CS 341
Computer Architecture and Organization

Lecturer: Bob Wilson

Welcome to CS341

- This course teaches computer architecture and organization from the embedded system POV
- Textbooks are:
  - Professional Assembly Language
  - Shaum's Outline Series, Digital Principles
- The course syllabus is on my CS341 website: www.cs.umb.edu/~bobw/CS341/index.html
- Go over syllabus

Getting Started

- Linux Account
  - Apply for CS341 ASAP! (Science 3rd Floor Linux/PC Lab)
  - Upload mp files from your tutor-vserver VM for grading
  - Don't use chown, chgrp, or chmod on any of your mp directories or files! That could enable cheating.
- Remote Internet access from your own PC
  - Use Secure Shell 2 or putty for secure remote access
  - Login into "users.cs.umb.edu" with Linux ID and password
- Remote Internet access from your tutor-vserver VM
  - Use SCP to download starting mp files
  - Use SCP to upload finished mp files

Homework

- Familiarize yourself with the course syllabus
- Locate and start reading course references:
  - Web Based / Linked from syllabus web page
- First reading assignment:
  - Professional Assembly Language Programming, pp 1-16)
  - Familiarize yourself with my CS341 site linked references
- Read the instructions on the syllabus for installing the VMWare tutor environment on your own PC

Textbook Commentary

- This textbook is one of the few books that uses the GNU (aka ATT) syntax for i386 assembly language instructions
- We'll be using the GNU syntax in this course
- Most other books (e.g. the previous textbook) require learning and using a translation for the syntax which was always a pain to deal with
- However, it has a couple disadvantages

Textbook Commentary

- The textbook teaches Intel i386 assembly language programming and development tools from the point of view where the code is being run on the Linux O/S where it is being developed
- The text material on the development tools must be adapted for cross compilation and cross assembly to run under Tutor which is simulating an embedded system

Textbook Commentary

- The book assumes that you will write your assembly language programs to run on the development host with a Linux O/S
- It shows you how to use Linux system calls for I/O operations that we will not be using
- We will run our assembly language programs on an embedded system virtual machine under Tutor – not Linux
- We need to use direct I/O instructions (e.g. `in` and `out`) that are not covered in the book

Embedded Systems

- Embedded processors are inside a system that is not usually thought of as a computer
- There are many more processors in embedded systems than there are in IT applications such as laptops, desktops and servers (99% / 1%)
- There are complex challenges for embedded system programming and these programmers need specialized knowledge and are well-paid

Embedded Systems

- Examples:
  - Automobile engine controls, GPS systems, etc.
  - Appliances such as microwave ovens, TVs, etc.
  - Manufacturing plants / robotic machines
  - Chemical and petroleum plants - control systems
  - Aircraft/Ships/Rockets - guidance and control
  - Building HVAC, elevator, and security systems
  - Communications – routers, switches, and modems
  - Medical instrumentation and implanted devices

