MSc/Diploma in Information Engineering

Detailed Course Syllabus

4.1 DYNAMICS & CONTROL

AIM

To provide the basic concepts of classical linear control theory and discrete time systems, and an introduction to state variable analysis.

SYLLABUS

Classical Control Theory (10 lectures)

Open-loop and Closed-loop control, differential equation representation, Laplace transforms and transfer functions, block diagrams, steady-state and transient responses, poles and zeros.

Frequency response analysis, Bode plots, Nyquist stability analysis.

Root locus analysis.

Compensation techniques.

Discrete Time Systems (5 lectures)

Basic concepts and definitions of discrete time signals and systems.

Time domain approach to analysis, number sequences, difference equations.

Frequency domain approach to analysis, Z-transforms, pulse transfer functions.

Stability of discrete time systems, the unit circle, bilinear transformation.

State Variable Analysis (5 lectures)

Fundamental concepts and definitions.

Representation of linear continuous SISO and MIMO systems in state variable form. State variable representation of discrete time systems.

Eigenvalues and Eigenvectors. Solution of state variable equations.

Recommended Texts

J.J. D'Azzo and C.H. Houpis, "Linear Control System Analysis and Design", McGraw-Hill, 1988.

I.J. Nagrath and M. Gopal, "Control System Engineering", Wiley, 1982.

4.2 SOFTWARE ENGINEERING 1: SPECIFICATION, DESIGN AND CONSTRUCTION

AIMS

To introduce concepts of software specification, design and construction with emphasis on underlying mathematical and engineering principles.

SYLLABUS

The software life cycle. (2 lectures)

Specification.

- Formal and informal specification.
- Introduction to logical operators, quantifiers, propositional, calculus, predicate calculus, logical reasoning.
- Axiomatic specification.
- Model based specification e.g. Z.

(8 lectures)

Design.

- Concepts of abstraction and refinement.
- Function oriented design.
- Object oriented design.

(3 lectures)

Construction.

- Structured programming.
- Construction from formal specification.
- Verification.

(7 lectures)

Recommended Texts

Program Construction and Verification, R.C. Backhouse, Prentice-Hall, 1986.

Software Engineering, 3rd Edition, I.Sommerville, Addison Wesley, 1989.

Software Engineering Concepts, R. Fairley, McGraw-Hill, 1985.

A Method of Programming, E.W. Dijkstra & W.J.H. Feijen, Addison Wesley, 1988.

4.3 MEASUREMENT & INSTRUMENTATION

AIM

To develop an understanding of the basic principles underlying measurement and instrumentation today.

SYLLABUS

Instruments and instrumentation systems as information machines. Architecture *of instrumentation systems: system* under observation sensors, signals, a to d and d to a conversion, signal conditioning, information processing of measurement information, *effectuation*, human-machine interface.

Sensors, transducers and actuators: *models, model based* classification, converters, modulators, coupled stores, loading, impedance matching.

Signal conditioning: bridges, phase sensitive rectifiers, oscillators.

Information processing of measurement information: intelligence in instrumentation, *signal estimation, model based* measurement, influence and intrinsic error avoidance and compensation, parallel and feedback structures.
Errors and uncertainty: analysis and models.

Calibration, standards, traceability.

Design of instruments and instrument systems: design process, life-cycle, *task definition, requirements,* solution generation.

<u>Books</u>

E.O. Doebelin, Measurement *Systems, McGraw Hill*, 1990.

J.P. Bentley, Principles of Measurement Systems, Longman, 1983.

P.H. Sydenham, Handbook of Measurement, Volumes 1 & 2, Wiley, 1983.

B.E. Jones, Instrumentation, Measurement and Feedback, McGraw Hill, 1977.

H.K.P. Neubert, Instrument Transducers, Clarendon Press, 1975.

B.E. Jones, Instrumentation, Science and Technology, Volumes 1, 2 & 3, Adam Hilger, 1983.

A. Finkelstein/A.C.W. Finkelstein, View of Design Methodology, *IEE Proceedings,* Vol.2, *Pt.A, No.4,* 1983.

4.4 SIGNAL THEORY

AIM

To provide the basic concepts and methods necessary to the *analysis and processing* of signals of one-dimension, and an introduction to two-dimensional signals.

SYLLABUS

<u>Fundamentals</u> (2 lectures)

Signal models and classification (continuous / discrete: deterministic / random : energy / power)

<u>Continuous-time Signals</u> (4 lectures)

Review of Fourier methods (Fourier Series, Fourier Transform, Parseval's Signal reconstruction (zero and first-order hold, linear interpolation, ideal l.p. filter).
The Discrete Fourier Transform.
The Fast Fourier Transform.

