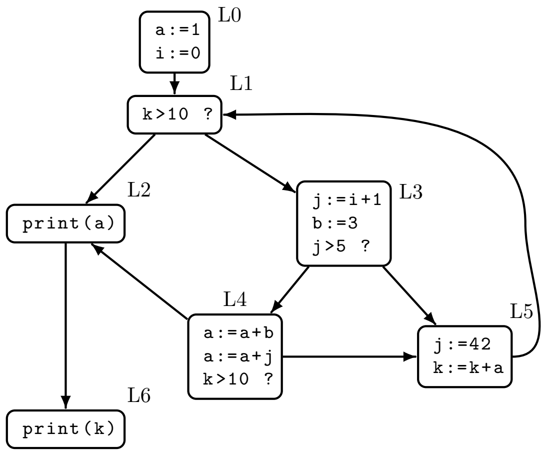
TD 4
Liveness Analysis

4.1 Liveness by hand

EXERCISE #1 ► **Liveness by hand - CC 2016**

In Figure 4.1, we give a CFG and we recall that a *variable is alive after a block if there exists a path from this block to one use of this variable that do not contain a definition of it.*



bloc	variables vivantes en sortie du bloc
L0	
L1	
L2	
L3	
L4	
L5	
L6	$\emptyset$

Figure 4.1: CFG and alive variables to complete

1. (by hand) Fill the array with “out”-alive variables for each block.
2. Remove dead code.

4.2 Liveness with fixpoint!

Let us recall the notations here: A variable at the left-hand side of an assignement is *killed* by the block. A variable whose value is used in this bloc (before any assignment) is *generated*.

$$LV_{exit}(\ell) = \begin{cases} \emptyset & \text{if } \ell = \text{final} \\ \bigcup\{LV_{entry}(\ell') | (\ell, \ell') \in flow(G)\} \end{cases}$$

$$LV_{entry}(\ell) = \left(LV_{exit}(\ell) \backslash kill_{LV}(\ell)\right) \cup gen_{LV}(\ell)$$

The sets are initialised to $\emptyset$ and computed iteratively, until reaching a fixpoint.

EXERCISE #2 ► **Live variables**

Generate the CFG for the following program:

```
while d>0 then {
    a:=b+c;
    d:=d-b;
    e:=a+f;
    if e>0 then {
        f:=a+d;
        b:=d+f;
    }
    else{
        e:=a-c;
        }
    b:=a+c;
}
```

On this CFG:

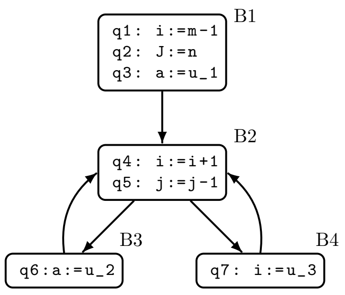
- Compute Gen, $Kill$ for each block ℓ
- Compute $In(\ell) = LV_{entry}(\ell)$ and $Out(\ell) = LV_{exit}(\ell)$ iteratively.
- Suppress the dead code.

			Step		Step		Step		Step	
ℓ	$kill(\ell)$	$gen(\ell)$	$In(\ell)$	$Out(\ell)$	$In(\ell)$	$Out(\ell)$	$In(\ell)$	$Out(\ell)$	$In(\ell)$	$Out(\ell)$

			Step		Step		Step		Step	
ℓ	$kill(\ell)$	$gen(\ell)$	$In(\ell)$	$Out(\ell)$	$In(\ell)$	$Out(\ell)$	$In(\ell)$	$Out(\ell)$	$In(\ell)$	$Out(\ell)$

EXERCISE #3 ▸ **Live Variables**

After code generation, we obtain the following graph:



On this graph, perform liveness analysis and suppress the dead code.

			Step		Step		Step		Step	
ℓ	$kill(\ell)$	$gen(\ell)$	$In(\ell)$	$Out(\ell)$	$In(\ell)$	$Out(\ell)$	$In(\ell)$	$Out(\ell)$	$In(\ell)$	$Out(\ell)$

			Step		Step		Step		Step	
ℓ	$kill(\ell)$	$gen(\ell)$	$In(\ell)$	$Out(\ell)$	$In(\ell)$	$Out(\ell)$	$In(\ell)$	$Out(\ell)$	$In(\ell)$	$Out(\ell)$