Embedded Systems

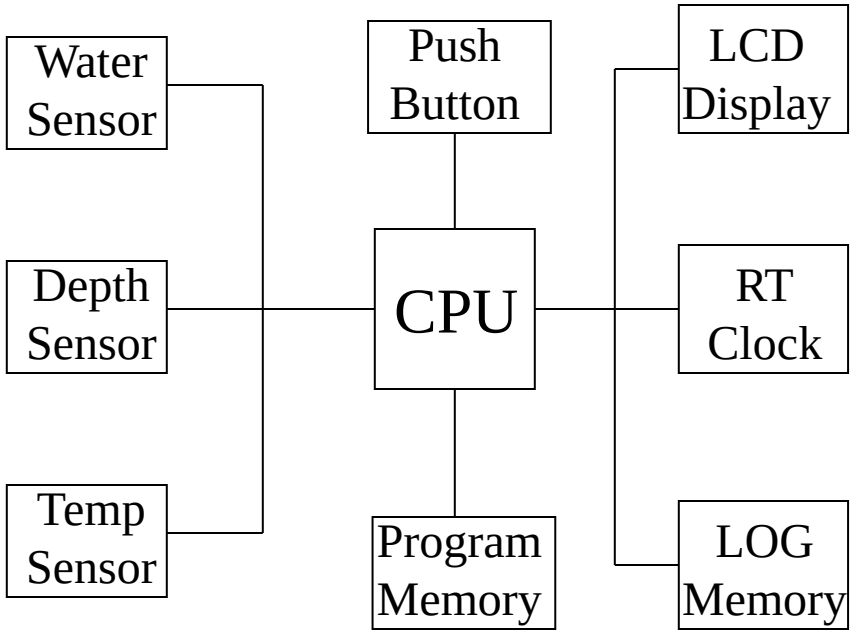
- Considerations for embedded system software
  - The processors are NOT powerful Pentiums with Gigabytes of memory / disk and Gigabit networks
  - Code/data space and bandwidth are critical resources
  - Cost may be critical for high volume products
  - There may be hard real time constraints so the SW efficiency and timing are usually critical factors
  - The cost of a bug in the SW may include injury or death for a person or even worse many people

Embedded System Example

SCUBA Diving "Computer"