<u>Random Signals (Stochastic Processes)</u> (4 lectures)

Fundamental concepts (the ensemble, ensemble statistics, stationary and ergodicity).
Correlation *functions.*
Spectral density and spectral estimation.
The Gaussian process.
Processing of random signals (memoryless and dynamic systems)
Models of random signals.

<u>Detection of signals in noise</u> (4 lectures)

Performance *criteria (S/N ratio, Decision Theoretic).*
Matched Filters.
Multiple signal systems.

<u>Booklist</u>

J.G. Proakis & D.G. Manolakis, "Introduction to Digital Signal *Processing", Macmillan,* 1988.

R.E. Ziemer, W.H. Tranter, D.R. Fannin, "Signal and Systems: continuous and discrete", Macmillan, 1989.

C.D. McGillem & G.R. Cooper, *"Continuous and Discrete Signal* and System Analysis", Holt Rinehart & Winston, 1984, 2nd edition.

AIMS

To provide an understanding of the design principles, structure and operation of von Neumann machines and to introduce alternative non-von Neumann models of computation.

SYLLABUS

Levels within a computer system
Hierarchy of languages
- high level programming languages
- low level programming languages
- microprogramming languages

The machine has an implementation of a language
(2 lectures)

Von Neumann machines
- processor / memory / communication

Memory
Virtual memory
Structure of a processor
- instruction sets
- addressing modes

Implementation of the control section by microprogramming
(10 lectures)

Example architectures
- 8086 / 68000
- transputer

(2 lectures)

Flynn's classification
- pipelining
- array processors
- MIMD machines

(2 lectures)

Non-von Neumann architectures
- VLSI architectures: systolic and wavefront machines
- data flow architectures
- functional architectures

(4 lectures)

<u>Recommended Texts</u>

Structured Computer Organisation, 2nd edition, A.S. Tannenbaum, Prentice Hall, 1984.

Computer Organisation, 2nd edition, G.W. Gorsline, Prentice Hall, 1986.

Computer Architecture and Parallel Processing, K. Hwang & F.A. Briggs, McGraw Hill, 1985.

AIM

To provide the basic methods of formulating differential equations for lumped parameter engineering systems using the unifying principles afforded by energy manipulation elements and conservation laws.

SYLLABUS

<u>Introduction</u> (1 lecture)

Scope, overview, iterative nature of modelling.

<u>Basics</u> (5 lectures)

(i) **System Variables** definitions of effort (e) flow (f) and respective accumulation variables for different energy domains.
(ii) **System elements** C, L, R, TF, GY, SE, SF. Flow store (C), effort store (L) with examples. Energy, coenergy for each. Unilateral converter - dissipator (R), Content, Co-content. Bilateral converters - Transformer (TF), Gyrator (GY) with examples. Sources - SE (effort), SF (flow).
(iii) **Energy conversion** through (a) TF, GY (b) Coupled storage fields with examples.
(iv) **Modulated elements.**
(v) **Interconnection of elements** - effort compatibility, flow continuity - treated as additional multiport elements - '0', '1' junctions.

<u>Differential equation (d.e.) formulation</u> (1 lecture)

Internal (state space), External descriptions, Introduction to methods of formulation.

<u>Simple methods</u> of d.e. formulation based on conservation laws. Examples from differing energy domains with particular emphasis on process modelling.
(4 lectures)

<u>Bond graph method for d.e. formulation</u> (5 lectures)

Introduction, bond graph sketching, causality assignment, rules for forming d.e. from a graph. Examples for differing systems.

<u>Variational methods for d.e. formulation</u> (4 lectures)

Admissible variables, generalised coordinates, <u>Nodal</u> variational analysis leading to extended Lagrangian equations, <u>Loop</u> variational analysis leading to extended Langrangian equations. Applications including simple robot arm, energy converter systems.

<u>Recommended Text</u>

P.E. Wellstead "Introduction to Physical System Modelling" Academic Press, 1979.

4.7 OPTIMISATION & OPTIMAL CONTROL

AIM

To provide an understanding of the broad spectrum of optimisation techniques in the static and dynamic contexts and to highlight areas of practical application to single and large scale systems.

SYLLABUS

Principles of Optimisation (4 lectures)

Basic concepts, finite and infinite dimensional optimisation, optimality conditions, classes of problems, limitations of analytical methods.

Finite dimensional optimisation algorithms: linear searches, gradient and direct search methods, methods for dealing with constraints, Langrangian techniques. Convergence. On-line optimisation, integrated system optimisation and parameter estimation. Examples of application.

Optimisation of Large Scale Systems (4 lectures)

Definition of a large scale system, interconnected systems; decentralised, distributed and hierarchical structures and control concepts; coordination concepts.

