# Lenguajes de Programación 2016-1 Tarea 3

Ricardo Garcia Garcia

Juan Carlos López López

Luis Rodrigo Rojo Morales

24 de noviembre de 2015 Facultad de Ciencias UNAM

# Problema I

Haga el juicio de tipo para la función fibonacci y el predicado empty?

Acción	Stack	Sustitución
Inicio	$\llbracket 1  rbracket = [\mathrm{n}]  ightarrow \llbracket 2  rbracket$	Vacio
	[3] = boolean	
	$[\leq] = [n] \rightarrow [2] \rightarrow [3] = \text{number} \rightarrow \text{number} \rightarrow \text{boolean}$	
	[4] = number	
	[else] = [5] = [6]	
	$[+] = \boxed{7} \rightarrow \boxed{9} \rightarrow \boxed{6} = \text{number} \rightarrow \text{number} \rightarrow \text{number}$	
	$\boxed{1} = \boxed{8} \rightarrow \boxed{7}$	
	$[-] = [n] \rightarrow [1] \rightarrow [8] = [n] \rightarrow [2] \rightarrow [10] = \text{number} \rightarrow \text{number}$	
	$\rightarrow$ number	
	$\boxed{1} = \boxed{10} \rightarrow \boxed{9}$	
	$\begin{bmatrix} 2 \end{bmatrix} = \begin{bmatrix} 4 \end{bmatrix} = \begin{bmatrix} 6 \end{bmatrix}$	
Paso 3	[3] = boolean	$\boxed{ \boxed{1} \mapsto [n] \to \boxed{2} }$
	$[\leq =] = [n] \rightarrow [2] \rightarrow [3] = \text{number} \rightarrow \text{number} \rightarrow \text{boolean}$	
	[4] = number	
	[else] = [5] = [6]	
	$[+] = [ \boxed{7} ] \rightarrow [ \boxed{9} ] \rightarrow [ \boxed{6} ] = \text{number} \rightarrow \text{number} \rightarrow \text{number}$	
	$[n] \to \boxed{2} = \boxed{8} \to \boxed{7}$	
	$[-] = [n] \rightarrow [1] \rightarrow [8] = [n] \rightarrow [2] \rightarrow [10] = \text{number} \rightarrow \text{number}$	
	$\rightarrow$ number	
	$[n] \to [2] = [10] \to [9]$	
	$[\![2]\!] = [\![4]\!] = [\![6]\!]$	

