CS 503/591C
Embedded Systems

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Before there were embedded reporters...

...there were embedded systems.

What is an Embedded System?

What is an Embedded System?

- Computing system with a non-standard interface (often no keyboard or screen)
- Often involved in sensing and control (so may not even talk to a human)
- Typically a custom system for a very specific application
- Can be extremely small and low-powered

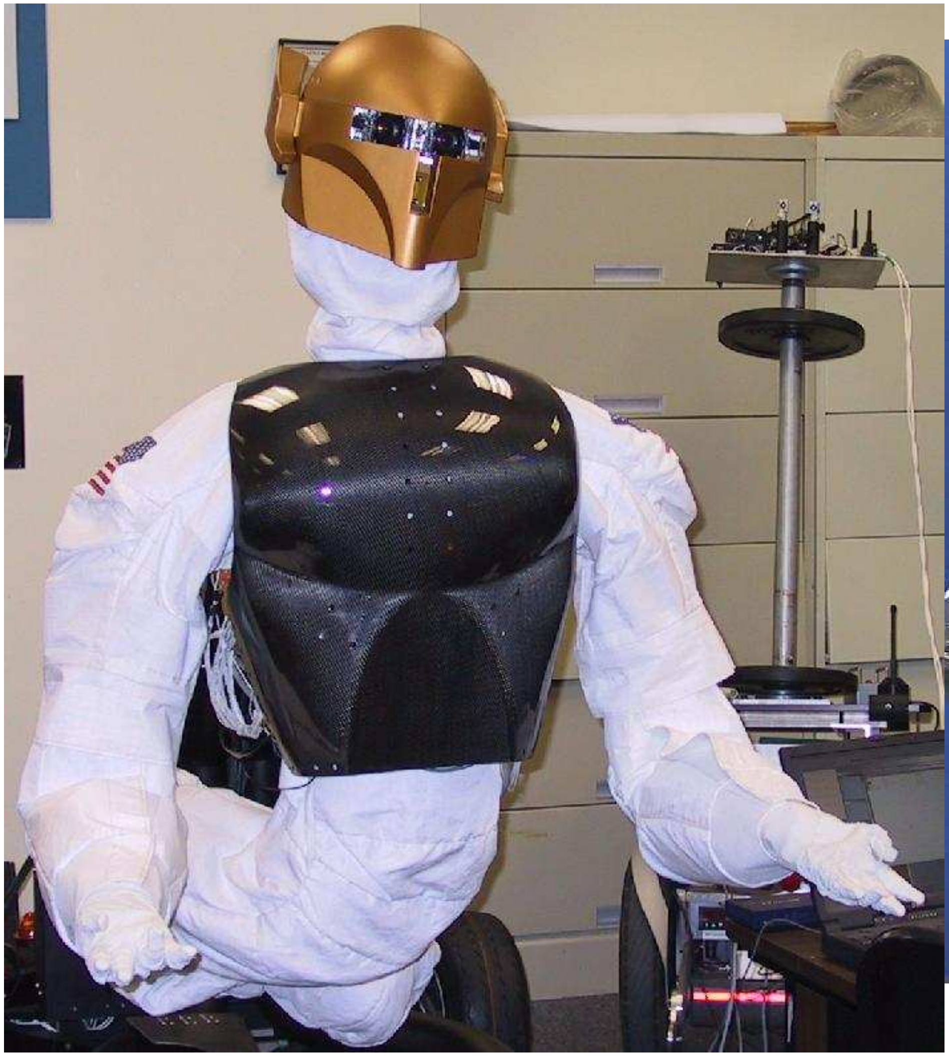
Robotics

Mark Tilden
Los Alamos
National Labs and
Hasboro

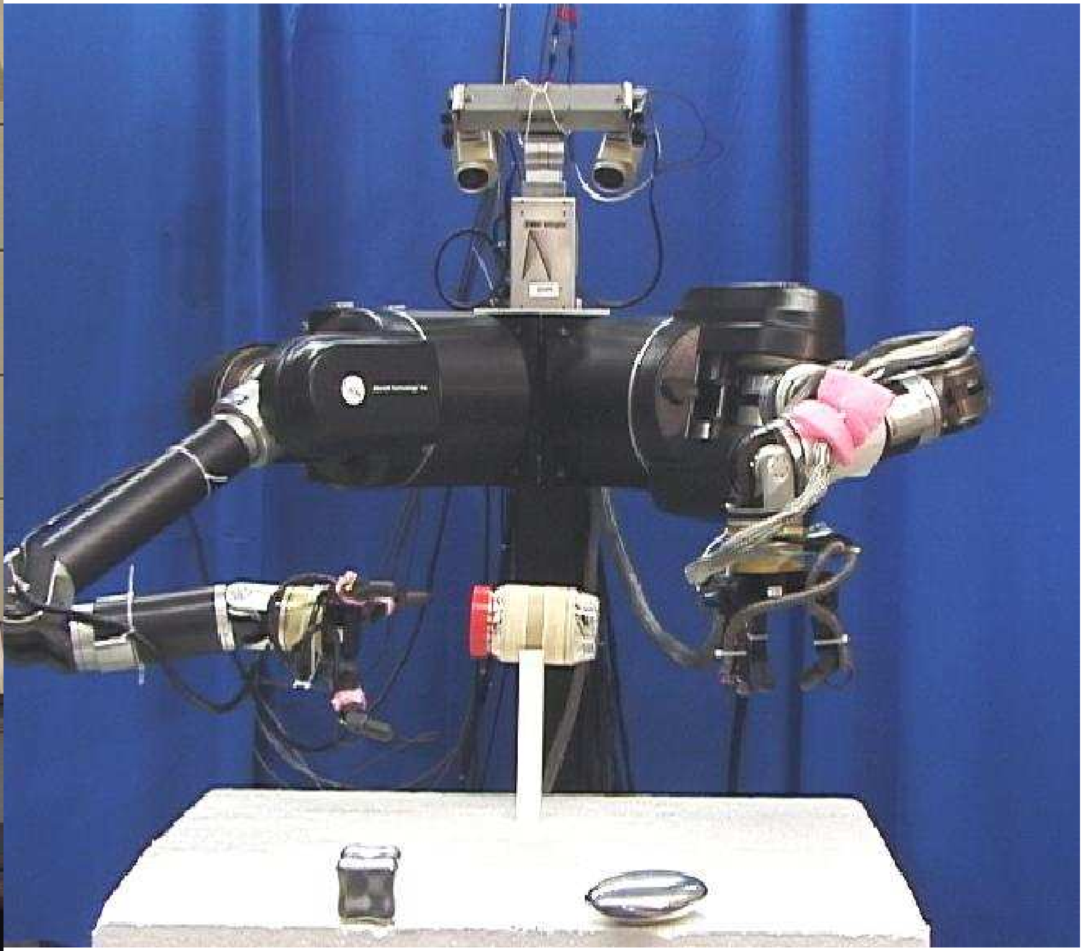
picture from
Robosapiens

Humanoid Robotics

NASA/JSC Robonaut



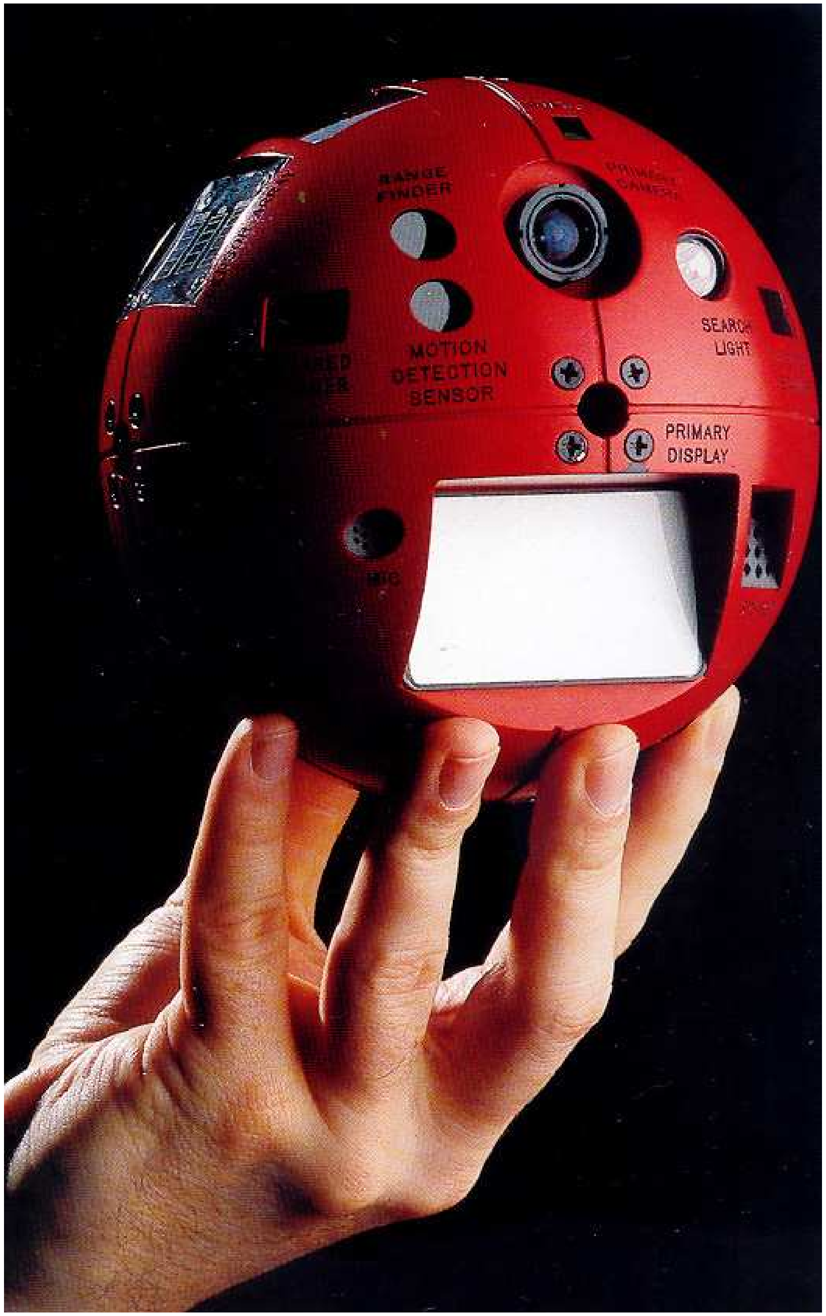
UMass Torso



Personal Satellite Assistants

NASA Ames
Research Center

