Chapter 1

Introduction to 6.270

6.270 is a hands-on, learn-by-doing class in which participants design and build a robot that will play in a competition at the end of IAP. The goal for the students is to design a machine that will be able to navigate its way around the playing surface, recognize other opponents, and manipulate game objects. Unlike the machines in Introduction to Design (2.70), 6.270 robots are totally autonomous, so once a round begins, there is no human intervention (in 2.70 the machines are controlled by joystick).

The goal of 6.270 is to teach students about robotic design by giving them the hardware, software, and information they need to design, build, and debug their own robot. The subject includes concepts and applications that are related to various MIT classes (e.g. 6.001, 6.002, 6.004, and 2.70). *However,* there are no formal prerequisites for 6.270. We've found that people can learn everything they need to know by working with each other, being introduced to some material in class, and mostly, by hacking on their robots. All undergraduate students, from freshmen to seniors, are encouraged to register and take the class.

One caveat: 6.270 does require that you be psyched to put forth a real effort! We expect most students to spend about eighty hours over the month of IAP building their robots. Other commitments during the month of IAP are not recommended. We've also noticed that people who make a real commitment to the class are more confident, feel more involved, and have a lot more fun. So, if you are going to take 6.270, be ready for a month-long immersion into robotics!

1.1 Registration Policy

Registration in the class is limited to forty (40) teams. We would accept more students if resources permitted, but they do not.

All entrants will be organized into teams. There are a couple of reasons for this. First, we find that people learn a lot in the close and intense relationship of a small

team. Second, we think the class would be too much work for one person to handle alone.

This class will take up enough of your time that you will not be able to work on other projects such as another course, UROP, or Thesis. Past students that have tried to do several time consuming projects have usually dropped out of the subject, or have not been able to produce a working robot. This year the duration of the subject will be shorter than past years because of the shortening of the IAP period so it is especially important you estimate the amount of time you will have before registering.

You are encouraged to form a team of two to three people and register together. You may also register alone, in which case we will find you a team with two other people.

1.2 Kit Fee and Toolkit Fee

Your 6.270 kit, which is yours to keep at the end of the contest, is valued at about $750. The class is mostly financed by our commercial sponsors (namely Microsoft, Motorola, LEGO, Hawker, and Polaroid) and Course Six, but part of the budget is derived from the entry fee.

The team will be required to forfeit the kit back to the EECS department if it fails to present something to the organizers by the preliminary round of the contest (Monday, January 27th). Teams that do not return their kit once it is forfeited or lose their kit will be charged the full $750 for the kit through the Bursar's office.

Separate from the 6.270 kit, a complete set of electronic hand tools will be reserved for purchase by your team. This kit will include a soldering iron, diagonal cutters, long nose pliers, wire strippers, a multimeter, and several other useful implements.

The 6.270 tool kit will have a retail value between $75 and $100; we expect to sell the kits for between $50 and $60 (we can give you these prices due to the quantity discounts we get in purchasing for the class). *You will be expected to either provide your own electronic assembly tools or purchase the standard tool kit.* It is very important that you have a good set of tools to work with. You will save many hours of debugging and frustration if you use good tools and assemble the material carefully. A sharp tipped soldering iron is essential to assembling your microprocessor board.

A final word about contest costs: if it is difficult for you to afford the contest costs, both the 6.270 kit and the toolkit are returnable (if in good condition) for a refund. If you would like to take the class, but you cannot afford to put up the money to register for the class and buy the toolkit, come talk to the organizers. We can probably work something out. Cost should not be a factor in determining whether you are able to take the course.

1.3 Credit Guidelines

6.270 is offered as MIT subject 6.190 for six units of Pass/Fail credit. Taking the class for credit is optional. You will be doing a lot of work in the class regardless; if you sign up for credit you will get official recognition for taking the class. If you sign up for credit but then do not complete the requirement, your registration will be dropped; it will be as if you never signed up in the first place.

Our job as instructors is to ensure that credit is properly awarded to students deserving of it. Our basic assumption is that anyone who is in the class is going to be doing a lot of work; the guidelines should add only a little bit of overhead to you in reporting your work to us. Hopefully, you may even learn a little more by going through the process of reporting on your progress.