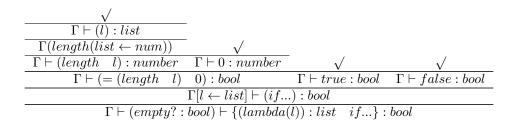
Paso 3 $ \langle -  =   n   \rightarrow   2   \rightarrow \text{boolean} = \text{number} \rightarrow \text{bunber} \rightarrow \text{boolean}$ $  1   \rightarrow   n   \rightarrow   2  $ $  3   \rightarrow \text{boolean}$ $  4   = \text{number}$ $  6   \text{s}   =   6  $ $  +   =   7   \rightarrow   9   \rightarrow   6  $ $  +   =   7   \rightarrow   9  $ $  +   =   7  $ $  +   =   7   \rightarrow   9  $ $  +   =   7$			
clse  =   5   = 6     +   =   7   → 9   → 6   = number → number   n   → 2   =   8   → 7     -   =   n   →   1   → 8   =   n   →   2   → 10   = number → number   n   → 2   =   10   → 9	Paso 3		$\boxed{\boxed{1}} \mapsto [n] \to \boxed{\boxed{2}}$
$   +   =   7   \rightarrow   9   \rightarrow   6   = \text{number} \rightarrow \text{number} \rightarrow \text{number} \\   n  \rightarrow   2   =   8 \rightarrow   7   \\   -   n  \rightarrow   1   \rightarrow   8 =   n  \rightarrow   2   \rightarrow   10   = \text{number} \rightarrow \text{number} \\   n  \rightarrow   2   =   10   \rightarrow   9   \\   2   =   4   =   6   $ $   2   =   4   =   6   $ Paso 5   $  n   = \text{number} \rightarrow   1   \rightarrow   1   \rightarrow   1   \rightarrow   2   $   3 $\rightarrow \text{boolean} $   1 $\rightarrow \text{number} \rightarrow   1   \rightarrow   $			$[3] \mapsto \text{boolean}$
$   +   =   7   \rightarrow   9   \rightarrow   6   = \text{number} \rightarrow \text{number} \rightarrow \text{number} \\   n  \rightarrow   2   =   8 \rightarrow   7   \\   -   n  \rightarrow   1   \rightarrow   8 =   n  \rightarrow   2   \rightarrow   10   = \text{number} \rightarrow \text{number} \\   n  \rightarrow   2   =   10   \rightarrow   9   \\   2   =   4   =   6   $ $   2   =   4   =   6   $ Paso 5   $  n   = \text{number} \rightarrow   1   \rightarrow   1   \rightarrow   1   \rightarrow   2   $   3 $\rightarrow \text{boolean} $   1 $\rightarrow \text{number} \rightarrow   1   \rightarrow   $		[else] = [5] = [6]	
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$		$[+] = [7] \rightarrow [9] \rightarrow [6] = \text{number} \rightarrow \text{number} \rightarrow \text{number}$	
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$		$[n] \rightarrow [2] = [8] \rightarrow [7]$	
→ number         →		$[-] = [n] \rightarrow [1] \rightarrow [8] = [n] \rightarrow [2] \rightarrow [10] = \text{number} \rightarrow \text{number}$	
2     4     6		$\rightarrow$ number	
2     4     6		$[n] \rightarrow [2] = [10] \rightarrow [9]$	
2  = number   4  = number   6  = 5  = 6    1  = 7  → 9  → 6  = number → number → number   1  → 1  → 8  = 1  → 1  → 8  = 1  → 1  → 1  → 1  → 1  → 1  → 1  → 1		$[\![2]\!] = [\![4]\!] = [\![6]\!]$	
2  = number   4  = number   else  =   5  =   6	Paso 5	[n] = number	$[\![1]\!]\mapsto [\![n]\!] \to [\![2]\!]$
$ \begin{bmatrix} 4 \end{bmatrix} = \text{number} \\ [\text{else}] = \boxed{5} = \boxed{6} \\ [+] = \boxed{7} \rightarrow 9 \rightarrow 6 \end{bmatrix} = \text{number} \rightarrow \text{number} \rightarrow \text{number} \\ [n] \rightarrow 2 = \boxed{8} \rightarrow 7 \\ [-] = [n] \rightarrow [1] \rightarrow \boxed{8} = [n] \rightarrow [2] \rightarrow \boxed{10} = \text{number} \rightarrow \text{number} \\ \rightarrow \text{number} \rightarrow \text{number} \rightarrow \text{number} \rightarrow \text{number} \rightarrow \text{number} \rightarrow \text{number} \\ \rightarrow \text{number} = \boxed{2} = \boxed{10} \rightarrow \boxed{9} \\ 2 = 4 = \boxed{6} $ $ \begin{bmatrix} 2 \end{bmatrix} = \text{number} \\ 4 \end{bmatrix} = \text{number} \rightarrow \boxed{2} = \boxed{6} $ $ \begin{bmatrix} 1 \end{bmatrix} \rightarrow \text{number} \rightarrow \boxed{2} \\ 3 \Rightarrow \text{boolean} \\ [n] \rightarrow \text{number} \rightarrow \boxed{2} \\ 4 \Rightarrow \text{number} \rightarrow \boxed{2} = \boxed{8} \rightarrow \boxed{7} \\ [-] = \text{number} \rightarrow \boxed{1} \rightarrow \boxed{8} = \text{number} \rightarrow \text{number} \rightarrow \text{number} \\ \rightarrow \text{number} \rightarrow \boxed{2} = \boxed{3} \Rightarrow \text{boolean} \\ [n] \rightarrow \text{number} \rightarrow \boxed{2} = \boxed{10} \rightarrow \boxed{9} \\ 2 = 4 = \boxed{6} $ $ \begin{bmatrix} 1 \end{bmatrix} \rightarrow \text{number} \rightarrow \boxed{2} \\ 3 \Rightarrow \text{boolean} \\ [n] \rightarrow \text{number} \rightarrow \boxed{2} = \boxed{3} \Rightarrow \text{boolean} \\ [n] \rightarrow \text{number} \rightarrow \boxed{2} = \boxed{3} \Rightarrow \text{boolean} \\ [n] \rightarrow \text{number} \rightarrow \boxed{2} = \boxed{3} \Rightarrow \text{boolean} \\ [n] \rightarrow \text{number} \rightarrow \boxed{2} = \boxed{3} \Rightarrow \text{boolean} \\ [n] \rightarrow \text{number} \rightarrow \boxed{2} = \boxed{3} \Rightarrow \text{boolean} \\ [n] \rightarrow \text{number} \rightarrow \boxed{2} = \boxed{3} \Rightarrow \text{boolean} \\ [n] \rightarrow \text{number} \rightarrow \boxed{2} = \boxed{3} \Rightarrow \text{boolean} \\ [n] \rightarrow \text{number} \rightarrow \boxed{2} = \boxed{3} \Rightarrow \text{boolean} \\ [n] \rightarrow \text{number} \rightarrow \boxed{2} = \boxed{3} \Rightarrow \text{boolean} \\ [n] \rightarrow \text{number} \rightarrow \boxed{2} = \boxed{3} \Rightarrow \text{boolean} \\ [n] \rightarrow \text{number} \rightarrow \boxed{2} = \boxed{3} \Rightarrow \text{boolean} \\ [n] \rightarrow \text{number} \rightarrow \boxed{2} = \boxed{3} \Rightarrow \text{boolean} \\ [n] \rightarrow \text{number} \rightarrow \boxed{2} = \boxed{3} \Rightarrow \text{boolean} \\ [n] \rightarrow \text{number} \rightarrow \boxed{2} = \boxed{3} \Rightarrow \text{boolean} \\ [n] \rightarrow \text{number} \rightarrow \boxed{2} = \boxed{3} \Rightarrow \text{boolean} \\ [n] \rightarrow \text{number} \rightarrow \boxed{2} = \boxed{3} \Rightarrow \text{boolean} \\ [n] \rightarrow \text{number} \rightarrow \boxed{2} = \boxed{3} \Rightarrow \text{boolean} \\ [n] \rightarrow \text{number} \rightarrow \boxed{2} = \boxed{3} \Rightarrow \text{boolean} \\ [n] \rightarrow \text{number} \rightarrow \boxed{2} = \boxed{3} \Rightarrow \text{boolean} \\ [n] \rightarrow \text{number} \rightarrow \boxed{2} = \boxed{3} \Rightarrow \text{boolean} \\ [n] \rightarrow \text{number} \rightarrow \boxed{2} = \boxed{3} \Rightarrow \text{boolean} \\ [n] \rightarrow \text{number} \rightarrow \boxed{2} = \boxed{3} \Rightarrow \text{boolean} \\ [n] \rightarrow \text{number} \rightarrow \boxed{2} = \boxed{3} \Rightarrow \text{boolean} \\ [n] \rightarrow \text{number} \rightarrow \boxed{2} = \boxed{3} \Rightarrow \text{boolean} \\ [n] \rightarrow \text{number} \rightarrow \boxed{2} = \boxed{3} \Rightarrow \text{boolean} \\ [n] \rightarrow \text{number} \rightarrow \boxed{2} = \boxed{3} \Rightarrow \text{boolean} \\ [n] \rightarrow \text{number} \rightarrow \boxed{2} = \boxed{3} \Rightarrow \text{boolean} \\ [n] \rightarrow \text{number} \rightarrow \boxed{2} = \boxed{3} \Rightarrow \text{boolean} \\ [n] \rightarrow \text{number} \rightarrow \boxed$		[2] = number	$[3] \mapsto \text{boolean}$
$[else] = \begin{bmatrix} 5 \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$			
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$		[else] = [5] = [6]	
$ \begin{bmatrix} \cdot \end{bmatrix} = \begin{bmatrix} n \end{bmatrix} \rightarrow \begin{bmatrix} 1 \end{bmatrix} \rightarrow \begin{bmatrix} 8 \end{bmatrix} = \begin{bmatrix} n \end{bmatrix} \rightarrow \begin{bmatrix} 2 \end{bmatrix} \rightarrow \begin{bmatrix} 10 \end{bmatrix} = \text{number} \rightarrow \text{number} \\ \rightarrow \text{number} \\ \rightarrow \text{number} \\ \begin{bmatrix} n \end{bmatrix} \rightarrow \begin{bmatrix} 2 \end{bmatrix} = \begin{bmatrix} 10 \end{bmatrix} \rightarrow \begin{bmatrix} 9 \end{bmatrix} \\ \begin{bmatrix} 2 \end{bmatrix} = \begin{bmatrix} 4 \end{bmatrix} = \begin{bmatrix} 6 \end{bmatrix} $ $ \begin{bmatrix} 4 \end{bmatrix} = \text{number} \\ 4 \end{bmatrix} = \text{number} $ $ \begin{bmatrix} 4 \end{bmatrix} = \text{number} \\ 4 \end{bmatrix} = \text{number} $ $ \begin{bmatrix} 4 \end{bmatrix} = \text{number} \rightarrow \begin{bmatrix} 4 \end{bmatrix} = \text{number} \rightarrow \begin{bmatrix} 1 \end{bmatrix} \rightarrow \text{number} \rightarrow \begin{bmatrix} 2 \end{bmatrix} \\ 3 \end{bmatrix} \rightarrow \text{boolean} $ $ \begin{bmatrix} n \end{bmatrix} \rightarrow \text{number} \rightarrow \begin{bmatrix} 2 \end{bmatrix} = \begin{bmatrix} 6 \end{bmatrix} \\ \vdots \rightarrow \vdots \rightarrow \vdots \rightarrow \begin{bmatrix} 6 \end{bmatrix} \\ \vdots \rightarrow \vdots \rightarrow \vdots \rightarrow \begin{bmatrix} 6 \end{bmatrix} \\ \vdots \rightarrow \vdots \rightarrow \vdots \rightarrow \begin{bmatrix} 6 \end{bmatrix} \\ \vdots \rightarrow \vdots \rightarrow \vdots \rightarrow \vdots \rightarrow \begin{bmatrix} 6 \end{bmatrix} \\ \vdots \rightarrow \vdots \rightarrow \vdots \rightarrow \vdots \rightarrow \vdots \rightarrow \begin{bmatrix} 6 \end{bmatrix} \\ \vdots \rightarrow \vdots$		$[\pm] - [7] \rightarrow [9] \rightarrow [6] - number \rightarrow number \rightarrow number$	
