CDS 130-001 Computing for Scientists

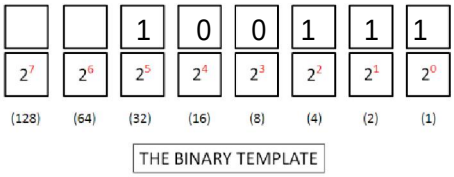
Final Exam - Sample Final Exam With Solution

Dec. 08, 2011

This is a closed-book closed-computer exam. Calculators are allowed. You should show your work and the answer on the space provided immediately following or beside each question on the exam sheets. If additional space is needed, please use the back of the paper and indicate such usage.

1. Convert 100111_2 to its base ten equivalent using the template method

Answer:



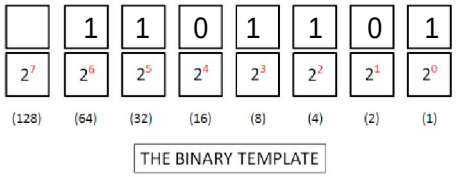
32+0+0+4+2+1 = 39.

Therefore, the base 10 equivalent is 39.

2. Convert 109_{10} to its binary equivalent using either the template method or long-division method.

Answer

(1) Template Method



109 - 64 = 45 à 1 at P(64)
45 - 32 = 13 à 1 at P(32)
13 < 16 à 0 at P (16)
13 - 8 = 5 à 1 at P(8)
5 - 4 = 1 à 1 at P(4)
1 < 2 à 0 at P(2)
1 à 1 at P(1)

Thus, the binary number is 1101101

or (2) Long-division method

divisor	dividend	remainder
2	(109)	1
2	(54)	0
2	(27)	1
2	(13)	1
2	(6)	0
2	(3)	1
2	(1)	1
	(0)	

The binary is the sequence of the remainder from the bottom to the top, therefore, the answer is 1101101

3. Carry out the binary addition of **11101_2 + 01101_2 ?** Keep your operation and answer in binary format.

Answer:

```
      11 1  (carry-on)
      11101
    + 01101
---------------------------
     101010
```

4. Carry out the binary multiplication of **110_2 x 101_2?** Keep your operation and answer in binary format

Answer:

```
        110
     X  101
-------------------
        110
       000
+     110
----------------------
      11110
```

5. What is the decimal value of 135_{16}?

Answer:

$135_{16} = 1 \times 16^2 + 3 \times 16^1 + 5 \times 16^0 = 256 + 48 + 5 = 309_{10}$

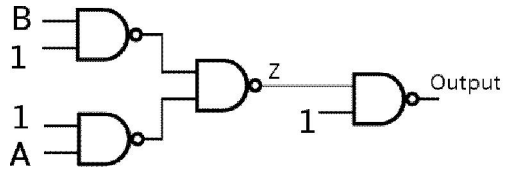
6. Use ASCII code to encode the string "JOBS" into a binary sequence. Express each character in a 8-bit binary number.

Answer:
Find the decimal number first, then use long-division to find the binary number

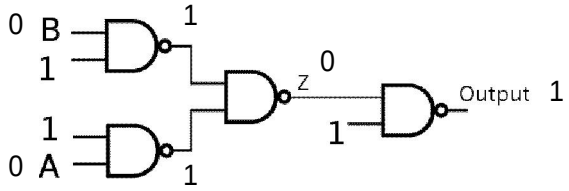
J -> 74 -> 1001010 -> 0100 1010
O ->79 -> 1001111 -> 0100 1111
B -> 66 -> 1000010 -> 0100 0010
S -> 83 -> 1010011 -> 0101 0011

Therefore, the binary sequence of "JOBS" represented in a computer memory is
0100 1010 0100 1111 0100 0010 0101 0011

7. In the image below, four NANDS are connected and three of the inputs are set to 1. What are the values of Z and output if B = 0 and A = 0?

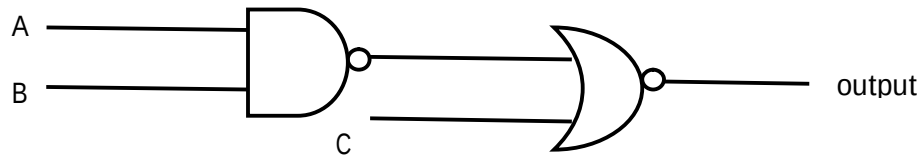


Answer:



Z = 0
output = 1

8. Fill out the logic table corresponding to the Logic Circuit shown below, which consists of a NAND gate and an NOR gate. Show all input bit pattern combinations A, B and C in the table. For each input bit pattern combination, calculate the corresponding output.



A	B	C	Output
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	1
1	1	1	0

9. Considering the following iteration code, what is A(5)?

```
A(1)=5;
for i=[2:5]
  A(i)=A(i-1)+3;
end
```

Answer:

A(1) = 5
i=2 A(2) = A(1) + 3 = 5 + 3 = 8
i=3 A(3) = A(2) + 3 = 8 + 3 = 11
i=4 A(4) = A(3) + 3 = 11 + 3 = 14
i=4 A(5) = A(4) + 3 = 14 + 3 = 17
Therefore, A(5) is 17

10. (a) Translate the following statement into a mathematical model.