Large scale static optimal control: on-line hierarchical control, compensation for model reality differences.

Optimal Control (12 lectures)

Optimal control problem and its classification.

Variational methods, Pontryagin's maximum principle, linear-quadratic optimal control problem and the continuous *matrix Ricatti equation. Control* under constraints, time optimal control.

Optimality principle, dynamic programming, discrete linear-quadratic optimal control and the discrete matrix Ricatti equation, application of the discrete Kalman filter.

Numerical methods for solving optimal control problems.

Recommended Texts

W. Findeisen, F.N. Bailey, M. Brdys, K. Malinowski, P. Tatjewski and A. Wosniak, "Control and Coordination in Hierarchical *Systems", Wiley, 1980.*

P.E. Gill, W. Murray and M.H. Wright, "Practical Optimisation", Academic Press, 1981.

M. Noton, "Modern Control Engineering", Pergamon, 1972.

4.8 SYSTEM IDENTIFICATION

AIM

To describe techniques for identifying structure and estimating parameters of dynamic mathematical models, to describe the use *of these models in adaptive control, and to describe recent* developments in expert control systems.

SYLLABUS

Parameter estimation (7 lectures)

Parameter and estimation in linear systems, basic concepts and definitions. Least squares parameter estimation, explicit and implicit methods, non-recursive and recursive methods, generalised least squares method, maximum likelihood estimates, Bayes estimates, recursive estimators.

Parameter estimation in nonlinear systems.

Quantitative model validation.

Adaptive Control (7 lectures)

Basic concepts: the adaptive control problem and adaptive schemes.

Model reference adaptive systems.

Gain scheduling.

Self-tuning regulators and auto-tuning. Practical aspects, choice of test signals and parameters.

Examples of application.

Expert Control Systems (3 lectures)

Application of intelligent knowledge based systems techniques to expert regulatory control, adaptive control and system fault diagnosis.

Kalman Filters (3 lectures)

Basic concepts of process state estimation, Wiener filtering problem. Kalman-Bucy filter, continuous and discrete Kalman filters. Simultaneous estimation of parameters and states, the extended Kalman filter.

Recommended Texts

P. Eykhoff, "System Identification, Parameter and State Estimation", Wiley, 1974.

K.J. Astrom and B. Wittenmark, "Adaptive Control", Addison-Wesley, 1989.

4.9 NONLINEAR SYSTEMS

AIM

To cover the theory of finite-dimensional, continuous time systems by focusing on fundamentals of nonlinear systems, stability theory and nonlinear control.

SYLLABUS

Basics of nonlinear ordinary equations: existence and uniqueness, flows, qualitative theory, linearisation, global features and classification of dynamics.
(6 lectures)

Describing function methods. (2 lectures)

Lyapunov stability theory: Lyapunov's second method, stability criteria. (4 lectures)

Application of Lyapunov techniques to model reference adaptive control. (4 lectures)

Averaging methods and normal forms. (2 lectures)

Centre manifolds and their applications. (2 lectures)

Recommended Texts

Vidyasagar, "Nonlinear systems analysis".

Cuckenheimer and Holmes, "Nonlinear oscillations, dynamical systems and bifurcations of vector fields", 1982.

Sastry and Bodson, "Adaptive control", 1989.

4.10 CONTROL SYSTEMS DESIGN

AIM

To provide an overall framework for the control systems design problem and to introduce both Single Input Single Output and Multi Input Multi Output frequency response design techniques.

SYLLABUS

The Control Systems Design Problem (2 lectures)

Discussion of issues and general methodologies, feedback configurations.

Background Analysis (5 lectures)

Advanced control concepts: controllability, observability, internal-external stability.

Realisation of transfer function matrices, poles, zeros.

Return ratio, return difference and sensitivity matrices.

Single Input - Single Output Design (7 lectures)

Regulator and servomechanism design using classical techniques.

Bode methodology for design of lead-lag and lag-lead compensators.

Root locus design approach, minor loop design.

Multi Input - Multi Output Design Methods (6 lectures)

Approaches for multi input - multi output design.

Generalised Nyquist based methodology: Nyquist diagrams, performance, stability, interaction.

The characteristic locus design method.

Other frequency response design techniques: Inverse Nyquist Array method.

Recommended Texts

J.M. Maciejowski, "Multivariable Feedback Design", Addison Wesley, 1989.

J.L. Melsa and D.G. Schultz, "Linear Control Systems", McGraw Hill, 1969.

K. Ogato, "Modern Control Engineering", Prentice Hall, 1970.

DESIGN (10 hrs)

AIM

To provide an introduction to the basic concepts and methods underlying the design of engineering systems.