$ \begin{bmatrix} \cdot \end{bmatrix} = \begin{bmatrix} n \end{bmatrix} \rightarrow \begin{bmatrix} 1 \end{bmatrix} \rightarrow \begin{bmatrix} 8 \end{bmatrix} = \begin{bmatrix} n \end{bmatrix} \rightarrow \begin{bmatrix} 2 \end{bmatrix} \rightarrow \begin{bmatrix} 10 \end{bmatrix} = \text{number} \rightarrow \text{number} \\ \rightarrow \text{number} \\ \rightarrow \text{number} \\ \begin{bmatrix} n \end{bmatrix} \rightarrow \begin{bmatrix} 2 \end{bmatrix} = \begin{bmatrix} 10 \end{bmatrix} \rightarrow \begin{bmatrix} 9 \end{bmatrix} \\ \begin{bmatrix} 2 \end{bmatrix} = \begin{bmatrix} 4 \end{bmatrix} = \begin{bmatrix} 6 \end{bmatrix} $ $ \begin{bmatrix} 4 \end{bmatrix} = \text{number} \\ 4 \end{bmatrix} = \text{number} $ $ \begin{bmatrix} 4 \end{bmatrix} = \text{number} \\ 4 \end{bmatrix} = \text{number} $ $ \begin{bmatrix} 4 \end{bmatrix} = \text{number} \rightarrow \begin{bmatrix} 4 \end{bmatrix} = \text{number} \rightarrow \begin{bmatrix} 1 \end{bmatrix} \rightarrow \text{number} \rightarrow \begin{bmatrix} 2 \end{bmatrix} \\ 3 \end{bmatrix} \rightarrow \text{boolean} $ $ \begin{bmatrix} n \end{bmatrix} \rightarrow \text{number} \rightarrow \begin{bmatrix} 2 \end{bmatrix} = \begin{bmatrix} 6 \end{bmatrix} \\ \vdots \rightarrow \vdots \rightarrow \vdots \rightarrow \begin{bmatrix} 6 \end{bmatrix} \\ \vdots \rightarrow \vdots \rightarrow \vdots \rightarrow \begin{bmatrix} 6 \end{bmatrix} \\ \vdots \rightarrow \vdots \rightarrow \vdots \rightarrow \begin{bmatrix} 6 \end{bmatrix} \\ \vdots \rightarrow \vdots \rightarrow \vdots \rightarrow \vdots \rightarrow \begin{bmatrix} 6 \end{bmatrix} \\ \vdots \rightarrow \vdots \rightarrow \vdots \rightarrow \vdots \rightarrow \vdots \rightarrow \begin{bmatrix} 6 \end{bmatrix} \\ \vdots \rightarrow \vdots$			
Paso 3 [2] = $10$ $\rightarrow$ 9 [2] = $10$ $\rightarrow$ 10 $\rightarrow$ 11 $\rightarrow$ 12 $\rightarrow$ 13 $\rightarrow$ boolean [1] $\rightarrow$ number $\rightarrow$ 12 $\rightarrow$ 13 $\rightarrow$ boolean [1] $\rightarrow$ number $\rightarrow$ 12 $\rightarrow$ 13 $\rightarrow$ boolean [1] $\rightarrow$ number $\rightarrow$ 12 $\rightarrow$ 13 $\rightarrow$ boolean [1] $\rightarrow$ number $\rightarrow$ 12 $\rightarrow$ 10 $\rightarrow$ number $\rightarrow$ number $\rightarrow$ 11 $\rightarrow$ 18 $\rightarrow$ number $\rightarrow$ 10 $\rightarrow$ 11 $\rightarrow$ 12 $\rightarrow$ 10 $\rightarrow$ 11 $\rightarrow$ 12 $\rightarrow$ 11 $\rightarrow$ 12 $\rightarrow$ 13 $\rightarrow$ boolean [1] $\rightarrow$ number $\rightarrow$ 12 $\rightarrow$ 13 $\rightarrow$ boolean [1] $\rightarrow$ number $\rightarrow$ 13 $\rightarrow$ boolean [1] $\rightarrow$ number $\rightarrow$ 13 $\rightarrow$ boolean [1] $\rightarrow$ number $\rightarrow$ 10 $\rightarrow$ 10 $\rightarrow$ 11 $\rightarrow$ 12 $\rightarrow$ 13 $\rightarrow$ boolean [1] $\rightarrow$ number $\rightarrow$ 10 $\rightarrow$ 10 $\rightarrow$ 10 $\rightarrow$ 11 $\rightarrow$ 12 $\rightarrow$ 12 $\rightarrow$ 13 $\rightarrow$ boolean [1] $\rightarrow$ number $\rightarrow$ 10 $\rightarrow$ 12 $\rightarrow$ 13 $\rightarrow$ boolean [1] $\rightarrow$ number $\rightarrow$ 10 $\rightarrow$ 12 $\rightarrow$ 13 $\rightarrow$ boolean [1] $\rightarrow$ number $\rightarrow$ 10 $\rightarrow$ 12 $\rightarrow$ 13 $\rightarrow$ boolean [1] $\rightarrow$ number $\rightarrow$ 10 $\rightarrow$ 12 $\rightarrow$ 13 $\rightarrow$ boolean [1] $\rightarrow$ number $\rightarrow$ 10 $\rightarrow$ 13 $\rightarrow$ 14 $\rightarrow$ 15 $\rightarrow$ 15 $\rightarrow$ 16 $\rightarrow$ 17 $\rightarrow$ 17 $\rightarrow$ 19 $\rightarrow$ 16 $\rightarrow$ number $\rightarrow$		$\begin{bmatrix} 11 \end{bmatrix} \rightarrow \begin{bmatrix} 2 \end{bmatrix} = \begin{bmatrix} 0 \end{bmatrix} \rightarrow \begin{bmatrix} 1 \end{bmatrix}$	
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$		$[-] = [n] \rightarrow [1] \rightarrow [8] = [n] \rightarrow [2] \rightarrow [10] = \text{number} \rightarrow \text{number}$	
Paso 3 [2] = number [4] = number   2]   3			
Paso 3 [2] = number [4] = number   [2] = number   [2] = [6]   [3] $\rightarrow$ boolean   [n] $\rightarrow$ number   [2] = [8] $\rightarrow$ [7]   [1] = number $\rightarrow$ 1] $\rightarrow$ [8] = number $\rightarrow$ number   number $\rightarrow$ number   number $\rightarrow$		$\begin{bmatrix} \mathbf{n} \end{bmatrix} \to \begin{bmatrix} 2 \end{bmatrix} = \begin{bmatrix} 10 \end{bmatrix} \to \begin{bmatrix} 9 \end{bmatrix}$	
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$			
$[else] = \begin{bmatrix} 5 \end{bmatrix} = \begin{bmatrix} 6 \\ \\ [+] = \begin{bmatrix} 7 \end{bmatrix} \rightarrow 9 \end{bmatrix} \rightarrow \begin{bmatrix} 6 \end{bmatrix} = \text{number} \rightarrow \text{number} \rightarrow \text{number} \\ \text{number} \rightarrow \begin{bmatrix} 2 \end{bmatrix} = \begin{bmatrix} 8 \end{bmatrix} \rightarrow \begin{bmatrix} 7 \end{bmatrix} \\ [-] = \text{number} \rightarrow \text{number} \rightarrow \text{number} \\ \rightarrow \text{number} \rightarrow \text{number} \rightarrow \text{number} \rightarrow \text{number} \rightarrow \text{number} \\ \text{number} \rightarrow \begin{bmatrix} 2 \end{bmatrix} = \begin{bmatrix} 10 \end{bmatrix} \rightarrow \begin{bmatrix} 9 \end{bmatrix} \\ 2 \end{bmatrix} = \begin{bmatrix} 4 \end{bmatrix} = \begin{bmatrix} 6 \end{bmatrix} \\ [+] = \begin{bmatrix} 7 \end{bmatrix} \rightarrow \begin{bmatrix} 9 \end{bmatrix} \rightarrow \begin{bmatrix} 6 \end{bmatrix} = \text{number} \rightarrow \text{number} \rightarrow \text{number} \\ \text{number} \rightarrow \begin{bmatrix} 2 \end{bmatrix} = \begin{bmatrix} 8 \end{bmatrix} \rightarrow \begin{bmatrix} 7 \end{bmatrix} \\ [-] = \text{number} \rightarrow \text{number} \rightarrow \text{number} \rightarrow \text{number} \rightarrow \text{number} \rightarrow \text{number} \\ \text{number} \rightarrow nu$	Paso 3	[2] = number	$[1] \mapsto \text{number} \rightarrow [2]$
$[+] = [7] \rightarrow [9] \rightarrow [6] = \text{number} \rightarrow \text{number}$ $\text{number} \rightarrow [2] = [8] \rightarrow [7]$ $[-] = \text{number} \rightarrow [1] \rightarrow [8] = \text{number} \rightarrow [2] \rightarrow [10] = \text{number}$ $\rightarrow \text{number} \rightarrow \text{number}$ $\text{number} \rightarrow \text{number}$ $\text{number} \rightarrow \text{number}$ $\text{number} \rightarrow [2] = [10] \rightarrow [9]$ $[2] = [4] = [6]$ Paso 3 $[4] = \text{number}$ $[4] = \text{number}$ $[4] = [7] \rightarrow [9] \rightarrow [6] = \text{number} \rightarrow \text{number}$ $\text{number} \rightarrow [2] = [8] \rightarrow [7]$ $[-] = \text{number} \rightarrow [1] \rightarrow [8] = \text{number} \rightarrow \text{number}$ $\text{number} \rightarrow [2] = [10] \rightarrow [9]$ $[2] = [4] = [6]$ $[3] \rightarrow \text{boolean}$ $[n] \rightarrow \text{number}$ $[2] \rightarrow \text{number}$ $[2] \rightarrow \text{number} \rightarrow [2]$ $[3] \rightarrow \text{boolean}$ $[n] \rightarrow \text{number}$ $[2] \rightarrow \text{number} \rightarrow [2]$ $[3] \rightarrow \text{boolean}$ $[n] \rightarrow \text{number} \rightarrow [2]$ $[4] \rightarrow \text{number} \rightarrow [2]$ $[2] \rightarrow \text{number} \rightarrow [2]$ $[3] \rightarrow \text{boolean}$ $[n] \rightarrow \text{number} \rightarrow [2]$ $[3] \rightarrow \text{boolean}$ $[4] \rightarrow \text{number} \rightarrow [2]$		$\boxed{4}$ = number	$[3] \mapsto \text{boolean}$
$[+] = [7] \rightarrow [9] \rightarrow [6] = \text{number} \rightarrow \text{number}$ $\text{number} \rightarrow [2] = [8] \rightarrow [7]$ $[-] = \text{number} \rightarrow [1] \rightarrow [8] = \text{number} \rightarrow [2] \rightarrow [10] = \text{number}$ $\rightarrow \text{number} \rightarrow \text{number}$ $\text{number} \rightarrow \text{number}$ $\text{number} \rightarrow \text{number}$ $\text{number} \rightarrow [2] = [10] \rightarrow [9]$ $[2] = [4] = [6]$ Paso 3 $[4] = \text{number}$ $[4] = \text{number}$ $[4] = [7] \rightarrow [9] \rightarrow [6] = \text{number} \rightarrow \text{number}$ $\text{number} \rightarrow [2] = [8] \rightarrow [7]$ $[-] = \text{number} \rightarrow [1] \rightarrow [8] = \text{number} \rightarrow \text{number}$ $\text{number} \rightarrow [2] = [10] \rightarrow [9]$ $[2] = [4] = [6]$ $[3] \rightarrow \text{boolean}$ $[n] \rightarrow \text{number}$ $[2] \rightarrow \text{number}$ $[2] \rightarrow \text{number} \rightarrow [2]$ $[3] \rightarrow \text{boolean}$ $[n] \rightarrow \text{number}$ $[2] \rightarrow \text{number} \rightarrow [2]$ $[3] \rightarrow \text{boolean}$ $[n] \rightarrow \text{number} \rightarrow [2]$ $[4] \rightarrow \text{number} \rightarrow [2]$ $[2] \rightarrow \text{number} \rightarrow [2]$ $[3] \rightarrow \text{boolean}$ $[n] \rightarrow \text{number} \rightarrow [2]$ $[3] \rightarrow \text{boolean}$ $[4] \rightarrow \text{number} \rightarrow [2]$		[else] = [5] = [6]	$[n] \mapsto \text{number}$