Embedded System Example

SCUBA Diving Computer Block Diagram

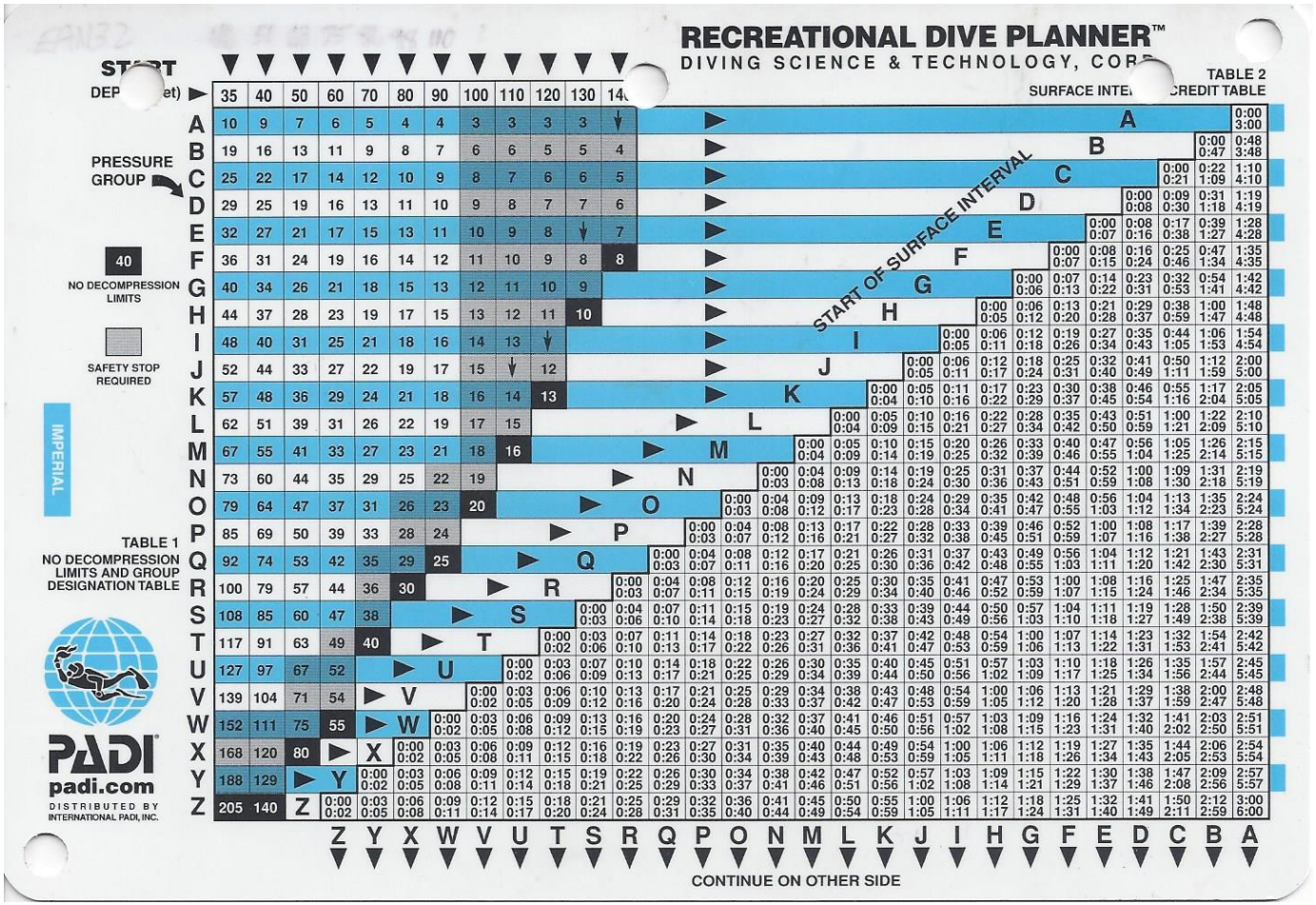


Embedded System Example

- Diving Computer Software Functionality
  - Automatically turn on when in the water
  - Track/display times and depths during the dive
  - Calculate the amount of Nitrogen absorbed
  - Display the safe remaining dive time (to avoid DCS)
  - Pace the diver's ascent, e.g. deco/safety stops
  - Record dive data in non-volatile log memory
  - Keep track of surface interval before next dive
  - Keep track of safe time before flying

