CpE 213
Digital Systems Design
Hardware Review

Lecture 3

Friday 8/26/2005

UNIVERSITY OF MISSOURI-ROLLA

The Name. The Degree. The Difference.

Overview

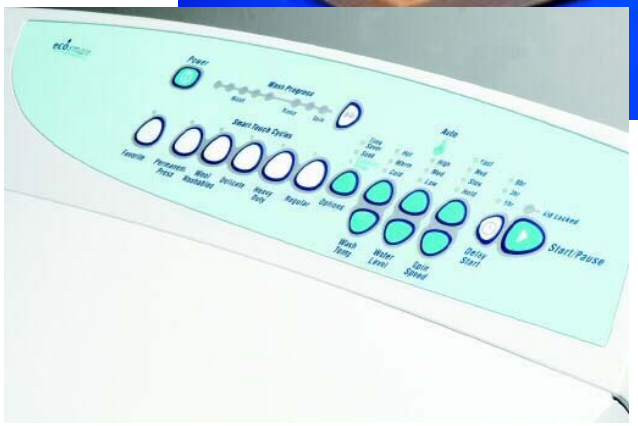
- Announcements
- Application: washing machine
- Logic review
- Memory

Announcements

- Homework 1 is due on Friday 9/2.
- Picture deadline is Friday 9/2.
- Group deadline is Friday 9/2.
  - Please form groups of three students.

Application du jour

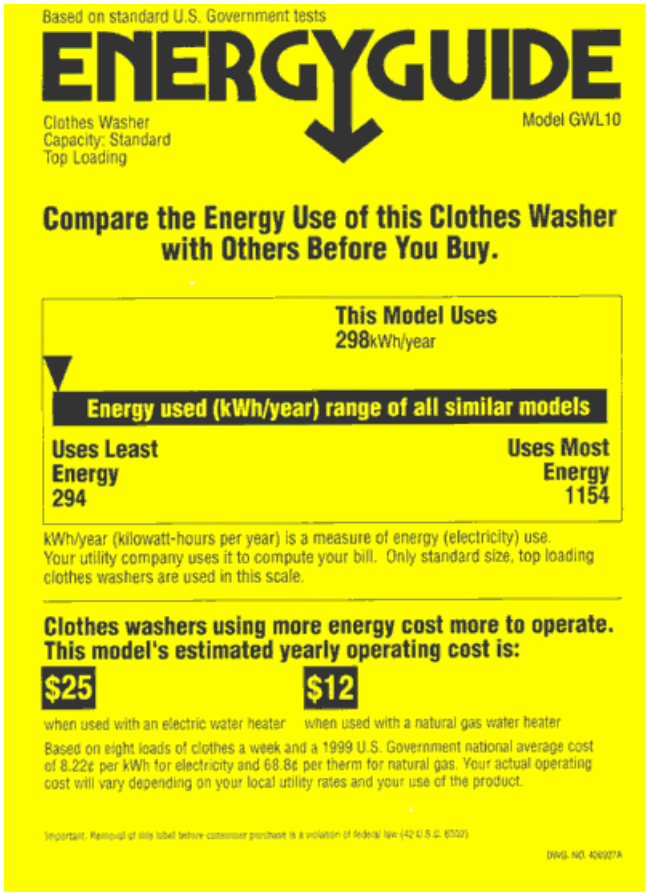
GWL11 Ecosmart Washer



Fisher&Paykel
innovative living

- Brushless DC magnetic motor is directly connected to the agitator by a single stainless steel shaft.
- Agitator is directly in contact with electronics.
- Incorporates no belts, pulleys, or transmission, which are the first things to wear down and break in a conventional washer.
- Parts that aren't there can't fail.

Benefits of electronic controls


Based on standard U.S. Government tests

ENERGYGUIDE

Clothes Washer
Capacity: Standard
Top Loading

Model GWL10

Compare the Energy Use of this Clothes Washer with Others Before You Buy.

This Model Uses
298kWh/year

Energy used (kWh/year) range of all similar models

Uses Least Energy	Uses Most Energy
294	1154

kWh/year (kilowatt-hours per year) is a measure of energy (electricity) use. Your utility company uses it to compute your bill. Only standard size, top loading clothes washers are used in this scale.

Clothes washers using more energy cost more to operate. This model's estimated yearly operating cost is:

$25 when used with an electric water heater

$12 when used with a natural gas water heater

Based on eight loads of clothes a week and a 1999 U.S. Government national average cost of 8.22¢ per kWh for electricity and 68.8¢ per therm for natural gas. Your actual operating cost will vary depending on your local utility rates and your use of the product.

Important: Removal of this label before consumer purchase is a violation of federal law (42 U.S.C. 6302).

