SEMESTER – IV

SEMESTER – IV

COMMUNICATION SYSTEMS – I EC - 4001

Course Code	**EC – 4001**	Credits: 4	**L-3, T-1, P-0**
Name of the Course	**COMMUNICATION SYSTEMS – I**		
Lectures to be delivered	**52 (1 Hr Each) (L = 39, T = 13 for each semester)**		
Semester End Examination	**Max. Time = 3 hrs.**	**Max. Marks: 100**	**Min. Pass Marks: 40**
Continuous Assessment (based on sessional tests (2) 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%)		**Max. Marks: 50**	

INSTRUCTIONS

1. **For Paper Setters:** The question paper will consist of five sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus and each question will carry 20% of the total marks of the semester end examination for the course.

2. **For candidates:** Candidates are required to attempt five questions in all selecting one question from each of the sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.

SECTION – A

Base Band Signals and Systems.

Introduction, Definition of Communication, Communication System Block Diagram, Need for Wireless Communication, Need of Modulation, General Definition of Modulation, types of various signals, Basic Transmission signals.

AM Transmission and Reception

i) **Analog Modulation: -** Theory, power & current calculation, AM modulation of a complex wave.

ii) AM Transmission:

Introduction, Generation of Amplitude Modulation, Low Level and High Level Modulation. Basic Principle of AM Generation; Square Law Diode Modulation, Amplitude Modulation in Amplifier Circuits, Vander Bijl Modulation, Suppressed Carrier AM Generation (Balanced Modulator), Ring Modulator, Product Modulator/Balanced Modulator, High Power Linear Modulators.

iii) AM Reception:

Tuned Radio Frequency (TRF) Receiver, Super hetrodyne Receiver, Basic Elements of AM Super-hetrodyne Receiver, RF Amplifier, Neutralization of RF Amplifiers, Class of operation of RF Amplifiers, High power RF Amplifiers, Image Frequency Rejection, Cascade RF Amplifiers, Methods of increasing Bandwidth, Frequency conversion and Mixers, Additive Mixing, Bipolar Transistor Additive Mixer, Self Excited Additive Mixers, Multiplicative Mixing, Multiplicative Mixer using Dual Gate MOSFET, Tracking and Alignment, IF Amplifier, AM Detector, Square Law Detector, Envelope or Diode Detector, AM Detector with AGC, Distortion in Diode Detectors, AM Detector.

Circuit using Transistor, Double hetro-dyne Receiver, AM receiver using a Phase Locked Loop (PLL), AM receiver characteristics.

SECTION – B

FM Transmission and Reception

i) **Frequency Modulation**: Theory of FM, Mathematical Analysis of FM, Spectra of FM signals, Narrow/Wide Band FM.

ii) FM Transmission:

FM Allocation Standards, Generation of FM by Direct Method, Varactor Diode, Modulator, Indirect Generation of FM, The Armstrong Method, RC Phase Shift Method, Frequency Stablished Reactance, FM Transmitter, FM Stereo Transmitter.

iii) FM Reception:

Direct Methods of Frequency Demodulation, Travis Detector/Frequency Discrimination (Balanced slope Detector), Foster Seely or Phase Discriminator, Radio Detector, Indirect Method of FM Demodulation, FM Detector using PLL, Zero Crossing Detector as a Frequency Demodulator, Pre-emphasis and De-emphasis, Limiters, The FM Receiver, RF Amplifier, FM Stereo Receiver, Transceiver.

SECTION – C

Theory of Phase modulation, PM & FM, Comparison of AM & FM, Comparison of PM & FM , SSB Transmission and Reception:

SSB Transmission**:**

Introduction, Advantage of SSB Transmission, Generation of SSB, The Filter method, The Phase – shift Method, The Third Method, AM Compatible SSB Modulation, Pilot Carrier SSB, Independent Side-band systems (ISB), Vestigial Side-band (CSSB) Receiver, ISB/Suppressed Carrier Receiver.

SECTION – D

Pulse Modulation Transmission and Reception:

Introduction, Pulse amplitude Modulation (PAM), Natural PAM Frequency spectra for PAM, PAM Time Multiplexing Flat-top PAM, PAM Modulator Circuit, Demodulation of PAM Signals, Pulse Time Modulation (PTM), Pulse Width Modulation (PWM), Pulse Position Modulation (PPM), PPM Demodulator.

BOOKS:

1. Modern Communication Theory – Sharma & Sinha.
2. Communication Systems – Taub & Schilling.
3. Electronic Communication systems – George Kennedy.
4. Modern Electronic Communication – Ashok Raj.

