CDS 130-003 Computing for Scientists

Final Exam Review

December 16, 2010

Topics
Session 1: Computer Fundamentals
Session 2: Measurements
Session 3: Scientific Simulation
Session 4: Visualization
Session 5: Data Analysis
Session 6: Ethics
Session 7: Communication and Collaboration

Session 1: Computer Fundamentals
CH1: Binary Representation
- Binary to decimal conversion: “template” method
- Decimal to binary conversion: long division method

CH2: Data Storage
- Data density
- Bits and bytes
- ASCII table, encoding

CH3: Logic Circuits and Logic Tables
- Transistor: the building block
- AND gate, AND table; OR gate, OR table; NOT gate, NOT table
- NAND gate, NAND table
- XOR (EOR) gate, XOR table
- Adding binary number

Session 2: Measurements
CH1: Sensors
- Electric measurement
- CCD (Charge Coupled Device)

CH2: Sensor Limitations
- Lower limit and upper limit
- Resolutions: Time, Space, and Level
- ADC: Analog to Digital Converter
- Signal, noise and background
- Signal to Noise Ration (SNR)

Session 3: Scientific Simulation
CH1: Mathematical model
- Scientific model to mathematic model

CH2: Numerical method
- Iteration
- Differential equation
- Interval and sub-interval

- Integration
- Integration accuracy and size of sub-interval (or number of iteration)

CH3: Verification and Validation

- Scientific method: characterization, hypothesis, prediction and testing

Session 4: Visualization

CH1: Introduction

- Scientific visualization

CH2: Visualization Pipeline

- Data acquisition, data mapping, rendering

CH3: 2-D Data Visualization

- Height-plot, “plot.m” method, “surf.m” method
- 2-D data array
- Nested-FOR-loop
- Computer color: RGB system, RGB cube
- Colormap in Matlab
- “image.m” method in Matlab

Session 5: Data Analysis

CH1: Statistical Measures

- Min, max, mean, variance, standard deviation

CH2: Histogram Method

- Data acquisition, data mapping, rendering

CH3: Regression Method

- Least square principle
- Linear regression
- Correlation coefficient

Session 6: Ethics

- Why is computing ethics different from ethics in other disciplines?
- Issues of computing ethics?

Session 7: Communication

CH1: Effective Scientific Communication

- Effective oral presentation

CH2: Scientific Collaboration

- Wiki, pbworks, google.doc

Sample Final Exam (2010 December 16)

This is a close-book exam. Calculator is allowed. Your answer to a question should be given on the exam paper, immediately following that question.

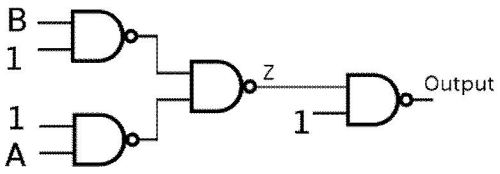
1. **Binary-to-decimal**
Convert 00111 to decimal.

2. **Decimal-to-binary**
Convert 49 to binary.

3. **ASCII table**
What is the decimal number corresponding to character "B" in ASCII table? What is the binary number corresponding to character "B" in ASCII table?

4. **Logic Gates and Logic Tables**
In the image below, four NANDS are connected and three of the inputs are set to 1. What are the values of Z if B = 1 and A = 0? For reference, the logic table associated with a NAND gate is shown.

A. Z=0, output=0
B. Z=0, output=1
C. Z=1, output=0
D: Z=1, output=1
E: can not be determined



5. **Sensor: Analog to Digital Converter**
In a 7 bit analog to digital converter, how many different levels of data can be recorded?

A. 7
B. 70
C. 128
D. 256
E. 1024

6. **Sensor: resolution**
A scientific temperature sensors has an operational range between -200 and 200 degrees Fahrenheit, and use 12 bits to convert the data. What is the temperature resolution of the detector?

7. **Iteration**
Considering the following iteration code, what is A(12)?

```
A(9)=13;
for i=[10:12]
  A(i)=A(i-1)+37;
end
```

The following statement is used for questions 8, 9, 10, and 11

> My bank offers 5% interest on my account compounded yearly. Every year I deposit an additional $100. Assuming that on the first year your account had a balance of $100.

---

8. **Scientific Model to Mathematical Model**
Translate the above statement into a mathematical representation

9. **Mathematical Model to Computational Model**
Translate your mathematical representation into Matlab/Octave code that uses iteration to specify your balance after 10 years.

10. **Interval and sub-interval**
When you are asked to calculate the balance for the next 10 years on a yearly basis, what is the interval and sub-interval of the calculation?