SYLLABUS

The design process. (1)

The system life cycle. (1)

Task definition, requirement analysis, typical features of system requirement specifications. (1)

Generation of system design concepts: abstraction, decomposition, re-use of proven concepts, analogies, convergent methods, divergent methods, variation of design concepts, system integration. (2)

Overview of analysis of engineering design concepts: modelling, simulation, sensitivity analysis, uncertainty, gaming. (2)

Evaluation of systems: objectives, effectiveness, costs, optimising and satisficing, conflicts, trade-offs. (2)

Decisions: nature of decision in design, decisions under uncertainty and under risk. (1)

<u>Books</u>: There is no single book that covers all or a substantial part of the course. It is proposed that it be covered by lecture notes and a reading list of papers and book chapters.

RELIABILITY (10 hrs)

AIM

To give an understanding of the need to design engineering systems to an acceptable level. To provide a knowledge of the techniques of reliability analysis.

SYLLABUS

Reliability Theory: basic definitions and relationships. (2)

Determination of acceptable levels of failure. Economic, Safety and risk considerations. (1/2)

Problems of data collections, effect of quality, environmental conditions and operating stress or failure rate. Data banks. (1/2)

System structures: series, parallel, standby and k out of n configurations. (2)

Maintained systems: distinction of repair and maintenance, analysis of simple maintenance policies. (1)

Multi-state systems: state transition models, transient and steady state solutions. (2)

System diagnostics: fault tree analysis, top-down and bottom-up approach. Diagnostic charts. (2)

<u>Books</u>:

E.E. Lewis, "Introduction to Reliability Engineering", Wiley, 1987.

P.D.T. O'Conner, "Practical Reliability Engineering", Heyden, 1981.

4.12 ARTIFICIAL INTELLIGENCE

AIM

To provide an overview of artificial intelligence techniques and to discuss applications specific to course specialisations.

SYLLABUS

The nature of intelligence.
Review and overview of artificial intelligence techniques.
(2 lectures)

Visual perception, understanding natural language.
(2 lectures)

Knowledge representation and manipulation:
- languages (Lisp and Prolog)
- architectures and problem solving techniques for AI
- data base design for knowledge acquisition and retrieval
- fuzzy set theory
- probabilistic reasoning

(5 lectures)

Human Computer Interface. (2 lectures)

Expert systems, rule bases, forward and backward chaining, shells. (3 lectures)

Production systems.
Semantic nets.
Frames.
Logic (first order predicate).
(4 lectures)

Deep knowledge. Qualitative modelling. (2 lectures)

<u>*Recommended Texts*</u>

E. Rich, "Artificial Intelligence", McGraw Hill, 1985.

P.H. Winston, "Artificial Intelligence", Addison Wesley, 1984.

R.A. Frost, "Introduction to Knowledge Based Systems", Collins, 1986.

L. Sterling & E. Shapiro, "The Art of Prolog", MIT Press, 1986.

4.13 DIGITAL SIGNAL PROCESSING

AIM

To provide methods for the analysis and synthesis of digital signal processing systems.

SYLLABUS

<u>Discrete-time Systems</u> (2 lectures)

Review of discrete convolution, Z-transfer function, discrete frequency response.

IIR and FIR systems - structures, properties, representations.

<u>Design of Digital Filters</u> (5 lectures)

Introduction and informal design (pole-zero placement).
Design of linear-phase FIR filters (windowing, frequency sampling, equi-ripple).
Design of IIR filters (Bilinear transform of analogue filter, Matched Z-transform, Direct (least square) methods).

<u>Realisation of Digital Systems</u> (4 lectures)

FIR systems (Direct, Cascade, Frequency Sampling, Lattice).
IIR systems (Direct, Cascade, Parallel, Lattice).
Signal flow graphs and Transposed systems.
State-space representations.

<u>Quantisation effects in Digital Systems</u> (5 lectures)

Number representations.
A/D conversion noise.
Coefficient quantisation.
Product quantisation.
Limit cycle oscillations.
Scaling.
Quantisation effects in DFT/FFT analysis.

<u>Adaptive Filters</u>

Relevance / applications.
The LMSE criterion/
The Widrow LMS algorithm

<u>**Booklist**</u>

J.G. Proakis & D.G. Manolakis, "Introduction to Digital Signal Processing", Macmillan, 1988.
R.E. Ziemer, W.H. Tranter, D.R. Fannin, "Signals and Systems: continuous and discrete", Macmillan, 1989.
C.D. McGillem & G.R. Cooper, "Continuous and Discrete Signal and Systems Analysis", 2nd edition, Holt Rinehart and Winston, 1984.

4.14 ADVANCED CONTROL SYSTEMS: ANALYSIS AND SYNTHESIS

AIM

To introduce advanced concepts and tools from linear systems and to provide an introduction to modern methods for synthesis and design of control systems.