1.3.1 Credit Guidelines

The following requirements for credit have been established:

- **Individual Journal Reports.**

  Each individual desiring credit must turn in a journal report that will be due on Thursday, January 30th. The journals are meant to help you with your thought processes. You should try to make an entry every day or every other day. The journals should include:

  - ideas that you have contributed to the development of the robot;
  - what management techniques your team is using;
  - strategies you have thought of;
  - problems you have encountered;
  - actual construction work, programming, or other tangible results.

  These ideas are examples of thoughts you might include. You are free to include anything else you think is appropriate. Pictures are a good way to try to convey your ideas and for reference.

  After the contest is over, you can pick up your journals to think about your ideas.

  The purpose of the individual journal is to get a sense of what each person on a team is contributing to the design, so it's important to make sure we know what you've done.

- **Team Video Reports.**

  In addition to the individual reports, a team video report will be made once per week.

  A video station will be set up in the 6.270 lab area. To make your report, you and your team can simply go to the camera and make a brief presentation on the status of your robot. This presentation should focus on issues that the team has worked on together, such as the current state of the robot, the strategy of the robot, and how the team arrived at a consensus (or not!) on particular issues.

  Hopefully, the video station concept will make the design reporting a fun and painless process. Any ideas presented to the camera *will remain confidential* for the duration of the contest.

- **Recitation Attendance.** You must attend at least three of the four meetings for your recitation section.

- **Completed Robot.** Your team must "show" a robot the day of Round 1. Its functionality (or lack thereof) has no affect on your receiving credit for the work you have done; the combination of the individual journals, the video reports, and class participation will be the main indicators of your involvement.

- **Program Listing.** You must turn in a copy of the program that your robot uses in the contest.

These subject requirements are meant to be useful to both you, the class participant, and the instructors, who will be authorizing credit. You should have no problem at all receiving credit if all of the requirements are satisfied. If you have any questions about your standing in the subject at any time, feel free to ask any of the instructors for feedback.

Please note that there is no leeway on any of the due dates, due to the scheduling constraints of the Registrar and the sanity of the organizers. Please do not ask for extensions.

1.3.2 Design Units

Since design is an important factor in 6.270, the EECS department will be offering 6 design units for EECS students that take 6.270. There are some guidelines and requirements for getting the design units.

First you must complete all the requirements to get credit for the course. It will come on your transcript. At the end of the contest, you must do an evaluation of your robot. In all design processes there should be some type of evaluation and redesign.

You will need to submit a 5-10 page paper. The paper should include, but need not be limited to, the following:

- An overall summary of your robot. This could include pictures or drawings.
- An evaluation of your robot's performance.
- Your individual redesign of the robot. If you were given an opportunity to retake the course with the same goals how would you make your robot different?
- Possible design flaws in the goals of the contest.

This paper should be submitted by Monday, February 24th to the EECS undergraduate office. The papers should be your individual evaluations, and not a general group evaluation.

1.4 Schedule

The schedule of activities between the start of IAP and the eve of the contest is very tight. You will have to work steadily and with determination to produce a working machine by the end of the course. In no fashion do we, the contest organizers, say that this course is not time consuming! In fact, we believe that you should be spending somewhere between 30 and 40 hours a week on average. However, since it is IAP, we can assume it is the main timesink you've signed up for.

There will be about 120 students taking the 1997 6.270 course, making it one of the largest courses taught during IAP. Since much of the learning, we believe, occurs with hands-on instruction, the class will be too large as a whole to teach on this basis. Therefore we have several class meeting formats, including lectures, recitations, lab demos, and lab sessions.

We recommend that you attend all of the lectures and recitations (for the section you are in) and **be on time**. We will deal with administrative and "bug fix" matters at the beginning of each meeting.

To make the course more personal, each organizer and TA will be the primary advisor for about 8 teams. The TA and organizer pair will be similar to the recitation instructor and TA pair you have in your normal classes. While these people are your primary advisors, you can approach anyone with questions you may have.