$\begin{array}{c} \operatorname{number} \to 2 = 8 \to 7 \\ [\cdot] = \operatorname{number} \to [1] \to 8 = \operatorname{number} \to [2] \to 10 = \operatorname{number} \\ \to \operatorname{number} \to \operatorname{number} \\ \operatorname{number} \to \operatorname{number} \\ \operatorname{number} \to 2 = 10 \to 9 \\ 2 = 4 = 6 \\ \end{array}$ $\begin{array}{c} \operatorname{Paso} 3 \\ 4 = \operatorname{number} \\ [\operatorname{else}] = 5 = 6 \\ [+] = 7 \to 9 \to 6 = \operatorname{number} \to \operatorname{number} \\ \operatorname{number} \to \operatorname{number} \to 11 \to 8 = \operatorname{number} \to \operatorname{number} \\ \operatorname{number} \to \operatorname{number} \to \operatorname{number} \to \operatorname{number} \to \operatorname{number} \\ \operatorname{number} \to \operatorname{number} \to \operatorname{number} \to \operatorname{number} \to \operatorname{number} \to 10 = \\ \operatorname{number} \to 2 = 10 \to 9 \\ 2 = 4 = 6 \\ \end{array}$ $\begin{array}{c} \operatorname{Paso} 3 \\ [\operatorname{else}] = 5 = 6 \\ [+] = 7 \to 9 \to 6 = \operatorname{number} \to \operatorname{number} \to \operatorname{number} \\ \operatorname{number} \to 2 = 8 \to 7 \\ [-] = \operatorname{number} \to [1] \to 8 = \operatorname{number} \to \operatorname{number} \\ \operatorname{number} \to \operatorname{number} \to \operatorname{number} \to \operatorname{number} \\ \operatorname{number} \to \operatorname{number} \to \operatorname{number} \to \operatorname{number} \to 10 = \\ \operatorname{number} \to \operatorname{number} \to \operatorname{number} \to \operatorname{number} \to 10 = \\ \operatorname{number} \to \operatorname{number} \to \operatorname{number} \\ \operatorname{number} \to \operatorname{number} \to \operatorname{number} \to \operatorname{number} \\ \operatorname{number} \to \operatorname{number} \to \operatorname{number} \to \operatorname{number} \to 10 = \\ \operatorname{number} \to \operatorname{number} \to \operatorname{number} \to \operatorname{number} \to 10 = \\ \operatorname{number} \to \operatorname{number} \to \operatorname{number} \to \operatorname{number} \to 10 = \\ \operatorname{number} \to \operatorname{number} \to \operatorname{number} \to \operatorname{number} \to 10 = \\ \operatorname{number} \to 10 = 10 \to 10 = \\ \operatorname{number} \to 10 \to 10 \to 10 = \\ \operatorname{number} \to 10 \to 10 = 10 = \\ \operatorname{number} \to 10 \to 10 = \\ \operatorname{number}$		$[+] = [7] \rightarrow [9] \rightarrow [6] = \text{number} \rightarrow \text{number} \rightarrow \text{number}$	
$[-] = \text{number} \rightarrow [1] \rightarrow [8] = \text{number} \rightarrow [2] \rightarrow [10] = \text{number}$ $\rightarrow \text{number} \rightarrow \text{number}$ $\text{number} \rightarrow [2] = [10] \rightarrow [9]$ $2 = [4] = [6]$ Paso 3 $[4] = \text{number}$ $[else] = [5] = [6]$ $[+] = [7] \rightarrow [9] \rightarrow [6] = \text{number} \rightarrow \text{number}$ $\text{number} \rightarrow [2] = [8] \rightarrow [7]$ $[-] = \text{number} \rightarrow [1] \rightarrow [8] = \text{number} \rightarrow \text{number}$ $\text{number} \rightarrow \text{number} \rightarrow \text{number}$ $\text{number} \rightarrow [2] = [10] \rightarrow [9]$ $[-] = \text{number} \rightarrow [1] \rightarrow [8] = \text{number} \rightarrow \text{number}$ $\text{number} \rightarrow [2] = [3] \rightarrow [4] \rightarrow [4]$ $\text{Paso 3}  [else] = [5] = [6]$ $[+] = [7] \rightarrow [9] \rightarrow [6] = \text{number} \rightarrow \text{number}$ $\text{number} \rightarrow [2] = [8] \rightarrow [7]$ $[-] = \text{number} \rightarrow [1] \rightarrow [8] = \text{number} \rightarrow \text{number}$ $\text{number} \rightarrow $		number $\rightarrow \boxed{2} = \boxed{8} \rightarrow \boxed{7}$	
Paso 3			
$\begin{array}{cccccccccccccccccccccccccccccccccccc$			
Paso 3 $4$ = number $2$ = $6$ $3$ $4$ = number $4$ = $6$ $3$ $4$ = number $4$ = $6$ = $6$ $4$ = $6$ = $6$ $6$ = $6$ $6$ = $6$ = $6$ = $6$ $6$ $6$ = $6$ $6$			
Paso 3 $ \begin{bmatrix} 4 \end{bmatrix} = \text{number} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $ $ \begin{bmatrix}   1 \end{bmatrix} \Rightarrow \text{number} \Rightarrow   2 \end{bmatrix} $			
$[else] = \begin{bmatrix} 5 \end{bmatrix} = \begin{bmatrix} 6 \end{bmatrix}$ $[+] = \begin{bmatrix} 7 \end{bmatrix} \rightarrow \begin{bmatrix} 9 \end{bmatrix} \rightarrow \begin{bmatrix} 6 \end{bmatrix} = \text{number} \rightarrow \text{number} \rightarrow \text{number}$ $\text{number} \rightarrow \begin{bmatrix} 2 \end{bmatrix} = \begin{bmatrix} 8 \end{bmatrix} \rightarrow \begin{bmatrix} 7 \end{bmatrix}$ $[-] = \text{number} \rightarrow \text{number} \rightarrow \text{number}$ $\text{number} \rightarrow \text{number} \rightarrow \text{number}$ $\text{number} \rightarrow \begin{bmatrix} 2 \end{bmatrix} = \begin{bmatrix} 10 \end{bmatrix} \rightarrow \begin{bmatrix} 9 \end{bmatrix}$ $\begin{bmatrix} 2 \end{bmatrix} = \begin{bmatrix} 4 \end{bmatrix} = \begin{bmatrix} 6 \end{bmatrix}$ $[+] = \begin{bmatrix} 7 \end{bmatrix} \rightarrow \begin{bmatrix} 9 \end{bmatrix} \rightarrow \begin{bmatrix} 6 \end{bmatrix} = \text{number} \rightarrow \text{number} \rightarrow \text{number}$ $\text{number} \rightarrow \begin{bmatrix} 2 \end{bmatrix} = \begin{bmatrix} 8 \end{bmatrix} \rightarrow \begin{bmatrix} 7 \end{bmatrix}$ $[-] = \text{number} \rightarrow \text{number} \rightarrow \text{number} \rightarrow \text{number} \rightarrow \text{number}$ $\text{number} \rightarrow \text{number} \rightarrow \text{number} \rightarrow \text{number} \rightarrow \text{number}$ $\text{number} \rightarrow \text{number} \rightarrow \text{number} \rightarrow \text{number} \rightarrow \text{number}$ $\text{number} \rightarrow $	D 0		dah 1 dah
$[+] = \boxed{7} \rightarrow \boxed{9} \rightarrow \boxed{6} = \text{number} \rightarrow \text{number} \rightarrow \text{number}$ $\text{number} \rightarrow \boxed{2} = \boxed{8} \rightarrow \boxed{7}$ $[-] = \text{number} \rightarrow \text{number} \rightarrow \text{number} \rightarrow \text{number} \rightarrow \text{number} \rightarrow \text{number}$ $\text{number} \rightarrow \text{number} $	Paso 3		
$\begin{array}{c} \operatorname{number} \to [2] = [8] \to [7] \\ [-] = \operatorname{number} \to [1] \to [8] = \operatorname{number} \to \operatorname{number} \to$			
$\begin{array}{c} \operatorname{number} \to [2] = [8] \to [7] \\ [-] = \operatorname{number} \to [1] \to [8] = \operatorname{number} \to \operatorname{number} \to$		$[+] = [\![7]\!]  [\![9]\!]  [\![6]\!] = \text{number} \rightarrow \text{number} \rightarrow \text{number}$	$[n] \mapsto number$
		$number \to [2] = [8] \to [7]$	$[2] \mapsto \text{number}$
number $\rightarrow$ number $\rightarrow$ number number number $\rightarrow$ [2] = [10] $\rightarrow$ [9]  [2] = [4] = [6]  Paso 3 [else] = [5] = [6] [+] = [7] $\rightarrow$ [9] $\rightarrow$ [6] = number $\rightarrow$ number $\rightarrow$ number $\rightarrow$ number $\rightarrow$ [2] = [8] $\rightarrow$ [7] [-] = number $\rightarrow$ [1] $\rightarrow$ [8] = number $\rightarrow$ [2] = [10] $\rightarrow$ [9] [4] $\rightarrow$ number $\rightarrow$ numbe		$[-]$ = number $\rightarrow$ $[1]$ $\rightarrow$ $[8]$ = number $\rightarrow$ number $\rightarrow$ $[10]$ =	
Paso 3 [else] = $\begin{bmatrix} 5 \end{bmatrix}$ = $\begin{bmatrix} 6 \end{bmatrix}$			
Paso 3 [else] = $\begin{bmatrix} 5 \end{bmatrix}$ = $\begin{bmatrix} 6 \end{bmatrix}$		$number \to \boxed{2} = \boxed{10} \to \boxed{9}$	
Paso 3 [else] = $\begin{bmatrix} 5 \end{bmatrix}$ = $\begin{bmatrix} 6 \end{bmatrix}$ [1] $\mapsto$ number $\rightarrow$ $\begin{bmatrix} 2 \end{bmatrix}$ [1] $\mapsto$ number $\rightarrow$ $\begin{bmatrix} 2 \end{bmatrix}$ [1] $\mapsto$ number $\rightarrow$ $\begin{bmatrix} 2 \end{bmatrix}$ [2] = number $\rightarrow$ $\begin{bmatrix} 2 \end{bmatrix}$ = $\begin{bmatrix} 1 \end{bmatrix}$ $\mapsto$ number $\rightarrow$ $\begin{bmatrix} 2 \end{bmatrix}$ $\mapsto$ number $\rightarrow$ number $\rightarrow$ number $\rightarrow$			
$[+] = \boxed{7} \rightarrow \boxed{9} \rightarrow \boxed{6} = \text{number} \rightarrow \text{number} \rightarrow \text{number}$ $\text{number} \rightarrow \boxed{2} = \boxed{8} \rightarrow \boxed{7}$ $[-] = \text{number} \rightarrow \boxed{1} \rightarrow \boxed{8} = \text{number} \rightarrow \text{number} \rightarrow \boxed{10} =$ $\text{number} \rightarrow \text{number} \rightarrow \text{number}$ $\text{number} \rightarrow \text{number} \rightarrow \text{number}$ $\text{number} \rightarrow \boxed{2} = \boxed{10} \rightarrow \boxed{9}$ $\boxed{2} = \text{number} = \boxed{6}$	Paso 3		$1 \mapsto \text{number} \rightarrow 2$
$\begin{array}{c} \operatorname{number} \to \boxed{2} = \boxed{8} \to \boxed{7} \\ [-] = \operatorname{number} \to [1] \to \boxed{8} = \operatorname{number} \to \operatorname{number} \to [10] = \\ \operatorname{number} \to \operatorname{number} \to \operatorname{number} \\ \operatorname{number} \to \boxed{2} = \boxed{10} \to \boxed{9} \\ \boxed{2} = \operatorname{number} = \boxed{6} \end{array}$		· · · <u>· · · · · · · · · · · · · · · · </u>	
$[-] = \text{number} \rightarrow [1] \rightarrow [8] = \text{number} \rightarrow \text{number} \rightarrow [10] = \\ \text{number} \rightarrow \text{number} \rightarrow \text{number} \\ \text{number} \rightarrow [2] = [10] \rightarrow [9] \\ [2] = \text{number} = [6]$ $[4] \mapsto \text{number}$			- <del></del>
$\begin{array}{c} \mathrm{number} \to \mathrm{number} \\ \mathrm{number} \to \left[ \begin{array}{c} 2 \end{array} \right] = \left[ \begin{array}{c} 10 \end{array} \right] \to \left[ \begin{array}{c} 9 \end{array} \right] \\ \left[ \begin{array}{c} 2 \end{array} \right] = \mathrm{number} = \left[ \begin{array}{c} 6 \end{array} \right] \end{array}$			
$\begin{array}{c} \operatorname{number} \to \boxed{2} = \boxed{10} \to \boxed{9} \\ \boxed{2} = \operatorname{number} = \boxed{6} \end{array}$			$[z] \mapsto \text{number}$
[2] = number = [6]			1
			$[4] \mapsto \text{number}$
	Paso 3	$[+] = [7] \rightarrow [9] \rightarrow [6] = \text{number} \rightarrow \text{number} \rightarrow \text{number}$	$[1] \mapsto \text{number} \rightarrow [2]$
$   \text{ number } \rightarrow [\![2]\!] = [\![8]\!] \rightarrow [\![7]\!] $ $   [\![3]\!] \mapsto \text{boolean} $		$number \to \lfloor \!\lfloor 2 \!\rfloor \!\rfloor = \lfloor \!\lfloor 8 \!\rfloor \!\rfloor \to \lfloor \!\lceil 7 \!\rfloor \!\rfloor$	$[3] \mapsto \text{boolean}$