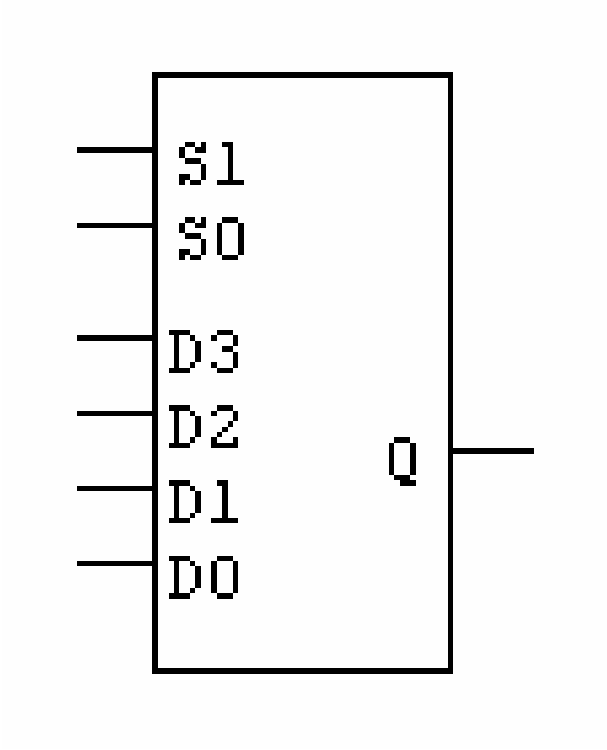
DWG. NO. 406927A

- Intelligent auto-water sensing uses only the amount of water needed for each individual load.
- Accurately controlled water temperatures ensure optimum wash performance.
- Delay start allows you to effortlessly wash during off-peak energy hours.
- Automatically balances the load.

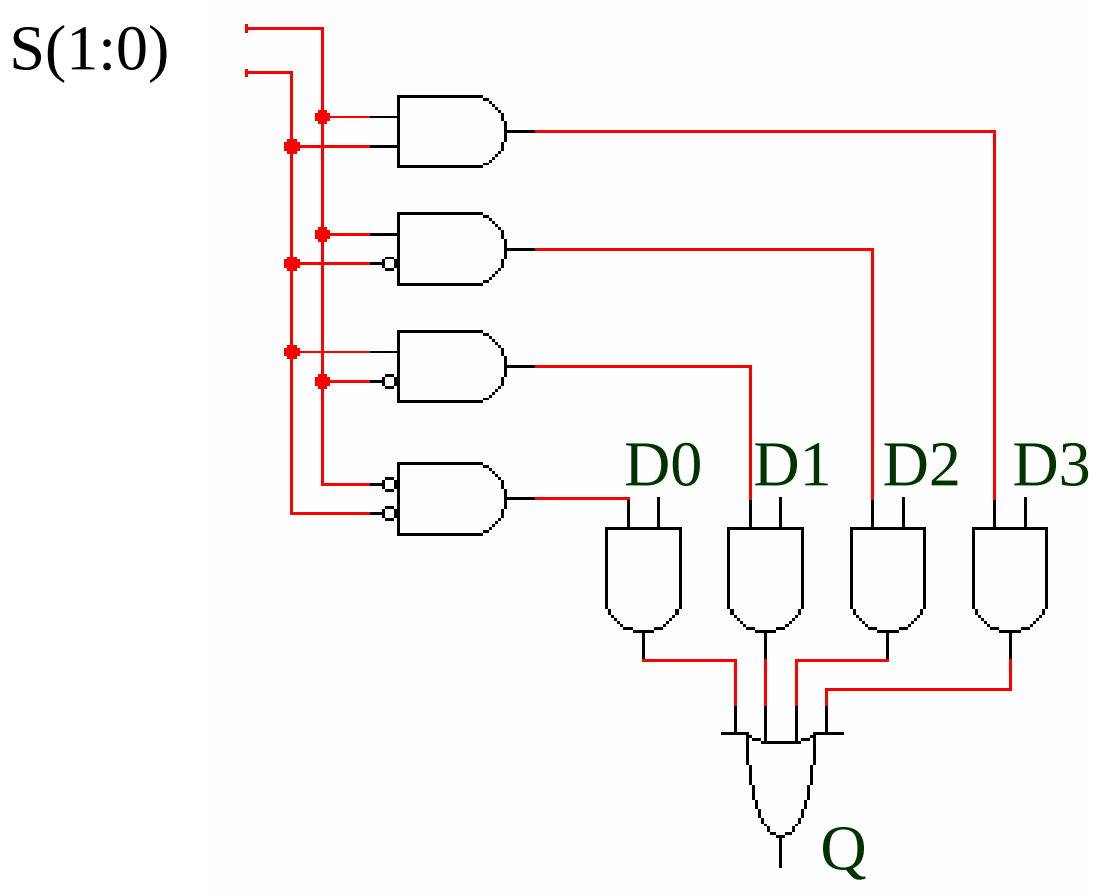
Review of Digital Logic

Hardware review

- What is it?
- What is it used for?

