## Week 2 — *C++ starter: Manipulating floating point numbers*

The goal of the present exercises is to manipulate the floating point numbers in C++

### Exercise 1: *Casting integers and float*

- Execute the following program:

```cpp
int a = 0.5;
std::cout << a << std::endl;
```

- Launch the program and describe what you observe. How could this be avoided.
- Execute now

```cpp
double a = 1/2;
std::cout << a << std::endl;
```

- Please explain again what happened.
- Can this happen in Python language?

### Exercise 2: *Overflow*

- The exponential function can be computed using the following function:

```cpp
double x  = 10.;
double a = exp(x);
std::cout << a << std::endl;
```

  (use the manual if you seek for information about the `exp` function)

- Create a function which computes the following hyperbolic tangent:

$$\tanh(x) = \frac{\exp(x) - \exp(-x)}{\exp(x) + \exp(-x)} \tag{1}$$

- Make a loop to compute 10 points of the curve $\tanh(x)$ for $x \in [0, 1000]$.
- Try to factor the $\exp(x)$ to find an expression avoiding the overflow.

### Exercise 3: *Underflow*

- Find (and program) the best way to evaluate the function

$$\tanh(x) - 1 = \frac{\exp(x) - \exp(-x)}{\exp(x) + \exp(-x)} - 1 \tag{2}$$

- Let us now consider the motion of two photons moving at the velocity $v = 3 \cdot 10^8$ m/s in the same direction. Their position evolution can be computed with:

$$p_i(t) = p_i(0) + tv \tag{3}$$

with $p_i(t)$ ($i$ being 0 or 1) their position at time $t$.

If we discretize time we can provide the time integration scheme:

$$p_i^{n+1} = p_i^n + dt \cdot v \tag{4}$$

- Program the function

```
double evolution(double pn, double v, double dt);
```

  which returns the new position provided the position at the previous step (`pn`), the velocity (`v`) and the time step (`dt`)

- Make a program which sets the initial position of the two photons being $p_0(0) = 0$ and $p_1(0) = 10^{-3}$. Thus they are distant by one millimeter.
- Then compute the positions evolution during 40 time steps with $dt = 1000$ seconds (less than 1 hour).
- Compute the distance $p_1(t) - p_0(t)$. Explain what you see.