SYLLABUS

Linear Systems Analysis (6 lectures)

Jordan canonical form, internal - external stability. Controllability, observability, relationship between state space and transfer function models.

Frequency transmission, transmission blocking, invariant forms.

Smith-MacMillan form, poles, zeros, matrix fraction descriptions. System properties under feedback.

State Space Synthesis Methods (4 lectures)

Pole assignment by state feedback, pole assignment and tracking.

Design of asymptotic observers. Squaring down and multivariable root locus.

Algebraic Synthesis Methods for Continuous and Discrete Time Systems (6 lectures)

The general feedback configuration. Proper and stable fractional representations. Smith McMillan form at ∞ and in a performance region.

Stabilisation: the family of stabilising controllers. Robustness, simultaneous design, dead beat control.

Singular Value Analysis of Control System (4 lectures)

Control systems performance and the return ratio and difference.

Principal gains and phases.

Criteria for performance and compensation of control systems based on singular values.

Recommended Texts

C.T. Chen, "Linear Systems Theory and Design", Holt Rinehart, 1984.

R.E. Skelton, "Dynamic Systems Control: linear systems analysis and synthesis", Wiley, 1988.

J.M. Maciejowski, "Multivariable Feedback Design", Addison Wesley, 1989.

4.15 PROCESS CONTROL

AIM

To describe methods used for the modelling, simulation and control of process plant.

SYLLABUS

Modelling of Unit Processes (8 lectures)

Introduction to engineering system modelling: classification of models, objectives of modelling, stages in model development, computer implementation, model validation.

Application of laws of accumulation and conservation. Models of process industrial plant such as hydraulic tanks, mixing, chemical reactions and boiling processes. Models of gas flow systems and compressors. Models of heat exchangers. Introduction to staged operations and models of distillation columns.

Models of process control instrumentation including transducers, transmitters, actuators and controllers.

Computer Process Control (4 lectures)

Structures for computer control: direct digital control, distributed control and hierarchical control.

Computer control algorithms: digital filters, PID algorithm, derivative kick and integral wind-up effects and their avoidance, tuning techniques, nonlinear control algorithms.

Control of Unit Processes and Systems (8 lectures)

Dynamic behaviour of unit processes: capacity, delay, lag and their combinations.

PI and PID controllers, control of dead time, Smith prediction techniques. Cascade, ratio, feedforward and multi-loop control.

Design of control systems for complete plant: degrees of freedom, relative gain array, alternative loop configurations and selection of loops.

Examples such as distillation columns, reactors and anti-surge control of centrifugal compressors.

Recommended Texts

R.G.E. Franks, "Modelling and Simulation in Chemical Engineering", Wiley, 1972.

G. Stephanopoulos, "Chemical Process Control: an introduction to theory and practice", Prentice Hall, 1984.

F.G. Shinskey, "Process Control Systems: application, design, adjustment", 2nd edition, McGraw Hill, 1979.

4.16 INSTRUMENT SYSTEMS

AIM

To provide an introduction to instrumentation for complex measurements such as analytical instrumentation.

SYLLABUS

The functional architecture of systems for indirect measurement: integration response and interpretation. (1)

Review of energy-matter interaction and the physical effects used in analysis. (1)

The principles and basic architecture of typical analytical instruments. (8)

The method of selection of appropriate analytical principles illustrated by significant examples. (3)

Case studies. (6)

<u>Books</u>:

H.H. Willard et al, "Introduction to Instrumental Methods of Analysis", 7th edition, Wadsworth Inc., Belmont, CA, USA, 1988.

4.17 IMAGE PROCESSING

AIM

To introduce the students to the fields of imaging and image processing. Imaging refers to how images are formed and acquired for processing and image processing details the many operations that can be used on images. The module mainly covers the basic concepts occasionally describes the complex methods necessary to produce useful image processing systems. It is the nature of the subject that it is only possible to describe each individual subject area briefly. The main emphasis will be on computer based methods.

SYLLABUS

Introduction to the area of imaging and image processing. Image generation. The generation of 2-d representations of the 3-d world. (2)

How images are generated. Use of solid state arrays, laser scanners. How practical aspects including resolution, image size etc. affect the performance and utility. Digital image representation (discrete representation of 2-d analogue signals), sampling and quantisation. (3)

Techniques for improving image quality: restoration, geometric correction, enhancement. Use of degradation models. (3)

Compression and coding of images. Binary, grey scale and colour images. Practical techniques. Performance aspects: coding efficiency, quality of results, processing speed. (2)

Image segmentation. Techniques: thresholding, edge detection, region growing. Limitations, advantages and properties. (1)

Image measurements - area, perimeter, moments, circularity. Their use in applications, recognition and object description. (2)