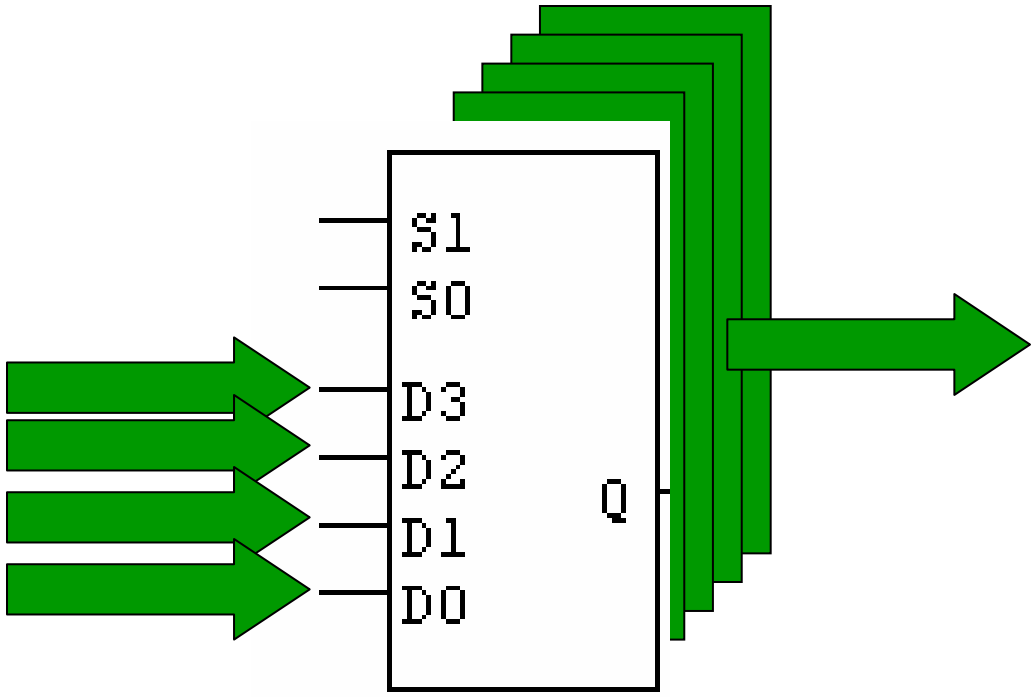


Mux = decoder + selector

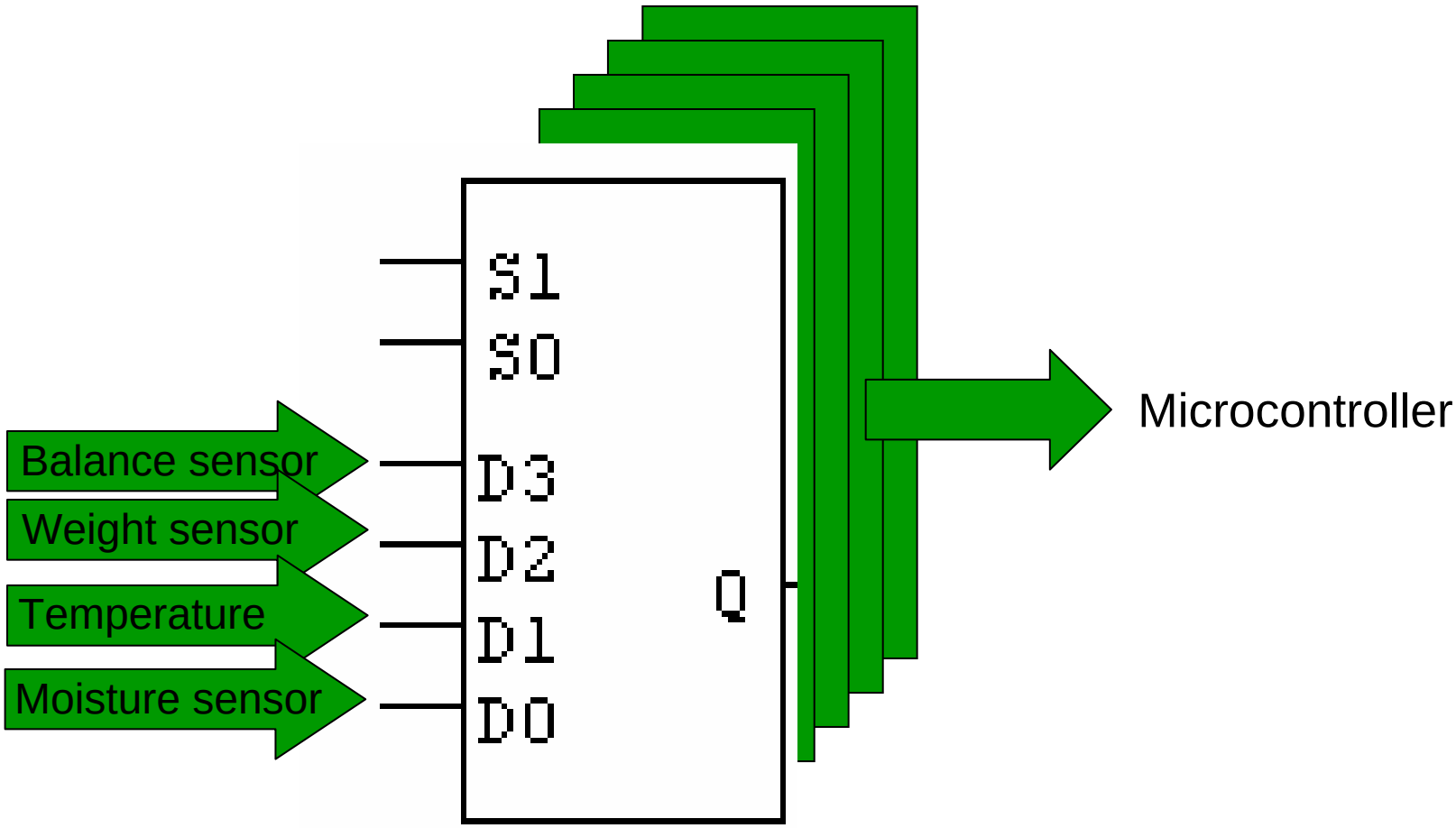


Bus = 3-dimensional mux

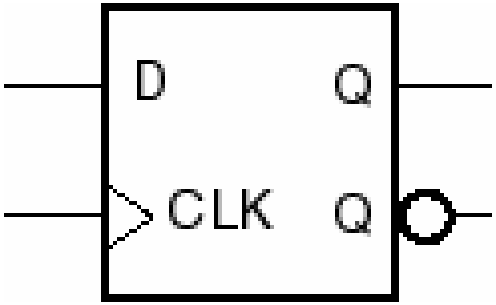
- Stack 8 muxes to get an 8 bit bus



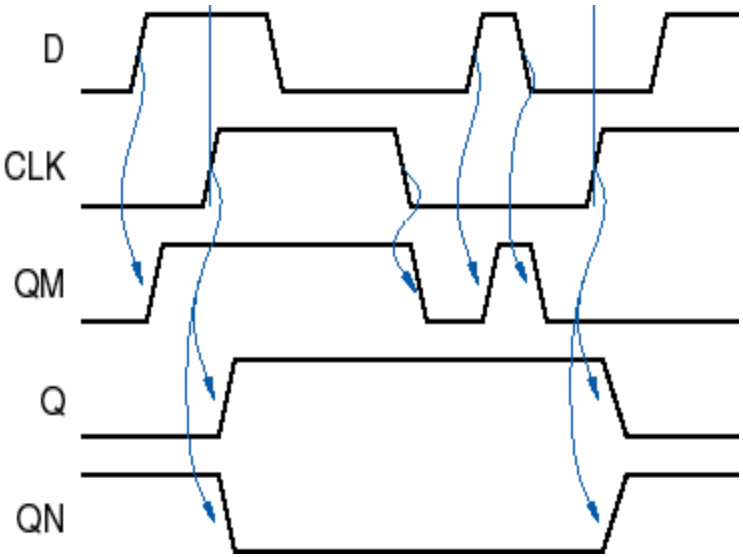