It is imperative that you check your e-mail often. Most notices will be posted through electronic mail. In addition, we will mention these notices in labs and lectures. You should check your mail at least once a day, if not more. This is the best way we can get in touch with the whole class on short notice.

- **General Lectures** The objective of the general lectures is to introduce you to the basics of the course. These sessions will try to give you an overview of the course and what you will be doing. The lectures will take place during the first week of the course. Since the students in this class typically have widely varying experience with the material, we will try to keep the lectures as general as possible.

  The lectures will also show you where to find advanced topics and more detailed answers for ambitious teams. There will be five basic lectures, from two to three hours each, to be held in 34-101. Check the schedule below for times and dates. It is important that you attend these lectures because they will give you the essential starting blocks.

- **Catch-Up IC Session** This is a general lecture for students who have had no C programming experience. We will go over the basics of the C language in particular how it applies to the IC language which will be used in the course. The main purpose of this lecture is to introduce basic concepts like variables, functions, and syntax. The lecture will be held in 34-101 on Thursday, January 9th at 12:00 PM.

- **Recitations** Detailed material will be presented in recitations rather than in lectures, to encourage a more interactive format. There will be several recitation sections, led by someone who has already taken 6.270 so they can tell you about their experiences and how to avoid the 6.270 pitfalls. The recitation leader will usually be one of your TA's or an organizer.

  The size of the recitation will be between 5 and 6 teams. The recitations are meant for group discussions, thinking about problems, sharing ideas, and experimenting. Many of the recitations will have hands-on experiments and will require you to have built sensors and motors.

  Recitations will be held during the second and third weeks of the course. There will be two recitations per week. The schedule for the recitations will be discussed during the first lecture.

- **Laboratory Sessions** This is supervised time for building your robot. Lab time will be critical when working on your circuit boards. After that, building motors and sensors will be important. During the final week, testing machines on the table will be the focus of lab activity.

  There will be smaller lab discussions where the TA's will give ideas on mounting sensors, soldering, programming, and general construction. It is also a good idea to use the lab facilities because there will be people there who can help you with your ideas. One of the goals of 6.270 is to teach interactively, and by working

in the labs you will be able to share ideas with other people and experiment with ideas you may not have thought of.

Labs will be held on the 6th floor of building 38. They will be open from 8:45 AM to 11:45 PM during the weekdays, and noon to 10:00 PM on Saturday and Sunday. The final few days of the course, the lab will be open 24 hours.

1.4.1 Important Dates

Before reading the listing of the full month of meetings, please note the following *very important* meetings:

Parts-Sorting Session. Attendance at this session is mandatory: each team must provide one person-hour of manual labor helping to sort out the kit parts. Usually this session is a lot of fun as you get to meet other people in the class and see all of the electronic goodies.

Date, Time, and Place: Sunday, January 5th, 1:00 pm, Room 38-201 (The Chu Lounge).

Official Orientation Meeting. Attendance at this session is mandatory: each team must have at least 50% of its members in attendance. In this session, we will go over the contest rules and organization of the class, and hand out the kits.

Date, Time, and Place: Monday, January 6th, 10:00 am to 1:00 pm, Room 34-101.

The Contest, First Round. Your machine must compete in the first round to qualify for the second round.

Date, Time, and Place: Monday, January 27th, 6:00 pm, Room 26-100.

Robot Impounding. All work on robots will cease one day after the first round. All robots, including the ones that haven't made it past the second round will be impounded in 38-600.

Date, Time, and Place: Tuesday, January 28th, 6:00 pm, Room 38-600 (the lab).

The Contest, Second Round The second round of the double elimination contest will take place. There should be TV cameras to cover the event for local TV.

Date, Time, and Place: Wednesday, January 29th, 11:00 am, Room 26-100, **if necessary**.

The Contest, Final Round. Robots will be released from impoundment at 10:00 am, on Wednesday, January 29th. You must check your robot into 26-100 by 10:30 am. Good luck!

Date, Time, and Place: Wednesday, January 29th, 6:00 pm, Room 26-100.