SEMESTER – IV

Electronic Measurement & Measuring Instruments EC (ID) - 4002

Course Code	**EC (ID) - 4002**	Credits: 4	**L-3, T-1, P-0**
Name of the Course	**Electronic Measurement & Measuring Instruments**		
Lectures to be delivered	**52 (1 Hr Each) (L = 39, T = 13 for each semester)**		
Semester End Examination	**Max. Time = 3 hrs.**	**Max. Marks: 100**	**Min. Pass Marks: 40**
Continuous Assessment (based on sessional tests (2) 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%)		**Max. Marks: 50**	

INSTRUCTIONS

1. **For Paper Setters:** The question paper will consist of five sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus and each question will carry 20% of the total marks of the semester end examination for the course.

2. **For candidates:** Candidates are required to attempt five questions in all selecting one question from each of the sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.

SECTION – A

ELECTRONIC INSTRUMENTS

Electronic voltmeter, VIVM Transistor voltmeter, Electronic Multimeter, CRO's study of various stages in brief, measurement of voltage, current phase and frequency, special purpose oscilloscope measurement of inductance, capacitance, effective resistance at high frequency, Q meters, LCR meter.

SECTION – B

INSTRUMENTS FOR GENERATION AND ANALYSIS OF WAVEFORMS

Signal generators, function generator, wave analyzer, harmonic distortion analyzer, spectrum analyzer, spectrum analysis.

INSTRUMENT TRANSFORMER

Current and potential transformers, constructional features, ratio and phase angle error.

SECTION – C

TRANSDUCERS

Principles of operation, qualitative treatment of strain gauge, LVDT, thermocouple, piezo-electric crystal and photoelectric transducers.

DATA ACQUISITION SYSTEM

Necessity of recorders, Recording Requirements, Graphic Recorders, Strip chart Recorders, Magnetic tape Recorders, Digital Tape Recorders.

SECTION – D

DISPLAY DEVICES

Electronic Indicating Instruments, seven segment display, Fourteen segmental display, Nixie tube.

TELEMETERY

Introduction, Method of data transmission, Types of Telementary Systems and applications.

BOOKS RECOMMENDED

1. A.K.Sawhney – Electrical and Electronic Measurements and Instrumentation.
2. B.Stout - Basic Electrical Measurements.
3. D.Cooper – Electronic Instrumentation and Measurement Techniques.
4. Terman & Petit – Electronics Measurement.

SEMESTER – IV

ELECTRONIC LOGIC CIRCUIT DESIGN EC - 4003

Course Code	**EC – 4003**	Credits: 4	**L-3, T-1, P-0**
Name of the Course	**ELECTRONIC LOGIC CIRCUIT DESIGN**		
Lectures to be delivered	**52 (1 Hr Each) (L = 39, T = 13 for each semester)**		
Semester End Examination	**Max. Time = 3 hrs.**	**Max. Marks: 100**	**Min. Pass Marks: 40**
Continuous Assessment (based on sessional tests (2) 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%)		**Max. Marks: 50**	

INSTRUCTIONS

1. **For Paper Setters:** The question paper will consist of five sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus and each question will carry 20% of the total marks of the semester end examination for the course.

2. **For candidates:** Candidates are required to attempt five questions in all selecting one question from each of the sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.

SECTION – A

INTRODUCTION:

The switching circuit, classification of switching circuits.

SEQUENTIAL CIRCUITS:

Asynchronous and synchronous circuits, state diagram and state table.

SECTION – B

SEQUENTIAL LOGIC DESIGN:

Introduction, register, application of shift register, ripple or asynchronous counters, synchronous counters, up down counters, modulo counters, Decade counter. Design of counters (Binary & non-Binary)

SYNCHRONOUS SEQUENTIAL CIRCUIT DESIGN:

Sequential circuits, introductory example, finite state model – Basic definition, capabilities and limitation of finite state machines, state equivalence & machine minimization, simplification of incompletely specified machines, Extraction of maximal compatibles, synthesis & analysis of synchronous sequential circuits.

SECTION – C

DESIGN OF ASYNCHRONOUS SEQUENTIAL CIRCUITS:

Introduction to asynchronous circuits, timing diagram, state diagram & flow tables, fundamental mode circuits, synthesis, state assignment in asynchronous sequential circuits, pulse mode circuits.

SECTION – D

HAZARDS:

Introduction, gate delays, generation of spikes, production of static hazards in combinational networks, elimination of static hazards, design of hazard free combinational networks, hazard free asynchronous circuit design, dynamic hazards, essential hazards.

DECOMPOSITION OF SEQUENTIAL SYSTEMS:

Advantage of modularity, types of decomposition, conditions for serial and parallel decomposition.

