# HONORS SUBJECTS IN CSE

# SYLLABUS OF

# High Performance Computing

**Course Objectives:**

The objective of the subject is to

- Introduce the basic concepts related to HPC architecture and parallel computing.
- To discuss various computational techniques for studying soft matter systems.
- To understand the methods to extract maximum performance in a multicore, shared memory execution environment processor.
- To understand Symmetric and Distributed architectures.
- To understand the implementation of large-scale parallel programs on tightly coupled parallel systems using the message passing paradigm.

**Course Outcomes:**

After the completion of the course, student will be able to:

- Design, formulate, solve and implement high performance versions of standard single threaded algorithms.
- Demonstrate the architectural features in the GPU and MIC hardware accelerators.
- Design programs to extract maximum performance in a multicore, shared memory execution environment processor.
- Develop and deploy large scale parallel programs on tightly coupled parallel systems using the message passing paradigm.
- Analyze Symmetric and Distributed architectures.

**Syllabus:**

**Graphics Processing Units:** Introduction to Heterogeneous Parallel Computing, GPU architecture, Thread hierarchy, GPU Memory Hierarchy.

**GPU Programming:** Vector Addition, Matrix Multiplication algorithms. 1D, 2D, and 3D Stencil Operations, Image Processing algorithms – Image Blur, Gray scaling. Histogramming, Convolution, Scan, Reduction techniques.

**Many Integrated Cores:** Introduction to Many Integrated Cores. MIC, Xeon Phi architecture, Thread hierarchy, Memory Hierarchy, Memory Bandwidth and performance considerations.

**Shared Memory Parallel Programming:** Symmetric and Distributed architectures, OpenMP Introduction, Thread creation, Parallel regions. Work sharing, Synchronization.

**Message Passing Interface:** MPI Introduction, Collective communication, Data grouping for communication.

**Text Books:**


1. Programming Massively Parallel Processors A Hands-on Approach, 3e, Wen-Mei W Hwu, David B Kirk and Morgan Kaufmann-2019
2. Intel Xeon Phi Coprocessor Architecture and Tools, Rezaur Rahman, Apress Open, 1st edition-2013
3. Using OpenMP, Barbara Chapman, Gabriele Jost, Rudd Vander Pas, MIT Press, 2008


**Reference books:**


1. "A Parallel Algorithm Synthesis Procedure for High-Performance Computer Architectures" by Dunn Ian N, 2003

# SOFTWARE METRICS

**Course Objectives:**

The main objective of the course is to expose the students to different software metrics used in projects and their Management. Upon completion of this course, the student should be able to:

- Analyze basics of Measurement.
- Learn about different Methods of Data Collection.
- Learn about measuring Internal and External Product Attributes.
- Analyze software quality measurements and metrics.
- Plan measurement programs.

**Course Outcomes:** At the end of the course the student will be able to:

- Understand and analyze various fundamentals of measurement and software metrics.
- Apply frame work and analysis techniques for software measurement.
- Analyze internal and external attributes of software product for effort estimation.
- Apply reliability models for predicting software quality.
- Able to create a plan for measurement program and apply the metrics tools.

**Syllabus**

**Fundamentals of Measurement**: Measurement: what is it and why do it?: Measurement in Software Engineering, Scope of Software Metrics, The Basics of measurement: The representational theory of measurement, Measurement and models, Measurement scales and scale types, meaningfulness in measurement.

**A Goal-Based Framework For Software Measurement**: Classifying software measures, Determining what to Measure, Applying the framework, Software measurement validation, Performing Software Measurement validation. Empirical investigation: Principles of Empirical Studies, Planning Experiments, Planning case studies as quasi-experiments ,Relevant and Meaningful Studies.

**Software Metrics Data Collection**: Defining good data ,Data collection for incident reports, How to collect data, Reliability of data collection Procedures. Analyzing software measurement data: Statistical distributions and hypothesis testing, Classical data analysis techniques, Examples of simple analysis techniques.

**Measuring internal product attributes**: Size Properties of Software Size, Code size, Design size, Requirements analysis and Specification size, Functional size measures and estimators, Applications of size measures.

**Measuring internal product attributes**: Structure: Aspects of Structural Measures, Control flow structure of program units, Design-level Attributes, Object-oriented Structural attributes and measures.

**Measuring External Product Attributes**: Modeling software quality, Measuring aspects of quality, Usability Measures, Maintainability measures, Security Measures Software Reliability: Measurement and Prediction: Basics of reliability theory, The software reliability problem, Parametric reliability growth models, Predictive accuracy,

**Resource measurement**: Productivity, teams, tools and method, making process predictions, Planning a measurement program, Measurement in Practice, Empirical Research in Software Engineering, Metrics Tools.

**Text Books:**


1. Fenton, Pfleeger, Software Metrics, A Rigorous and Practical Approach, 2nd Edition, Thomson, 1998.
2. Stephen H. Kan, Metrics & Models in Software Quality Engineering, 2nd Edition, Addision-weseley Pearson Education, 2002.


