Uva Wellassa University

Uva Wellassa University, Sri Lanka

End Semester Examination – September/October 2012

MRT 452-3 Solute Transport Modelling Methods

Duration: Three (03) hours

Total five (05) questions
Answer **all** questions

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01. i. Define the *groundwater potential* at a given point in an aquifer. [2.5 marks]

ii. Derive a mathematical expression for the *hydraulic head (h)* in terms of the total mechanical energy of a unit volume of flowing groundwater. [7.5 marks]

iii. With a simple illustration show that the hydraulic head is constant throughout a groundwater column under static conditions. [7.5 marks]

iv. State Darcy's law defining all terms used. [2.5 marks]

02. i. Describe the two types of groundwater models commonly used. [2.5 marks]

ii. Explain why groundwater models are used in hydrogeological studies. [05 marks]

iii. Discuss three different applications of groundwater models emphasizing their benefits and drawbacks critically. [7.5 marks]

iv. Illustrate the *finite difference* and *finite element* discretizations of a selected groundwater problem domain. [05 marks]

03. i. Illustrate the concept of *representative elemental volume* (REV) as applied in groundwater modelling. [2.5 marks]

ii. Under steady-state conditions there is no net change between the volume of groundwater entering the REV and the volume that leaves it. If the volume flow rates along x, y and z directions of the REV are q_x, q_y and q_z, respectively, derive the continuity equation for steady-state conditions. [10 marks]

iii. Express the continuity equation under steady-state conditions for a homogeneous, isotropic medium in terms of hydraulic head (h). [05 marks]

iv. What are the possible boundary conditions in above (iii)? [2.5 marks]

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04. i. The hydraulic heads at nodes of a regularly-spaced 2-D square finite difference grid are denoted by $h_{(i,j)}$, $h_{(i+1,j)}$, $h_{(i-1,j)}$, $h_{(i,j+1)}$, $h_{(i,j-1)}$ etc. where (i,j) is the position of any node in a Cartesian coordinate system. Formulate the finite difference scheme for the continuity equation in above Question 03 (iii) for a 2-D case using central approximation approach.

[15 marks]

ii. With a suitable example justify the need of *numerical methods* to solve for hydraulic head distribution when the number of unknown head values increases.

[05 marks]

05. i. Briefly describe the mechanisms of advection, diffusion and dispersion in solute transport. [05 marks]

ii. Write down the governing equation of solute transport in a 3-D transient groundwater system and discuss its components. [05 marks]

iii What do you mean by retardation factor? How is it incorporated into solute transport equation shown under section (ii) when sorption of solutes is present? Explain how biochemical and geochemical reactions are incorporated into the governing equation of above (ii) with sorption and first-order reactions.

[05 marks]

iv. For 1-D case the advective transport of a solute concentration is given by $\frac{\partial}{\partial x}(q_x C)$ where q_x is the volume flow rate in x direction corrected for effective porosity and C is the solute concentration. Formulate the finite difference approximation using cell interface concentrations.

[05 marks]