Appendix I
Detailed list of outcomes

Items in regular font are required of all students. Items in italics are required only of students enrolled for upper division credit.

1. Explain the nature of electricity, the electrical properties of materials, and the concept of an electrical circuit.
    - Describe electrical "charge", "current", and "voltage" in terms of atoms, protons, electrons, and ions.
    - Describe the functional difference between conductors, insulators, and semiconductors, and explain this difference in terms of valence.
    - Give examples of common and/or effective conductors, insulators, and semiconductors.
    - Describe and explain the electrical properties (conductivity and/or resistivity) of air, freshwater, and seawater using appropriate quantities and units.
    - Describe 6 different physical principles that can be used to produce an electrical voltage, and give an example of at least one device that employs each method.
    - Explain why electrical circuits are called "circuits".
2. Describe hazards associated with electricity. Describe and explain reasons for standard electrical safety practices and procedures.
    - Explain electrocution by describing how contact with an electrical system can affect critical physiological systems in your body.
    - Describe differences in the principle of operation, speed of operation, and purpose of fuses versus ground-fault interrupt (GFI) devices. Explain which type of device is most effective at protecting you from electrical shock and why.
    - Describe routine steps you can (and should!) take to protect yourself from electrical shock when working with or near electrical systems.
    - Describe particularly dangerous electrical situations to avoid.
    - Discuss hazards and protective measures/procedures you should use when working with solder and soldering irons.
    - Describe a safety reason for using a chip extractor rather than your fingers to remove DIP components from sockets.
3. Describe common uses, varieties, and sources for the major classes of circuit components.
    - Power sources (batteries, generators, photocells)
    - Conductive pathways: Wires, Connectors, Sockets, Headers, printed circuit boards
    - Switches
    - Resistors, potentiometers, trimpots
    - Capacitors
    - Inductors
    - Diodes (including zeners and LEDs)
    - Lights
    - Transistors (bipolar and FET)
    - Operational Amplifiers
    - Instrumentation amplifiers
    - Logic gates
    - Flip-flops, Registers and Memory
    - A/D and D/A converters

- Microcontrollers and microprocessors
- Sensors (Light, Temp, Strain)
- Motors (AC, DC, Stepper)
- Solenoids & relays
- RF transmitters and receivers
- Fiber optic receivers/transmitters

4. List major sources for electronic parts and for detailed information about those parts and their applications.
    - Give the names and locations of at least 3 retailers of electronic parts located within a half hour drive of CSUMB.
    - Give the names and website addresses of at least 3 major national or international electronics parts/tools distributors that will mail you a catalog of their products and allow you to order parts over the web.
    - Give the names and websites of at least 3 major semiconductor manufacturers who have datasheets for their components available on the web.
    - Find specified information about a particular semiconductor component by obtaining and correctly interpreting its datasheet.
    - List the names of at least 2 popular magazines and at least 2 popular web sites that feature articles describing fun and educational electronics projects for people with beginning to intermediate electronics skills.
5. Apply basic circuit theory to analyze/explain/predict/adjust the behavior of very simple sub-circuits commonly used as building blocks in more complex electronic circuits.
    - Calculate the effective resistance of series and parallel combinations of resistors.
    - Calculate the effective capacitance of series and parallel combinations of capacitors.
    - Calculate the effective inductance of series and parallel combinations of inductors.
    - Given any three of the following four quantities in a voltage divider (Vin, Vout, R1, R2) calculate the fourth. Explain why this calculation is invalid if the output is "loaded" by a low impedance circuit.
    - Explain the operation of the following op-amp circuits (assume an ideal op-amp approximation): voltage follower (buffer), inverting amplifier,non-inverting amplifier, inverting summer, integrator, differentiator.
    - Build and explain the operation of a 1 pole RC high-pass filter and a 1 pole RC low-pass filter. Given any two of the following 3 quantities (cutoff frequency in Hz, R, C) for such a filter, calculate the third quantity.
    - Describe the operation of an emitter follower.
    - Describe the operation of a transistor switch made with a Power MOSFET.
    - Explain the concept of a Thevenin equivalent circuit and a Norton equivalent circuit.
6. Draw and interpret schematic circuit diagrams.
    - Know symbols for a wire, switch, battery, resistor, capacitor, inductor, diode, LED, generic IC, solenoid, relay, transformer, incandescent lamp, motor, bipolar transistor, field effect transistor, amplifier, safety/chassis ground, signal ground.
    - Know and use standard conventions for uncluttered schematic layout.
7. Demonstrate proper use of standard tools for construction, testing, and repair of electrical circuits and systems.
    - Demonstrate and explain effectiveness of proper techniques for handling ESD sensitive components.
    - Demonstrate correct use of a solderless breadboard
    - Demonstrate correct use of wire strippers and wire cutters
    - Demonstrate correct use of a (manual) wire-wrap tool
    - Demonstrate safe and effective use of solder and a soldering iron for electrically joining two wires or other components.
    - Demonstrate correct use of a multimeter to measure DC voltage, AC voltage, resistance, and current.