Statistical, structural and syntactic pattern recognition and KBS techniques. Advantages, limitations and performance of each for a number of example applications. (2)

Image processing hardware - PC-based, custom. Simple techniques for popular operations. Special computer architectures, parallel processing. (2)

Colour image processing - multispectral, segmentation, recognition, coding. (1)

Introduction to computer vision - interpretation of 3-d scenes. Use of CAD models. Acquisition of 3-d information using stereo, motion, structured lighting, prior knowledge. (2)

<u>Recommended Texts</u>:

R.C. Gonzalez & P. Wintz, "Digital Image Processing", 2nd edition, Addison Wesley, 1987.
M.C. Fairhurst, "Computer Vision for Robotic Systems", Prentice Hall, 1988.

4.18 SENSORS & SENSING

AIM

To provide an introduction to the physical basis of sensors and transducers used in modern instrumentation and to understand the variety of sensing techniques available as a result.

SYLLABUS

Review of the basic principles of sensors, their classification, and their performance characteristics. (1)

The derivation of sensor principles from general physical effects. (1)

The principles, capabilities and limitations of significant sensor types, including solid state sensors and fibre optical sensors. (1)

Noise in sensors; its physical nature and characterisation, limits of sensing. (2)

Sensing of a particular variable; illustration of the principles of sensor selection and the integration of a sensor into an instrumentation system, treated by case study using the example of flow or other appropriate variable. (3)

Design of a sensor; case study of a force sensor. (3)

4.19 PROGRAMMING LANGUAGES: DEFINITION, TRANSLATION AND IMPLEMENTATION

AIMS

To introduce methods of definition, translation and implement-ation of procedural programming languages with emphasis on real time systems.

SYLLABUS

Formal languages.
Specification of syntax and semantics.
Grammars, BNF, syntax diagrams.
Semantic specification, typing.

(4 lectures)

Programming language translators.
- Compilation and interpretation
- Lexical analysis
- Syntactic and semantic analysis
- Code generation

(4 lectures)

Real time language requirements. (2 lectures)

Concurrency.

- Process interactions:
  - communications
  - synchronisation
  - deadlock, livestock and fairness.
- Language constructs for parallelism.

(5 lectures)

Implementation of procedural languages. (3 lectures)

Classes of programming languages. (2 lectures)

<u>Recommended Texts</u>

J. Woodcock and M. Loomes, "Software Engineering Mathematics", Pitman, 1988.

A.V. Aho et al, "Compilers", Addison Wesley, 1986.

A. Silberschatz and J. Petersen, "Operating System Concepts", 3rd edition, Addison Wesley, 1988.

4.20 DIGITAL INSTRUMENTATION SYSTEMS

AIM

To provide an introduction to the equipment end techniques used in the digital implementation of advanced information processing in instrumentation.

SYLLABUS

Review of the architecture of an instrumentation system and its components. (1)

Signal conditioning. (3)

Interfaces; a-d and d-a converters. (3)

Communication links and networks. (3)

Artificial intelligence in instrumentation: smart sensors, indirect measurement, pattern recognition, interpretation, knowledge based systems. (4)

Human machine interface; controls and displays. (3)

Case studies. (3)

4.21 MEASUREMENT & INSTRUMENTATION IN PHYSIOLOGY & MEDICINE

AIM

To provide an understanding of the principles of measurement in physiology and medicine and the use of instrumentation in the clinical setting.

SYLLABUS

Introduction - Principles of physiological measurement; measure-ment and instrumentation for diagnosis and management; the vital signs; the role of cardiovascular, respiratory CNS measurement; maintenance of homeostasis; interrelationships between variables. (2 lectures)

Measurement of pressure and flow. (3 lectures)

Measurement of core and peripheral temperature. (1 lecture)

Respiratory instrumentation; ventilators. (1 lecture)

Cardiovascular instrumentation; pacemakers, defibrillators. (1 lecture)

Measurement of electrical signals: ECG, EEG, EMG. (2 lectures)

Blood gas analysis. Biochemical measurement. (2 lectures)

Imaging modalities: including X-ray, ultrasonics, CT and MRI. (3 lectures)

Safety considerations. (1 lecture)

Instrumentation for critical care. (2 lectures)

Therapeutic instrumentation e.g. bladder/incontinence. (1 lecture)

Ambulatory monitoring. (1 lecture)

TOTAL 20 lectures

Booklist:

D.W. Hill and A.M. Dolan, "Intensive Care Instrumentation", 2nd edition, London: Academic Press, 1982.

P. Rolfe (ed.), "Non-invasive Physiological Measurement", London: Academic Press, vol.1, 1979.

4.23 DIGITAL DESIGN

AIM

To describe the range of techniques for designing digital logic hardware using both simple (discrete) and complex (LSI) digital components.

