Name:

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UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
Online End Semester Examination, November-December 2021

Course: Computational Physics **Semester: III**
Program: B. Sc. (H) : Physics

Time 03 hrs.
Course Code: PHYS 2014K **Max. Marks: 100**

SECTION A

1. **Each Question will carry 4 Marks**
2. **Instruction: Complete the statement / Select the correct answer(s)/Write short answers**

S. No.	**Question**	**CO**
Q1	Explain the importance of "Modules" in FORTRAN 90. Explain this by writing a program to calculate arithmetic and geometric mean. You should display the use of modules in this.	**CO1**
Q2	GNUPLOT has inbuilt facility to perform analysis of the data using regression. Considering that you have following data (stored in filename "data-Cp.txt"): # Temperature (T, Kelvin) Heat Capacity (Cp, kJ/kg-K) 100 1.01 200 1.10 300 1.15 400 1.25 500 1.40 Using the data, write a GNUPLOT script which performs linear regression to fit the equation of a line $C_p = mT + C$ and find various coefficients; m and C are the slope and intercept, respectively.	**CO3**
Q3	Discuss following commands used in LaTeX: a) \ldots b) \ddots c) \vdots d) \cdots e) \emph	**CO1**
Q4	What are various curve smoothing/interpolation schemes present in GNUPLOT. Discuss each scheme briefly.	**CO3**
Q5	Write following equations in LaTeX: a) $y = x\tan(\cos x) + \log(\sin x) + 5$ b) $\phi = e^{i\theta} + m\cosh x + \log(\tan\gamma)$	**CO1**

SECTION B

1. **Each question will carry 10 marks**
2. **Instruction: Write short / brief notes**

Q6	Write a GNUPLOT script to plot the following data and produce an image output in .png format. Label the axes and give title to the plot as "Year-wise comparison of Stock Prices". The name of the data file is "stock.txt".	**CO3**

	Year **Stock-1 Price** **Stock-2 Price** 1975 49 162 1976 52 144 1977 67 140 1978 53 122 1979 67 125 1980 46 117 1981 60 116 1982 50 113 1983 66 96 1984 70 101 1985 91 93 1986 133 92 1987 127 95 1988 136 79 1989 154 78 1990 127 85	
Q7	Write in brief the facility of "multiple axes" plot. Plot the data given in file "TwoAxis.txt" using multiple axes facility of GNUPLOT: **Year** **Number of Petrol Cars Sold (× 1000)** **Number of Diesel Cars Sold (×1000)** 1990 500 690 1991 700 860 1992 900 980 1994 860 700 1999 800 780	**CO3**
Q8	Find the dominant term(s) having the steepest increase in n in the following expressions showing the processing time spent by an algorithm: a) $T(n) = 500n + 100n^{1.5} + 50n \log_{10} n$ b) $T(n) = n^2 \log_2 n + n(\log_2 n)^2$ c) $T(n) = 100n + 0.01n^2$ d) $T(n) = 2n + n^{0.5} + 0.5n^{1.25}$ e) $T(n) = 100n \log_3 n + n^3 + 100n$	**CO1**
Q9	Write the following text using LaTeX: The reaction of defects with the surface leads to changes in the concentration of A and B atoms at the boundary, simultaneously with surface motion. When a vacancy reacts with the surface, the loss of an atom from the surface is compensated by moving the surface inward. This process also increases the concentration of that particular atom at boundary node. Similarly, the reaction of a dumbbell deposits an atom at the surface. The gain of an atom at the surface results in moving the surface outward. At the same time, the boundary node gains an atom from the loss of the dumbbell interstitial. With these considerations, we may write the reaction rates of A and B atoms as follows: $\psi_A = -[\psi_{AA} + \psi_{AB}(\mathrm{B}^{\rightarrow}) + \psi_v(\mathrm{A})]$ $\psi_B = -[\psi_{BB} + \psi_{AB}(\mathrm{A}^{\rightarrow}) + \psi_v(\mathrm{B})]$ The surface normal velocity is obtained from the mass balance across the surface, which is written in the form $\vec{v} \cdot \vec{n}(C^+ - C^-) = (J^+ - J^-) \cdot \vec{n}$	**CO1**

	Make sure that the equations have numbering, and they should be referred in the text body.	