11. What is the balance in the 4th year?

12. **Differential equations**
Translate the following differential equation into its iteration equation representation:

$$\frac{dP}{dt} = 0.5 \times P$$

13. **Integration**

$$f(x) = x^3$$

$$F = \int_0^{4.0} x^3 dx$$

Consider the integration of the function, $f(x)=x^3$, overe the interval of x=0 to x=4.0. You are asked to make a numerical approximation of this integration using the area method, that is, to find the geometric area underneath the function with the sum of a series of rectangles.
If you choose the sub-interval Δx=1.0, what is the approximated area?

14. If the sub-interval is chosen to be Δx=0.1, do you think that you will get a different value of the numerical integration? Explain why?

15. **Scientific Method**
Describe in a few sentences in your own words what a scientific method is. . .

16. **Visualization Pipeline**
Briefly describe the three key steps of the visualization pipeline . . .

17. **Create 2-D array**
One creates a 2-D array in Matlab/Octave using the following statement:
>a=[3, 3, 3, 3; 1, 2, 3, 4; 4, 4, 4, 4; 5, 6 ,7, 8]
How many rows are in this 2-D array? What is value of a(3,2)?

18. Consid code consisting of doubly nested FOR loops:

```
for i=[1:3]
    for j=[1:3]
        a(i,j)=i*j+2
    end
end
```

What are three values in column 2 (j=2)?

19. Write down Matlab/Octave code, in which you use the doubly-nested FOR loop structure, to generate a 2D array with 10 rows and 20 columns, and to set the values of all elements in this 2D array equal to 100.

20. In the RGB color system, what the color represented by the 3-element array (1, 0, 0)? What color is represented by the 3-element array (0,0,0)?

21. Does typical scientific data have color? Why is a colormap so useful in visualizing scientific data?

22. Consider the data array a=[3, 9, 5, 4, 10, 12]. What is the mean, the variance, and the standard deviation of the data in this array?

23. In a histogram, what is plotted along the Y-axis (the vertical axis)?
(A) index
(B) data value
(C) frequency
(D) variance
(E) average

24. Consider the following Matlab/Octave FOR-loop. What is output by the final statement, " A "?

```
A=[1,2,3,4,5,6,7,8,9,10];
for i=[1:10]
  if (A(i) > 4)
    A(i)=0;
  end
end
A
```

25. What is data regression?

26. Briefly discuss why the computing ethics is different from ethics in other disciplines. There is no standard answer to this question. You are free to express your opinion on this.

27. List at least three examples that raise computing ethics issues. One example is music sharing.

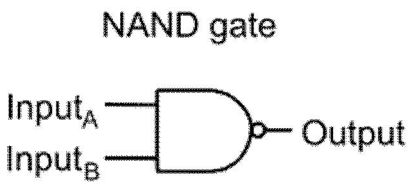
Information Sheet

1. ASCII Table

Dec	Hx	Oct	Char	Dec	Hx	Oct	Html	Chr	Dec	Hx	Oct	Html	Chr	Dec	Hx	Oct	Html	Chr
0	0	000	NUL (null)	32	20	040		Space	64	40	100	@	@	96	60	140	`	`
1	1	001	SOH (start of heading)	33	21	041	!	!	65	41	101	A	A	97	61	141	a	a
2	2	002	STX (start of text)	34	22	042	"	"	66	42	102	B	B	98	62	142	b	b
3	3	003	ETX (end of text)	35	23	043	#	#	67	43	103	C	C	99	63	143	c	c
4	4	004	EOT (end of transmission)	36	24	044	$	$	68	44	104	D	D	100	64	144	d	d
5	5	005	ENQ (enquiry)	37	25	045	%	%	69	45	105	E	E	101	65	145	e	e
6	6	006	ACK (acknowledge)	38	26	046	&	&	70	46	106	F	F	102	66	146	f	f
7	7	007	BEL (bell)	39	27	047	'	'	71	47	107	G	G	103	67	147	g	g
8	8	010	BS (backspace)	40	28	050	(	(	72	48	110	H	H	104	68	150	h	h
9	9	011	TAB (horizontal tab)	41	29	051	)	)	73	49	111	I	I	105	69	151	i	i
10	A	012	LF (NL line feed, new line)	42	2A	052	*	*	74	4A	112	J	J	106	6A	152	j	j
11	B	013	VT (vertical tab)	43	2B	053	+	+	75	4B	113	K	K	107	6B	153	k	k
12	C	014	FF (NP form feed, new page)	44	2C	054	,	,	76	4C	114	L	L	108	6C	154	l	l
13	D	015	CR (carriage return)	45	2D	055	-	-	77	4D	115	M	M	109	6D	155	m	m
14	E	016	SO (shift out)	46	2E	056	.	.	78	4E	116	N	N	110	6E	156	n	n
15	F	017	SI (shift in)	47	2F	057	/	/	79	4F	117	O	O	111	6F	157	o	o
16	10	020	DLE (data link escape)	48	30	060	0	0	80	50	120	P	P	112	70	160	p	p
17	11	021	DC1 (device control 1)	49	31	061	1	1	81	51	121	Q	Q	113	71	161	q	q
18	12	022	DC2 (device control 2)	50	32	062	2	2	82	52	122	R	R	114	72	162	r	r
19	13	023	DC3 (device control 3)	51	33	063	3	3	83	53	123	S	S	115	73	163	s	s
20	14	024	DC4 (device control 4)	52	34	064	4	4	84	54	124	T	T	116	74	164	t	t
21	15	025	NAK (negative acknowledge)	53	35	065	5	5	85	55	125	U	U	117	75	165	u	u
22	16	026	SYN (synchronous idle)	54	36	066	6	6	86	56	126	V	V	118	76	166	v	v
23	17	027	ETB (end of trans. block)	55	37	067	7	7	87	57	127	W	W	119	77	167	w	w
24	18	030	CAN (cancel)	56	38	070	8	8	88	58	130	X	X	120	78	170	x	x
25	19	031	EM (end of medium)	57	39	071	9	9	89	59	131	Y	Y	121	79	171	y	y
26	1A	032	SUB (substitute)	58	3A	072	:	:	90	5A	132	Z	Z	122	7A	172	z	z
27	1B	033	ESC (escape)	59	3B	073	;	;	91	5B	133	[	[	123	7B	173	{	{
28	1C	034	FS (file separator)	60	3C	074	<	<	92	5C	134	\	\	124	7C	174			|
29	1D	035	GS (group separator)	61	3D	075	=	=	93	5D	135	]	]	125	7D	175	}	}
30	1E	036	RS (record separator)	62	3E	076	>	>	94	5E	136	^	^	126	7E	176	~	~
31	1F	037	US (unit separator)	63	3F	077	?	?	95	5F	137	_	_	127	7F	177	&#127;	DEL

