

A little bit of physics

$$1 \text{ year} = 365 \text{ days} = 3 \times 10^7 \frac{\text{seconds}}{\text{year}}$$

$$\begin{aligned} T &= 20 \text{ billion years} \\ &\approx 2 \cdot 10^{10} \text{ years} \\ &= 6 \cdot 10^{17} \text{ seconds} \end{aligned}$$

$$\Delta t = \frac{\text{dist}}{\text{velo}}$$

$\overline{\Delta t}$  ← smallest possible time interval

$t$  = time during which the light goes through the smallest elementary particle.

Heisenberg's uncertainty principle.

$$\Delta x \Delta p \gg \hbar - \text{plank's constant}$$

Q Next Thursday: Quiz / Test.

$a+b$  add(a, b)

$$\begin{cases} \text{add}(m, 0) = m \\ \text{add}(m, n+1) = \text{add}(m, n) + 1 \end{cases}$$

$$\text{PR } \begin{cases} f(\bar{m}, 0) = g(\bar{m}) \\ f(\bar{m}, n+1) = h(\bar{m}, n, f(\bar{m}, n)) \end{cases}$$

General case  $k=1$

$$\begin{cases} f(m_1, 0) = g(m_1) \\ f(m_1, n+1) = h(m_1, n, f(m_1, n)) \end{cases}$$

$$\begin{cases} f(m_1, 0) = g(m_1) = \pi_1^{-1} \\ f(m_1, n+1) = f(m_1, n) + 1 \end{cases}$$

$\Rightarrow h = \sigma_0 \pi_3^3 \Rightarrow a + b$  is PR  $(\pi_1^3, \sigma_0 \pi_3^3)$

Describe in Java code:

$prev(0) = 0$   
 $prev(n+1) = n$

$\Rightarrow$ 

```
prev = 0
for (i=0; i<n; i++) {
    prev = i;
}
```

$sub(m, 0) = m$

$sub(m, n+1) = sub(m, n) - 1$

```
int sub = m;
```

```
for (i=0; i<n; i++) {
    (
        prev = 0;
        for (j=0; j<sub; j++) {
            prev = j;
        }
        sub = prev;
    )
}
```

+ Dig motivation:

1) what is computable?

To prove that something is NOT computable we need to have a formal def. of computable function.

Church's Thesis: any computable

Anything that ~~has~~ can be computed by any computational device can be compiled by a Java program, computed, by

So to prove that  $\text{sum}$  is not computable we can prove that this  $\text{sum}$  can NOT be computed by Java program.

Problem: Java is huge, difficult to describe  $\rightarrow$  it is impossible to prove anything.

We need a simplified definition that will still cover all Java-computable f-s but that will be easier to describe and thus, easier to prove.

1st attempt: Natural #s,  $\sigma$  }  $\Rightarrow$  p.r. fn.  
for-loops, ++;

Are we covering all computable f.s?  
Almost all, but not all.

2nd attempt  $\mu$ -recursive fn.

2c)  $\mu m (b+m == a) \Rightarrow$  This is  $a-b$

Smallest  $m$  s.t. that  
 $b+m == a$

if  $a > b \rightarrow a-b$   
 $a \leq b \rightarrow 0$

+ here  $a > b$  is  $\mu$ .rec.

$a > b \Leftrightarrow a-b > 0$

$(a-b) > 0$

positive(0) = 0

positive(n+1) = 1

positive(k) =  $\begin{cases} 1 & \text{if } k > 0 \\ 0 & \text{otherwise} \end{cases}$

positive(k) =  $\begin{cases} 1 & \text{if } k > 0 \\ 0 & \text{otherwise} \end{cases} \Rightarrow$

```
// Java code :
```

```
int positive = 0
```

```
for (i = 0; i < n; i++)
```

```
{
```

```
    positive = 1;
```

```
}
```