**References:**


1. Sheppard, Software Engineering Metrics, 1st Edition, Mc GrawHill Publications, 1994.

2. Pertis et al, Software Metrics, An Analysis and Evaluation, 1st Edition, MIT Press, 1981.

# SOCIAL MEDIA ANALYTICS

**Course Objectives:**

- To understand the basics of online social networks and large-scale data availability in social networks.
- To understand and analyse the several computational, algorithmic, and modelling challenges of massive networks.
- To understand the structure and analyse large network models and algorithms
- To understand the robustness and fragility of networks, algorithms for WWW.
- To understand how prediction and recommendation in online social networks are done

**Course Outcomes:**

- To learn and explore the basics of online social networks and large-scale data availability in social networks.
- To acquire knowledge on several computational, algorithmic, and modelling challenges of massive networks.
- To acquire knowledge on large network models and implement the algorithms.
- To understand the robustness and fragility of networks and learn various algorithms used in WWW.
- To acquire knowledge on prediction and recommendations performed in online social networks.

**Syllabus:**

**Internet and Social Media :** History of Internet – Viewing the Internet as a Mass Medium – New Developments in the field of Internet – Definition of Social Media – Understanding Social Media – Significance of Social Media – Categories of Social Media – Mainstream Media Vs Alternative Media.

**Introduction to Networks in Social media** : Introduction to Social Network ,Types of Networks, Network Data and Measures , Network Growth Models , Link prediction , Link Analysis, Community Structure in Networks.

**Data Visualization**: Notation for Social Network Data, Introduction to Python/Colab, Graph Visualization Tools ; Community Detection, Cascade Behaviour and Network Effects, Anomaly detection.

**Graph Representations:** Types of Graphs, Graph Representation, Graph Representation Learning, Coding on Graph Representation Learning, study on DeepWalk, Node2Vec, GCN, graph neural network, Graph Convolutional Network, Graph Attention Network.

**Case Studies**: The students are advised to acquaint themselves with different social media platforms and perform different data analytics with respect to Community detections, COVID -19, Pinterest

**Text Books:**


1. Social Network Analysis, Tanmoy Chakraborty, Wiley, 2021-(NPTEL lectures also available)
2. Social Network Analysis: Methods and Applications, Stanley Wasserman, Katherine Faus



**Reference Books: 1.** Network Science, Albert-Lazzlo Barabasi

# REINFORCEMENT LEARNING

**Course Objectives:**

- To provide the fundamentals of Reinforcement learning.
- To solve problems based on reinforcement learning.
- To study and analyse about different decision making process.
- To study about various methods used for problem solving

**Course Outcomes:**

- Enumerate the elements of Reinforcement Learning
- Solve the n-armed Bandit problem
- Compare different Finite Markov Decision Process
- Discuss about Monte Carlo Methods in solving real world problems
- List the Applications and Case Studies of Reinforcement Learning

**Syllabus:**

**The Reinforcement Learning Problem:** Reinforcement Learning, Examples, Elements of

Reinforcement Learning, Limitations and Scope, An Extended Example: Tic-Tac-Toe, Summary, History of Reinforcement Learning.

**Multi-arm Bandits:** An n-Armed Bandit Problem, Action-Value Methods, Incremental Implementation, Tracking a Non-stationary Problem, Optimistic Initial Values, Upper-Confidence-Bound Action Selection, Gradient Bandits, Associative Search (Contextual Bandits)

**Finite Markov Decision Processes:** The Agent–Environment Interface, Goals and Rewards, Returns, Unified Notation for Episodic and Continuing Tasks, The Markov Property, Markov Decision Processes, Value Functions, Optimal Value Functions, Optimality and Approximation.

**Monte Carlo Methods:** Monte Carlo Prediction, Monte Carlo Estimation of Action Values, Monte Carlo Control, Monte Carlo Control without Exploring Starts, Off-policy Prediction via Importance Sampling, Incremental Implementation, Off-Policy Monte Carlo Control, Importance Sampling on Truncated Returns

**Applications and Case Studies**: TD-Gammon, Samuel's Checkers Player, TheAcrobot, Elevator Dispatching, Dynamic Channel Allocation, Job-Shop Scheduling.

**Text Books:**

1. Richard S. Sutton and Andrew G. Barto, “Reinforcement Learning-An Introduction”,2nd Edition, The

MIT Press,2018

2. Marco Wiering , Martijn van Otterlo Reinforcement Learning: State-of-the-Art (Adaptation,

Learning, and Optimization (12)) 2012th Edition

**Reference Books:**

1. Vincent François-Lavet , Peter Henderson , Riashat Islam, An Introduction to Deep Reinforcement

Learning (Foundations and Trends(r) in Machine Learning) , 2019