Source: www.LookupTables.com

2. NAND gate and its logic table



Input A	Input B	Output
0	0	1
0	1	1
1	0	1
1	1	0

Answers

1. 7
2. 110001
3. "B" in ascii, 66 in decimal, 1000010 in binary
4. C
5. C
6. temperature range = 200 - (-200) = 400, number of levels = 2^{12} = 4096
resolution = temperature / number_of_levels = 400/4096 = 0.0977
7. 124

8. P(i+1) = P(i) + 0.05*P(i) + 100
9. P(1)=100
for i=[1:9]
P(i+1) = P(i) + 0.05*P(i) + 100
end
10. Interval from 1 to 10, sub-interval is 1
11. $431

12. P(i+1) - P(i) = 0.5*P(i)
P(i+1) = P(i) + 0.5*P(i)

13. Divide the integration area into the following rectangles. The height of the rectangle is determined from the x-value of left point.
(1) x from (0,1), height= 0, area = 0
(2) x from (1, 2), height=1, area = 1
(3) x from (2, 3), height = 8, area=8
(4) x from (3, 4), height = 27, area = 27
The integration value = total area = 0 + 1+ 8 + 27 = 36

14. The integration value will be different. When a smaller sub-interval is used, one approximates the integration value with a larger number of rectangles, and the residual area between the true area and the approximated area thus gets smaller.

15. Scientific method is the process of carrying out robust scientific research. It involves (1) characterization of the data from measurements or observations, (2) make hypothesis about the formulation of the data, (3) make the prediction based on the hypothesis, and (4) testing the predicted data with observation. The four steps are usually repeated as in a cycle, until the hypothesis is proved to be correct.

16. (1) Step 1 - data acquisition, which is to convert any input data (input) into a discrete dataset (output). (2) Step 2- data mapping, which is to map the discrete dataset from step one (input) onto a 3-D scene (output) in computer memory. (3) Step 3 - rendering, which is to display the 3-D scene created in step 2 (input) onto a projected 2-D image (output).

17. Answer: 4 rows, a(3,2) = 4
18. a(1,2)=4, a(2,2)=6, a(3,2)= 8
19.

```
for i=[1:10]
    for j=[1:20]
        a(i,j)=100
    end
end
```

20. (1,0,0) is red, (0,0,0) is black
21. No. A colormap is a pseudo-color table, which is encoded to better visualize the distribution of scientific data.
22. mean = 7.16, variance = 13.36, standard deviation = 3.65
23. C
24. A = [1, 2, 3, 4, 0, 0, 0, 0, 0, 0]
25. Regression, or correlation, refer to the data analysis method to find the relationship that might exists between two quantities.

26. This is an open question. You may talk about that internet is relatively new, so there are no common rules formed yet. You can talk about that the internet is anonymous, global, fast and reproductive et al.

27. There are many of them, e.g., identity collection by social network service, music sharing, video sharing, software piracy, identity leaking, employee monitoring et al.