**BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI**
**INSTRUCTION DIVISION**
**FIRST SEMESTER 2008-2009**

**Course Handout (Part II)**

Date: 02/08/2008

In addition to part-I (General Handout for all courses appended to the timetable) this portion gives further specific details regarding the course.

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| **Course No.** | **: AAOC C321** |
| **Course Title** | **: Control Systems** |
| **Instructor-in-charge** | **: HARI OM BANSAL** |
| **Instructors** | **:** Srinivas Reddy K, R Purohit, A Ananda Kumar, Anita Thakur |

**1. Scope & Objective of the Course:**

Feedback automatic control systems are an essential feature of numerous industrial processes, scientific instruments and even commercial, social and management situations. A thorough understanding of the elementary principles of this all embracing technology is of great relevance for all engineers and scientists. This course tries to bring out the basic principles of Feedback Control Systems.

**2. Text Book**: Nagrath I. J. and M. Gopal, Control Systems Engineering, New Age International (P) Limited, 5th ed, 2007.

**3. Reference Books:**

(i) Kuo, B. C., and Golnaraghi, F., Automatic Control Systems, John Wiley & Sons, 8th ed, 2003.

(ii) Drof, R. C., and Bishop, R. H., Modern Control Systems, Addison Wesley, 7th ed, 1995.

## 4. Course Plan:

| Lect. No. | Topic | Learning object(s) | Ref. to Text Book/ Class Notes |
|---|---|---|---|
| 1. | Introduction<br>Concept of Measurement, feedback and automatic control<br>Example from various fields | General understanding of the concept of control.<br>Identification of various examples encountered in life from engineering and non-engineering fields as well. | 1.1, 1.2 |
| 2. | History of Control;<br>Classification of Systems;<br>Linear/non-linear<br>time invariant/ time varying<br>lumped/distributed parameters<br>analog/digital | -do- | 1.3, 1.4 |
| 3. | Mathematical Modelling.<br>Integro-differential equations for electrical, mechanical and electromechanical systems<br>Transfer functions | Understanding examples from various fields and making block diagram model of the same.<br>Working out transfer function by various methods. | 2.1, 2.2, 2.4 |
| 4. | Example of Control with armature Controlled dc motor as drive.<br>Block diagram development, closed loop transfer function | - do - | 2.4 |
| 5. | Example of Control with field controlled dc motor, gear reduction, disturbance input<br>Block diagram reduction examples. | - do - | 2.4,2.5 |
| 6-7. | Signal flow graph<br>Mason's gain formula, Various Examples | - do - | 2.6, |
| 8. | Hydraulic System<br>Example | - do - | Class Notes, 2.2 |
| 9. | Thermal System<br>Example | - do - | Class Notes, 2.2 |
| 10. | Open loop and closed loop example.<br>Effect on gain, dynamic response disturbance input | Learning about more examples of open loop and closed loop control systems and their comparison | 3.1 |
| 11. | Sensitivity to parameter variation.<br>Concept of frequency content in signals, regenerative feedback, further examples | - do - | 3.2, 3.6, 3.7 |
| 12. | carrier control system,<br>Linearisation of non-linear relationship of ac servomotor, ac tacho generator | Learning about control components and their use in various examples; making block diagram and deriving transfer function. | 4.1, 4,2, 4.3 |
| 13. | Synchro pairs, Stepper motors | - do - | 4.3,4.4 |
| 14. | Hydraulic power supply, valve, actuator | - do - | 4.5 |

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| 15. | Hydraulic control system<br>Pneumatic control components | - do - | 4.5, 4.6 |
| 16. | Various Test signals in time domain,<br>Response of zeroth and first order systems<br>Second order systems | Transient response analysis of dynamic systems to different excitations<br>- do - | 5.1, 5.2, 5.3<br>5.4 |
| 17-18. | Time response specifications of second order systems, error constants, effect of adding pole(s)/zero(s) | - do - | 5.4, 5,5, 5.6 |
| 19 - 20. | Compensation Techniques<br>Higher order systems. | To design control system for given time domain specifications. | 5.7, 5.8, 5.10 |
| 21 | Stability; Routh Test | To apply Routh Test to closed loop system stability study. | 6.1, 6.2, 6.3, 6.4, 6.6 |
| 22. | Root Locus.<br>Introduction,<br>Magnitude and Angle criterion | To draw root locus for various systems and therefrom infer information on time response and stability | 7.1, 7.2 |
| 23. | Root Locus for second order systems without zero and with zeros | - do - | 7.2 |
| 24. | Other rules of root locus.<br>Higher order examples. | - do - | 7.3<br>7.5 |
| 25. | Higher order examples (contd.)<br>Root contours | - do - | 7.4 |
| 26. | Frequency Response; Introduction,<br>Polar plot | To plot frequency response of systems and use for analysis by frequency domain approach. | 8.1, 8.2, 8.3 |
| 27. | Bode plot | - do - | 8.4 |
| 28-29. | Identification of Transfer function from Bode plot, Gain margin and phase margin | - do - | 8.5 & 8.6, 9.4 |
| 30. | Nyquist criterion; Introduction.<br>Nyquist contour | Investigation of the stability of closed loop system using their open loop transfer function frequency plot. | 9.1, 9.2, 9.3 |
| 31-32. | Nyquist stability criterion. Various Examples | - do - | 9.3 |
| 33-36. | Introduction to Design | To design lag, lead compensators, Tuning of PID controllers | 10.1-10.7 |
| 37-40 | State variable analysis and design | Analysis and design of a system using state variable approach | 12.1 to 12..9 |

**5. Home Assignments:**

Assignment sheets will be distributed in Tutorial classes and assistance will be given in solving them during tutorial classes; problems to be solved using computer will be given as take home assignments. There will be evaluation based on these assignments. The detailed breakup of marks for these assignments will be announced in the class.

**6. Reading Assignments:** To be announced in the class from time-to-time.

**7. Evaluation Scheme:**

| Component | Duration | Weightage | Date & Time | Remarks |
|---|---|---|---|---|
| Test I | 50 min | 60 | 25/9 9.00-9.50 AM | CB |
| Test II | 50 min | 60 | 30/10 9.00-9.50 AM | OB |
| Quiz | 50 min | 40 | 20/11 9.00-9.50 AM | CB |
| MATLAB Online Test/Assignment | 50 min | 20 | To be announced by Instructor-in Charge | CB |
| Comprehensive Exam. | 3 hours | 120 | 8/12 FN | CB |

**8. Chamber Consultation Hours:** to be announced in the class.

**9. Notices:** All notices will be displayed on FD-II Notice Board only.

**Instructor-In-Charge**
**AAOC C321**