- Demonstrate correct and effective use of an oscilloscope, including:
    - Proper connection, disconnection, and handling of scope probes.
    - Appropriate adjustment of horizontal (time) and vertical (voltage) scales.
    - Effective use of triggering and holdoff to "freeze" critical parts of a periodic or quasi-periodic waveform on the display screen.
    - Ability to compare timing and amplitude characteristics of two signals (on a 2 or more channel scope).
    - Ability to measure period or frequency of a periodic signal.
    - Ability to recognize 60Hz interference in a measured signal.
    - Ability to recognize, explain, and correct aliasing errors when using a digital scope.

8. Describe common circuit construction techniques. Discuss the advantages and disadvantages of each technique for marine/field use.
    - Demonstrate effective use of a solderless breadboard for constructing prototype circuits and describe its major advantages/disadvantages over other techniques of circuit construction.
    - Build, or at least describe how you would build a wire-wrapped circuit, and describe the major advantages/disadvantages of wire-wrap over other techniques of circuit construction.
    - Build, or at least describe how you would build a soldered breadboard circuit, and describe the major advantages/disadvantages of soldering over other techniques of circuit construction.
    - Describe the typical industrial process used to create printed circuit boards, and describe the major advantages/disadvantages of printed circuit boards over other techniques of circuit construction. Describe 3 ways that YOU could get your circuits onto a printed circuit board.
    - Describe the typical industrial process used to create microfabricated integrated circuits or MEMS devices, and describe the major advantages/disadvantages of microfabrication over other techniques of circuit construction.
9. Describe and demonstrate use of a systematic approach to diagnosing and correcting problems in non-working circuits or devices.

Appendix II
Contents of Electronics Kit

At the beginning of the semester, you will have checked out to you a locker (located in the lab) containing a basic set of electronic tools and parts. You are responsible for returning everything in good working order at the end of the semester and will be billed for the replacement cost of any damaged or missing items. Your kit will contain approximately the items listed below (an exact list will be provided to you when you check out the kit):

!!!WARNING!!!
Some of the most expensive parts in your kit are sensitive to static electricity and can be damaged or destroyed simply by contact with your body or clothing.

DO NOT TOUCH ANYTHING IN YOUR KIT UNTIL YOU HAVE RECEIVED INSTRUCTION ON HOW TO HANDLE "ESD-SENSTIVE" COMPONENTS.

Tools:

- 1 Solderless prototyping breadboard ("protoboard")
- 1 pair of wire strippers
- 1 pair of diagonal cutoff pliers (wire clippers)
- 1 pair of needle nosed pliers
- 1 multimeter with red and black leads
- 5 color-coded "mini-grabber" clip leads
- 1 chip extractor
- 1 wire-wrap tool
- 1 small flat-blade screwdriver (for trimpot adjustments)

Electronic Parts:

- 1 Parallax BS1-IC (or compatible) "BASIC-Stamp" microcontroller
- 1 National Semiconductor ADC0834 analog-to-digital converter
- 1 LM324 quad operational amplifiers
- 1 voltage regulator (5.0 volts)
- 10 red light-emitting diodes (LEDs)
- 2 signal diodes (1N914 or similar)
- 1 NPN transistor
- 1 PNP transistor
- Trimpot assortment:
  - 2 x 100 ohm
  - 2 x 1 k
  - 2 x 10 k
- Resistor assortment:
  - 10 x 470 ohm
  - 10 x 1 k
  - 4 x 3.3 k
  - 10 x 10 k
  - 4 x 100 k
  - 2 x 1 M
- Capacitor assortment:
  - Large (e.g., 33 uF) electrolytic or tantalum for filtering
  - Medium (e.g. 0.1 uF, 1uF) tantalum
  - Small (33 pF, 1000 pF, 4700 pF) ceramic

The following additional parts may be added to your kits later, or may be available to you through the Metacognitive Grab-Bag loan program. ☺

- 4 Power MOSFET transistors (e.g., TIP120)
- 1 fiber optic transmitter
- 1 fiber optic receiver
- 1 optical fiber
- 1 small DC motor (Contains magnets; keep away from computer disks & ATM/credit cards!)

Appendix III
Detailed Description of the ROV Project

The details of the ROV project in this course may vary from semester to semester, depending on a number of factors. This semester (Fall 2001), is the first offering of this course, so we'll be starting from scratch! As our goal, we will attempt to design and build a working prototype ROV that can be used by one person to observe marine life in a kelp forest from a kayak. Future classes may do the same thing again, or they may pick up where this class leaves off by enhancing the ROV with more instruments, fancier controls, etc.

