

**Scientific Computing 1**  
**Handout 6**  
**November 18, 2014**

**The IEEE 754 Standard**

data type	$p$	$t$	$e_{\min}$	$e_{\max}$	$u$	$x_{\min}$	$x_{\max}$
single	2	$23 + 1$	-125	128	$\approx 5.96 \cdot 10^{-8}$	$\approx 10^{-38}$	$\approx 10^{38}$
double	2	$52 + 1$	-1021	1024	$\approx 1.11 \cdot 10^{-16}$	$\approx 10^{-308}$	$\approx 10^{308}$

Table 1: IEEE standard 754, data types.

**Storage pattern for single-and double-variables:**

single: (32 bit)

```
S EEEEEEEEE MMMMMMMMMMMMMMMMMMMMMMMMM
0 1      8 9                31
```

double: (64 bit)

```
S EEEEEEEEEEEEE MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
0 1      11 12                63
```

Flag	Example	Result
<i>invalid</i>	$0/0, 0 \cdot \infty, \sqrt{-1},$ $\infty/\infty, +\infty + (-\infty)$	NaN ("not a number")
<i>overflow</i>	$x_{\max} * x_{\max}$	$\pm\infty$ in MATLAB: Inf
<i>division by zero</i>	$x/0$ for $x \neq 0$	$\pm\infty$
<i>underflow</i>	$x_{\min}/p^s, 1 < s < t$	subnormal number
<i>inexact</i>	$\text{rd}(x \circ y) \neq x \circ y$	correctly rounded result

Table 2: IEEE Standard 754, Exception Handling.

**Examples:**

$$0 \ 11111111 \ 000000000000000000000000 = +\infty$$

$$1 \ 11111111 \ 000000000000000000000000 = -\infty$$

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$$0 \ 11111111 \ 000001000000000000000000 = \text{NaN}$$

$$1 \ 11111111 \ 00100010001001010101010 = \text{NaN}$$

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$$0 \ 10000000 \ 000000000000000000000000 = +1.0 * 2^{128-127} = 2$$

$$0 \ 10000001 \ 101000000000000000000000 = +1.101 * 2^{129-127} = 6.5$$

$$1 \ 10000001 \ 101000000000000000000000 = -1.101 * 2^{129-127} = -6.5$$

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$$0 \ 00000001 \ 000000000000000000000000 = +1.0 * 2^{1-127} = 2^{-126} = x_{\min}$$

$$0 \ 00000000 \ 100000000000000000000000 = +0.1 * 2^{-126} = 2^{-127}$$

$$0 \ 00000000 \ 000000000000000000000001 = +0.0\dots01 * 2^{-126} = 2^{-149}$$

= smallest representable number