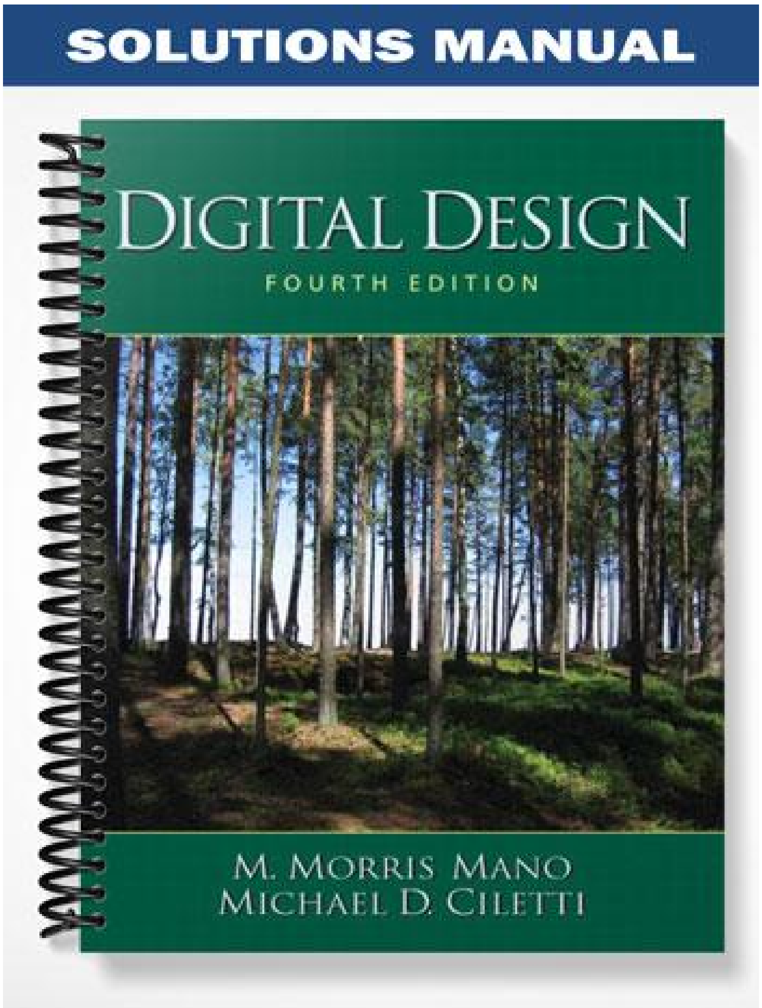
SOLUTIONS MANUAL
DIGITAL DESIGN
FOURTH EDITION
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DIGITAL DESIGN

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CHAPTER 1

1.1

Base-10:	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Octal:	20	21	22	23	24	25	26	27	30	31	32	33	34	35	36	37	40
Hex:	10	11	12	13	14	15	16	17	18	19	1A	1B	1C	1D	1E	1F	20
Base-13	A	B	C	10	11	12	13	14	15	16	17	18	19	23	24	25	26

1.2 **(a)** 32,768 **(b)** 67,108,864 **(c)** 6,871,947,674

1.3 $(4310)_5 = 4 * 5^3 + 3 * 5^2 + 1 * 5^1 = 580_{10}$

$(198)_{12} = 1 * 12^2 + 9 * 12^1 + 8 * 12^0 = 260_{10}$

$(735)_8 = 7 * 8^2 + 3 * 8^1 + 5 * 8^0 = 477_{10}$

$(525)_6 = 5 * 6^2 + 2 * 6^1 + 5 * 6^0 = 197_{10}$

1.4 14-bit binary: 11_1111_1111_1111
Decimal: $2^{14} -1 = 16{,}383_{10}$
Hexadecimal: $3FFF_{16}$

