**University of Management and Technology**

**School of Science (SSC)**

***Department of Physics***

**Course Code: PH-309**

**Course Title:** Computational Physics

**Program: BS Physics**

**Course Outline (Fall Semester 2022)**

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| **Lecture****Schedule**  | **Sec. P** | **Pre-requisite** |  |
| **Course Instructor** | Dr. Bilal Ramzan | **Contact** | Bilal.ramzan@umt.edu.pk |
| **Course****Description**  | This hands-on course provides an introduction to computational methods in solving problems in physics. It teaches programming tactics, numerical methods and their implementation, together with methods of linear algebra. These computational methods are applied to problems in physics, including the modelling of classical physical systems to quantum systems, as well as to data analysis such as linear and nonlinear fits to data sets. Applications of high performance computing are included where possible, such as an introduction to parallel computing and also to visualization techniques. |
| **Expected****Outcomes**  | After successfully completing this course the student will:* be able to understand the importance of the Numerical Techniques in modeling different problems of Physics (classical to quantum or advance Level);
* able to understand the initial value problems (RK Method);
* able to understand the boundary value problems (Using Matlab);
* apply the knowledge of mathematics in Physics and vice versa;
* Be able to understand and discuss the principles and governing mathematical physics modeling
* Identify modern programming methods;
* Describe the capabilities and limitations of computational methods in physics;
* Identify and describe the characteristics of various numerical methods;
* Establish tactics for encapsulating and hiding complexity;
* Independently program computers using leading-edge tools;
* Formulate and solve computationally a selection of problems in physics;
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| **Text Book**  | 1. The Students Edition of Matlab Version 4 (available in library)
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| **Reference Books** | 1. Introduction to Computational Physics, by T. Pang, Cambridge (2010)
2. Numerical methods for Physics, A. L.Garcia,Createspace,(2017)
3. Computational Methods in Physics, Chemistry and Biology by P. Harrison, Wiley, (2001).
4. More Physics with MATLAB, by D. Green, World Scientific, (2015)
5. Computational Physics by H. J. Gardner, World Scientific, Singapore (1997).
6. Numerical Recipes: The Art of Scientific Computing by W. H. Press, B. P. Flannery, Saul A. Teukolsky, and William T. Vetterling Cambridge University Press, (1988).
7. Mathematica for Physics: R. L. Zimmerman Addison Wesley Publishing Company, (1994.)
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| **Assignments**  | Presentations and projects will be assigned as an assignment. | **Quizzes** | Class activities will be performed in the class related to lectures completed in the class.One Major quiz will be announced well before time by the department. |
| **Mid Term****Examination**  | A 60-minutes exam will cover all the material covered during the first half of the semester. | **Final** **Examination** | A 120-minutes exam will cover all the material covered during the semester. |
| **Attendance** **Policy**  | Students missing more than 20% of the lectures will receive an “SA” grade in the course and will not be allowed to take final exam.  |
| **Grading** **Policy**  | Assign+ Quizzes + Presentation/class activity+ attendance: 10+10+5+5Mid Term Examination: 30Final Examination: 40  |

Department of Physics

PH-309 Computational Physics

**Lecture Plan (Fall 2022)**

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| **Week** | **TOPICS** |
| 1 | Self-Introduction, Student Teacher Interaction, knowing my studentsDiscussing the importance of computers in solving complex problems, Analytical and numerical solutions, Example of Newtonian Mechanics and Understanding the gravity, Self-Gravity and External Gravity |
| 2 | Parkers Model, Parkers solar wind solutions, Hydrostatic equilibrium, Static cases, Steady state solutions, Solving Parkers model analytically, Installation of MATLAB, Defining functions in MATLAB, Obtaining different velocity profiles, Hydrodynamics, One fluid Model |
| 3 | Revision Hydrodynamics, One fluid model (Parkers Model is one fluid Model), Solving equations numerically by computers, making program for one fluid Model by Using MATLAB, Obtaining subsonic solutions, Obtaining supersonic solutions, Understanding transonic solutions, Solving momentum equation , finite solutions, infinite or unphysical solutions, acceleration of fluid along spatially axis |
| 4 | Total Flux vs mass flux, magnetic flux, adiabatic index of the gases, Total energy flux conservation (i.e., Bernoulli's principal), Gas acceleration (in constant Area) analysis, Gas acceleration in converging/diverging environment, Mapping of transonic solutions, Understanding of Transonic winds, Why there is no sonic point in one dimensional Geometry., What exactly sonic point or critical point is? |
| 5 | Two fluid model, Stream, streamlines, introduction of two fluids, shear between two fluid, instability Analysis, Kelvin Helmholtz instability, How to deal two fluids by computers, Gravity against two fluids, Energy exchange mechanism, Resonance of particle vs wave, Numerical Codes |
| 6 | Pressure plots, Contour plots, velocity along x axis, density variation along x axis, why density is less in supersonic regimes, why density is more in subsonic regimes, Why adiabatic index of the gas is important, practice to write Analytical programs, Flow area vs mass flux |
| 7 | Numerical solutions of Ordinary differential equations, Initial value problems, RK-4 method to integrate ODES, Complex equations using Numerical method |
| 8 | Data Analysis of Big data file |
| 9 | Understanding the Galactic data and visualization |
| 10 | Introduction to simulation techniques and computer graphics, use of computation and computer graphics to simulate the behavior of complex physical systems,  |
| 11 | computational techniques in investigating and visualizing fundamental physics |
| 12 | scientific packages, introduction to scientific work bench for problem solving in electronics and other branches of physics |
| 13 | Project Discussion |
| 14 | Making Project |
| 15 | Final |