		$[n] \mapsto \text{number}$
	$\begin{array}{c} \text{number} \to \text{number} \\ \text{number} \to \boxed{2} = \boxed{10} \to \boxed{9} \end{array}$	$[2] \mapsto \text{number}$
	2 = number = $6$	$\begin{bmatrix} 1 \\ 4 \end{bmatrix} \mapsto \text{number}$
		$5 \mapsto 6$
Paso 5	$ \boxed{ \boxed{7} } = \text{number} $	$\boxed{\boxed{1}} \mapsto \text{number} \rightarrow \boxed{2}$
	$\begin{bmatrix} 9 \end{bmatrix}$ = number	$\begin{bmatrix} 3 \end{bmatrix} \mapsto \text{boolean}$
	$\begin{bmatrix} 6 \end{bmatrix} = \text{number}$	$ \begin{array}{c} [n] \mapsto \text{number} \\ [2] \mapsto \text{number} \end{array} $
		$     \begin{bmatrix} 2 \end{bmatrix} \mapsto \text{number} \\     \begin{bmatrix} 4 \end{bmatrix} \mapsto \text{number} $
	$\begin{array}{c} \text{number} \rightarrow \text{number} \rightarrow \text{number} \\ \text{number} \rightarrow \text{number} \end{array}$	
	$\underline{\text{number}} \to \underline{[2]} = \underline{[10]} \to \underline{[9]}$	$5 \mapsto 6$
	[2] = number = $[6]$	
Paso 3	$\begin{bmatrix} 9 \end{bmatrix}$ = number	$\boxed{\begin{array}{c} \boxed{1} \\ \boxed{2} \end{array}} \mapsto \text{number} \rightarrow \boxed{2}$
	$\begin{bmatrix} 6 \end{bmatrix} = \text{number}$	$ \begin{array}{c} [3] \mapsto \text{boolean} \\ [n] \mapsto \text{number} \end{array} $
	$ \begin{array}{c c} \text{number} \rightarrow & \boxed{2} = & \boxed{8} \rightarrow \text{number} \\ [-] = \text{number} \rightarrow & \boxed{1} \rightarrow & \boxed{8} = \text{number} \rightarrow \text{number} \rightarrow & \boxed{10} = \\ \end{array} $	$[1] \mapsto \text{number}$ $[2] \mapsto \text{number}$
	$\begin{array}{c} \text{number} \rightarrow \text{number} \\ \end{array}$	[-]
	$\boxed{\text{number} \rightarrow \boxed{2}} = \boxed{10} \rightarrow \boxed{9}$	$\boxed{4} \mapsto \text{number}$
		$\begin{bmatrix} 5 \\ \end{bmatrix} \mapsto \begin{bmatrix} 6 \\ \end{bmatrix}$
D 2	1 C h	$\boxed{7} \mapsto \text{number}$
Paso 3	$ \begin{bmatrix} 6 \end{bmatrix} = \text{number} \\ \text{number} \to \begin{bmatrix} 2 \end{bmatrix} = \begin{bmatrix} 8 \end{bmatrix} \to \text{number} $	$     \begin{bmatrix}       1 \\       \hline       \end{bmatrix} \mapsto \text{number} \rightarrow \begin{bmatrix}       2     \end{bmatrix} \\       \hline       \end{bmatrix} \mapsto \text{boolean} $
	$[-] = \text{number} \rightarrow [1] \rightarrow [8] = \text{number} \rightarrow \text{number} \rightarrow [10] = [1]$	$[n] \mapsto \text{number}$
	$number \rightarrow number \rightarrow number$	
	$\boxed{\text{number} \rightarrow \boxed{2}} = \boxed{10} \rightarrow \text{number}$	$[2] \mapsto \text{number}$
		$\begin{bmatrix} 4 \end{bmatrix} \mapsto \text{number}$
		$ \begin{bmatrix} 5 \\ 7 \end{bmatrix} \mapsto \begin{bmatrix} 6 \\ \end{bmatrix} $ number
		$9 \mapsto \text{number}$
Paso 3	$number \to [2] = [8] \to number$	$1 \rightarrow \text{number} \rightarrow 2$
	$ \boxed{ [-] = \text{number} \rightarrow [1] \rightarrow \boxed{8} } = \text{number} \rightarrow \text{number} \rightarrow \boxed{10}  = $	$\boxed{3} \mapsto \text{boolean}$
	$number \rightarrow number \rightarrow number$	
	$\begin{array}{c} \text{number} \to \boxed{2} = \boxed{10} \to \text{number} \\ \boxed{2} = \text{number} = \text{number} \end{array}$	$   \begin{array}{c}     [n] \mapsto \text{number} \\     [2] \mapsto \text{number}   \end{array} $
		$\begin{bmatrix} 4 \end{bmatrix} \mapsto \text{number}$
		$5 \mapsto \text{number}$
		$7 \mapsto \text{number}$
		$9 \rightarrow \text{number}$
D F		$   \begin{bmatrix}       6   \end{bmatrix} \mapsto \text{number} $
Paso 5	$ \begin{array}{c} \text{number} = [8] \\ [2] = \text{number} \end{array} $	$     \begin{bmatrix}       1 \\       \hline       \end{bmatrix} \mapsto \text{number} \rightarrow \begin{bmatrix}       2     \end{bmatrix} \\       \hline       \end{bmatrix} \mapsto \text{boolean} $
	$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	$[n] \mapsto \text{number}$
	$\begin{array}{c} \text{number} \rightarrow \text{number} \rightarrow \text{number} \\ \end{array}$	
	$\begin{array}{c} \text{number} \to \boxed{2} = \boxed{10} \to \text{number} \end{array}$	$[2] \mapsto \text{number}$
	[2] = number = number	$\boxed{4} \mapsto \text{number}$
		$\left[\begin{array}{c} \underline{[5]} \mapsto \text{number} \end{array}\right]$