1.5 Let b = base

(a) 14/2 = (b + 4)/2 = 5, so b = 6

(b) 54/4 = (5*b + 4)/4 = b + 3, so 5 * b = 52 – 4, and b = 8

(c) (2 *b + 4) + (b + 7) = 4b, so b = 11

1.6 $(x – 3)(x – 6) = x^2 –(6 + 3)x + 6*3 = x^2 -11x + 22$

Therefore: 6 + 3 = b + 1m so b = 8
Also, $6*3 = (18)_{10} = (22)_8$

1.7 $68BE = 0110\_1000\_1011\_1110 = 110\_100\_010\_111\_110 = (64276)_8$

1.8 **(a)** Results of repeated division by 2 (quotients are followed by remainders):

431_{10} = 215(1); 107(1); 53(1); 26(1); 13(0); 6(1) 3(0) 1(1)
Answer: $1111\_1010_2 = FA_{16}$

(b) Results of repeated division by 16:

431_{10} = 26(15); 1(10) (Faster)
Answer: FA = 1111_1010

1.9 **(a)** $10110.0101_2 = 16 + 4 + 2 + .25 + .0625 = 22.3125$

(b) $16.5_{16} = 16 + 6 + 5*(.0615) = 22.3125$

(c) $26.24_8 = 2 * 8 + 6 + 2/8 + 4/64 = 22.3125$

(d) $FAFA.B_{16} = 15*16^3 + 10*16^2 + 15*16 + 10 + 11/16 = 64,250.6875$

(e) $1010.1010_2 = 8 + 2 + .5 + .125 = 10.625$

1.10 **(a)** $1.10010_2 = 0001.1001_2 = 1.9_{16} = 1 + 9/16 = 1.563_{10}$

(b) $110.010_2 = 0110.0100_2 = 6.4_{16} = 6 + 4/16 = 6.25_{10}$

Reason: 110.010_2 is the same as 1.10010_2 shifted to the left by two places.

1.11

```
        1011.11
101 | 111011.0000
       101
      01001
        101
        1001
         101
         1000
          101
          0110
```

The quotient is carried to two decimal places, giving 1011.11
Checking: $111011_2 / 101_2 = 59_{10} / 5_{10} \cong 1011.11_2 = 58.75_{10}$

1.12 **(a)** 10000 and 110111

```
      1011              1011
      +101              x101
     10000 = 16_10      1011
                       1011
                       110111 = 55_10
```

(b) 62_h and 958_h

```
  2E_h   0010_1110              2E_h
 +34_h   0011_0100              x34_h
  62_h   0110_0010 = 98_10      B^3 8
                               8^2 A
                               9 5 8_h = 2392_10
```

1.13 **(a)** Convert 27.315 to binary:

	Integer Quotient		Remainder	Coefficient
27/2 =	13	+	½	$a_0 = 1$
13/2	6	+	½	$a_1 = 1$
6/2	3	+	0	$a_2 = 0$
3/2	1	+	½	$a_3 = 1$
½	0	+	½	$a_4 = 1$

$27_{10} = 11011_2$

		Integer		Fraction	Coefficient
.315 x 2	=	0	+	.630	$a_{-1} = 0$
.630 x 2	=	1	+	.26	$a_{-2} = 1$
.26 x 2	=	0	+	.52	$a_{-3} = 0$
.52 x 2	=	1	+	.04	$a_{-4} = 1$

$.315_{10} \cong .0101_2 = .25 + .0625 = .3125$

$27.315 \cong 11011.0101_2$

(b) 2/3 ≅ .6666666667

		Integer		Fraction	Coefficient
.6666_6666_67 x 2	=	1	+	.3333_3333_34	$a_{-1} = 1$
.3333333334 x 2	=	0	+	.6666666668	$a_{-2} = 0$
.6666666668 x 2	=	1	+	.3333333336	$a_{-3} = 1$
.3333333336 x 2	=	0	+	.6666666672	$a_{-4} = 0$
.6666666672 x 2	=	1	+	.3333333344	$a_{-5} = 1$
.3333333344 x 2	=	0	+	.6666666688	$a_{-6} = 0$
.6666666688 x 2	=	1	+	.3333333376	$a_{-7} = 1$
.3333333376 x 2	=	0	+	.6666666752	$a_{-8} = 0$

$.6666666667_{10} \cong .10101010_2 = .5 + .125 + .0313 + ..0078 = .6641_{10}$

$.101010102 = .1010\_1010_2 = .AA_{16} = 10/16 + 10/256 = .6641_{10}$ (Same as (b)).

