619. **Clinical Health Education Clerkship**
Fall, Winter, Spring, Summer. 6 to 12 credits. May reenroll for a maximum of 12 credits. Grade P in all courses offered in terms 1 through 8.
Clinical experiences for developing and applying skills in patient and family health education. Identification of behavioral components of health care. Assessment of educational needs of patient and family.

620. **Directed Studies in Community Medicine**
Fall, Winter, Spring, Summer. 1 to 6 credits. May reenroll for a maximum of 24 credits. Approval of department.
Individual projects on special problems related to community medicine.

COMPUTER SCIENCE   CPS

College of Engineering

100. **About Computers**
Fall, Winter, Spring, Summer. 4(3-2)
Computer impact on the individual and society. How computers work. Computer applications. Laboratory experience in accessing data bases, use of a spreadsheet and word processing.

112. **Computing for Engineers and Scientists I**
Fall, Winter, Spring, Summer. 3(2-2) MTH 112 or concurrently. Student may not receive credit in both CPS 112 and CPS 120.
Algorithms; data representation, structures, type; decision structures. Design and implementation of algorithms. Applications from engineering, mathematics, and science. Computer arithmetic; microcomputers, mainframes, editors, files.

113. **Computing for Engineers and Scientists II**
Winter, Spring. 3(2-2) CPS 112, MTH 112.
Continuation of CPS 112 with emphasis upon more complex problem solving tasks. Development of self-sufficiency. Use of reference manuals and documentation. Networks, operating systems, software systems.

115. **Introduction to Computing**
Fall, Winter, Spring, Summer. 4(3-4)
Applications of computers in business, education, government and industry. Introduction to computing systems and programming in BASIC.

124. **APL-Computer Programming for Scientists**
Fall, Winter, Spring. 3(3-0) LBS 112 or concurrently. Interdepartmental with and administered by Lyman Briggs School.
APL programming; interactive programming techniques; arithmetic, logical, and extended APL operators; functions, applications to concurrent topics in mathematics; principles of operation of time-shared computers.

214. **Computing for Engineers and Scientists III**
Fall, Winter, Spring, Summer. 3(2-2) CPS 113; MTH 113.
Continuation of CPS 113. Data and instruction structures from both the high-level and implementation perspectives. Emphasis upon problem solving tasks requiring complex data and instructional structures.

251. **Algorithms and Computing I**
Fall, Winter, Spring. 3(2-4) MTH 112.
Algorithms, numeric and character data, data types, variables, expressions, decision structures, arrays, and procedures. Design and implementation of algorithms in PASCAL.

252. **Algorithms and Computing II**
Winter, Spring, Summer. 3(2-4) CPS 251, MTH 113.
Problem solving methods, numeric computation, string processing, number and character representation, data structures, and programming style. Design and implementation of algorithms in PASCAL.

292. **Selected Topics**
Fall, Winter, Spring, Summer. 1 to 4 credits. May reenroll for a maximum of 8 credits when different topics are taken.
Topics selected will in general supplement and enrich existing courses, and lead to the development of new courses.

295. **Independent Study**
Fall, Winter, Spring, Summer. 1 credit. May reenroll for a maximum of 4 credits in CPS 295 and CPS 495 combined. Approval of department.
Independent undergraduate research in computer science.

301. **FORTRAN Laboratory**
Fall, Winter, Spring, Summer. 1(0-3) CPS 252 or concurrently. Students may not receive credit in CPS 301 and in CPS 120.
Programming laboratory using FORTRAN.

304. **PASCAL Programming**
Fall, Summer. 2(1-3) CPS 113, MTH 113. Students with credit in CPS 251 may not receive credit in CPS 304.
Programming style, problem solving methods, linear data structure, trees. Design and implementation of algorithms in PASCAL.

305. **List Processing Languages**
Winter. 3(3-0) CPS 113 or CPS 252.
Development and implementation of computer programs in string and list processing languages. Emphasis upon non-numeric applications. Structure of a simple list processing language. Comparison of list processing languages.

306. **COBOL Programming**
Spring. 3(3-0) CPS 112 or CPS 115 or CPS 251.
The mechanics of COBOL, a business data processing language; presented with illustrative problems.