Washing machine example



D flip-flop

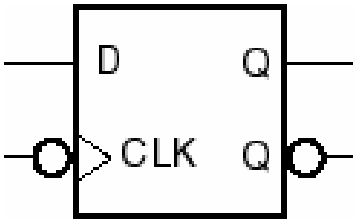


operation

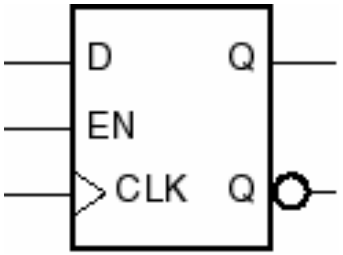


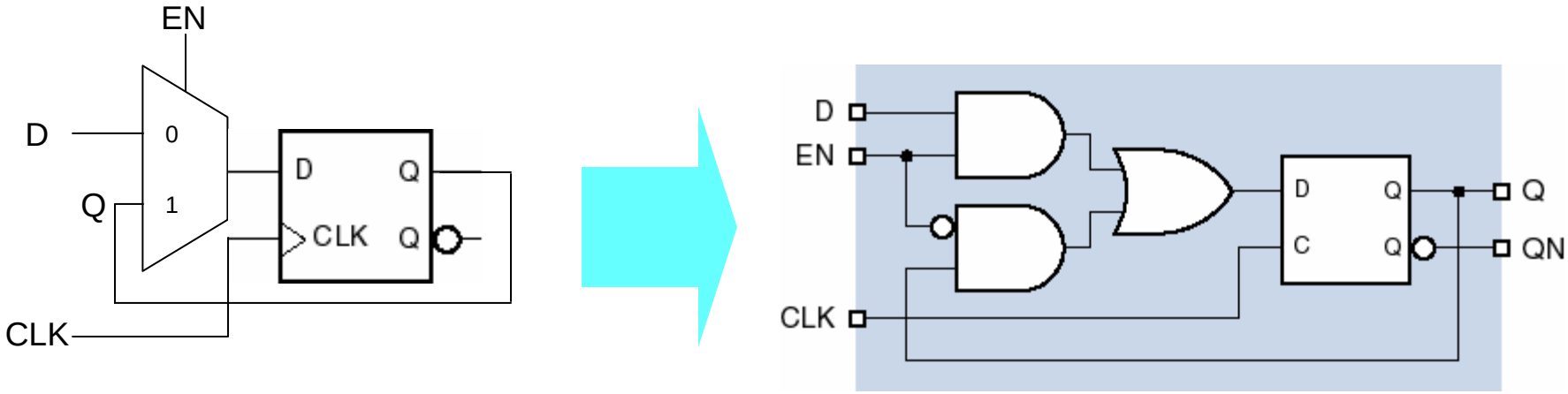
D flip-flop variations

- negative-edge triggered



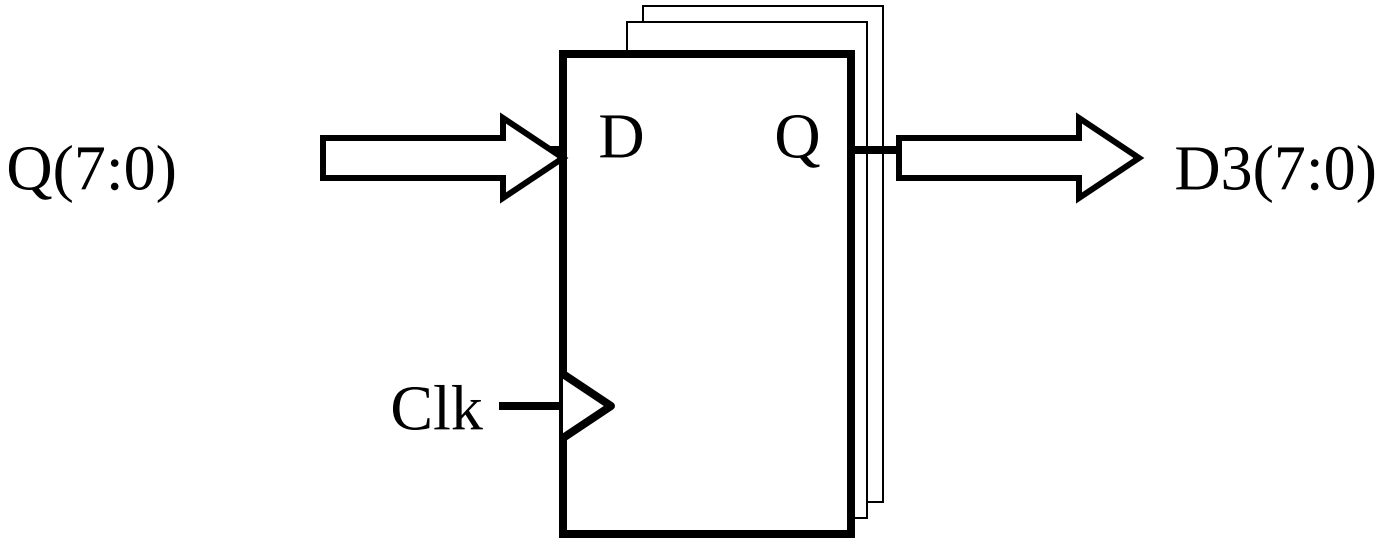