1.4.2 Progress Schedule

The time allocated for the 6.270 course is short. There are only 21 days between the day you get your kit and the preliminary contest. It is therefore imperative that you set a personal schedule with goals before you begin the course. You may want to distribute the work among the team members in order to optimize team productivity.

Here is a checklist of important tasks you will need to do in order to make a working robot with the completion dates to prevent end of IAP stress:

- ◯ **Course Notes** Read the Course notes as soon as possible. All of the details covered in class will be in the course notes. They contain the administrative material as well. You should read this by the end of the first week, **Friday, January 10th.** If you come and ask us a question without reading the notes, we will be more hesitant to answer your question.

- ◯ **Microprocessor Board** The assembly of the microprocessor board should take between 10-15 hours for someone who has not soldered before. You should complete soldering by the morning of **Wednesday, January 8th.**

- ◯ **Sensor Assembly** You should assemble your sensors early so that you can play around with them. This will take you about one day. Soldering the sensors together and testing their properties should be done by **Friday, January 10th.**

- ◯ **Motor Assembly** You should "LEGOize" at least two motors so you can build a simple bot. By building a simple gearing mechanism early, you can test out the properties of the motor such as the torque and speed. We expect you to have simple gear assemblies being controlled by the microprocessor board by the evening of **Friday, January 10th.**

- ◯ **Strategy** By the beginning to the middle of the second week your team should formulate a strategy for your robot. In the past teams have spent many days pondering over strategies. The indecisiveness usually leads to panic during the last week. You should get a strategy and stick with it rather than trying to restructure your strategy every day. To be at a reasonable pace, without too much stress at the end, you should have a defined strategy by **Monday, January 13rd.**

- **Simple Tasks** While you are formulating your strategy, your robot will need to do some simple tasks depending on the contest. You should use your simple bot and sensors to program these tasks. The tasks will be discussed in recitation. You should formulate your strategy, depending on how easy these task are. The tasks should be tested by **Wednesday, January 15th.**

- **Structure of Robot** During the first week, your team should "fool around" with the LEGO to get familiar with the structural properties. Once you have decided upon a strategy, you should complete the actual robot, with motor attachments and sensors by **Friday, January 17th.**

- **Programming** This is where you will have to tie everything together. You will need to combine your strategy, sensors, and robot to make the robot do what you want it to do. Do not underestimate the amount of time needed for this activity. Hopefully the simple tasks that you had a simple robot do during the first week will fit into your strategy. Complete your basic program by **Tuesday, January 21st.**

- **Debugging and Testing.** Your code probably won't work perfectly the first time you try it out. You should spend a few days testing out the machine and fixing any quirks it may have. This will be the long and tedious process of fine tuning your machine. By **Friday, January 24th,** you should have a pretty robust machine.

- **Mock Contest** We will hold a mock contest on the afternoon of **Saturday, January 25th** so that you can see how your machine performs against other machines. It is advisable to try your machine against other machines before this day.

- **Final Revisions** The final fine tuning of the machines can be done on **Monday, January 27th.**

Many of the teams that have done well in the past have been teams that have completed a final design and strategy early, and have left time to debug the machine. When the course is four weeks long, teams have the tendency to take the second week off because they feel they are ahead, and that programming is a cinch. Be aware, though, that you will want as much time as possible for debugging.