(b) Then Translate your mathematical model into MATLAB programming code. Your code should be able to calculate the balance from year 1 to year 10. There is no need of doing the calculation in the exam. Only MATLAB code is needed.

My bank offers 2.5% interest on my account compounded yearly. Every year I deposit an additional $1000. Assuming that on the first year your account had a balance of $2000.

Answer:

(a) The mathematical model is
B(i+1) = B(i) + 0.025 x B(i) + 1000

(b)

```
B(1) = 2000;
for i=[2:10]
   B(i) = B(i-1) + 0.025*B(i-1) + 1000;
end
B
```

or

```
B(1) = 2000;
for i=[1:9]
   B(i+1) = B(i) + 0.025*B(i) + 1000;
end
B
```

11. Write down the mathematic model of the following scientific model. Note that you need to use two iterative mathematic equations.

- The birth rate of rabbits is 50%. The death rate or rabbits is 0.02 times the number of rabbits multiplied by the number of foxes.
- The death rate of foxes is 10%. The birth rate of foxes is 0.001 times the number of foxes multiplied by the number foxes

Answer:

The mathematical model can be described by the following two iterative mathematical equations. Let the population of rabbits is R(i), and that of foxes is F(i), then

(1) R(i+1) = 0.5 * R(i) - 0.02*R(i)*F(i)
(2) F(i+1) = -0.1* F(i) + 0.001*F(i) * R(i)

12. For any give data array "array", what are the differences of the output on a plot window when the Matlab code "plot(array,'-*r')" and the code "plot(array,'--ob')" are executed?

Answer:

The first plot will show the data as a solid (1) red (2) line with data marker of "*" symbol (3), while the second plot will show the same data as a dotted (1) blue line (2) with data marker of "o" symbol (3). Therefore, there are three different features as labeled as (1), (2) and (3) above.

13. Briefly answer the following questions?

(a) What is iteration?

Answer: one fundamental computational method to model a dynamic system. It uses the value at the current step to find the value in the next step.

(b) what is algorithm?

Answer: a computational method expressed as a finite set of well-defined instruction. It is the middle layer between the mathematic model and the code implementation.

(c) What is initial condition?

Answer: the initial value at the first step of calculation in a dynamic system

(d) What are the pros and cons if a smaller sub-interval is used in the iterative calculation?

Answer: The pro is to increase the accuracy of the calculation result, and the con is to increase the calculation steps, thus make the calculation less efficient.

14 Convert the following differential equation into a mathematic model expressed in an iterative equation?

$$\frac{dP}{dt} = 2(P-1)$$

Answer:

$$\frac{\Delta P}{\Delta t} = 2*(P-1)$$

$$\frac{\Delta P}{\Delta t} = \frac{P(i+1)-P(i)}{t(i+1)-t(i)} = \frac{P(i+1)-P(i)}{1} = 2*(P(i)-1)$$

$$P(i+1) = P(i) + 2*(P(i)-1)$$

15.

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

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

Consider the integration of the function, $f(x)=x^3$, from the interval of x=0 to x=4.0. You are asked to make a numerical approximation of this integration using the rectangle 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 integration result?

Answer: The integration is equivalent to find the area underneath the function in the X-Y plot, which can be approximated by a sequence of rectangles. Since the interval is from 0 to 4.0, and the sub-interval is 1.0, there are in total four rectangles in this approximation.

The width of all rectangles is Δx=1.0.

The height of the first rectangle $y(1)=x(1)^3=0$, since x(1)=0

The height of the second rectangle $y(2)= x(1)^3=1$, since x(1)=1

The height of the second rectangle $y(2)= x(1)^3=8$, since x(1)=2

The height of the second rectangle $y(2)= x(1)^3=27$, since x(1)=3

Therefore, the total area of the four rectangles is

F= Δx*y(1) + Δx*y(2) + Δx*y(3) + Δx*y(3) = 1.0*0 + 1.0*1 + 1.0*8 + 1.0*27 = 1 +8 +27 = 36

The approximated integration result is 36.

16. One creates a 2-D array in Matlab using the following statement:

```
>a=[3, 3, 3, 3; 1, 2, 3, 4; 4, 4, 4, 4; 5, 6 ,7, 8]
```

How many rows in this 2-D array? What is value of a(3,2)? What is a(2,3)?