picture from *Robosapiens*

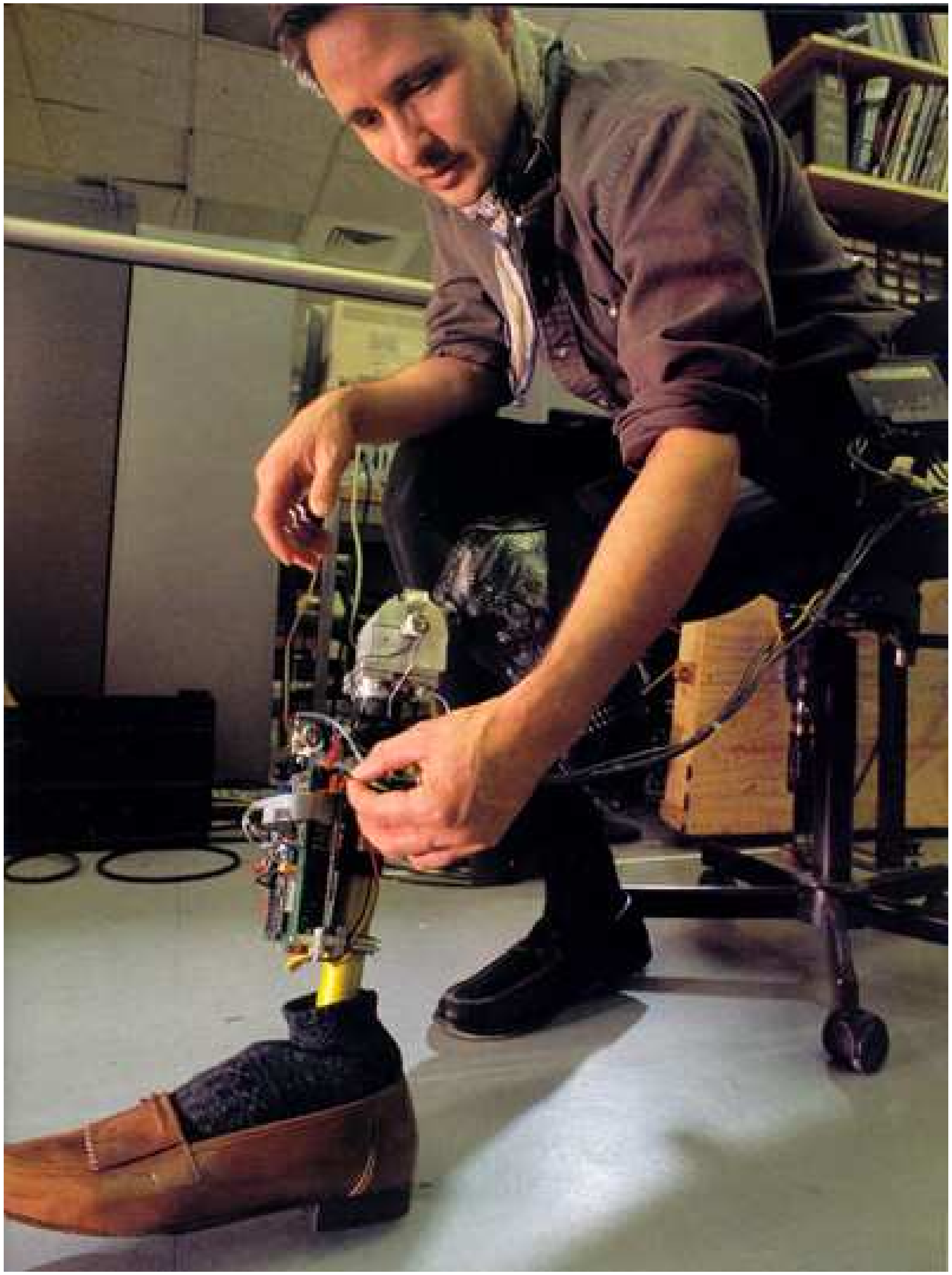

RANGE FINDER
PRIMARY CAMERA
SEARCH LIGHT
MOTION DETECTION SENSOR
PRIMARY DISPLAY
MIC

Wearable Computing

Intelligent Prosthetics

Hugh Herr
MIT Leg Lab

picture from
Robosapiens



What are Some of the Challenges to Designing Embedded Systems?

- How to use sensors to extract the important information out of the environment?
- How to affect the environment through "actuation"?
- How to connect the two?
    - Communication
    - Robustness
    - Power
    - Sensor interfaces
    - Noise
    - ...

Class Goals

To understand ...

- Some of the theory behind the design of embedded systems
- Practical issues in the design and implementation of embedded systems
- Some of the current research issues

To be creative and have fun.

