**1. Boolean Algebra and Digital Circuits**

(a) (i) E = A • B + B • (A’ + A • B)

E = A • B + B • ((A’ + A) • (A’ + B)) Distributive

E = A • B + B • (A’ + B) Negation + Simplification

E = B • (A + (A’ + B)) Distributive + Commutative

E = B • (1 + B) Negation + Associative

E = B Simplification + Simplification

(ii) E = (A + B)’ • (C + D + F)’ + (A’ • B’)

E = (A’ • B’) • (C + D + F)’ + (A’ • B’) de Morgan

E = (A’ • B’) • ((C + D + F)’ + 1) Distributive

E = A’ • B’ Simplification

(b) E = A • (B + A • B) + A • C

E = A • B + A • A • B + A • C Distributive

E = A • B + A • B + A • C Idempotent

E = A • (B + B + C) Distributive

E = A • (B + C) Idempotent

A

E

A • (B + C)

B

C

B + C

(c) E = A • B

E = ((A • B)’)’ Negation

E = ((A’ + B’)’ de Morgan

E = ((A + A)’ + (B + B)’)’ Idempotent

A

E

(A + A)’

B

((A + A)’ + (B + B)’)’

(B + B)’

**2. Binary Arithmetic**

(a) (i) 9=01001 | 11=01011 > -11=10101 (Inverse +1)

9 01001

+(-11) 10101

=  **11110**

(ii) 12=01100 > -12=10100 | 10=01010 > -10=10110

-12 10100

+(-10) 10110

= **01010** (discard last carry)

(b) 189/2=94m1 > 94/2=47m0 > 47/2=23m1 > 23/2=11m1 > 11/2=5m1 > 5/2=2m1 > 2/2=1m0 > 1/2=0m1

27/2=13m1 > 13/2=6m1 > 6/2=3m0 > 3/2=1m1 > 1/2=0m1

189=10111101 | 27=11011

**111** (111 is also 7 in decimal, which is consistent with 189/27=7)

11011|10111101

- 11011

101000

- 11011

011011

* 11011

0

**3. Floating Point Numbers**

(a) 31/2=15m1 > 15/2=7m1 > 7/2=3m1 > 3/2=1m1 > 1/2=0m1 | 31=11111

1/16+1/32+1/256+1/512… | 0.1=00011**0011**… (repeating pattern)

11111.000110011… = 1.1111000110011…\*2^4 (normalize)

4+127=131 = 1000 0011 (exponent binary)

Sign|Exponent |Significand (23 bits, after cutting off 1.)

**1|1000 0011|1111 0001 1001 1001 1001 101** (rounded last bit to 1)

Hex friendly format: 1100 0001 1111 1000 1100 1100 1100 1101 = **C1F8CCCC** (D if rounded)

(b) 40F109D5 = 0100 0000 1111 0001 0000 1001 1101 0101

Sign|Exponent |Significand (23 bits, after cutting off 1.)

**0|1000 0001|1110 0010 0001 0011 1010 101**

1000 0001=129 > 129-127=2 (2^2 exponent)

1.111 0001 0000 1001 1101 0101 \* 2^2 (add hidden bit)

111.1 0001 0000 1001 1101 0101 (denormalize)

=7+1/2+1/32+1/2048… = **7.532450199127197265625**