I		l d=h
		$[7] \mapsto \text{number}$
		$[9] \mapsto \text{number}$
		$[6] \mapsto \text{number}$
Paso 4		$\left[\begin{array}{c} 1 \end{array}\right] \mapsto \text{number} \rightarrow \left[\begin{array}{c} 2 \end{array}\right]$
	$[-]$ = number $\rightarrow$ [1] $\rightarrow$ number = number $\rightarrow$ number $\rightarrow$ [10] =	$[3] \mapsto \text{boolean}$
	$number \rightarrow number \rightarrow number$	
	$ \underline{\text{number}} \to [2] = [10] \to \text{number} $	$[n] \mapsto \text{number}$
	[2] = number = number	$[2] \mapsto \text{number}$
		$[4] \mapsto \text{number}$
		$\begin{bmatrix} 5 \end{bmatrix} \mapsto \text{number}$
		$[7] \mapsto \text{number}$
		$[9] \mapsto \text{number}$
		$\boxed{6} \mapsto \text{number}$
		$\boxed{8} \mapsto \text{number}$
Paso 3	$[-]$ = number $\rightarrow$ $[1]$ $\rightarrow$ number = number $\rightarrow$ number $\rightarrow$ $[10]$ =	$1 \mapsto \text{number} \to \text{number}$
	$number \rightarrow number \rightarrow number$	
	$number \rightarrow number = \boxed{10} \rightarrow number$	$\boxed{3} \mapsto \text{boolean}$
	number = number = number	$[n] \mapsto \text{number}$
		$[2] \mapsto \text{number}$
		$[4] \mapsto \text{number}$
		$\begin{bmatrix} 5 \end{bmatrix} \mapsto \text{number}$
		$[7] \mapsto \text{number}$
		$[9] \mapsto \text{number}$
		$\begin{bmatrix} 6 \end{bmatrix} \mapsto \text{number}$
		$[8] \mapsto \text{number}$
		$[2] \mapsto \text{number}$
Paso 5	[1] = number	$[1] \mapsto \text{number} \to \text{number}$
	number = [10]	$[3] \mapsto \text{boolean}$
	$number \to \overline{num}ber = \boxed{10} \to number$	$[n] \mapsto \text{number}$
	number = number = number	$[2] \mapsto \text{number}$
		$[4] \mapsto \text{number}$
		$[5] \mapsto \text{number}$
		$[7] \mapsto \text{number}$
		$[9] \mapsto \text{number}$
		$[6] \mapsto \text{number}$
		$[8] \mapsto \text{number}$
		$\boxed{2} \mapsto \text{number}$
Paso 3	number = [10]	$1 \mapsto \text{number} \to \text{number}$
	$number \to \overline{number} = [10] \to number$	$\boxed{3} \mapsto \text{boolean}$
	number = number = number	$[\overline{\mathrm{n}}] \mapsto \mathrm{number}$
		$[2] \mapsto \text{number}$
		$[4] \mapsto \text{number}$
		$[5] \mapsto \text{number}$
		$[7] \mapsto \text{number}$
		$[9] \mapsto \text{number}$
		$[6] \mapsto \text{number}$
		$\boxed{8} \mapsto \text{number}$
		·