6.270 1997 Schedule: Week 1

Time	Monday 1/6	Tuesday 1/7	Wednesday 1/18	Thursday 1/9	Friday 1/10
10:00	**Opening Lecture** **34-101** General Information Distribute Kits Video Presentation	**Lab Hours** **6.111 Lab** 38-6th floor (go up in 36)	**Lab Hours** **6.111 Lab** 38-6th floor (go up in 36)	**Lab Hours** **6.111 Lab** 38-6th floor (go up in 36)	**Lab Hours** **6.111 Lab** 38-6th floor (go up in 36)
11:00					
12:00				**Beginners' C** **34-101**	
1:00					
2:00	**Lab Hours** **6.111 Lab** 38-6th floor (go up in 36)				
3:00		**Lecture #2** **34-101** Team Organization The Board, Demos Brainstorming	**Lecture #3** **34-101** Sensors, Batteries, Motors, and LEGO	**Lecture #4** **34-101** Software Welcome to IC	**Lecture #5** **34-101** Integrating Systems Control Theory
4:00	***Soldering Demos Offered Periodically***				
5:00					
6:00					
7:00	**Lab Hours** **6.111 Lab** 38-6th floor (go up in 36)	**Lab Hours** **6.111 Lab** 38-6th floor (go up in 36)	**LEGO Lab** Group 1 34-301 **LEGO Lab** Group 2 34-302	**LEGO Lab** Group 1 34-301 **LEGO Lab** Group 2 34-302	**Lab Hours** **6.111 Lab** 38-6th floor (go up in 36)
8:00					
9:00	***Soldering Demos Offered Periodically***		**Lab Hours** **6.111 Lab** 38-6th floor (go up in 36)	**Lab Hours** **6.111 Lab** 38-6th floor (go up in 36)	
10:00					
11:00					

- Solder boards
- Experiment with LEGOs

- Finish soldering boards
- Begin wiring motors and sensors

- Experiment with sensors and the processor board

- Begin programming simple tasks
- Build simple robots

- Begin geartrain and chasis design
- *Do video report #1 over the weekend!*

6.270 1997 Schedule: Week 2

Time	Monday 1/13	Tuesday 1/14	Wednesday 1/15	Thursday 1/16	Friday 1/17
10:00	**Lab Hours** **6.111 Lab** 38-6th floor (go up in 36)	**Lab Hours** **6.111 Lab** 38-6th floor (go up in 36)	**Lab Hours** **6.111 Lab** 38-6th floor (go up in 36)	**Lab Hours** **6.111 Lab** 38-6th floor (go up in 36)	**Lab Hours** **6.111 Lab** 38-6th floor (go up in 36)
11:00					
12:00		**Recitation #1** Group 1 34-301	**Recitation #1** Group 5 34-301	**Recitation #2** Group 1 34-301	**Recitation #2** Group 5 34-301
1:00		**Recitation #1** Group 2 34-302	**Recitation #1** Group 6 34-302	**Recitation #2** Group 2 34-302	**Recitation #2** Group 6 34-302
2:00		**Recitation #1** Group 3 34-301	**Recitation #1** Group 7 34-301	**Recitation #2** Group 3 34-301	**Recitation #2** Group 7 34-301
3:00					
4:00					
5:00					
6:00					
7:00	**Lab Hours** **6.111 Lab**	**Recitation #1** Group 4 34-302	**Recitation #1** Group 8 34-302	**Recitation #2** Group 4 34-302	**Recitation #2** Group 8 34-302
8:00	38-6th floor (go up in 36)	**Lab Hours** **6.111 Lab**	**Lab Hours** **6.111 Lab**	**Lab Hours** **6.111 Lab**	**Lab Hours** **6.111 Lab**
9:00		38-6th floor (go up in 36)	38-6th floor (go up in 36)	38-6th floor (go up in 36)	38-6th floor (go up in 36)
10:00					
11:00					

- Finalize strategy
- Finish testing simple programs
- Start programming for final strategy

- Finish construction of robot

- Begin integration of software, mechanics, and sensors.
- *Do video report #2 over the weekend!*