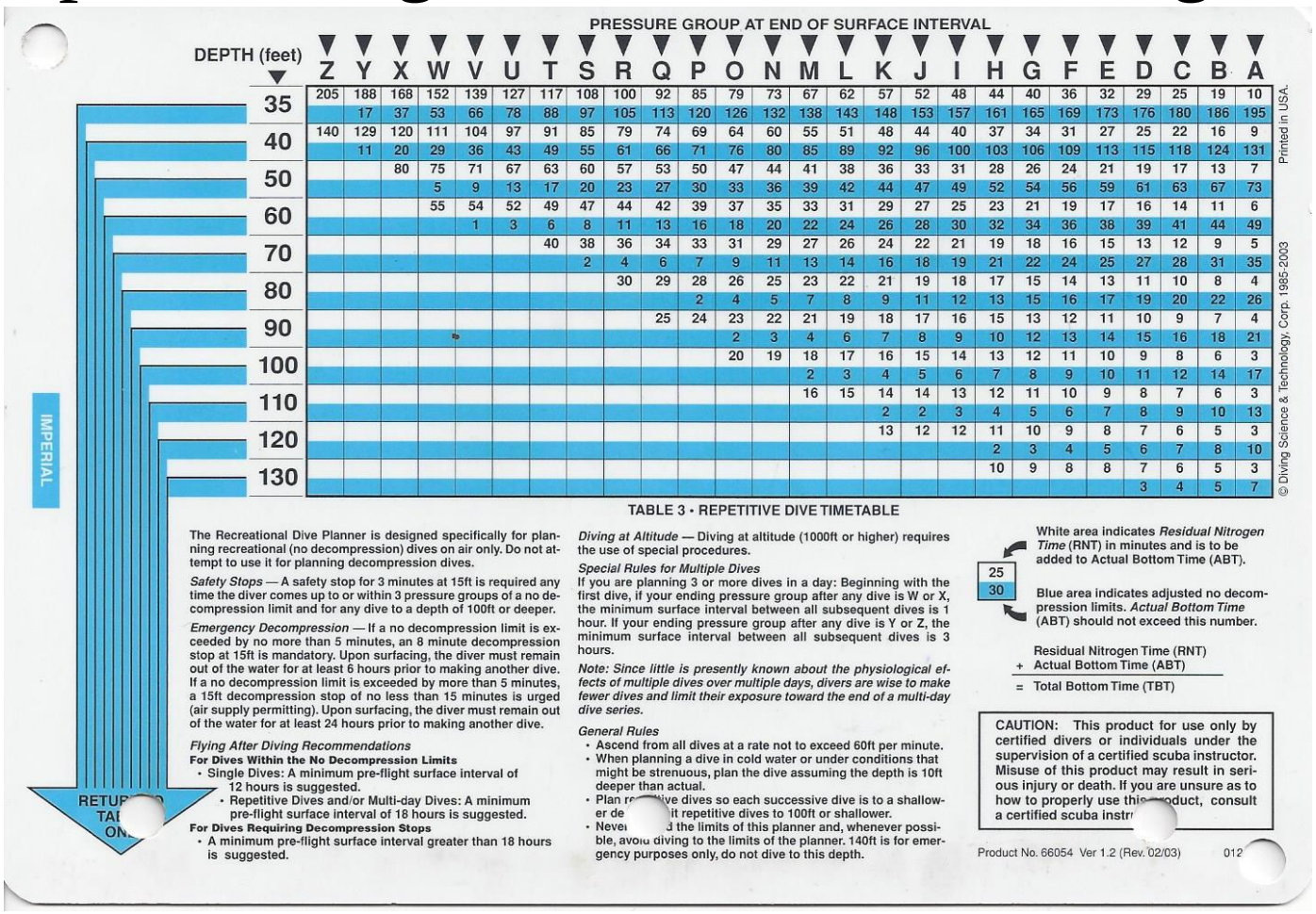
Embedded System Example

- Implement algorithms based on diving tables



Embedded System Example

- Implement algorithms based on diving tables



PRESSURE GROUP AT END OF SURFACE INTERVAL

DEPTH (feet)	Z	Y	X	W	V	U	T	S	R	Q	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
35	205	188	168	152	139	127	117	108	100	92	85	79	73	67	62	57	52	48	44	40	36	32	29	25	19	10
		17	37	53	66	78	88	97	105	113	120	126	132	138	143	148	153	157	161	165	169	173	176	180	186	195
40	140	129	120	111	104	97	91	85	79	74	69	64	60	55	51	48	44	40	37	34	31	27	25	22	16	9
		11	20	29	36	43	49	55	61	66	71	76	80	85	89	92	96	100	103	106	109	113	115	118	124	131
50			80	75	71	67	63	60	57	53	50	47	44	41	38	36	33	31	28	26	24	21	19	17	13	7
				5	9	13	17	20	23	27	30	33	36	39	42	44	47	49	52	54	56	59	61	63	67	73
60				55	54	52	49	47	44	42	39	37	35	33	31	29	27	25	23	21	19	17	16	14	11	6
					1	3	6	8	11	13	16	18	20	22	24	26	28	30	32	34	36	38	39	41	44	49
70							40	38	36	34	33	31	29	27	26	24	22	21	19	18	16	15	13	12	9	5
								2	4	6	7	9	11	13	14	16	18	19	21	22	24	25	27	28	31	35
80									30	29	28	26	25	23	22	21	19	18	17	15	14	13	11	10	8	4
											2	4	5	7	8	9	11	12	13	15	16	17	19	20	22	26
90										25	24	23	22	21	19	18	17	16	15	13	12	11	10	9	7	4
												2	3	4	6	7	8	9	10	12	13	14	15	16	18	21
100												20	19	18	17	16	15	14	13	12	11	10	9	8	6	3
														2	3	4	5	6	7	8	9	10	11	12	14	17
110														16	15	14	14	13	12	11	10	9	8	7	6	3
																2	2	3	4	5	6	7	8	9	10	13
120																13	12	12	11	10	9	8	7	6	5	3
																			2	3	4	5	6	7	8	10
130																			10	9	8	8	7	6	5	3
																							3	4	5	7

IMPERIAL

RETURN TABLE ON

TABLE 3 • REPETITIVE DIVE TIMETABLE

The Recreational Dive Planner is designed specifically for planning recreational (no decompression) dives on air only. Do not attempt to use it for planning decompression dives.