The basic framework, floatation, and ballast for the ROV will be designed and built by students in another one of my classes this semester (ESSP 443: "Physical Marine Ecology"). The ROV Instrumentation and Control class will focus on the sensors (video camera, depth gauge, compass) and control electronics for the propulsion systems.

Although I have some ideas of what will work well and have already purchased most of the parts, there are NO INSTRUCTIONS for building this ROV. I'll show you pictures and describe design features of some other inexpensive ROV's to get you started, but beyond that you'll be designing it as you go. The following specifications will constrain your design:

Minimum specifications :

- ROV, tether, and controls must be small and lightweight enough to be deployed, operated, and retrieved safely by one person from a Kayak.
- For safety reasons, as well as portability and ease of use in a kayak, the ROV, instruments, and controls must operate from readily available (and/or rechargeable) batteries, and no voltages may exceed 12 Volts. Ideally, we'll be able to run the ROV from a single 12 VDC rechargeable "gel-cell" motorcycle battery.
- Color video camera on ROV can be rotated at least 180 degrees to look up, down, or straight ahead.
- Live video image is displayed at surface on small, portable TV monitor.
- Submersible portions of ROV (including tether) must withstand pressurized seawater to a depth of 10 m.
- Entire system (ROV and topside controls/monitor) must be able to withstand moderately rough handling, so that it may be transported in and moved among cars, boats, planes, etc. without damage.
- Topside controls and video monitor must be protected, so they will float and remain dry if accidentally knocked or dropped into the water.
- ROV controls and propulsion system allow ROV to move up/down, forward/backward, right-turn/left-turn.
- Total parts cost not to exceed $500

Additional desirable specifications:

- Maximum depth range exceeding recommended recreational diving depth of 120 feet – let's shoot for 50 m or more, so we can explore places recreational divers can't!
- Ability to move laterally (sideways without turning) to cruise horizontally along walls while observing things on the wall.
- Sophisticated motor speed control (not just on-off)
- 2 Cameras (one for tether management)
- Relatively hi-res color camera with macro capability as well as long-range vision.
- Video light(s).
- Depth information.
- Compass heading information
- Automatic depth control.

- Trimable buoyancy (or adjustable vertical thrust to generate effective neutral buoyancy).

Appendix III-B
Detailed Description of the Robot Project
(carried over from earlier version of syllabus)

As mentioned in the syllabus, the details of the robot project in this course will vary from semester to semester, depending on a number of factors. This semester (Fall 2001), we will be designing and building a remote-controlled system for pointing a video camera in any direction while it is in a clear plastic housing underwater.

I have structured the project to help you learn the widest possible variety of electronic circuits and techniques consistent with time limitations during the semester. You will discover, in some cases, that there are simpler or more efficient (but less educational) ways to accomplish the desired tasks. For example, the camera pointing system needs two motors (one to control vertical angle and one to control horizontal angle). We'll use two very different types of motors and two very different methods for controlling the motors, even though it would be easier and more efficient to use two identical motor systems. This way you'll get a chance to learn about the challenges, advantages, and disadvantages of each approach and be better prepared for future opportunities and challenges. With that in mind, here's an outline of the basic structure for our robotic camera system:

The camera (a simple, tiny, PC board-mounted video camera) will be attached to a frame that can rotate in a vertical plane to point the camera anywhere from straight up to straight down. The angle will be controlled by a DC electric motor in a feedback-controlled (servo) system, so that the camera will move to any angle specified by a user on the surface. This entire assembly will be mounted on another frame that can rotate left or right through a total of at least 360 degrees. This horizontal angle will be controlled by a stepper motor operating in an open loop mode. Together, the two motors will enable the camera to be pointed in ANY direction. If we get this working and still have time left in the semester, we may add an electronic compass for geo-referenced directional control. Power for the motors, servo circuitry, and video camera will be provided by a battery and voltage regulator inside the underwater housing. Analog control signals from the surface (powered by a different battery) will first be converted to digital data and then transmitted via optical fiber to the housing, where the data will be decoded and used to control camera position. Video signals (NTSC) will be sent to the surface via coaxial video cable or transmitted via optical fiber.

The overall project will be broken into several sub-projects. You will work on these in small groups, with each group getting some exposure to both analog and digital circuits.

- Vertical motor position sensing circuitry (analog).
- Control box with two angle sensors (analog).
- Regulated power supplies for camera, motors, and servo circuitry (analog).
- Regulated power supply for control box on surface (analog).
- Video link from camera to TV monitor (analog).
- A/D conversion hardware in control box (mixture of analog and digital).
- A/D conversion microcontroller software in control box (digital).
- Fiber optic data transmission/reception circuits (digital).
- Fiber optic data transmission microcontroller software (digital).
- Fiber optic data reception microcontroller software (digital).
- D/A conversion hardware in housing (mixture of analog and digital).
- D/A conversion microcontroller software in housing (digital).
- Analog feedback control systems in housing (analog).
- Motor drive circuitry (analog for DC motor, digital for stepper motor).