

Course Name: Homework #1

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Problem 1

Give an appropriate positive constant c such that $f(n) \leq c \cdot g(n)$ for all $n > 1$.^[1]

1. $f(n) = n^2 + n + 1, g(n) = 2n^3$
2. $f(n) = n\sqrt{n} + n^2, g(n) = n^2$
3. $f(n) = n^2 - n + 1, g(n) = n^2/2$

Solution

We solve each solution algebraically to determine a possible constant c .

Part One

$$\begin{aligned}
 n^2 + n + 1 &= \\
 &\leq n^2 + n^2 + n^2 \\
 &= 3n^2 \\
 &\leq c \cdot 2n^3
 \end{aligned}$$

Thus a valid c could be when $c = 2$.

Part Two

$$\begin{aligned}
 n^2 + n\sqrt{n} &= \\
 &= n^2 + n^{3/2} \\
 &\leq n^2 + n^{4/2} \\
 &= n^2 + n^2 \\
 &= 2n^2 \\
 &\leq c \cdot n^2
 \end{aligned}$$

Thus a valid c is $c = 2$.

Part Three

$$\begin{aligned}
 n^2 - n + 1 &= \\
 &\leq n^2 \\
 &\leq c \cdot n^2/2
 \end{aligned}$$

Thus a valid c is $c = 2$.

Problem 2

Let $\Sigma = \{0, 1\}$. Construct a DFA A that recognizes the language that consists of all binary numbers that can be divided by 5.

Let the state q_k indicate the remainder of k divided by 5. For example, the remainder of 2 would correlate to state q_2 because $7 \bmod 5 = 2$.

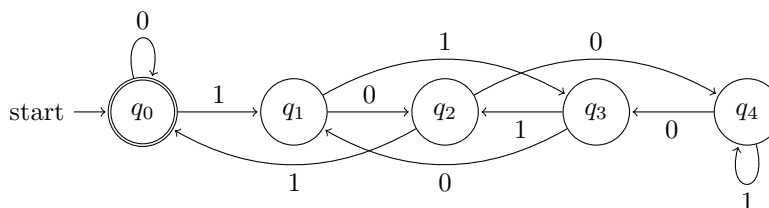


Figure 1: DFA, A , this is really beautiful, ya know?

Justification

Take a given binary number, x . Since there are only two inputs to our state machine, x can either become $x0$ or $x1$. When a 0 comes into the state machine, it is the same as taking the binary number and multiplying it by two. When a 1 comes into the machine, it is the same as multiplying by two and adding one.

Using this knowledge, we can construct a transition table that tell us where to go:

	$x \bmod 5 = 0$	$x \bmod 5 = 1$	$x \bmod 5 = 2$	$x \bmod 5 = 3$	$x \bmod 5 = 4$
$x0$	0	2	4	1	3
$x1$	1	3	0	2	4

Therefore on state q_0 or $(x \bmod 5 = 0)$, a transition line should go to state q_0 for the input 0 and a line should go to state q_1 for input 1. Continuing this gives us the Figure 1.

Problem 3

Write part of `QUICK-SORT(list, start, end)`

```
1: function QUICK-SORT(list, start, end)
2:   if start  $\geq$  end then
3:     return
4:   end if
5:   mid  $\leftarrow$  PARTITION(list, start, end)
6:   QUICK-SORT(list, start, mid - 1)
7:   QUICK-SORT(list, mid + 1, end)
8: end function
```

Algorithm 1: Start of QuickSort

Problem 4

question

solution

partA

References

- [1] Van Brummelen J, O'Brien M, Gruyer D, et al. Autonomous vehicle perception: The technology of today and tomorrow[J]. Transportation research part C: emerging technologies, 2018, 89: 384-406.