69

UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

MAIN EXAMINATION 2005

TITLE OF THE PAPER: COMPUTATIONAL PHYSICS-I

COURSE NUMBER : P262

TIME ALLOWED : THREE HOURS

INSTRUCTIONS:

ANSWER ANY **FOUR** OUT OF **FIVE** QUESTIONS.

EACH QUESTION CARRIES **25** MARKS.
MARKS FOR DIFFERENT SECTIONS ARE SHOWN IN THE RIGHT-HAND MARGIN.

THIS PAPER HAS **FOUR** PAGES, INCLUDING THIS PAGE.

DO NOT OPEN THE PAPER UNTIL THE INVIGILATOR HAS GIVEN PERMISSION.

Q1.

(A) Answer the following: [5]

(i) What is the difference between a bit and a byte?

(ii) What is the difference between the representation of integer and floating point?

(iii) What is the difference between RAM and Hard Disk Memory?

(iv) What is the difference between algorithm and a pseudocode ?

(v) Do you need computer word in storing a character data?

(B) Assume that a computer word is made of 48 bits for single precision .

(i) What will be the limits on integer numbers? [1]

(ii) With one byte for exponentiation, estimate the precision of fractional part and the upper and lower limit on exponentiation. [3]

(iii) How many bits are required for double precision? [1]

(C) Consider a data file 'dat1.txt' which has following data.

```
1.5  4.4
3.5  6.9
4.8  8.1
```

Write Maple statements which will

(i) Read this file, [2]

(ii) Convert the data into a matrix [3]

(D) Write a program to generate 10 data pairs *(x_i, y_i)* using [5]

$$y_i = 0.1 + x_i \exp(-0.1x_i) + \sin(\pi x_i / 180.0)$$

for $x_{i+1} = x_i + \Delta x$ where $\Delta x = 0.01$

(E) Bonnet recursion formula for Legendre Polynomial is given by [5]

$$(n+1)P_{n+1}(x) = (2n+1)xP_n(x) - nP_{n-1}(x) \qquad \text{for } n = 1,2,3.....$$

Given that $P_0(x)=1$, $P_1(x)=x$, write a pseudo-code to calculate $P_m(x)$ for any $m \geq 2$.

Q.2:

(A) If the launching velocity *V* of a satellite from the surface of the earth is less than V_e where V_e is the escape velocity, the maximum height *h* that can be obtained for vertical launch is given by

$$h = \frac{2R^2 g}{2Rg - V^2}$$

where *R* is the radius of the earth. $R = 6.2712 \times 10^6$ *m* and $g = 9.8\ m\ s^{-2}$.

Write Maple commands to

(a) calculate velocity *V* for h from *200km* to *300km* in steps of *10km*. [10]

(b) plot *V* vs *h* . [5]

(B) Gravitational force *F* between two bodies of masses (in units of kg)

m_1 and m_2 and assumed as point masses is given by the formula

$$F = \frac{Gm_1m_2}{r^2}$$

Where G = 6.672 E-11 Nm^2kg^{-2} and
r = distances between bodies(assumed as point masses) in meters.

The kinetic energy given to a body under constant acceleration due to some external force $F(r)$ is given by the integral

$$KE = \int_a^b F(r)dr$$

where a is the initial and b is the final distance of the body respectively.

Write a program with Maple commands to calculate kinetic energy gained by a falling body of mass *m=5kg* on to surface of earth from a height of *1000m to 100m (from the surface of the earth) in the interval of 100m .* [10]

Given: Radius of the earth = 6.2712E+6 m
Mass of earth = 5.976E+24 kg.

Q.3. For a certain material the equation for the electrical resistance *R(T)* as a function of temperature *T (in units C)* is given by

$$R(T) = R_0(1 + 0.001T - 0.0005\,T^2)$$

where R_0 = 10 Ω at $T=0^0$ C.

Write a program
(i) to calculate a value of R(T) for $0 \leq T < 100^0C$ for 20 different values of T at equal intervals. [13]
(ii) using the above data points, write Maple commands to calculate [12]

$$\sum_{i=1}^{20} T_i,\ \sum_{i=1}^{20} R_i,\ \sum_{i=1}^{20} T_i^2,\ \sum_{i=1}^{20} R_i^2,\ \sum_{i=1}^{20} T_iR_i$$

$$\sum_{i=1}^{20} (T_i^2 - T_iR_i)$$

Q.4. Simple pendulum does not swing forever. They loose energy as a result of friction at the pivot and in the medium in which they move. Assuming that the damping is due to friction in the medium only, the acceleration $\frac{dv}{dt}$ of the vibrating mass at any time is given by the equation

$$\frac{d^2v}{dt^2} = -\frac{g}{L}v - \alpha\frac{dv}{dt}$$

where v= velocity.
Here α = damping constant =8.0 s^{-1}.
L = length of the pendulum = *1 m*.
g = acceleration due to gravity = $9.81\ ms^{-2}$.

Given the initial condition at $t = 0$, $v = v_0=1$ and $\frac{dv}{dt} = 0$, determine the velocity v as a function of time in the interval $0 \le t \le 1\ s$ with Maple commands for solving differential equation

(i) To find exact solution, and by default numeric method available. [20]

(ii) Plot both solutions on one graph. [5]

Q.5. A projectile of mass M = 0.5kg is shot at an angle θ above the horizontal. Consider the motion to be planar. The projectile is subjected to a drag force of magnitude F_d . The differential equation for the velocity V is given as

$$M\frac{dV_y}{dt} = -Mg - F_d \sin\vartheta$$

$$M\frac{dV_x}{dt} = -F_d \cos\vartheta$$

with initial conditions at time $t = 0$, $V_x(0) = 100\ ms^{-1}$ and $V_y(0) = 121\ ms^{-1}$. Assume that $F_d = k v^2$.

Here $g = 9.8\ ms^{-2}$,
k = co-efficient for air resistance = 0.002 kgm^{-1} and
$V^2 = V_x^2 + V_y^2$.

(i) Write a pseudo code to solve these equations by Euler method to a required convergence criteria. Assume the later to be 0.01. Consider time interval $(0,10s)$. [20]
Note: The angle θ is to be determined from initial values of V_x and V_y .

(iii) Plot the solution $V(t)$ vs t . [5]

Note: Euler method:

The solution to the equation of the form $\frac{dy}{dx} = f(x,y)$ *with initial boundary condition* $y(x_0) = \alpha$ *is given by*

$$y_{i+1} = y_i + hf(x_i, y_i)$$

where $h = x_{i+1} - x_i$

@@@@END OF EXAMINATION@@@@