311. **Machine Organization and Assembly Language Programming**
Fall, Winter, Spring. 4(3-3) CPS 252, MTH 214. Interdepartmental with Electrical Engineering.
Machine structure, registers and operations. Subprogram linkage. Discrimination of translator, loader and execution tasks. Programming in assembly language.

312. **Generative Coding and Information Structures**
Winter, Spring. 4(3-2) CPS 311.
Macro facilities, conditional assembly, interaction with monitor, assembly language I/O. Use of buffer, stack, queue, deque, tree and list data structures. Interpreters, recursive routines.
Approved through Fall 1988.

313. **Introduction to System Programming**
Fall, Spring, Summer. 4(3-2) CPS 312.
Loaders and operating systems. Study of existing batch and time-sharing systems. Design and implementation of part of an operating system. Segments, overlays, multi-processing and multiprogramming.
Approved through Fall 1988.

316. **Systems Software Development**
Fall, Winter, Spring. 4(3-3) CPS 311.
Software engineering concepts. Design and implementation of systems software components. Assembly, macro and loader processing.

321. **Introduction to Discrete Structures**
Fall, Winter, Spring. 3(3-0) CPS 252, MTH 214.
Set operations, relations, functions and mappings. Boolean algebra, Boolean matrices, truth tables, minimization. Propositional and predicate calculus, well formed formulas, precedence relations, quantifiers. Applications to computer science.

322. **Introduction to Theory of Computing**
Fall, Winter, Spring. 3(3-0) CPS 321, MTH 215.
Finite state machines; stack automata; turing machines; language classifications, regular languages and grammars; relationship and conversion between finite state automata and grammars; computability; introduction to recursive functions.

330. **Digital Logic Fundamentals**
Fall, Winter, Spring, Summer. 4(4-0) CPS 252. Interdepartmental with and administered by the Department of Electrical Engineering and Systems Science.
Boolean algebra, combinational logic and minimization, sequential system fundamentals and components; arithmetic operations and devices; memory devices and ensembles; digital integrated circuits; practical engineering design problems.

333. **Algorithms and Data Structures**
Fall, Winter, Spring. 4(3-3) Not open to students with credit in CPS 471. CPS 311, CPS 321 or MTH 382.
Analysis of algorithms; abstract data types. Lists, trees, graphs, sets. Classical algorithms including sorting and searching.

400. **Organization of Programming Languages**
Fall, Spring. 4(4-0) CPS 316, CPS 322, CPS 333.
Specification and implementation of programming languages; data types and control structures, memory management, lexical analysis and parsing; case studies of major programming languages.

412. **Computer Communications**
Fall, Winter, Spring. 3(3-0) CPS 311; STT 351 or STT 441.
Computer networks; analysis by queueing theory; network design algorithms, routing and flow.

413. **Operating Systems**
Fall, Winter, Spring. 4(3-3) CPS 311.
Major concepts of operating system principles. Resource allocation, memory management, protection, concurrent processes, interprocess communication, scheduling algorithms, file systems; design of multiprogramming and multiprocessing systems.

414. Interactive Computer Graphics
Spring, Summer. 4(3-3) CPS 316.
Design of interactive graphics systems including display devices, processors, data structures, interrupt processing and graphical techniques. Two and three dimensional transformations, perspectives, hidden surface removal, shading. Graphics languages.

416. Digital Design
Fall, Spring, Summer. 3(3-0) CPS 311, CPS 322.
Combinational logic with MSI LSI (medium-scale and large-scale integrated circuits) and microprocessors. Synchronous and asynchronous machines. Processor and control logic design.
Approved through Fall 1988.

417. Digital Design Laboratory
Fall, Winter, Summer. 2(1-3) CPS 416 or concurrently.
Designing, constructing and testing computer related circuits using discrete logic, MSI, LSI and microprocessors.
Approved through Fall 1988.

423. Computer Architecture
Fall, Winter, Spring. 3(3-0) CPS 416.
Computer arithmetic algorithms memory systems, computer design, input-output system design, ditigal system simulation.
Approved through Fall 1988.

424. Computer Architecture I
Fall, Winter, Spring. 4(3-3) E E 330.
Interdepartmental with Electrical Engineering.
Computer organization; control unit implementation; input-output, interrupt, and interface design; digital system simulation.