BOOKS RECOMMENDED:

1. Switching and finite automata theory – ZVI Kohavi.
2. Logical design of switching circuits – Douglas Lewin.

SEMESTER – IV

NETWORK ANALYSIS AND SYNTHESIS EC - 4004

Course Code	**EC – 4004**	Credits: 4	**L-3, T-1, P-0**
Name of the Course	**NETWORK ANALYSIS AND SYNTHESIS**		
Lectures to be delivered	**52 (1 Hr Each) (L = 39, T = 13 for each semester)**		
Semester End Examination	**Max. Time = 3 hrs.**	**Max. Marks: 100**	**Min. Pass Marks: 40**
Continuous Assessment (based on sessional tests (2) 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%)		**Max. Marks: 50**	

INSTRUCTIONS

1. **For Paper Setters:** The question paper will consist of five sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus and each question will carry 20% of the total marks of the semester end examination for the course.

2. **For candidates:** Candidates are required to attempt five questions in all selecting one question from each of the sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.

SECTION – A
TRANSIENT RESPONSE:

Transient Response of RC, RL, RLC Circuits to various excitation signals such as step, ramp, impulse and sinusoidal excitations using lap lace transform.

NETWORK FUNCTIONS:

Terminal pairs or Ports, Network functions for one-port and two-port networks, poles and zeros of Network functions, restrictions on pole and zero locations for driving points functions and transfer functions, Time domain behavior from the pole zero plot.

SECTION – B
CHARACTERISTICS AND PARAMETERS OF TWO PORT NETWORKS:

Relationship of two-port variables, short-circuit Admittance parameters, open circuit impedance, parameters, Transmission parameters, hybrid parameters, relationships between parameter sets, Inter connection of two port networks.

SECTION – C
TOPOLOGY:

Principles of network topology, network analysis using graph theory.

TYPES OF FILTERS AND THEIR CHARACTERISTICS:

Filter fundamentals, high-pass, low-pass, band-pass and band-reject Filters.

SECTION – D
NETWORK SYNTHESIS:

Positive real functions, Synthesis of one port and two port networks, elementary Ideas of Active networks

TEXT BOOKS:

1. Network Analysis & Synthesis: Umesh Sinha; Satya Prakash Pub.
2. Network Analysis & Synthesis: F.F.Kuo; John Wiley & sons Inc.

REFERENCE BOOKS:

1. Introduction to modern Network Synthesis: Van Valkenburg John Wiley.
2. Network Analysis: Van Valkenburg; PHI.
3. Basic circuit theory: Dasoer Kuh, Mc Graw Hill.
4. A course in Electrical Circuit Analysis by Soni & Gupta; Dhanpat Rai Publication.
5. Circuit Analysis: G.K.Mittal; Khanna Publication.
6. Networks and systems: D.Roy Choudhary; New Age International

SEMESTER – IV

PULSE SHAPING & WAVE GENERATION EC – 4005

Course Code	**EC - 4005**	Credits: 4	**L-3, T-1, P-0**
Name of the Course	**PULSE SHAPING & WAVE GENERATION**		
Lectures to be delivered	**52 (1 Hr Each) (L = 39, T = 13 for each semester)**		
Semester End Examination	**Max. Time = 3 hrs.**	**Max. Marks: 100**	**Min. Pass Marks: 40**
Continuous Assessment (based on sessional tests (2) 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%)		**Max. Marks: 50**	

INSTRUCTIONS

1. **For Paper Setters:** The question paper will consist of five sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus and each question will carry 20% of the total marks of the semester end examination for the course.

2. **For candidates:** Candidates are required to attempt five questions in all selecting one question from each of the sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.

Section – A

Linear Wave Shaping: RC, RL and RLC Circuits:

The High – Pass RC Circuit (Sine, pulse, step, Square, Exponential & Ramp Circuits), the High – Pass Circuit as a Differentiator, The Low Pass RC circuit, The Low – Pass RC circuit as an Integrator, RL Circuits, RLC circuits.

Steady – State Switching Characteristics of devices:

The semi conductor diode, the temperature dependence of p-n charac, Diode transition capacitance, Avalanche diode, Diode Resistance, Transistor as a SWITCH, Transistor at Cut – Off, Break down Voltages, Latching Voltages, Reach – Through, Transistor SWITCH in Saturation, I/P Charac, Temp. Variation of Saturation parameters.

Section – B

(a) Clipping & Comparator circuits:
Clipping (limiting) circuits, Diode clippers, clipping at two independent levels, comparators, Applications of voltage comparators.