1.14

	(a)		(b)		(c)
	1000_0000		0000_0000		1101_1010
1s comp:	0111_1111	1s comp:	1111_1111	1s comp:	0010_0101
2s comp:	1000_0000	2s comp:	0000_0000	2s comp:	0010_0110

	(d)		(e)		(f)
	0111_0110		1000_0101		1111_1111
1s comp:	1000_1001	1s comp:	0111_1010	1s comp:	0000_0000
2s comp:	1000_1010	2s comp:	0111_1011	2s comp:	0000_0001

1.15

	(a)		(b)
	52,784,630		63,325,600
9s comp:	47,215,369	9s comp:	36,674,399
10s comp:	47,215,370	10s comp:	36,674,400

	(c)		(d)
	25,000,000		00,000,000
9s comp:	74,999,999	9s comp:	99,999,999
10s comp:	75,000,000	10s comp:	00,000,000

1.16

	B2FA	B2FA:	1011_0010_1111_1010
15s comp:	4D05	1s comp:	0100_1101_0000_0101
16s comp:	4D06	2s comp:	0100_1101_0000_0110 = 4D06

1.17 **(a)** 3409 → 03409 →96590 (9s comp) → 96591 (10s comp)
06428 – 03409 = 06428 + 96591 = 03019

(b) 1800 → 01800 → 98199 (9s comp) → 98200 (10 comp)
125 – 1800 = 00125 + 98200 = 98325 (negative)
Magnitude: 1675
Result: 125 – 1800 = 1675

(c) 6152 → 06152 → 93847 (9s comp) → 93848 (10s comp)
2043 – 6152 = 02043 + 93848 = 95891 (Negative)
Magnitude: 4109
Result: 2043 – 6152 = -4109

(d) 745 → 00745 → 99254 (9s comp) → 99255 (10s comp)
1631 -745 = 01631 + 99255 = 0886 (Positive)
Result: 1631 – 745 = 886

1.18 Note: Consider sign extension with 2s complement arithmetic.

(a)

	10001	
1s comp:	01110	
2s comp:	01111	
	10011	
Diff:	00010	

(**b**)

	100011	
1s comp:	1011100	with sign extension
2s comp:	1011101	
	0100010	
	1111111	sign bit indicates that the result is negative
	0000001	2s complement
	-000001	result

(c)

	101000	
1s comp:	1010111	
2s comp:	1011000	
	001001	
Diff:	1100001	(negative)
	0011111	(2s comp)
	-011111	(diff is -31)

(**d**)

	10101	
1s comp:	1101010	with sign extension
2s comp:	1101011	
	110000	
	0011011	sign bit indicates that the result is positive
	Check: 48 -21 = 27	

1.19 +9286 → 009286; +801 → 000801; -9286 → 990714; -801 → 999199

(a) (+9286) + (_801) = 009286 + 000801 = 010087

(b) (+9286) + (-801) = 009286 + 999199 = 008485

(c) (-9286) + (+801) = 990714 + 000801 = 991515

(d) (-9286) + (-801) = 990714 + 999199 = 989913

1.20 +49 → 0_110001 (Needs leading zero indicate + value); +29 → 0_011101 (Leading 0 indicates + value)
-49 → 1_001111; -29 → 1_100011

(a) (+29) + (-49) = 0_011101 + 1_001111 = 1_101100 (1 indicates negative value.)
Magnitude = 0_010100; Result (+29) + (-49) = -20

(b) (-29) + (+49) = 1_100011 + 0_110001 = 0_010100 (0 indicates positive value)
(-29) + (+49) = +20

(c) Must increase word size by 1 (sign extension) to accomodate overflow of values:
(-29) + (-49) = 11_100011 + 11_001111 = 10_110010 (1 indicates negative result)
Magnitude: 1_001110 = 78_{10}
Result: (-29) + (-49) = -78

1.21 +9742 → 009742 → 990257 (9's comp) → 990258 (10s) comp
+641 → 000641 → 999358 (9's comp) → 999359 (10s) comp