425. Computer Architecture II
Winter, Spring, Summer. 4(2-6) CPS 424. Interdepartmental with Electrical Engineering.
Microprogrammed control; pipelining; multiprocessing and parallel processing; fault tolerant computing. Implementation of a digital system combining simulation and hardware.

441. Design of Intelligent Systems I
Fall, Winter. 4(3-3) CPS 400 or concurrently. Students cannot receive credit for CPS 441 and CPS 841.
Foundations and problems of machine intelligence; application areas; representation of knowledge; control paradigms; the LISP programming language; expert systems; design of an intelligent system.

442. Design of Intelligent Systems II
Winter, Spring. 4(3-3) CPS 441. Students cannot receive credit for CPS 442 and CPS 842.
Memory organization and learning; planning; automated reasoning; the PROLOG language; in-depth study of a particular application/system; implementation of an intelligent system.

451. Design of Language Processors I
Fall. 4(3-3) CPS 316, CPS 322, CPS 333.
Grammars, languages and automata. Lexical analysis and symbol table management. Syntactic analysis. Software engineering and project management. First phase of three-term team project: design and implementation of lexical analyzer.

452. Design of Language Processors II
Winter. 4(3-3) CPS 451.
Continuation of CPS 451. Syntactic and semantic analysis. Generation of intermediate code. Compile-time error handling. Continuation of team project: design and implementation of parser.

453. Design of Language Processors III
Spring. 4(3-3) CPS 452.
Continuation of CPS 452. Code generation and register allocation. Code optimization. Continuation of team project: design and implementation of code generator and optimizer.

471. Algorithms and Data Structures
Fall. 4(4-0) MTH 215, one programming course in a high level language. Not open to students with credit in CPS 311.
Algorithms, data structures, control structures, data types, analysis of algorithms, lists, trees, graphs, sets, sorting and searching.

472. Machine Organization and System Programming
Winter. 4(4-0) CPS 322, CPS 471.
Machine organization, addressing formats, assembly language, assemblers, compilers, linkers, loaders, interrupt and I/O programming, paging and segmentation.

483. Design of Database Systems I
Fall, Winter. 4(3-3) CPS 316, CPS 322, CPS 333.
Storage and access of physical databases, sort/merge, indexing, hashing, multi-key and range accesses; parallel accesses, buffer size trade-offs; application development; design and implementation of a physical database system.

484. Design of Database Systems II
Winter, Spring. 4(3-3) CPS 483.
Data models; calculus based languages; database design methodology and theory; optimizing relational generics; network and multimedia databases; expert database systems; application development; implementing relational query interface to physical database system.

490. Selected Topics
Fall, Winter, Spring, Summer. 2 to 4 credits. May reenroll for a maximum of 9 credits when different topics are taken. Approval of department.
A new developing area of computer science selected by the department.

495. Independent Study
Fall, Winter, Spring, Summer. 1 credit. May reenroll for a maximum of 4 credits in CPS 295 and CPS 495 combined. Approval of department.
Independent undergraduate research in computer science.

801. Independent Study
Fall, Winter, Spring, Summer. 1 to 4 credits. May reenroll for a maximum of 8 credits. Approval of department.

805. Clustering and Scaling Algorithms
Fall. 3(3-0) CPS 301 or CPS 304, STT 441 or approval of department.
Algorithms that organize large amounts of data. Includes metric clustering, hierarchical clustering and multi-dimensional scaling.

806. Fundamentals of Pattern Recognition
Spring. 4(4-0) CPS 301 or CPS 304, MTH 334, STT 442.
Decision-theoretic and nonstatistical approaches; discriminant functions; parameter and density estimation; feature extraction; supervised and unsupervised learning; sample size effects; error estimation; design of pattern recognition systems; computational considerations.

809. Computer Arithmetic Algorithm Design
Fall. 4(4-0) E E 431 or CPS 423. Interdepartmental with and administered by Electrical Engineering.
Number systems; fast two-operand and multioperand addition/subtraction; standard, recoded and cellular array multipliers; high-performance dividers; floating-point arithmetic; error control; pipelining.

812. Computer Networks
Spring. 3(3-0) CPS 313, CPS 412, CPS 423. Interdepartmental with Electrical Engineering.
Data communication, baseband and broadband local area networks, logical link control, internet protocol, transport protocol, naming and addressing, interprocess communication, reliable broadcast protocol, distributed processing.