(b) Clamping & Switching Circuits:
Clamping Operation, Clamping circuit with source and diode resistance, clamping circuit theorem, Practical clamping circuits, Transistor as a SWITCH, SWITCH with inductive load, Damper diodes, SWITCH with capacitive load.

Section – C

Logic Circuits:

Digital operation of a system, OR-gate, AND – gate, NOT – gate, INHIBIT – operation, XOR – gate, De- Morgan's Laws, NAND and NOR gates, Registers, Dynamic Registers, Diode Matrices, Resistor – Transistor Logic (RTL and RCTL), Direct coupled Transistor logic (DCTL) Low – level logic, comparison of logic gates.

Section – D

Multi Vibrators:

Stable states of a binary, Fixed – bias Transistor binary, Self-bias transistor binary, Monostable multi vibrators.

Sampling gates:

Basic operating principle of gates, Uni-directional diode gate and its other forms, Bi-directional gates using transistors.

Books:

1. The art of Electronics: Paul Horowitz, Winfield Hill.
2. Pulse Shaping & Wave Generation: Milman & Taub.
3. Integrated Electronics: Millman & Halkias.
4. Electronics Devices & Circuits: Millman & Halkias.

SEMESTER – IV

SYSTEM SOFTWARE **CS (ID) – 4001**

Course Code	**CS (ID) – 4001**	Credits: 4	**L-3, T-1, P-0**
Name of the Course	**SYSTEM SOFTWARE**		
Lectures to be delivered	**52 (1 Hr Each) (L = 39, T = 13 for each semester)**		
Semester End Examination	**Max. Time = 3 hrs.**	**Max. Marks: 100**	**Min. Pass Marks: 40**
Continuous Assessment (based on sessional tests (2) 50%, Tutorials/Assignments 30%, Quiz/Seminar 10%, Attendance 10%)		**Max. Marks: 50**	

INSTRUCTIONS

1. **For Paper Setters:** The question paper will consist of five sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus and each question will carry 20% of the total marks of the semester end examination for the course.

2. **For candidates:** Candidates are required to attempt five questions in all selecting one question from each of the sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.

SECTION- A

Machine Architecture, instruction set, addressing modes of the chosen machine, arithmetic & logic operations, floating point operations.

C Programming: Reviews of syntax of C with emphasis on feature like pointers. Bit operations, Pre-processor, files.

SECTION - B

Assemblers, Cross Assemblers: Two pass assembler design. Data structure and algorithms.

Macro processor: Definitions, nested macro – definitions, macro expansion, conditional macro-expansion.

SECTION – C

Linking, Loading, and Relocation, Static and Dynamic linking, Loading and relocation. Editors, debuggers, interactive programming environments.

SECTION – D

DOS: Introduction to interrupts, structure of the interrupt vector table, internet types, software interrupts, Hardware interrupts, interrupts at a glance, interrupts calla from C, internal structure of DOS, Booting Dos, Com & Exe Programs, BIOS, Memory resident programs. Running Batch file.

Programming Examples of Text handling, file management, interface and device drivers, programming in C.

Suggested Text Books & References

1. Donovan, J.J., “System Programming”, Tata McGraw Hill.
2. Dhamdhare, D.M., “ Introduction to System Software”, Tata McGraw Hill.
3. Dhamdhare, D.M., “ System Programming & Operating System”, Tata McGraw Hill.

SEMESTER – IV

COMMUNICATION SYSTEMS LAB – I EC - 4006

Course Code	**EC – 4006**	Credits: 2	**L-0, T-0, P-2**
Name of the Course	**Communication Systems Lab – I**		
Lectures to be delivered	**26 hours of Lab sessions**		
Semester End Examination	**Max. Time = 3 hrs.**	**Max. Marks: 50**	**Min. Pass Marks: 20**
Laboratory	**Continuous Assessment (based on Lab work 30%, Lab record 25%, Viva 25%, Attendance 20%)**	**Max. Marks: 50**	**Min. Pass Marks: 25**

Instructions for paper setter/Candidates

Laboratory examination will consist of two parts:

i) Performing a practical examination assigned by the examiner (25 marks).
ii) Viva-voice examination (25 marks).

Viva-voice examination will be related to the practicals performed/projects executed by the candidate related to the paper during the course of the semester.

