Menoufia University
Faculty of Engineering, Shebin El-Kom
Mechanical Power Engineering Department
Second Semester Examination, 2013-2014
Date of Exam: 14/6/2014

Minufiya University

Subject: Numerical Methods in Mechanical Power Engineering
Code: MPE 322
Year: Third Year
Time Allowed: 3 hours
Total Marks: 90 marks

Remarks: No. of pages: 2 No. of questions: 6
Allowed Tables and Charts: *None*

Answer ALL the Following Questions (Assume any missing data)

(Question 1) :(16 Marks)

1-a) (5 marks)
Explain using a diagram what is meant by accuracy and precision

1-b) (5 marks)
Choose the correct answer (in each case, there might be more than one correct answer):

i. $\frac{d^2y}{dx^2} - 2\frac{dy}{dx} + y = xe^{-x} - x$ y(0)=0, y(20) = 0
(1. ODE 2. PDE 3. IVP 4. BVP)

ii. $\frac{d^2u}{dx^2} + 2xy\frac{d^2u}{dy^2} + u = 1$
(1. Linear 2. Non-linear 3. Elliptic 4. Parabolic 5. Hyperbolic)

iii. $4\frac{\partial^2 u}{\partial x^2} + y^2\frac{\partial u}{\partial x} + x\frac{\partial u}{\partial x} + \frac{\partial^2 u}{\partial y^2} + 4\frac{\partial^2 u}{\partial x\partial y} - 4xy = 0$
(1. Elliptic 2. Parabolic 3. Hyperbolic)

1-c) (6 marks)
Derive a finite difference expression to discretize the equation $\frac{\partial u}{\partial t} = -a\frac{\partial u}{\partial x}$ $a > 0$ using a forward time central space Crank Nicolson with averaging algorithm.

(Question 2) :(12 Marks)

An investigator has reported the data tabulated below. It is known that such data can be modeled by the following equation $x = e^{(y-b)/a}$ where a and b are parameters. Use a transformation to linearize this equation and then employ linear regression to determine a and b.
Based on your analysis predict y at x = 2.6.

x	1	2	3	4	5
y	0.5	2	2.9	3.5	4

(Question 3) :(12 Marks)

Use Heun's method to integrate $y = 5e^{0.6x} - 0.8y$ and find the value of y(3) with a step size of 1. The initial condition at x=0 is y=2. The maximum allowable absolute tolerance is 0.253.

(Question 4) :(14 Marks)

Find the value of y at t=1.2 for $t^2y'' - 2ty' + 2y = t^3 \ln t$ using the fourth order Runge-Kutta method when y(1)=1 & $y'(1)$=0. Take h=0.2

(Question 5) :(18 Marks)

Use the DuFort-Frankel's explicit method to solve $\frac{\partial T}{\partial t} = \alpha \frac{\partial^2 T}{\partial x^2}$ for the temperature distribution, after 3 time intervals, of a long, thin rod with a length of 10 cm and the following values: k= 0.49 cal/(s.cm.C), Δx = 2 cm, and Δt = 0.1 s. At t = 0, the temperature of the rod is zero and the boundary conditions are fixed for all times at $T(0)$ = 100 C and $T(10)$ = 50 C. Note that the rod is aluminum with C = 0.2174 cal/(g.C) and ρ = 2.7 g/cm^3.

(Question 6) :(18 Marks)

The non-dimensional transient heat conduction in an insulated rod can be written as

$$\frac{\partial u}{\partial \bar{t}} = \frac{\partial^2 u}{\partial \bar{x}^2}$$

Where: $\bar{x} = \frac{x}{L}$, $\bar{t} = \frac{t}{(\frac{\rho C L^2}{k})}$, $u = \frac{T - T_0}{T_L - T_0}$

where L = the rod length, k = thermal conductivity of the rod material, ρ = density, C = specific heat, T_o = temperature at x = 0, and T_L = temperature at $x = L$.

With the following boundary and initial conditions:

$u(0,\bar{t}) = 0$ & $u(1,\bar{t}) = 1$, $u(\bar{x}, 0) = 0$ for $0 \le \bar{x} \le 1$

Solve this non-dimensional equation for the temperature distribution using finite-difference methods and a second-order accurate implicit Crank-Nicolson formulation to integrate in time. Show not less than two time steps.

This exam measures the following ILOs

Question Number	Q1-a	Q1-b	Q1-c	Q1-a	Q1-b	Q1-c	Q2, Q3, Q4	Q5	Q5	Q6	
Skills	a2-2	a2-2	a2-2	b11-2	b2-3	b2-1	b11-1	b2-1	C6-1	C6-1 C15-1	
	Knowledge &Understanding Skills			Intellectual Skills					Professional Skills		