Pervasive and Ubiquitous Computing

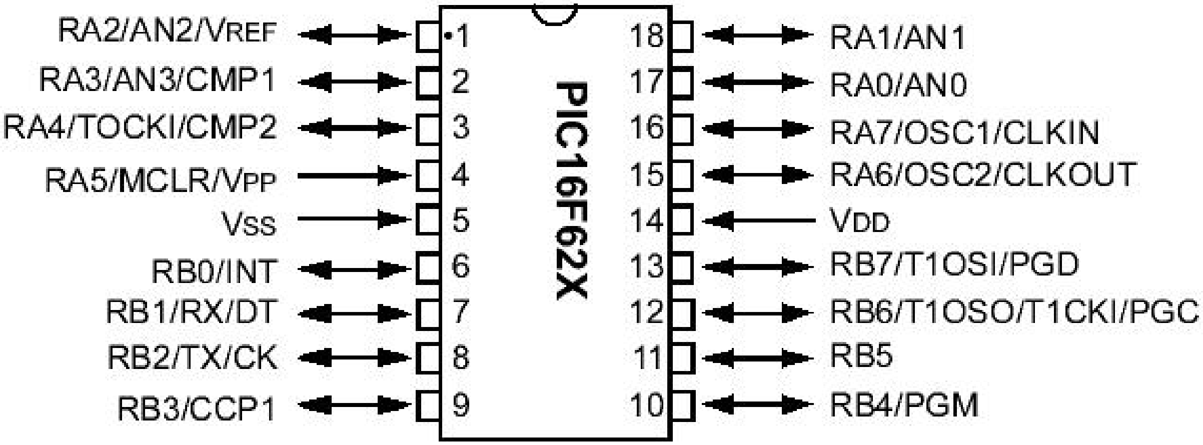
- Computing disappears into our environments and our clothing
- Computing and sensing everywhere
- Separation of the interface from the data. Allows a user to access her data:
  - From anywhere
  - Using whatever interface is currently available

Class Project:
Building an Interactive Room

- Ambient Interfaces:
  - Getting away from standard computer interfaces (keyboards, mice, and screens)
  - Embedding interfaces into objects in the world and into the room itself
  - Subtle presentation of information
- Proactive/automatic behavior
  - How to map what is sensed into how the room responds
  - Potential for learning custom behavior for different users

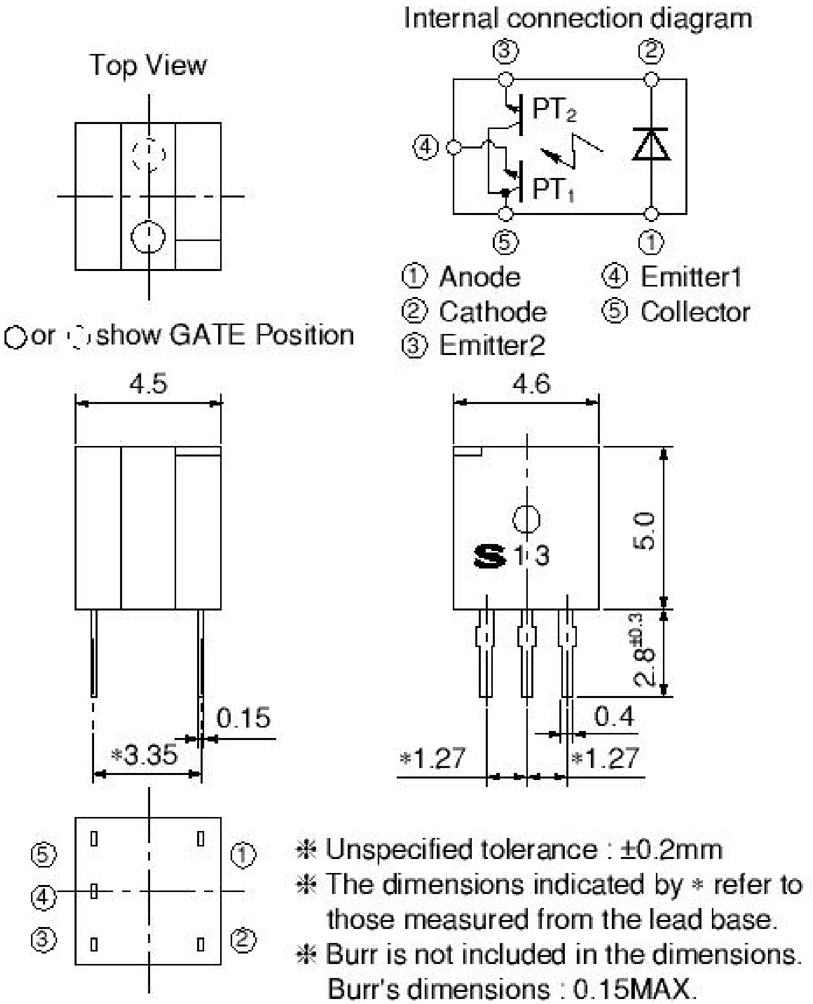
Our Computing Environment

- 2 linux boxes (probably more to come)
- Microchip 16F628 (start with 25 processors)
- Microchip 16F876 (start with 25)