813. Logic Design Methodologies
Spring. 3(3-0) CPS 423 or E E 431. Interdepartmental with and administered by Electrical Engineering.
Modeling and simulation of logic circuits; hardware description languages; design methodologies for logic arrays and bit-slice processors; fault tolerance, testability, computer aided design of logic circuits; automated routing algorithms.

815. Advanced Computer Architecture
Fall, Winter. 3(3-0) CPS 313, CPS 423. Interdepartmental with Electrical Engineering.
Classification of computer systems, memory organizations, cache memory, lookahead processor, stack processor, pipeline processor, vector processing, associative processor, super computer architectures, parallel processing, performance issues, case studies.

816. Fault-Tolerant Computing
Winter. 3(3-0) E E 813. Interdepartmental with and administered by Electrical Engineering.
Reliability evaluation; fault models and test pattern generation; design for testability; fault-tolerant design techniques; self-checking circuits and systems; system diagnosis and reconfiguration; case studies.

818. Introduction to Robotics
Spring. 3(3-0) E E 415 or M E 458 or approval of department. Interdepartmental with and administered by Electrical Engineering.
Robot configuration and geometry. Robot drive systems, kinematics, controller design, sensors, sensor-based robots. Economic, political and social implications. Industrial application.

822. Computer Vision
Winter. 4(4-0) MTH 334, CPS 252, STT 441.
Imaging geometry, sampling, coding. Picture transformations, enhancement. Edge detection, segmentation. Object and scene description and recognition applications.

831.   Theory of Formal Languages I
Fall. 3(3-0) CPS 322 or approval of department.
Definition of formal languages; acceptors and grammars; regular, linear and context free languages; closure properties.

832.   Theory of Formal Languages II
Winter. 3(3-0) CPS 831.
Context sensitive languages; derivation restricted grammars; semantics of formal languages.

835.   Analysis of Graph Algorithms
Fall. 3(3-0) MTH 334, CPS 322.
Basic concepts in graphs, fundamental graph algorithms: shortest paths, minimum spanning trees, network flow, connectivities, matching, their limitations and complexities, other graph algorithms, NP-complete graph problems.

841.   Artificial Intelligence I
Fall, Winter. 4(4-0) CPS 471, STT 441.
Knowledge representations, heuristics, theory of problem solving, expert systems, adaptive systems, natural language understanding, automatic theorem proving, vision systems.

842.   Artificial Intelligence II
Spring. 3(3-0) CPS 841.
Representation of inexact knowledge, learning systems, description of intelligent systems, case studies, term project.

876.   Performance Measurement Techniques
Fall. 3(3-0) CPS 313, CPS 322, STT 441.
Performance evaluations on computer systems, evaluation of the central processor. Systems analysis, simulation, programmed measurement, and instrumental measurement techniques. Case studies.

881.   Operating Systems Theory I
Winter. 3(3-0) CPS 313, STT 441.
Control of concurrent processes. Deterministic and probabilistic models of processor scheduling. Introduction to auxiliary and buffer storage models.

882.   Operating Systems Theory II
Spring. 3(3-0) CPS 881.
Auxiliary and buffer storage models. Storage allocation in paging systems. Multiprogrammed memory management.

884.   Large Data Base Theory
Summer. 3(3-0) CPS 313, CPS 452, or approval of department.
Data base management constituent parts; data definition, data manipulation, data retrieval and report generation. Hierarchical, network and relational data base models. Schemas, subschemas and access methods. Analytic and theoretical treatment.

890.   Special Topics
Fall, Winter, Spring, Summer. 2 to 4 credits. May reenroll for a maximum of 10 credits. Approval of department.
Special topics in computer science of current interest and importance.

899.   Master's Thesis Research
Fall, Winter, Spring, Summer. Variable credit. Approval of department.

906.   Advances in Pattern Recognition
Fall. 3(3-0) CPS 805, CPS 806, CPS 822.
Current research topics in pattern recognition, exploratory data analysis, syntactic pattern recognition and digital image processing; practical applications of pattern recognition methodology.