1		1 2 1 - Anymhon
		$     \begin{bmatrix} 2 \end{bmatrix} \mapsto \text{number} \\     \begin{bmatrix} 1 \end{bmatrix} \mapsto \text{number} $
D 4	1 , 1 , 1	LJ
Paso 4	$number \rightarrow number = number \rightarrow number$	$1$ $\mapsto$ number $\rightarrow$ number
	number = number = number	$\begin{bmatrix} 3 \end{bmatrix} \mapsto \text{boolean}$
		$ \begin{array}{c} [n] \mapsto \text{number} \\ [2] \mapsto \text{number} \end{array} $
		$[4] \mapsto \text{number}$
		$\begin{bmatrix} 5 \end{bmatrix} \mapsto \text{number}$
		$\begin{bmatrix} 7 \end{bmatrix} \mapsto \text{number}$
		$[9] \mapsto \text{number}$
		$[6] \mapsto \text{number}$
		$[8] \mapsto \text{number}$
		$[2] \mapsto \text{number}$
		$[1] \mapsto \text{number}$
		$[10] \mapsto \text{number}$
Paso 1	number = number = number	$[1] \mapsto \text{number} \to \text{number}$
		$[3] \mapsto \text{boolean}$
		$[\overline{\mathrm{n}}] \mapsto \mathrm{number}$
		$[2] \mapsto \text{number}$
		$[4] \mapsto \text{number}$
		$[5] \mapsto \text{number}$
		$[7] \mapsto \text{number}$
		$[9] \mapsto \text{number}$
		$6 \mapsto \text{number}$
		$8 \mapsto \text{number}$
		$2 \mapsto \text{number}$
		$[1] \mapsto \text{number}$
		$10 \mapsto \text{number}$
Paso 1	vacio	$1 \mapsto \text{number} \to \text{number}$
		$3 \mapsto boolean$
		$[n] \mapsto \text{number}$
		$[2] \mapsto \text{number}$
		$\boxed{4} \mapsto \text{number}$
		$5 \mapsto \text{number}$
		$7 \mapsto \text{number}$
		$\boxed{9} \mapsto \text{number}$
		$6 \mapsto \text{number}$
		$8 \mapsto \text{number}$
		$2 \mapsto \text{number}$
		$[1] \mapsto \text{number}$
		$10 \rightarrow \text{number}$
		<u>  -                                 </u>

```
(define Empty?
  (lambda (1)
      (if (= (length 1) 0) true false)))
```