- clock enable: if enable is not 1, retain old value of output
  - how: feed Q back into the D-input



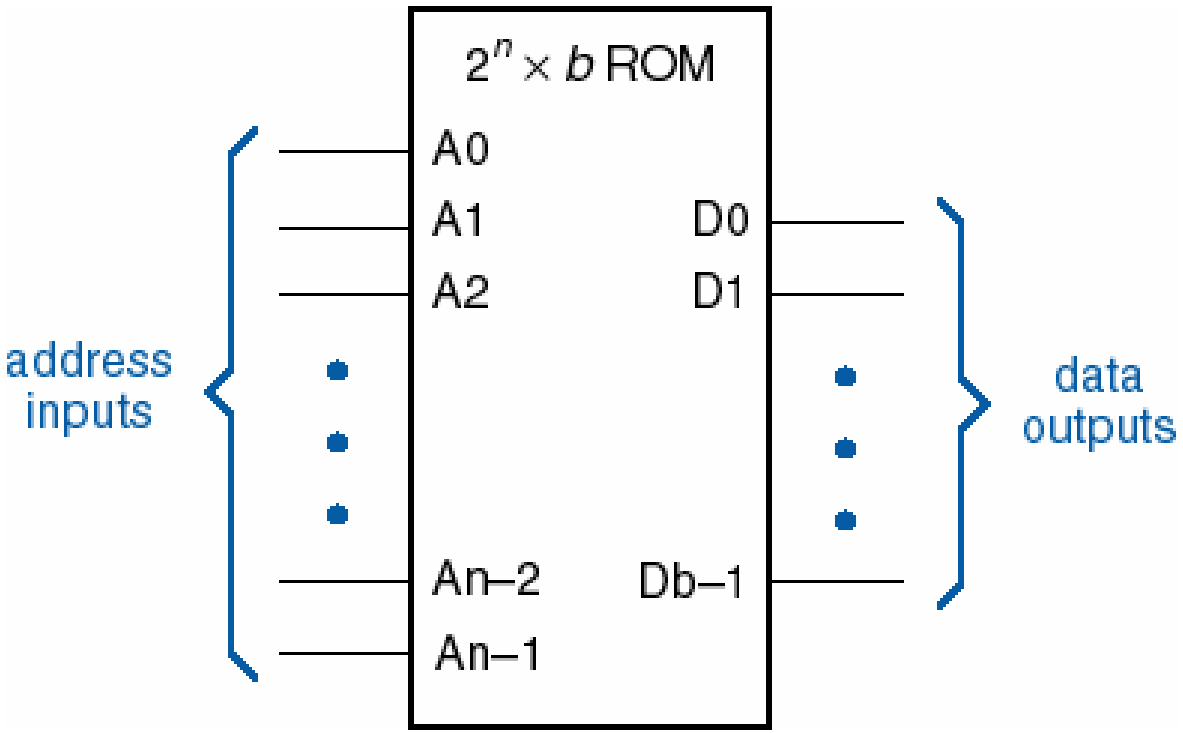


3D flip-flops = register

- Stack 8 flip flops to get 8 bit data register
- Strobe Clk to get D3 = Q;



Read Only Memory (ROM)