6.270 1997 Schedule: Week 3

Time	Monday 1/20	Tuesday 1/21	Wednesday 1/22	Thursday 1/23	Friday 1/24
10:00	Holiday - Lab Closed	**Lab Hours** **6.111 Lab** 38-6th floor (go up in 36)	**Lab Hours** **6.111 Lab** 38-6th floor (go up in 36)	**Lab Hours** **6.111 Lab** 38-6th floor (go up in 36)	**Lab Hours** **6.111 Lab** 38-6th floor (go up in 36)
11:00					
12:00		**Recitation #3** Group 1 34-301	**Recitation #3** Group 5 34-301	**Recitation #4** Group 1 34-301	**Recitation #4** Group 5 34-301
1:00		**Recitation #3** Group 2 34-302	**Recitation #3** Group 6 34-302	**Recitation #4** Group 2 34-302	**Recitation #4** Group 6 34-302
2:00		**Recitation #3** Group 3 34-301	**Recitation #3** Group 7 34-301	**Recitation #4** Group 3 34-301	**Recitation #4** Group 7 34-301
3:00					
4:00					
5:00					
6:00					
7:00		**Recitation #3** Group 4 34-302	**Recitation #3** Group 8 34-302	**Recitation #4** Group 4 34-302	**Recitation #4** Group 8 34-302
8:00		**Lab Hours** **6.111 Lab** 38-6th floor (go up in 36)	**Lab Hours** **6.111 Lab** 38-6th floor (go up in 36)	**Lab Hours** **6.111 Lab** 38-6th floor (go up in 36)	**Lab Hours** **6.111 Lab** 38-6th floor (go up in 36)
9:00					
10:00					
11:00					

- Finish your robot
- Test your robot against others on the table in lab
- *Do video report #3 over the weekend!*
- *Mock contest Saturday or Sunday!*

6.270 1997 Schedule: Week 4

Time	Monday 1/27	Tuesday 1/28	Wednesday 1/29	Thursday 1/30	Friday 1/31
10:00	**Lab Hours** **6.111 Lab** 38-6th floor (go up in 36)	**Lab Hours** **6.111 Lab** 38-6th floor (go up in 36)	**Pick up Robots** **Robot Check-in**		
11:00			**Round Two** **26-100**		
12:00				**Cleanup** **6.111 Lab** 1 person-hour per team required	
1:00					
2:00					
3:00					
4:00					
5:00					
6:00	**Round 1** **All Robots Must**	**Impounding** ***Get some sleep!***	**Final Contest** **26-100**		
7:00	**Be Here!** **26-100**				
8:00					
9:00					
10:00	***Get some sleep!***		PARTY!		
11:00					

- Final bug fixes
- Last chance lab!
- Turn in journals and videos

1.5 Computer Facilities

In this course you will have access to several types of computer facilities. Specifics will be covered in lecture. There is one main facility: the 6th floor lab in building 38. This facility will have playing fields so that you can debug your machine while you edit your code. You can download code to your robots at other Athena machines, but you may need a special connector. We recommend that you do most of your debugging at this facility.

1.5.1 6th Floor Laboratory

This area has some Athena machines, which can be used for your purposes. The machines are located near workbenches so you can fix any hardware problems. This is the *only computer location* where you may solder, build, glue, or cut hardware. All hardware work must be done at the benches and not at the Athena terminals. The terminals will already have their own cables, and you will not need to remove them. *There is to be no eating or drinking in the lab; you may do so in the hallways outside, but food will not be tolerated in the lab itself.*

1.5.2 Athena Clusters

In all Athena locations, there is to be *NO soldering, cutting, or gluing in the cluster. If anyone is caught doing any of these tasks, not only will you be asked to leave the cluster, but you will also be required to return your 6.270 kit and you will be thrown out of the course. There are no exceptions to the rule.* Debris from cutting wire, soldering, or gluing can get lodged inside the keyboards and short something.

1.5.3 Athena Etiquette

If you use other Athena clusters please follow the following rules so that 6.270 is not looked down upon.

- *Noise* Your machines will be quite noisy. If there are lots of people working in the cluster who are trying to get work done, please minimize the machine usage, or move to another cluster.
- *Tidiness* Don't leave your stuff lying around all over the place. Other people have to work and move around.
- *Hardware* Don't solder, glue, or cut any hardware in the clusters. If things go wrong because of this, 6.270 as a whole may suffer, and we may be denied access to Athena machines in the future.

- *Locked Screens* Don't leave your screen locked for long periods of time. Towards the end of the month, we will need every available machine. If you lock your screen for more than 20 minutes, we will log you out.
- *Multiple Machines* Don't log on at multiple machines. Also try to minimize the number of people in your team that are logged on. If everyone logs on, then we will need three times as many machines to download to the robots.

If there are any complaints about 6.270 people working in any of the clusters, we will have to make external Athena clusters off limits. Violation of the rules will not be tolerated and we will be enforcing them strictly.