Exercise 1: Copy-Constant Analysis
Consider the following program where $x$ is a global and $y$ is a local variable:

```
main():
    f():
        0  y = 5
        1  x = 3
        2  f()
        3  x = 7
        4  f()
        5
```

```
0 1 2 3 4 5
```

6  y = 7
7  x = y
8
9

a) Using Copy-Constants analysis (slides 558-560), compute the summary (transformation) $M \in \mathbb{M}$ for the procedure $f()$.

b) Now compute the transfer function for the calls to the procedure $f()$ using your summary, i.e. compute $H(M)$.

c) Having computed the transfer function for calls to the procedure $f()$, write out a constraint system $\mathcal{R}$ for Constant Propagation Analysis of the above program and solve it.

Exercise 2: Sharir/Pnueli, Cousot
Consider the following program (all variables are globals):
The main procedure is analyzed in the context \( d_0 = \{ x \mapsto \top, y \mapsto \top \} \). The procedure \( y2x \) is analyzed in the context \([3, d_0]^2\) and \([5, d_0]^2\).

a) Calculate the value for \([3, d_0]^2\).

b) Analyze \( y2x \) by calculating \([12, [3, d_0]^2]^2\).

c) Calculate the value for \([5, d_0]^2\).

d) Analyze \( y2x \) by calculating \([12, [5, d_0]^2]^2\).

e) Calculate the value for \([6, d_0]^2\).

Exercise 3: *Call-String Approach*

Consider the following program where \( x \) is a global and \( y \) is a local variable:

Using the Call-String approach, analyse the program with

a) \( d = 0 \) (here, it means empty call stack) and

b) \( d = 1 \) (not more than one call)

and give the result at the end of \texttt{main()} for each case.

c) Does a call stack \( d \geq 2 \) improve the solution?