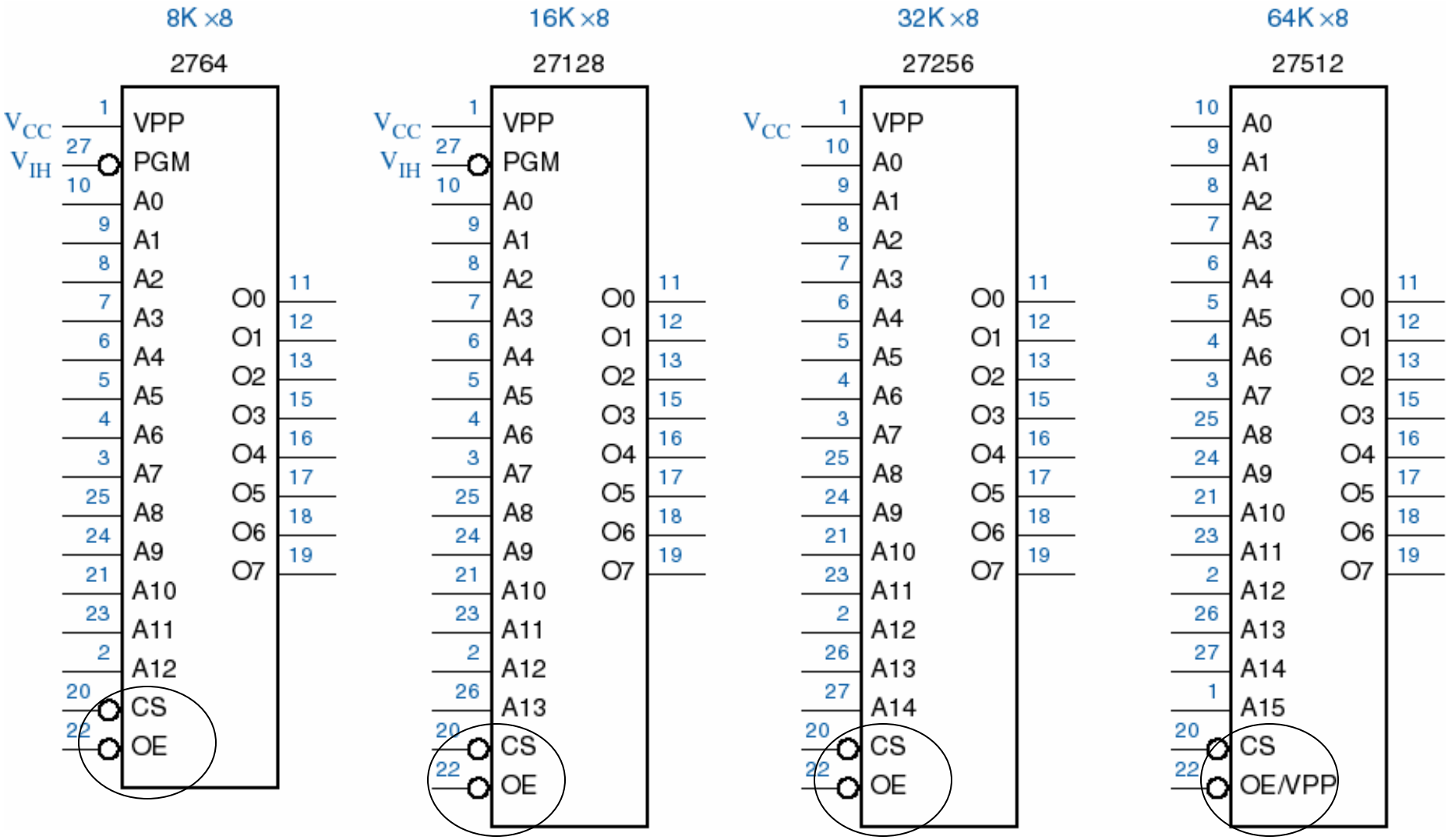
Types of ROM

- programming the ROM = storing the desired information in ROM
- different ROM kinds based on how programming is done
  - ROM
    - customer gives the supplier specs of ROM, comes back 4 weeks later to get the chip (usually ordered in 100s)
  - ROM
    - customer buys PROM and a PROM programmer kit, and programs ROM at home within a few minutes
  - PROM
    - a PROM that can be programmed, erased (all at once), reprogrammed,…
    - Fast reads: (ns)
  - PROM
    - a PROM that can be programmed, erased (individual bits), reprogrammed,…
    - also called “flash memory”
    - slow writes (ms), normal reads (ns)

Applications of EEPROMs

- used in digital cameras, USB drives
- used in CD players, for memorizing current volume, track, and other parameters
  - when CD player is unplugged from power source, these parameters are preserved in EEPROM
  - context restored when plugged back in (starts the song from where it was stopped with same volume and other settings)