## Problema II

Considera el siguiente programa:

```
(+ 1 (first (cons true empty)))
```

Este programa tiene un error de tipos.

Genera restricciones para este programa. Aísla el conjunto mas pequeño de estas restricciones tal que, resultas juntas, identifiquen el error de tipos.

Siéntete libre de etiquetar las sub-expresiones del programa con superíndices para usarlos cuando escribas y resuelvas tus restricciones.

Respuesta:

```
\boxed{1}(+\boxed{2}\boxed{1}\boxed{3} \text{ (first }\boxed{4} \text{ (cons }\boxed{5} \text{ true }\boxed{6} \text{ empty)))}
```

## Conjunto de Restricciones:

Si e1 y e2 expresiones cuales quiera dentro del lenguaje entonces:

1-[(+e1 e2)] = number si [e1] = number y [e2] = number

2-Si e es un numero entonces [e]= number

3-[(first e)] = number si [e] = nlist

 $4-[(\cos e1 \ e2)] = \text{nlist si } [e1] = \text{number y } [e2] = \text{nlist}$ 

5- si e=true o e=false entonces [e]=boolean

#### Inferencia:

Tenemos que:

```
A)Para \boxed{1} =[(+ 1 (first (cons true empty)))] = number si [1] = number y [(first (cons true empty))]= number (1) B)Para \boxed{2} = [1] number (2) C)Para \boxed{3} = [(first (cons true empty))]= number si [(cons true empty)]=nlist (3)
```

D)Para  $\boxed{4}$  = [(cons true empty)]=nlist si [true]= number y [empty] = nlist (4)

D) Para  $[4] = [(\cos true = mpty)] = \text{nlist si [true]} = \text{number y [empty]} = \text{nlist } (4]$ 

E)Para [5] = [true]!=number sino que [true] = boolean (5)

Por E) tenemos que el programa no puede continuar debido al error de tipos dadas las reglas del conjunto de restricciones

### Problema III

Considera la siguiente expresión con tipos:

Dejamos los tipos sin especificar (Cn) para que sean llenados por el proceso de inferencia de tipos. Deriva restricciones de tipos para el programa anterior. Luego resuelve estas restricciones. A partir de estas soluciones,

rellena los valores de las Cn. Asegúrate de mostrar todos los pasos especificados por los algoritmos (i.e., escribir la respuesta basándose en la intuición o el conocimiento es insuficiente). Deberás usar variables de tipo cuando sea necesario. Para no escribir tanto, puedes etiquetar cada expresión con una variable de tipos apropiada, y presentar el resto del algoritmo en términos solamente de estas variables de tipos.

Si e1 y e2 expresiones cuales quiera dentro del lenguaje entonces:

1.- [(cons e1 e2)]= nlist si [e1]= number y [e2]= nlist

Restricciones:

$$\boxed{1} = [f] \rightarrow \boxed{1}$$

$$\llbracket 2 \rrbracket = [x] \to \llbracket 2 \rrbracket$$

$$\llbracket 3 \rrbracket = [y] \to \llbracket 3 \rrbracket$$

$$\llbracket 4 \rrbracket = [\{ \cos x \ \{ f \ \{ f \ y \} \} \}] = \text{nlist si} \ [x] = \text{number y} \ [\{ f \ \{ f \ y \} \} ] = \text{nlist}$$

Gracias a estas restricciones podemos sacar los tipos C1...C6

## Problema IV

Considera los juicios de tipos discutidos en clase para un lenguaje glotón (en el capitulo de **Juicios de Tipos** del libro de Shriram). Considera ahora la versión perezosa del lenguaje. Pon especial atención a las reglas de tipado para:

- definición de funciones
- aplicación de funciones

Para cada una de estas, si crees que la regla original no cambia, explica por que no (Si crees que ninguna de las dos cambia, puedes responder las dos partes juntas). Si crees que algún otro juicio de tipos debe cambiar, menciónalo también.

### Problema V

¿Cuáles son las ventajas y desventajas de tener polimorfismo explícito e implícito en los lenguajes de programación?

#### Respuesta:

Polimorfismo Explicito

Ventajas	Desventajas	
-Permitir el reciclamiento de código.	-Poca legibilidad de código debido al hecho de poder	
	tener diversas funciones con el mismo nombre.	
Polimorfismo Implicito		
Ventajas	Desventajas	

## Problema VI

-?

Da las ventajas y desventajas de tener lenguajes de dominio específico (DSL) y de propósito general. También da al menos tres ejemplos de lenguajes DSL, cada ejemplo debe indicar el propósito del DSL y un ejemplo documentando su uso.

#### Lenguajes de Dominio Especifico (DSL)

Ventajas	Desventajas
-Proporciona apropiadas abstracciones y anotaciones.	-Aprenderlo para que solo pueda resolver un problema
	espepecifico.
-Nos permiten seguridad en nivel de dominio, mientras	-Encontrar, ajustar o mantener un alcance adecuado.
los metodos del lenguaje esten seguros esto nos permi-	
tira seguridad cada vez que los usemos.	
-Es mas sencillo desarrollar programas en un area en	-Gente no experta en el lenguaje no puede modificar o
especifico para programadores que no sean expertos en	crear codigo facilmente.
ella.	

#### Lenguajes de Propisito General (GPL)

Ventajas	Desventajas
-Nos ayuda a resolver problemas de diferentes areas.	-?.
-?.	-?.
-?.	-?.

Ejemplos DSL:

1. SQL: Este lenguaje fue creado para acceder a bases de datos relacionales facilmente. Ejemplo:

```
SELECT * FROM TABLA;
```

nos da toda la info alamacenada en TABLA.

2. XML: es un lenguaje de marcas desarrollado por el World Wide Web Consortium (W3C) utilizado para almacenar datos en forma legible. Ejemplo:

Almacena datos de un libro poniendo marcas al autor y titulo.

3. CSS: es un lenguaje usado para definir y crear la presentación de un documento estructurado escrito en HTML o XML Ejemplo:

```
p {
   text-align: center;
   color: red;
}
```

Alinea la etiqueta p y le pone color rojo.