2} ; O(\Delta x)^2 \)
- \( \frac{\Phi_{i+1} - 2\Phi_i + \Phi_{i-1}}{(\Delta x)^2} ; O(\Delta x)^2 \)

7) The finite difference representation of a 1D wave equation \( \frac{k^2}{\Delta x^2} \left( \frac{\partial^2 u}{\partial t^2} \right) = \frac{\partial^2 u}{\partial x^2} \) is given by  

- \( u(i+1, j+1) = \left( \frac{k\Delta t}{\Delta x} \right)^2 \left[ u(i+1, j) - 2u(i, j) + u(i-1, j) \right] + 2u(i, j) - u(i, j-1) \)
- \( u(i, j+1) = \left( \frac{k\Delta t}{\Delta x} \right)^2 \left[ u(i+1, j) - 2u(i, j) + u(i-1, j) \right] + 2u(i, j) - u(i, j-1) \)
- \( u(i+1, j+1) = \left( \frac{k\Delta t}{\Delta x} \right)^2 \left[ u(i+1, j) - 2u(i, j) + u(i-1, j) \right] + 2u(i, j) - u(i, j-1) \)
- \( u(i, j+1) = \left( \frac{k\Delta t}{\Delta x} \right)^2 \left[ u(i+1, j+1) - 2u(i, j+1) + u(i-1, j) \right] + 2u(i, j) - u(i, j-1) \)

8) The Laplace equation in two dimensions is an example of  

- Elliptic partial differential equation.
- Hyperbolic partial differential equation.
- Parabolic partial differential equation.
- All of the above.

9) \( \frac{\partial u}{\partial n} \bigg|_{r_2} = g \) is an example of  

- Dirichlet boundary condition.
- Neumann boundary condition.
- Mixed boundary condition.
- None of the above.
Accepted Answers:
Neumann boundary condition.

10) For an explicitly solved 1D wave equation, the aspect ratio is given as

\[
\left( \frac{k \Delta x}{\Delta t} \right)^2 \quad \text{and should be less than 1.}
\]

\[
\left( \frac{k \Delta x}{\Delta t} \right)^2 \quad \text{and should be less than 1.}
\]

\[
\left( \frac{k \Delta x}{\Delta t} \right)^2 \quad \text{and should be less than or equal to 1.}
\]

\[
\left( \frac{k \Delta x}{\Delta t} \right)^2 \quad \text{and should be less than or equal to 1.}
\]

Accepted Answers:
\[
\left( \frac{k \Delta x}{\Delta t} \right)^2 \quad \text{and should be less than or equal to 1.}
\]

11) Statement 1: For an explicit finite difference method, the values at present time-step are calculated using values from previous time-steps.
Statement 2: For an implicit finite difference method, the values at present time-step are calculated using values from future time-steps.
Statement 3: For an explicit finite difference method, the values at present time-step are calculated using values from future time-steps.
Statement 4: For an implicit finite difference method, the values at present time-step are calculated using values from previous time-steps.
Statement 5: Formulating a solution by an implicit method requires the solution of a set of simultaneous equations.
Statement 6: Formulating a solution by an explicit method requires the solution of a set of simultaneous equations.

- Statements 1 and 2 are correct, but not others.
- Statements 3 and 4 are correct, but not others.
- Statements 1 and 5 are correct, but not others.
- Statements 1 and 6 are correct, but not others.
- Statements 2 and 5 are correct, but not others.
- Statements 2 and 6 are correct, but not others.
- Statements 1 and 2 and 5 are correct, but not others.
- Statements 3 and 4 and 5 are correct, but not others.
- Statements 1 and 2 or 6 are correct, but not others.
- Statements 3 and 4 or 6 are correct, but not others.

Accepted Answers:
Statements 1 and 2 and 5 are correct, but not others.

12) Which of the following statement(s) is/are correct for the computational scheme stencil?
Figure (a) represents explicit method for aspect ratio < 1; figure (b) represents explicit method for aspect ratio = 1.

Figure (a) represents implicit method for aspect ratio < 1; figure (b) represents implicit method for aspect ratio = 1.

Figure (a) represents explicit method for aspect ratio = 1; figure (b) represents explicit method for aspect ratio < 1.

Figure (a) represents implicit method for aspect ratio = 1; figure (b) represents implicit method for aspect ratio < 1.

**Accepted Answers:**

*Figure (a) represents explicit method for aspect ratio < 1; figure (b) represents explicit method for aspect ratio = 1.*