CS 3340 HW 4
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#1 $43/2 = 21$ R 1
$21/2 = 10$ R 1
$10/2 = 5$ R 0
$5/2 = 2$ R 1
$2/2 = 1$ R 0
$1/2 = 0$ R 1
$43 = 101011$
$43 = 0010\ 1011$

$-102/2 = 51$ R 0
$51/2 = 25$ R 1
$25/2 = 12$ R 1
$12/2 = 6$ R 0
$6/2 = 3$ R 0
$3/2 = 1$ R 1
$1/2 = 0$ R 1
$102 = 1100\ 1100$
$102 = 0110\ 0110$
$-102 = 1001\ 1010$

$43 = 0010\ 1011$
$+102 = 0110\ 0110$
$145 = 1001\ 0001$ → positive = $0110\ 1111 = -111$

$145 \neq -111$ ∴ overflow

$43 = 0010\ 1011$
$+(-102) = +\ 1001\ 1010$
$-59 = 1100\ 0101$ → positive = $00111011 = 59$
$= -59$ ✓ no over/underflow

#2 26 octal $= 2 \times 8^1 + 6 \times 8^0 = 16 + 6 = 22_{10}$

$22/2 = 0$ R 0
$11/2 = 5$ R 1
$5/2 = 2$ R 1
$2/2 = 1$ R 0
$1/2 = 0$ R 1
$10\ 110$
$0101\ 0110_2 = 26_8$

12 octal $= 8 + 2 = 10_{10}$

$10/2 = 5$ R 0
$5/2 = 2$ R 1
$2/2 = 1$ R 0
$1/2 = 0$ R 1
$1010$
$00\ 1010_2 = 12$ octal

| Iteration | Step | Multiplier | Multiplicand | Product |
|---|---|---|---|---|
| 0 | Start | 00 1010 | 0000 0001 0110 | 0000 0000 0000 |
| 1 | Right bit = 0 | 00 1010 | 0000 0010 1100 | " |
| 1 | Shift | 00 0101 | " | " |
| 2 | Right bit = 1 | " | " | 0000 0010 1100 |
| 2 | Shift | 00 0010 | 0000 0101 1000 | " |
| 3 | RB = 0 | " | " | " |
| 3 | Shift | 00 0001 | 0000 1011 0000 | " |
| 4 | RB = 1 | " | " | $0000\ 1101\ 1100_2$ → $4+8+16+64+128 = 220_{10}$ |
| 4 | Shift | 00 0000 | 0001 0110 0000 | " |

all remaining 0's are 0 in multiplier

$220/8 = 27$ R 4
$27/8 = 3$ R 3
$3/8 = 0$ R 3
$= 334_8$

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#3 8 bit adder is binary tree height $\log_2 8 = 3$

$3 \times 4 =$ **12 time units total**

#4 $13 \times 7 = 13 \times (2^3 - 1)$

$= 13$ shift left 3

$- 13$

$13/2 = 6$ R1

$6/2 = 3$ R0

$3/2 = 1$ R1

$1/2 = 0$ R1

$= 0000\ 1101$

13 = 0000 1101

shift 3 = 0110 1000

-13 = 1111 0011

0110 1000

− 0000 1101

0101 1011 $= 91_{10} = 13 \times 7$ ✓

#5

$27/2 = 13$ R1

$13/2 = 6$ R1

$6/2 = 3$ R0

$3/2 = 1$ R1

$1/2 = 0$ R1

$01\ 1011_2 = 27_{10}$

$13/2 = 6$ R1

$6/2 = 3$ R0

$3/2 = 1$ R1

$1/2 = 0$ R1

$00\ 1101_2 = 13_{10}$

| Iteration | Step | Quotient | Divisor | Remainder |
|---|---|---|---|---|
| 0 | Start | 00 0000 | 0011 0100 0000 | 0000 0001 1011 |
| 1 | Rem = Rem − Div | " | " | 1100 1101 1011 |
| 1 | Rem < 0 | " | " | 0000 0001 1011 |
| 1 | Shift Div | " | 0001 1010 0000 | " |
| 2 | R = R − D | " | " | 1110 0111 1011 |
| | R < 0 | " | " | 0000 0001 1011 |
| | Shift D | " | 0000 1101 0000 | " |
| 3 | R = R − D | " | " | 1111 0100 1011 |
| | R < 0 | " | " | 0000 0001 1011 |
| | Shift D | " | 0000 0110 1000 | " |
| 4 | R = R − D | " | " | 1111 1011 0011 |
| | R < 0 | " | " | 0000 0001 1011 |
| | Shift D | " | 0000 0011 0100 | " |

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#5 continued

| Iteration | Step | Quotient | Divisor | Remainder |
|---|---|---|---|---|
| 5 | R = R - D | 00 0000 | 0000 0011 0100 | 1111 1110 0111 |
| | R < 0 | " | " | 0000 0001 1011 |
| | shift D | " | 0000 0001 1010 | " |
| 6 | R = R - D | " | " | 0000 0000 0001 |
| | R ≥ 0 | 00 0001 | " | " |
| | shift D | " | 0000 0000 1101 | " |
| 7 | R = R - D | " | " | 1111 1111 0100 |
| | R < 0 | " | " | 0000 0000 0001 |
| | shift D | 00 0010 | 0000 0000 0110 | " |

Quotient = $00\ 0010_2 = 2_{10}$

Remainder = $00\ldots001_2 = 1_{10}$

27 / 13 = 2R1 ✓

#6 $-3.75$

3.75

$11.75 \times 2 = 1.5$

$0.5 \times 2 = 1.0$

$3.75_{10} = 11.11_2$

$= 1.111 \times 2^1$

sign bit: 1 | mantissa: 1110 0000 00 | exponent: 1 0000

exponent = 1 + 15 = 16

single precision exponent = 8 bits = $2^3$ more possibilities = bigger range

single precision mantissa = 23 bits = much more precision

#7 $(4.41769875 \times 10^{-3} + 6.34665625 \times 10^{-3}) \times 1.05625 \times 10^{2}$

$4.41769875 \cdot 10^{-3}$ = | 0 | 001 0000 110 | 0 0111 |

+ 1.131 -8

$6.34665625 \cdot 10^{-3}$ = | 0 | 101 0000 000 | 0 0111 |

\+ + 1.625 -8

$1.0765 \times 10^{-2}$ = | 0 | 011 0000 011 | 0 1000 |

+ 1.378 -7

$1.05625 \cdot 10^{-2}$ = | 0 | 010 1101 000 | 0 1000 |

× + 1.352 -7

$1.1367 \times 10^{-4}$ = | 0 | 110 1110 011 | 00001 |

+ 1.862 -14