911.   General Automata Theory I
Fall of odd-numbered years. 3(3-0) CPS 423 or SYS 827 or approval of department. Interdepartmental with Electrical Engineering.
Characterization of machines and programs as automata; mathematical decomposition of finite automata.

921.   Multiprocessors and Parallel Processing
Fall. 3(3-0) CPS 812, CPS 815. Interdepartmental with Electrical Engineering.
Massively parallel processor, parallel memory, interconnection network, tightly and loosely complied multiprocessors, message-passing model, shared-memory model, operating systems, performance, parallel languages and algorithms.

922.   Advanced Computer Systems
Winter. 3(3-0) CPS 921, E E 813. Interdepartmental with Electrical Engineering.
VLSI and WSI architectures, mapping algorithms to architectures, functional programming, dataflow computer, concurrent symbolic processing and logical programming, computer architecture for artificial intelligence, recent advances in computer systems.

999.   Doctoral Dissertation Research
Fall, Winter, Spring, Summer. Variable credit. Approval of department.

COUNSELING, EDUCATIONAL PSYCHOLOGY AND SPECIAL EDUCATION   CEP

College of Education

400.   Classroom Testing and Grading
Winter, Summer. 3(3-0) T E 200 or T E 200A or T E 200B or T E 200C or approval of department.
Construction, use, and evaluation of teacher-made classroom tests, objective and essay, in elementary schools, secondary schools, and colleges. Statistical analysis of test scores and item responses. Grading problems.

401.   Standardized Tests and Testing Programs
Fall, Spring, Summer. 3(3-0) Approval of department.
An overview of standardized tests and sources of information about them. Selection and uses of standardized tests. Interpretation of standardized test scores. Local and widescale testing programs.

410.   Instructional Design and Technology
Winter, Spring, Summer. 2 to 4 credits. May reenroll for a maximum of 6 credits. T E 200 or T E 200A or T E 200B or T E 200C.
Students design plans for implementing instruction via systems approach and application of learning principles.

411.   School Learning I
Fall, Winter, Spring, Summer. 3(3-0) T E 200 or T E 200A or T E 200B or T E 200C.
Verbal learning, concept formation, problem solving and transfer with implications for teaching in schools.

412.   Human Growth and Development
Fall, Winter, Spring, Summer. 4(2-4) T E 200 or T E 200A or T E 200B or T E 200C.
Patterns in human growth and mental and emotional development of children 3 through 12 and adolescents 12 through 18; observation and participation in schools is an integral part of the course.

413.   Mental Health of School Children
Fall, Winter. 3(3-0) T E 200 or T E 200A or T E 200B or T E 200C.
Social and emotional adjustments of children. Emphasis on balancing factors favoring prevention and resolution of behavior difficulties and evaluation of school programs on basis of their contribution to mental health.

428B.   Curriculum for the Mentally Impaired
Winter. 3(3-0) CEP 460; CEP 428C, CEP 460C, CEP 467K concurrently or approval of instructor.
Development of curriculum for mentally impaired children and youth emphasizing current practice in pre-school through secondary school programs for the moderately and mildly mentally impaired.

428C.   Educational Procedures for the Mentally Impaired
Winter. 3(3-0) CEP 460; CEP 428B, CEP 460C, CEP 467K concurrently or approval of instructor.
Methods of instruction for mentally impaired children and youth including the assessment of individual abilities, the development of instructional objectives, and the teaching of nonacademic and academic skills.

428D.   Education of the Severely Impaired
Fall, Spring. 3(3-0) CEP 460 or approval of department.
Procedures in teaching severely impaired children and youth.

431A.   Educational Media in Instruction
Fall, Winter, Spring. 3(3-0) Juniors.
Educational media for preservice and inservice teachers, and media specialists. Selection and utilization of flat pictures, slides, filmstrips, motion picture films, sound, models, radio, and television. Equipment operation acquired through self instructional laboratory. Field trips required.

431B.   Basic Educational Graphics
Fall. 3(3-0) CEP 431A or approval of department.
A course for teachers and prospective teachers in the local production of visual instructional materials.

434.   Computers in the Classroom
Fall, Winter, Spring, Summer. 3(3-0) Juniors.
How to teach computer literacy and programming in public schools. Computer aided instruction in the classroom. Applying instructional design principles to the selection, evaluation, modification, and development of computer courseware.