SYLLABUS

Review of traditional digital design techniques. Combinational logic representations (truth table, Boolean equations, Karnaugh map) and associated minimisation techniques. Algorithmic minimisation technique based on Quine-McCluskey approach. Sequential logic design - synchronous and asynchronous. State diagram/table representations, state minimisation and assignment. Special design criteria for asynchronous design - hazard/race free design. MSI and LSI circuits. (6)

Implementation of combinational and sequential logic using programmable logic devices - PROM, PLA's, PAL's, PLD's. Architecture of such devices, examples of design software. (3)

Alternative logic description/specifications - flow-chart method based on algorithmic state machine (ASM), hardware description languages (HDL), register transfer languages (RTL). (3)

Design of complex digital systems - microprogramming, firmware, microprogram sequencers, microprogrammable/bit-slice processors. Design of a simple, microprogrammable microprocessor. (6)

VLSI programmable support chips (graphics processors) and digital signal processing (DSP) devices. Design of high-speed processor memory sub-systems - banked, interleaved, dual-porting, cache. (2)

<u>Recommended Texts</u>

D. Lewin, "Design of Logic Systems", 1986.

D. White, "Bit-Slice Design - controllers and ALU's", 1981.

D. Green, "Modern Logic Design", 1986.

4.25 VLSI DESIGN

AIM

To provide an introduction to and understanding of the essential elements and the practices of VLSI technology and circuit design.

SYLLABUS

Introduction to the VLSI design process. (1 lecture)

Review of semiconductor materials and fabrication processes: NMOS, CMOS, PMOS and bipolar devices. (3 lectures)

Design of basic MOS circuits: device characteristics, enhancement and depletion mode of operation, CMOS circuits. (3 lectures)

Mask generation: geometric layout rules, stick diagrams, clocking strategies, buffering. (3 lectures)

Design for testability: test generator for combinational and sequential circuits: yield. (2 lectures)

Overview of CAD aids available for the design, verification and testing of VLSI circuits. (3 lectures)

Case studies of typical designs. (4 lectures)

Future developments in VLSI technology and design. (1 lecture)

<u>Recommended Texts</u>

L. Brackenbury, "Design of VLSI Systems - a practical introduction", Macmillan, 1987.

A. Mukherjee, "Introduction to NMOS and CMOS VLSI Systems Design", Prentice Hall, 1986.

C. Mead & L. Conway, "Introduction to VLSI Systems", Addison Wesley, 1980.

N.H.E. Weste & K. Eshraghian, "Principles of CMOS VLSI Design", Addison Wesley, 1985.

4.26 and 4.27 MEDICAL INFORMATICS I and II:

The syllabus for this course is presented as 2 twenty-hour modules to be taught consecutively. Together they constitute an integrated programme in Medical Informatics.

AIM

To provide an understanding of the principal areas of medical informatics, that is the application of information technology to the acquisition, processing interpreting, storing and communicating of medical data and their use in medical research, medical education and patient care.

SYLLABUS:

4.26 Medical Informatics I

Introduction and historical development. (2 lectures)
The technology of medical informatic. (4 lectures)
Control System approaches, information loops & information processing. (2 lectures)
The nature of disease; reasoning strategies; criterion for decision: taxonomy of disease; decision and probability. (4 lectures)

Pattern recognition approaches; decision analysis. (2 lectures)

Qualitative reasoning; predicting outcome:evaluation. (2 lectures)

TOTAL 20 lectures

4.27 Medical Informatics II

Cognitive aspects of decision making. (2 lectures)
Knowledge-based systems in medicine; the acquisition and representation of medical knowledge. (2 lectures)
Case studies in medical informatics: e.g. clinical laboratory; operating theatre/critical care unit; ONCOCIN; DIABETA; image processing and interpreting; home monitoring/telemetry. (2 lectures)
Data banks and information retrieval. (2 lectures)
Ethical and legal aspects of I.T. (2 lectures)

TOTAL 20 lectures

Booklist:

E.R. Carson and D.G. Cramp (eds), "Computers and Control in Clinical Medicine", New York: Plenum, 1985.

D. Ingram and R. Bloch (eds), "Mathematical Methods in Medicine: part 1:statistical and analytical techniques", Chichester: Wiley, 1984. 510.2461 ING

R.A. Frost, "Introduction to Knowledge Base Systems", London: Collins, 1986.

4.28 MODELLING IN PHYSIOLOGY AND MEDICINE

AIM

To provide an understanding of modelling methodology and the range of modelling modalities relevant to applications in physiology and medicine.