Safety Stops — A safety stop for 3 minutes at 15ft is required any time the diver comes up to or within 3 pressure groups of a no decompression limit and for any dive to a depth of 100ft or deeper.

Emergency Decompression — If a no decompression limit is exceeded by no more than 5 minutes, an 8 minute decompression stop at 15ft is mandatory. Upon surfacing, the diver must remain out of the water for at least 6 hours prior to making another dive. If a no decompression limit is exceeded by more than 5 minutes, a 15ft decompression stop of no less than 15 minutes is urged (air supply permitting). Upon surfacing, the diver must remain out of the water for at least 24 hours prior to making another dive.

Flying After Diving Recommendations

For Dives Within the No Decompression Limits

- Single Dives: A minimum pre-flight surface interval of 12 hours is suggested.
- Repetitive Dives and/or Multi-day Dives: A minimum pre-flight surface interval of 18 hours is suggested.

For Dives Requiring Decompression Stops

- A minimum pre-flight surface interval greater than 18 hours is suggested.

Diving at Altitude — Diving at altitude (1000ft or higher) requires the use of special procedures.

Special Rules for Multiple Dives

If you are planning 3 or more dives in a day: Beginning with the first dive, if your ending pressure group after any dive is W or X, the minimum surface interval between all subsequent dives is 1 hour. If your ending pressure group after any dive is Y or Z, the minimum surface interval between all subsequent dives is 3 hours.

Note: Since little is presently known about the physiological effects of multiple dives over multiple days, divers are wise to make fewer dives and limit their exposure toward the end of a multi-day dive series.

General Rules

- Ascend from all dives at a rate not to exceed 60ft per minute.
- When planning a dive in cold water or under conditions that might be strenuous, plan the dive assuming the depth is 10ft deeper than actual.
- Plan repetitive dives so each successive dive is to a shallower depth limit repetitive dives to 100ft or shallower.
- Never exceed the limits of this planner and, whenever possible, avoid diving to the limits of the planner. 140ft is for emergency purposes only, do not dive to this depth.

25
30

White area indicates *Residual Nitrogen Time* (RNT) in minutes and is to be added to Actual Bottom Time (ABT).

Blue area indicates adjusted no decompression limits. *Actual Bottom Time* (ABT) should not exceed this number.

Residual Nitrogen Time (RNT)
\+ Actual Bottom Time (ABT)
= Total Bottom Time (TBT)

CAUTION: This product for use only by certified divers or individuals under the supervision of a certified scuba instructor. Misuse of this product may result in serious injury or death. If you are unsure as to how to properly use this product, consult a certified scuba instr

Product No. 66054 Ver 1.2 (Rev. 02/03) 012

Printed in USA.

Embedded System Example

- Diving Computer HW/SW Constraints
  - Small hockey puck sized device (wrist mounted)
  - Waterproof case (no fans for cooling with air)
  - Battery powered (no replacement under water)
  - Software in ROM (no hard drive to boot from)
  - Self-test code so diver can rely on its operation
  - Timing constraints (must provide real time information to the diver – not just a message to head for “the chamber” after the dive is over!)

Embedded System Example

- Team 1: How would you develop and install the software in the diving computer?

- Team 2: How would you test the software in the diving computer?

Embedded System Example

- What are the possible consequences of bugs in the diving computer software?
  - Diver gets “the bends” or an air embolism in blood
  - Diver’s buddies get injured/killed trying to rescue
  - Diver dies a painful death
- A bad example of a corporate cover up:

http://www.sfgate.com/news/article/Corporate-coverup-exposed-divers-to-grave-risk-2615088.php#page-2

- YouTube video:

http://www.youtube.com/watch?v=eNqPTOb31S8&NR=1