(a) (+9742) + (+641) → 010383

(b) (+9742) + (-641) →009742 + 999359 = 009102
Result: (+9742) + (-641) = 9102

(c) -9742) + (+641) = 990258 + 000641 = 990899 (negative)
Magnitude: 009101
Result: (-9742) + (641) = -9101

(d) (-9742) + (-641) = 990258 + 999359 = 989617 (Negative)
Magnitude: 10383
Result: (-9742) + (-641) = -10383

1.22 8,723
BCD**:** 1000_0111_0010_0011
ASCII: 0_011_1000_011_0111_011_0010_011_0001

1.23

```
      1000   0100   0010 ( 842)
      0101   0011   0111 (+537)
      1101   0111   1001
      0110
 0001 0011   0111   0101 (1,379)
```

1.24 **(a)**

6 3 1 1	Decimal
0 0 0 0	0
0 0 0 1	1
0 0 1 0	2
0 1 0 0	3
0 1 1 0	4 (*or* 0101)
0 1 1 1	5
1 0 0 0	6
1 0 1 0	7 (*or* 1001)
1 0 1 1	8
1 1 0 0	9

(b)

6 4 2 1	Decimal
0 0 0 0	0
0 0 0 1	1
0 0 1 0	2
0 0 1 1	3
0 1 0 0	4
0 1 0 1	5
1 0 0 0	6 (*or* 0110)
1 0 0 1	7
1 0 1 0	8
1 0 1 1	9

1.25
(a) $5,137_{10}$ BCD: 0101_0011_0111
(b) Excess-3: 1000_0100_0110_1010
(c) 2421: 1011_0001_0011_0111
(d) 6311: 0111_0001_0100_1001

1.26 5,137 9s Comp: 4,862
2421 code: 0100_1110_1100_1000
1s comp: 1011_0001_0011_0111 same as (c) in 1.25

1.27 For a deck with 52 cards, we need 6 bits (32 < 52 < 64). Let the msb's select the suit (e.g., diamonds, hearts, clubs, spades are encoded respectively as 00, 01, 10, and 11. The remaining four bits select the "number" of the card. Example: 0001 (ace) through 1011 (9), plus 101 through 1100 (jack, queen, king). This a jack of spades might be coded as 11_1010. (Note: only 52 out of 64 patterns are used.)

1.28

G	(dot)	(space)	B	o	o	l	e
01000111	11101111	01101000	01101110	00100000	11000100	11101111	11100101

1.29 Bill Gates

1.30 73 F4 E5 76 E5 4A EF 62 73

73:	0_111_0011	s
F4:	1_111_0100	t
E5:	1_110_0101	e
76:	0_111_0110	v
E5:	1_110_0101	e
4A:	0_100_1010	j
EF:	1_110_1111	o
62:	0_110_0010	b
73:	0_111_0011	s

1.31 62 + 32 = 94 printing characters

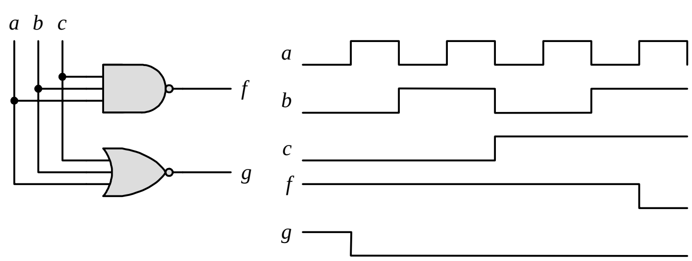
1.32 bit 6 from the right

1.33 **(a)** 897 **(b)** 564 **(c)** 871 **(d)** 2,199

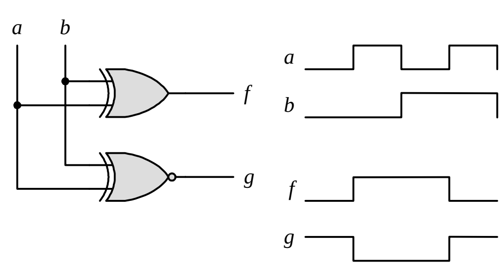
1.34 ASCII for decimal digits with odd parity:

(0):	10110000	(1):	00110001	(2):	00110010	(3):	10110011
(4):	00110100	(5):	10110101	(6):	10110110	(7):	00110111
(8):	00111000	(9):	10111001				

1.35 **(a)**



1.36



CHAPTER 2

2.1 **(a)**

x y z	$x + y + z$	$(x + y + z)'$	x'	y'	z'	$x'y'z'$
0 0 0	0	1	1	1	1	1
0 0 1	1	0	1	1	0	0
0 1 0	1	0	1	0	1	0
0 1 1	1	0	1	0	0	0
1 0 0	1	0	0	1	1	0
1 0 1	1	0	0	1	0	0
1 1 0	1	0	0	0	1	0
1 1 1	1	0	0	0	0	0

x y z	(xyz)	$(xyz)'$	x'	y'	z'	$x' + y' + z'$
0 0 0	0	1	1	1	1	1
0 0 1	0	1	1	1	0	1
0 1 0	0	1	1	0	1	1
0 1 1	0	1	1	0	0	1
1 0 0	0	1	0	1	1	1
1 0 1	0	1	0	1	0	1
1 1 0	0	1	0	0	1	1
1 1 1	1	0	0	0	0	0

(b)

x y z	$x + yz$	$(x + y)$	$(x + z)$	$(x + y)(x + z)$
0 0 0	0	0	0	0
0 0 1	0	0	1	0
0 1 0	0	1	0	0
0 1 1	1	1	1	1
1 0 0	1	1	1	1
1 0 1	1	1	1	1
1 1 0	1	1	1	1
1 1 1	1	1	1	1

(c)

x y z	$x(y + z)$	xy	xz	$xy + xz$
0 0 0	0	0	0	0
0 0 1	0	0	0	0
0 1 0	0	0	0	0
0 1 1	0	0	0	0
1 0 0	0	0	0	0
1 0 1	1	0	1	1
1 1 0	1	1	0	1
1 1 1	1	1	1	1

(c)

x y z	x	$y + z$	$x + (y + z)$	$(x + y)$	$(x + y) + z$
0 0 0	0	0	0	0	0
0 0 1	0	1	1	0	1
0 1 0	0	1	1	1	1
0 1 1	0	1	1	1	1
1 0 0	1	0	1	1	1
1 0 1	1	1	1	1	1
1 1 0	1	1	1	1	1
1 1 1	1	1	1	1	1

(d)

x y z	yz	$x(yz)$	xy	$(xy)z$
0 0 0	0	0	0	0
0 0 1	0	0	0	0
0 1 0	0	0	0	0
0 1 1	1	0	0	0
1 0 0	0	0	0	0
1 0 1	0	0	0	0
1 1 0	0	0	1	0
1 1 1	1	1	1	1

2.2 **(a)** $xy + xy' = x(y + y') = x$

(b) $(x + y)(x + y') = x + yy' = x(x + y') + y(x + y') = xx + xy' + xy + yy' = x$

(c) $xyz + x'y + xyz' = xy(z + z') + x'y = xy + x'y = y$

(d) $(A + B)'(A' + B') = (A'B')(A B) = (A'B')(BA) = A'(B'BA) = 0$

(e) $xyz' + x'yz + xyz + x'yz' = xy(z + z') + x'y(z + z') = xy + x'y = y$

(f) $(x + y + z')(x' + y' + z) = xx' + xy' + xz + x'y + yy' + yz + x'z' + y'z' + zz' =$
$= xy' + xz + x'y + yz + x'z' + y'z' = x \oplus y + (x \oplus z)' + (y \oplus z)'$

2.3 **(a)** $ABC + A'B + ABC' = AB + A'B = B$

(b) $x'yz + xz = (x'y + x)z = z(x + x')(x + y) = z(x + y)$

(c) $(x + y)'(x' + y') = x'y'(x' + y') = x'y'$

(d) $xy + x(wz + wz') = x(y + wz + wz') = x(w + y)$

(e) $(BC' + A'D)(AB' + CD') = BC'AB' + BC'CD' + A'DAB' + A'DCD' = 0$

(f) $(x + y' + z')(x' + z') = xx' + xz' + x'y' + y'z' + x'z' + z'z' = z' + y'(x' + z') = z' + x'y'$

