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# Virtual Machines

*Solutions to Sheet 1*

Exercise 1: *CMa Calculator* *4 Points*

```
loadc 4
loadc ρ(x)
load
dup
mul
mul
loadc 3
loadc ρ(x)
load
mul
add
loadc 1
add
loadc ρ(y)
load
loadc 26
sub
div
halt
```

Exercise 2: *Assembly programming* *10 Points*

```
loadc 6 /*n = 6*/

/*case n = 0*/
dup
jumpz firsttwo

/*case n = 1*/
dup
loadc 1
sub
jumpz firsttwo

/*n' = n - 2*/
loadc 2
sub

loadc 1 /*F_{n-n'-1}*/
loadc 1 /*F_{n-n'}  */

loop:
/*n' == 0*/
loadc 0
load
jumpz end

/*calc F_{n-n'+1}*/
loadc 1
load
loadc 2
load
loadc 1
store
pop
add

/*n' = n'- 1*/

loadc 0
load
loadc 1
sub
loadc 0
store
pop
jump loop

end: /*cleanup*/
loadc 0
store
pop
pop
halt

firsttwo:
halt
```

Exercise 3: *Comma Operator* *2 Points*

$$\begin{aligned}\text{code}_R\ (e', e)\ \rho = &\text{code}_R\ e'\ \rho\\ &\texttt{pop}\\ &\text{code}_R\ e\ \rho\end{aligned}$$

Exercise 4: *Short circuit evaluation* *2 Points*

$$\begin{aligned}\text{code}_R\ (e' || e)\ \rho = &\text{code}_R\ e'\ \rho\\ &\texttt{loadc 0}\\ &\texttt{neq}\\ &\texttt{jumpz true}\\ &\text{code}_R\ e\ \rho\\ &\texttt{jump end}\\ &\texttt{true:}\\ &\texttt{loadc 1}\\ &\texttt{end:}\end{aligned}$$

Exercise 5: *Conditional Expressions* *2 Points*

$$\begin{aligned}\text{code}_R\ (b\,?\,e_1 : e_2)\ \rho = &\text{code}_R\ b\ \rho\\ &\texttt{jumpz false}\\ &\text{code}_R\ e_1\\ &\texttt{jump end}\\ &\texttt{false:}\\ &\text{code}_R\ e_2\ \rho\\ &\texttt{end:}\end{aligned}$$