RA2/AN2/VREF
RA3/AN3/CMP1
RA4/TOCKI/CMP2
RA5/MCLR/VPP
VSS
RB0/INT
RB1/RX/DT
RB2/TX/CK
RB3/CCP1
1
2
3
4
5
6
7
8
9
PIC16F62X
18
17
16
15
14
13
12
11
10
RA1/AN1
RA0/AN0
RA7/OSC1/CLKIN
RA6/OSC2/CLKOUT
VDD
RB7/T1OSI/PGD
RB6/T1OSO/T1CKI/PGC
RB5
RB4/PGM

Some Sensors

- Tilt
- Vibration
- Distance
- Microswitches and keypads
- Force
- Light
- Heat


Internal connection diagram
③
②
④
PT₂
PT₁
⑤
①
① Anode
② Cathode
③ Emitter2
④ Emitter1
⑤ Collector
Top View
○or ◌ show GATE Position
4.5
4.6
5.0
2.8±0.3
0.15
*3.35
0.4
*1.27
*1.27
S 13
⑤
④
③
①
②

⁜ Unspecified tolerance : ±0.2mm
⁜ The dimensions indicated by * refer to those measured from the lead base.
⁜ Burr is not included in the dimensions. Burr's dimensions : 0.15MAX.

Some “Actuators”

- LEDs (light emitting diodes)
- IRED LEDs
- Microservos
- MP3/OGG player
- Voice synthesis system
- Light control (X10)

Preliminaries

- Familiarity with unix (linux, in particular)
- Some level of comfort with C (either now or very soon)
  - Adapting from java will be straightforward (mostly)
- Able to pace yourself

Text Books

- *Designing Embedded Hardware*, John Catsoulis, O'Reilly, 2003
- *Design with PIC Microcontrollers*, John B. Peatman, Prentice Hall, 1997

Neither available in the bookstore
Peatman is out of print

Grading

- Final Exam (20%)
- Project work (50%)
- A small number of homework assignments and pop quizzes (20%)
- Participation: class (5%) and lab (5%)

Project Work

- Milestones: demonstration of some key concept that we have studied in class
- Widgets: miniature projects that will become a component in our interactive room

Milestones

- Total of 6 throughout the semester
- Must be demonstrated in groups no larger than two students
- Deadlines are absolute: failing to demonstrate a milestone will incur a 5-point penalty

Widgets

- Of your own design
- Some will meet milestones
- Any number of participants may contribute to a widget (except for those that satisfy milestones)
- When you demonstrate a widget, it will be awarded points based on:
  - Difficulty
  - Quality of work
  - Creativity/applicability

Widgets (cont)

- Points will be split between participants
- Widgets may be constructed/demonstrated in steps (best to do things this way)
  - Points will be awarded based on the increment in functionality

Possible Widgets Include...

- Light “globes” with controllable color
- Detect when people enter the room and respond by turning on lights and music
- Select lighting and music effects by gesturing or through an EMG interface
- Keyboards embedded into your clothing
- Tracking a subject as they move through the room
- Wirelessly transmitting data
- Wireless communication through your skin

Standards and Base Code

- Our interactive room is ultimately a collaborative project
- We will need communication and interface standards to pull all of the pieces together
- Students who contribute to the creation of these standards (and the common base code) can receive widget points for their efforts

“ Intellectual Property”

- Components of a widget (except those that directly satisfy a milestone) may be shared with other class members (e.g., code or circuit designs)
- The IP owner may ask for a small payment in points (1 or 2 points, to be specific)
- IP history must be tracked and acknowledged when performing a demo

“ Industrial Espionage”

- Definition: obtaining IP without consent.
- This is considered cheating!