LIST OF EXPERIMENTS:

1. To study the Amplitude Modulation and demodulation experimental boards.

2. To study the frequency Modulation and demodulation experimental boards.

3. To study the function of a superhetrodyne receiver.

4. To study the operation of a phased lock loop.

5. To study the operation of a single mode band transmission system.

6. To study the operation of a balanced Modulator.

7. To study the vestigial sideband Transmission system.

8. To study the PAM, PWM, PPM, techniques.

SEMESTER – IV

Electronic Measurement and Instrumentation – Lab EC (ID) - 4007

Course Code	**EC(ID) – 4007**	Credits: 2	**L-0, T-0, P-3**
Name of the Course	**Electronic Measurement and Instrumentation Lab**		
Lectures to be delivered	**39 hours of Lab sessions**		
Semester End Examination	**Max. Time = 3 hrs.**	**Max. Marks: 50**	**Min. Pass Marks: 20**
Laboratory	**Continuous Assessment (based on Lab work 30%, Lab record 25%, Viva 25%, Attendance 20%)**	**Max. Marks: 50**	**Min. Pass Marks: 25**

Instructions for paper setter/Candidates

Laboratory examination will consist of two parts:

i) Performing a practical examination assigned by the examiner (25 marks).
ii) Viva-voice examination (25 marks).

Viva-voice examination will be related to the practicals performed/projects executed by the candidate related to the paper during the course of the semester.

1. Measurement of displacement using LVDT.
2. Measurement of distance using LDR.
3. Measurement of temperature using R.T.D.
4. Measurement of temperature using Thermocouple.
5. Measurement of pressure using Strain Gauge.
6. Measurement of pressure using Piezo – Electric Pick up.
7. Measurement of distance using Capacitive Pick up.
8. Measurement of distance using inductive.
9. Measurement of speed of DC Motor using Magnetic Pick up.
10. Measurement of speed of DC Motor using Photo Electric Pick up.

SEMESTER – IV

MAT - LAB EC – 4008

Course Code	**EC – 4008**	Credits: 2	L-0, T-0, P-3
Name of the Course	**MAT - LAB**		
Lectures to be delivered	**39 hours of Lab sessions**		
Semester End Examination	**Max. Time = 3 hrs.**	**Max. Marks: 50**	**Min. Pass Marks: 20**
Laboratory	**Continuous Assessment (based on Lab work 30%, Lab record 25%, Viva 25%, Attendance 20%)**	**Max. Marks: 50**	**Min. Pass Marks: 25**

Instructions for paper setter/Candidates

Laboratory examination will consist of two parts:
i) Performing a practical examination assigned by the examiner (25 marks).
ii) Viva-voice examination (25 marks).

Viva-voice examination will be related to the practicals performed/projects executed by the candidate related to the paper during the course of the semester.

LIST OF EXPERIMENTS

i) Roots of a quadratic equation.
ii) Guessing a number.
iii) Units conversion.
iv) Factorial Program
v) Simulation of an RC circuit.
vi) I-V characteristic of a MOSFET.
vii) Finding average with a dynamic array.
viii) Writing a binary file.
ix) Reading a binary file.
x) Plotting one and two-dimensional graphs using various MATLAB 2-D Plot types.
xi) Using functions in MATLAB environment.

The teacher concerned will give at least 10 more exercises to solve non-trivial problems using MATLAB environment.

Books:

a. Programming in MATLAB, Marc E.Herniter, Thomson ASIA Ptc Ltd. Singapore (2001).
b. MATLAB, The Language of Computing; The Maths work Inc.

SEMESTER – IV

ELECTRONIC CIRCUIT SIMULATION LAB EC – 4009

Course Code	**EC – 4009**	Credits: 2	L-0, T-0, P-3
Name of the Course	**ELECTRONIC CIRCUIT SIMULATION LAB**		
Lectures to be delivered	**39 hours of Lab sessions**		
Semester End Examination	**Max. Time = 3 hrs.**	**Max. Marks: 50**	**Min. Pass Marks: 20**
Laboratory	**Continuous Assessment (based on Lab work 30%, Lab record 25%, Viva 25%, Attendance 20%)**	**Max. Marks: 50**	**Min. Pass Marks: 25**

Instructions for paper setter/Candidates

Laboratory examination will consist of two parts:

i) Performing a practical examination assigned by the examiner (25 marks).

ii) Viva-voice examination (25 marks).

Viva-voice examination will be related to the practicals performed/projects executed by the candidate related to the paper during the course of the semester.

LIST OF EXPERIMENTS

1. Familiarization with electronic circuit simulation tool.

   Designing with electronic circuit simulation tool.
2. Design a full wave rectifier.
3. Design a full wave bridge rectifier.
4. Design a Voltage regulator using Zener diode.
5. Design a common emitter single stage amplifier.
6. Verify the operations of OR, AND, NOT, NOR, NAND and XOR gates.
7. Design a ring counter and twisted ring counter.
8. Design a mod – 8 up and down counter.
9. Design a square wave generator using IC555 timer.
10. Design a biased diode clipper.