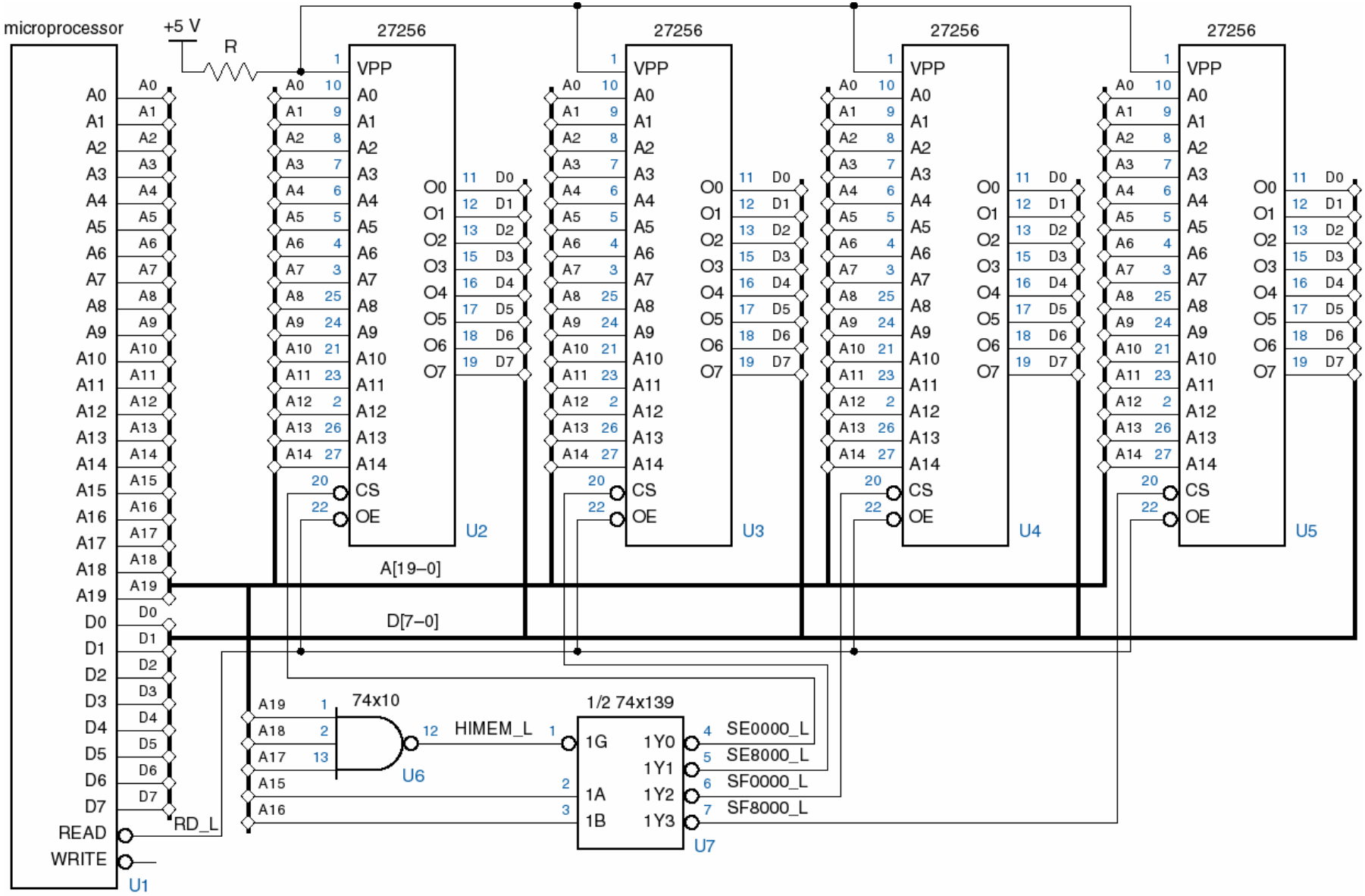
Typical Commercial EPROMs



uP ROM application

- a given uP has a 20-bit address bus
  -
- we want the top 128K locations to be 128K bytes of a ROM
  - the remaining would be RAM and I/O devices
- we have only 27256 ROM chips, each being 32K x 8
- how do we hook up the address bus to ROM chips?
- how many chunks of 128K do we have in a 1M “address space”?
  -
- how do we know when uP is accessing which chunks?
  -
- how many address bits we need to access 128K of ROM?
  -
- a 27256 ROM chip has 32K locations, which must be addressed by how many address bits?
  -