SYLLABUS

An overview of modelling methodology and modelling modalities (statistical, mathematical, logical and graphical forms). (2 lectures)

Approaches to mathematical modelling in physiology and medicine: continuous and discrete systems. (3 lectures)

System sensitivity; model reduction. (2 lectures)

Model identification: identifiability analysis, parameter estimation, Model Validation. (5 lectures)

Stochastic approaches, recursive estimation, patient tracking. (2 lectures)

Case studies. (6 lectures)

TOTAL 20 lectures

Booklist:

E.R. Carson, C. Cobelli and L. Finkelstein, "Mathematical Modelling of Metabolic and Endocrine Systems: model formulation, identification and validation", New York: Wiley, 1983.

E.R. Carson and D.G. Cramp (eds), "Computers and Control in Clinical Medicine", New York: Plenum, 1985.

D.G. Cramp and E.R. Carson (eds), "Measurement in Medicine:" vol.1: "The Circulatory System", 1986; vol.2 : "The Respiratory System", London:Croom Helm, 1988; vol.3: "Liver Function", London: Chapman and Hall, 1990. 612.1013 CRA

L. Finkelstein and E.R. Carson, "Mathematical Modelling of Dynamic Biological Systems", 2nd edition, Letchworth: Research Studies Press, 1985. 574.018 FIN

R.L. Flood and E.R. Carson, "Dealing with Complexity", New York: Plenum, Chapter 9, 1988.

D. Ingram and R. Bloch (eds), "Mathematical Methods in Medicine: part 1: Statistical and Analytical Techniques", 1984; part 2: Applications in Clinical Specialities", Chichester: Wiley.

510.2461 ING

4.29 RADIATION MEASUREMENT AND PRACTICE

AIM

To provide an understanding of the principles of radiation interactions, detection, measurement and protection and the use of clinical imaging devices and associated instrumentation.

SYLLABUS

Interactions of radiation with matter (X-rays, α, β, and γ particles, neutrons, magnetic resonance, laser light, thermal radiation). (2 lectures)

Detection devices (including: Geiger counters, scintillation devices, semiconductor detectors). (2 lectures)

Nuclear Electronics (nucleonics) - instrumentation systems. (2 lectures)

Radiation Therapy (cellular radiobiology, therapy machines, therapy planning). (3 lectures)

Dosimetry (measurement, long-term effects of radiation, legislation, codes of practice). (2 lectures)

Radiopharmaceuticals (production, choice of compound for diagnosis and therapy). (2 lectures)

Human Factors (patient-machine, patient-operator relationships) (1 lecture)

Case Studies (including: site visit, dynamic imaging, computer-based imaging and processing, studies of function). (6 lectures)

TOTAL 20 lectures

<u>Booklist</u>:

J.A. Sorenson and M.E. Phelps, "Physics in Nuclear Medicine", New York: Grune Stratton, 1980.

R.P. Parker, P.H.S. Smith and D.M. Taylor, "Basic Science of Nuclear Medicine", Edinburgh: Churchill Livingstone, 1978.

J.R. Greening, "Fundamentals of Radiation Dosimetry", Bristol: Hilger, 1981. [616.0757 GRE]

L. Stanton, "Basic Medical Radiation Physics", Butterworths, 1981. [612.01448 STA]

J. Walter, "A Short Textbook of Radiotherapy", Edinburgh: Churchill Livingstone, 1979. [615.842 WAL]

4.30 DIGITAL COMMUNICATIONS

AIM

To provide the basic concepts and methods necessary for the design of modern telecommunications systems for the provision of integrated audio, video and data services.

SYLLABUS

<u>Pulse-analogue Modulation</u> (4 lectures)

Sampling theorem. Sampling of band-pass signals. Reconstructions. Time-division-multiplexing (TDM), Pulse-amplitude-modulation (PAM), Pulse-time-modulation (PTM).

<u>Pulse Digital Modulation</u> (10 lectures)

Elements of Pulse Code Modulation (PCM). Noise in PCM systems. Measures of information. Channel capacity.
Differential PCM. Delta modulation. Digital multiplexers.

<u>Band-pass Data Transmission</u> (6 lectures)

Modelling.
Coherent binary signalling. Coherent binary PSK. Coherent binary FSK.
Coherent quadrature signalling.
Quadri-phase shift keying (QPSK).
Minimum shift keying (MSK)
Spectral properties of QPSK and MSK signals.

<u>Booklist</u>

A.B. Carlson, "Communication Systems", 3rd ed, McGraw-Hill, 1986.

K.W. Cattermole, "Principles of Pulse-code Modulation", American Elsevier, 1969.

Taub, Schilling, "Principles of Communication Systems", McGraw-Hill.

Simon Haykin, "Digital Communications", John Wiley, 1988.