Answer:

In 2-D, a =

```
3  3  3  3
1  2  3  4
4  4  4  4
5  6  7  8
```

There are four rows, four columns in the 2-D array.

a(3,2)=4

a(2,3)=3

17. What is the array "a" after executing the following Double-nested For Loops?

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

Answer:

```
a =
     3  4  5
     4  6  8
     5  8  11
```

18. What is the array "A" after executing the following Double-nested For Loops?

```
A = [1, 2, 3; 4, 5, 6; 7, 8, 9];
for m = [1:3]
     for n = [1:3]
          A(m,n) = m*n + 1;
     end
end
```

Answer:

```
A =
     2  3  4
     3  5  7
     4  6  10
```

19. What final value of c is printed out?

```
c = 1;
a = 1;
b = 2;
if(a + b < 3)
    c = c + 1;
 end
c
```

Answer:

```
c = 1
```

20. What final value of a, b, c is printed out?

```
a = 4;
b = 3;
c = 10;
if ( a < b && a < c)
   a = a + b + c;
end
a

if (a < b || a < c)
  a = a + b + c;
end
a
b
c
```

Answer:

a = 17
b = 3
c = 10

21: Does a usual scientific data set have color or not, such as temperature data? Why is color used in visualization?

Answer: A usual scientific data such as temperature does not have intrinsic color, although it has intrinsic value or intensity. Color in the visualization, such as in "imagesc" method, is used to indicate the value or intensity of a scientific data.

22. Describe the colors represented by the following [R, G, B] values

(1) [0, 0, 0]

(2) [1, 1, 1]

(3) [0.3, 0.3, 0.3]

(4) [1, 1, 0]

(5) [0, 1, 1]

Answer:

(1) Dark
(2) Bright
(3) Gray (close to dark)
(4) Yellow
(5) Cyan

23. For the following image and colormap,

```
MyImage=[1  2  3;
         4  5  6;
         7  8  9]
MyColorMap=[ 1    1    1;
           0.5  0.5  0.5;
             0    0    0]
```

(1) What is the color of the pixel MyImage(1,1)?

(2) What is the color of the pixel MyImage(1,3)?

Answer:

(1) There are only three colors and nine different data values. Thus, the three smallest data points get the first color (white), the three largest data points get the third color (dark), and the three middle data points get the second color (grey). T
Therefore, MyImage(1,1)=1, the color of this pixel is white

(2) Myimage(1,3) = 3, still in the range of three smallest values. The color is white.

24. Briefly describe the functionality of "plot()" and "imagesc()" methods in MATLAB?

Answer: "plot()" internal function is often used to plot 1-D data array, while "imagesc()" internal function is usually used to visualize a 2-D data array.

25. Write a MATLAB program to visualize the height plot of the following 2-D function (only the algorithm matters, syntax errors will not be graded). The X-interval is from -2.0 to +2.0 and sub-interval is 0.1, and the Y-interval is from -2.0 to +2.0 and the subinterval is 0.1

$$f(x,y)=(x+y)^2$$

Answer:

```
%define the interval, sub-interval, and number of iteration
x_start=-2.0;
x_end=2.0;
x_sub=0.1;
Nx=(x_end-x_start)/x_sub;  %number of points along x
y_start=-2.0;
y_end=2.0;
y_sub=0.1;
Ny=(y_end-y_start)/y_sub;  %number of  points along y

%calculate the 2-D data array corresponding to the function
for i=[1:Nx]
  for j=[1:Ny]
       x(i)=x_start+i*x_sub;
       y(j)=y_start+j*y_sub;
       f(i,j)=power((x(i) + y(j)),2);
  end
end
```

26. List at least three statistical measures? What are their corresponding functional names in MATLAB?

Answer:

minimum, "min()"

maximum, "max()"

mean or average, "mean()"

variance, "var()"

standard deviation, "std()"

27. What is plotted along the X-axis of a histogram? What is plotted along the Y-axis?

Answer: In a histogram plot, x-axis denotes the bin, y-axis denotes the frequency on each bin

28. What does regression mean? What does it mean if the correlation coefficient R is equal to one?

Answer: Regress means the possible correlation between two different data sets. If correlation coefficient is equal to one, it means that the two data sets are perfectly correlated.

Information Sheet

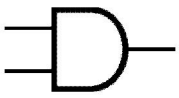
1. ASCII Table

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. Logical Gates and Tables

AND

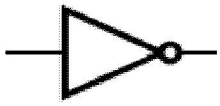


INPUT		OUTPUT
A	B	A AND B
0	0	0
0	1	0
1	0	0
1	1	1

OR

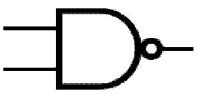
INPUT		OUTPUT
A	B	A OR B
0	0	0
0	1	1
1	0	1
1	1	1

NOT



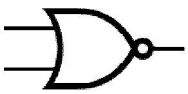
INPUT	OUTPUT
A	NOT A
0	1
1	0

NAND



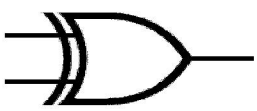
INPUT		OUTPUT
A	B	A NAND B
0	0	1
0	1	1
1	0	1
1	1	0

NOR



INPUT		OUTPUT
A	B	A NOR B
0	0	1
0	1	0
1	0	0
1	1	0

XOR



INPUT		OUTPUT
A	B	A XOR B
0	0	0
0	1	1
1	0	1
1	1	0