Section C

1. **Each Question carries 20 Marks.**
2. **Instruction: Write long answer.**

Q10

a) Differentiate between a function and a subroutine in FORTRAN 90. The increase in temperature dT of a chemical reaction can be calculated using

$$dT = 1 - \exp(-kT)$$

$$k = \exp(-q)$$

$$q = \frac{2000}{T + 273.16}$$

where T is the temperature in centigrade, and t is the time in seconds. Write a program in FORTRAN 90, which prints the temperature of such a reaction at 1 minute intervals. The initial temperature is supplied by the user and the above equation should be re-calculated once every second. The program should terminate when the temperature reaches twice the initial temperature. Your program should be modular, and use only subroutines for making the program modular.

b) During a test flight of an open-rotor aircraft, the test pilot has set the engine power level at 40,000 Newtons, which causes the 20,000-kg aircraft to attain a cruise speed of 180 m/s (meters/second). The engine throttles are then set to a power level of 60,000 Newtons, and the aircraft begins to accelerate. As the speed of the plane increases, the aerodynamic drag increases in proportion to the square of the airspeed. Eventually, the aircraft reaches a new cruise speed where the thrust from the engines is just offset by the drag. The equations used to estimate the velocity and acceleration of the aircraft from the time that the throttle is reset until the plane reaches its new cruise speed (at approximately 120 s) are as follows:

$$v = 0.00001t^3 - 0.00488t^2 + 0.75795t + 181.3566$$

$$a = 3 - 0.000062v^2$$

Write a program in FORTRAN 90 which asks the user to enter a time value that represents the time elapsed (in seconds) since the power level was increased. Compute and print the corresponding acceleration and velocity of the aircraft at the new time values. You should write a function for the velocity (v) and a subroutine for calculating the acceleration (a).

(**10+10**)

CO2

Q11

a) The cost of sending a package by an express delivery service is 50 Rs for the first 2 kg, and 20 Rs for each kg or fraction thereof over 2 kg. If the package weighs more than 70 kg, a 100 Rs excess weight surcharge is added to the cost. No package over 100 kg will be accepted. Write a program in FORTRAN 77 that accepts the weight of a package in grams and computes the cost of mailing the package. Be sure to handle the case of overweight packages. The program should be modular.

b) Write a program in FORTRAN 77 that computes the tax and tip on a restaurant bill for a patron with a $44.50 meal charge. The tax should be 6.75 percent of the meal cost. The tip should be 15 percent of the total after adding the tax. Display the meal cost, tax amount, tip amount, and total bill on the screen. Use functions to calculate the tax and tip.

OR

a) Write a program in FORTRAN 77 to evaluate the function

(**10+10**)

CO2

$$f(x) = \ln \frac{1}{1-x}$$

For any user-specified value of x, where ln is natural logarithm (logarithm to the base *e*). Write the program using a *while* loop so that the program repeats the calculation for each legal value of x entered into the program. When an illegal value of x is entered, terminate the program.

b) Radioactive elements decay at a rate characterized by their "half-life," defined as the time required for the original amount of radioactive material to decrease by half. For example, radon has a half-life of 3.8 days. If there are originally 100 mg of radon gas in an enclosed container, there will be 50 mg after 3.8 days, 25 mg after 7.6 days, and so forth. The process of radioactive decay can be described by the formula

$$A(t) = A_0 \exp(-t/\tau_0)$$

where A_0 is the initial amount, $A(t)$ is the amount after time t, t_0 is proportional to half-life t_{half}

$$t_0 = -\frac{t_{\text{half}}}{\ln(1/2)}$$

For Radon, $t_0 = 5.48$ days. Write a program in FORTRAN 77 that calculates and prints the amount of radon remaining from a given original sample mass after a specified number of days (print this for several intervals). This program should have provision to output the data in an external file, which should contain two columns: time and amount of radon remaining.