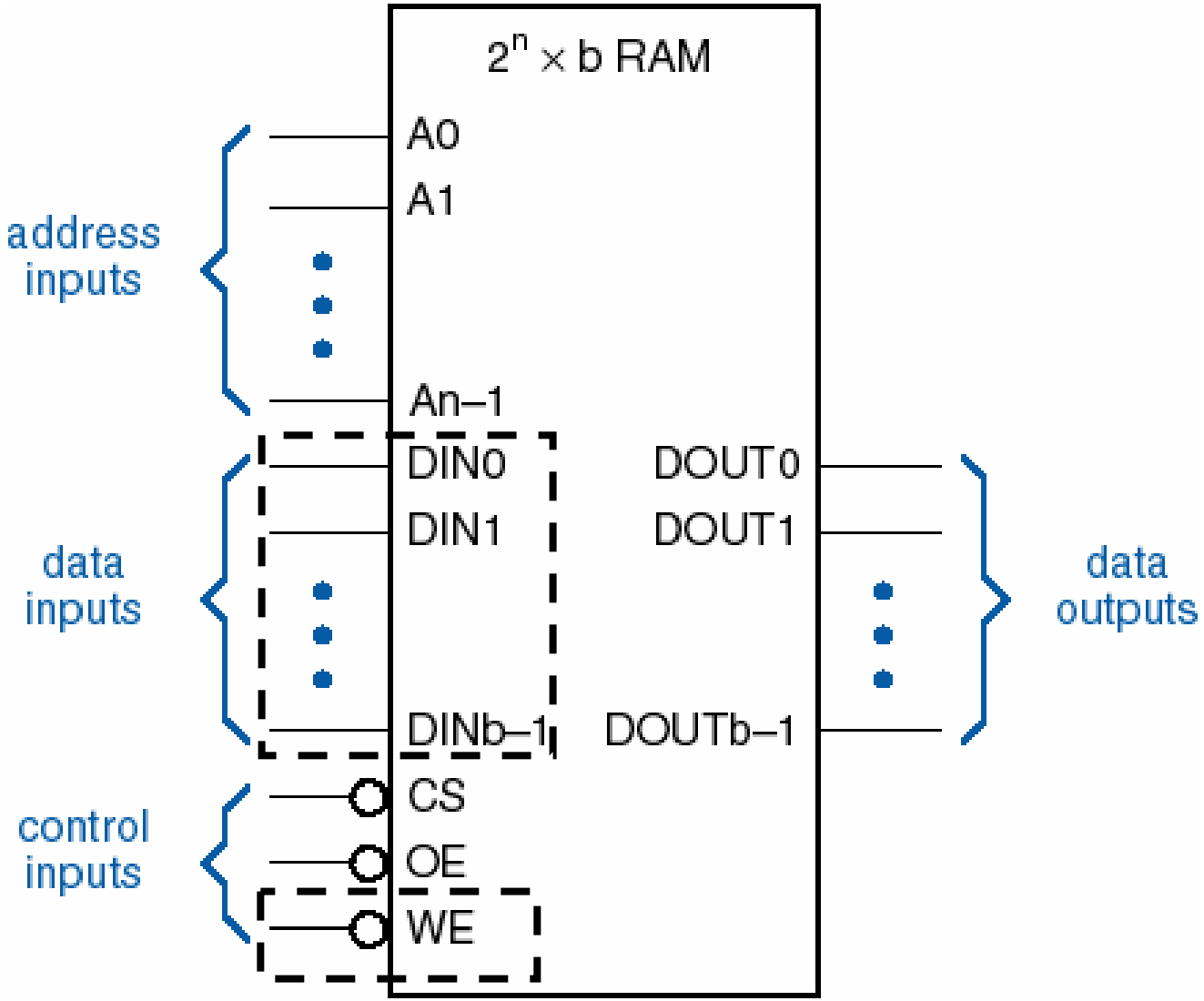
Microprocessor ROM Connections



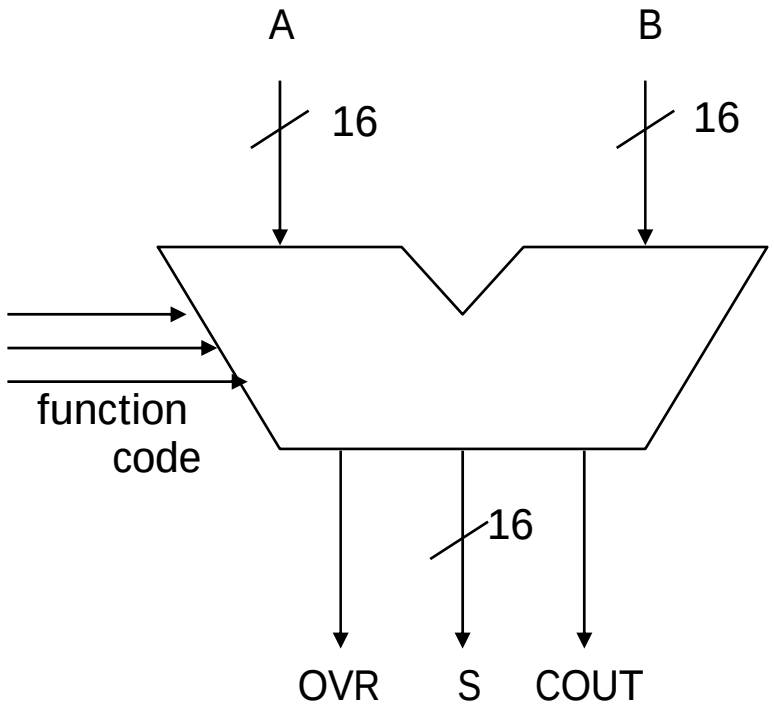
Read/write memory

- a.k.a. “RAM” (Random Access Memory)
  - time to access a bit is same for all bits
    - is tape a random access memory?
    - is ROM a random access memory?
- volatility
  - most RAMs lose their memory when power is removed
  - NVRAM =
- SRAM (Static RAM)
  - memory built from
  - six transistors per bit
- DRAM (Dynamic Memory)
  - one transistor per bit, not based on latches but on capacitors
  - memory lasts only for a few milliseconds
  - must “refresh” locations by reading or writing

SRAM


$2^n \times b$ RAM
A0
A1
An–1
address inputs
DIN0
DIN1
DINb–1
data inputs
DOUT0
DOUT1
DOUTb–1
data outputs
CS
OE
WE
control inputs

Arithmetic/Logic Unit (ALU)



Slide adapted from Dr. John Wawrzynek.

General Memory Characteristics

- Registers
  -
  -
  -
  -
  -
- RAM
  -
  -
    -
  -
  -
- ROM
  -
  -
  -

For Monday

- Review today's lecture notes and textbook.
- Begin Assignment 1.
- Print lecture notes for Lecture 4.
- Come to my office and have your picture taken for bonus 5%.
- Email me names of your group members (one email per group).