TECHNICAL UNIVERSITY OF MOMBASA

FACULTY OF APPLIED AND HEALTH SCIENCES

DEPARTMENT OF MATHEMATICS & PHYSICS

UNIVERSITY EXAMINATION FOR:

BACHELOR OF SCIENCE IN MATHEMATICS AND COMPUTER SCIENCE

AMA 4416: COMPUTATIONAL FLUID DYNAMICS

SPECIAL/ SUPPLIMENTARY EXAMINATIONS

SERIES: SEPTEMBER 2018

TIME: 2 HOURS

DATE: SEPTEMBER 2018

Instructions to Candidates

You should have the following for this examination

-Answer Booklet, examination pass and student ID

This paper consists of FIVE questions. Attempt QUESTION ONE and any other TWO questions.

Do not write on the question paper.

QUESTION ONE Compulsory (30 marks)

(a). Define the following terms : (i) Newtonian fluid (ii) Convergence

(iii) Solution error (iv) consistency (4 marks)

(b) (i) How does CFD work? (3 marks)

(ii) Explain in brief the stepwise procedure to solve a fluid flow problem using CFD solvers

. (6 marks)

(iii) List the common boundary conditions applied to the flow field. (2 marks)

(c). (i). What is discretization? (2 marks)

(ii). Compare the different discretization techniques, explaining in detail the Finite Volume Method

(8 marks)

(d). Explain without mathematical detail how pressure-correction methods may be used to solve the

coupled equations of of incompressible fluid flow. (5 marks)

QUESTION TWO (20 MARKS)

(a). Define a non-conformal mesh outlining its usefulness (3 marks)

(b). (i). Identify the six types of meshes used in CFD. (6 marks)

(ii). What is the advantage of using quadrilateral/hexahedron mesh for simple geometry? (2 marks)

(c). Derive the momentum equation used in CFD. (9 marks)

QUESTION THREE (20 MARKS)

(a) State the advantages and disadvantages of using Forward differencing method in CFD (3 marks)
(b) Use (i) Forward differencing (5 marks)
(ii) Backward differencing to solve the equation (6 marks)

$\frac{d\phi}{dt} = t^2 - 2\phi, \quad \phi(0) = 0$ numerically over the interval $0 \le t \le 1$ using a time step $\Delta t = 0.25$

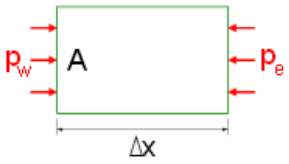
(c) List down six general desirable properties for a numerical scheme (6 marks)

QUESTION FOUR (20 MARKS)

(a).(i). How are velocity and pressure linked? (2 marks)

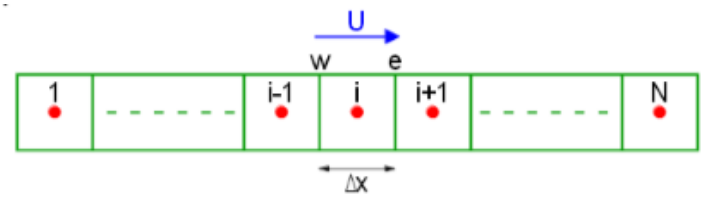
(ii). Describe the SIMPLE pressure correction method for the solution of coupled mass and momentum equations (6 marks)

(b). For the rectangular control volume with surface pressures shown, what is



(i). The net force in the X direction? (1 mark)
(ii). The net force in the X direction per unit volume? (2 marks)
(iii). The average pressure gradient in the X direction (2 marks)

(c). The steady –state advection and diffusion of a scalar with concentration ϕ along a 1-d pipe may be described by the equation $\frac{d}{dx}\left(\rho u\phi - \Gamma\frac{d\phi}{dx}\right) = s$ where ρ is density, u is velocity, Γ is diffusivity and s is source density. This is to be solved numerically by a finite –volume method on the uniform mesh of N cells shown below



i). By integrating the above equation over a one-dimensional cell centered on node i, write the 1-d advection-diffusion equation in finite –volume form. (3 marks)

ii) Write down numerical approximations for ϕ and $\frac{d\phi}{dx}$ on the east and west faces of internal cell i, using upwind differencing for advection and centered differencing for diffusion. Assume the flow is from left to right. (4 marks)

QUESTION FIVE (20 MARKS)

(a) .i) Explain the experiment done by Osborne Reynolds. (3 marks)

ii) Give the definition and meaning of the Reynolds number (3 marks)

(iii). What are its advantage s and disadvantages (3 marks)

(b) CFD gives an insight into flow patterns that are difficult to study using experimental techniques.

Compare and contrast experiments versus CFD simulations (8 marks)

(c). Why are the results of CFD simulations never 100% reliable? (3 marks)