Cheating

- Downloading code or homework answers off of the net
- Obtaining milestone code from classmates (except your one partner)
- Industrial espionage

Not Cheating

- Discussing homework or milestone code with your classmates
- Deriving inspiration from the net

- When in doubt: ask

Hand-In Policies

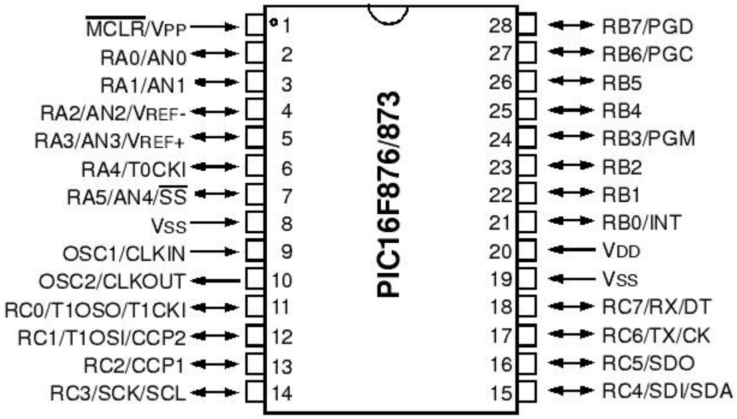
- Late homework will not be counted
- Late milestones will incur a 5-point penalty

Class Resources

- Web page:
  - www-anw.cs.umass.edu/~fagg/classes/503
- Wiki: a remotely editable web page
  - The TWikiGuest password is ...
- Newsgroup:
  - nntp://news.oit.umass.edu/cmpsci.edlab.cs503
  - On-campus access only
- The Lab...

Embedded Systems Lab Space

- LGRT T 212/214
- Anyone may work in the lab while it is open
  - Official lab times: M/W/F 12:20 – 1:10
  - All TA and instructor office hours (still TBD)
- Once we get started on widgets, you should try to spend 7-8 hours/week in the lab (really)


PIC16F876/873
MCLR/VPP 1
RA0/AN0 2
RA1/AN1 3
RA2/AN2/VREF- 4
RA3/AN3/VREF+ 5
RA4/T0CKI 6
RA5/AN4/SS 7
VSS 8
OSC1/CLKIN 9
OSC2/CLKOUT 10
RC0/T1OSO/T1CKI 11
RC1/T1OSI/CCP2 12
RC2/CCP1 13
RC3/SCK/SCL 14
28 RB7/PGD
27 RB6/PGC
26 RB5
25 RB4
24 RB3/PGM
23 RB2
22 RB1
21 RB0/INT
20 VDD
19 VSS
18 RC7/RX/DT
17 RC6/TX/CK
16 RC5/SDO
15 RC4/SDI/SDA

What is in the Lab?

- 2 linux-based computers (configured as standard EdLab machines)
  - Each is equipped with a microprocessor programmer
  - More computers may appear later in the semester
- A large set of tools
- Many components for building widgets
  - We plan to be ordering components throughout the semester: ask if you want something specific
  - If you bring in your own components, they must first be cleared with me

Lab Policies
(details on the web site)

- No food or drink
- Clean up after yourself
- Be courteous
- Eye protection must be worn while soldering
- No lab supplies or books leave the room
- Do not handle the projects of other students without permission

Lab Policies (cont)

- Do not play with the AC outlets
- Clear guests with the monitor
- If you break something: report it
- Check your wiring before you power up
- Do not pull chips out of circuit boards with your fingers (really)

Lab Next Week

- Lab procedure: “how not to poke your eye out with the soldering iron”
- You may attend any lab session
  - M/W/F 12:20-1:10
- You must attend one

Next Lecture:
Ubiquitous and Pervasive Computing

- Reading (see the Wiki):
  - *The Human Experience:* Abowd *et al.*
  - *Living laboratories: The future computing environments group at the Georgia Institute of Technology:* Abowd *et al.*

First Friday Event

- CS 150 at 3:30 (tomorrow)
- Topics
  - Curriculum information
  - Fall events
  - Jobs/Co-ops/Research positions for Fall
  - Library Carrels