2.4 **(a)** $A'C' + ABC + AC' = C' + ABC = (C + C')(C' + AB) = AB + C'$

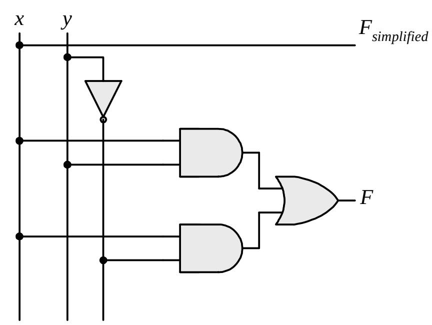
(b) $(x'y' + z)' + z + xy + wz = (x'y')'z' + z + xy + wz = [(x + y)z' + z] + xy + wz =$
$= (z + z')(z + x + y) + xy + wz = z + wz + x + xy + y = z(1 + w) + x(1 + y) + y = x + y + z$

(c) $A'B(D' + C'D) + B(A + A'CD) = B(A'D' + A'C'D + A + A'CD)$
$= B(A'D' + A + A'D(C + C') = B(A + A'(D' + D)) = B(A + A') = B$

(d) $(A' + C)(A' + C')(A + B + C'D) = (A' + CC')(A + B + C'D) = A'(A + B + C'D)$
$= AA' + A'B + A'C'D = A'(B + C'D)$

(e) $ABCD + A'BD + ABC'D = ABD + A'BD = BD$

2.5 **(a)**



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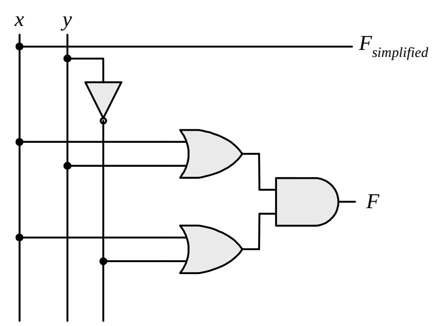

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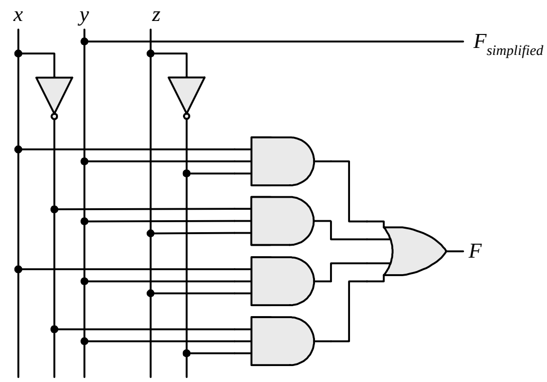
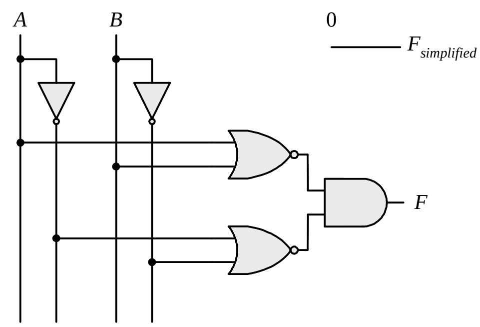


(d)



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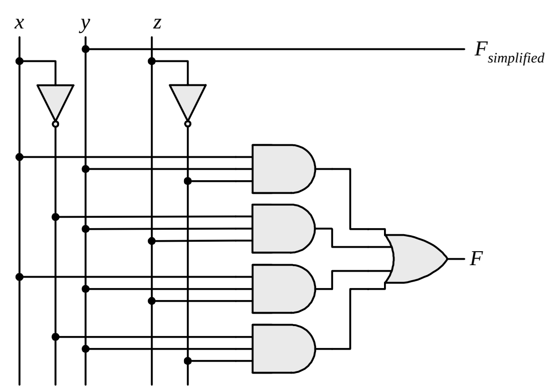

(f)