

2.1

Integer → *Integer* *Digit*
 → *Integer* *Digit* *Digit*
 → *Integer* *Digit* *Digit* *Digit*
 → *Digit* *Digit* *Digit* *Digit*
 → 4 *Digit* *Digit* *Digit*
 → 4 5 *Digit* *Digit*
 → 4 5 2 *Digit*
 → 4 5 2 0

If we have just one digit x , we can derive it as follows:

Integer → *Digit*
 → x

That is, we can derive x in just two steps. Since there is no production rule which takes the start symbol *Integer* to a terminal symbol, there is no valid derivation of length 1.

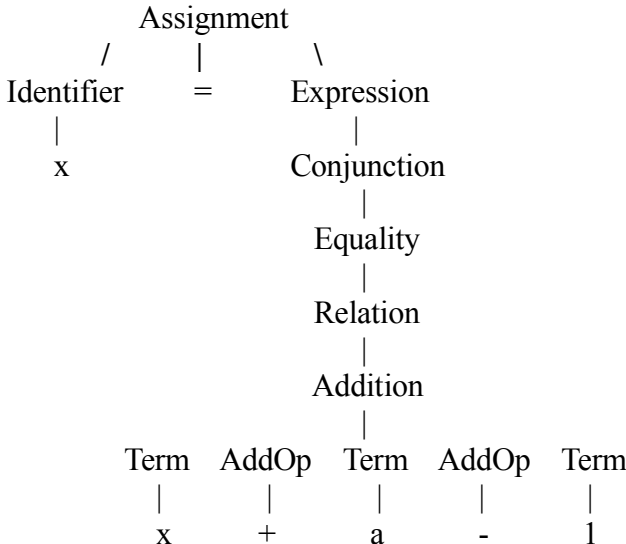
Now suppose that any string of digits of length $d-1$ requires at least $2(d-1)$ steps. Then a string of digits of length d may be written yx where x is one digit and y is a string of digits of length $d-1$. Since y is length $d-1$, a derivation of y is at least $2(d-1)$ steps. Then we know from above that a derivation of one digit requires at least 2 steps. So a derivation of yx (of length d) must be at least $2 + 2(d-1) = 2d$ steps.

2.4

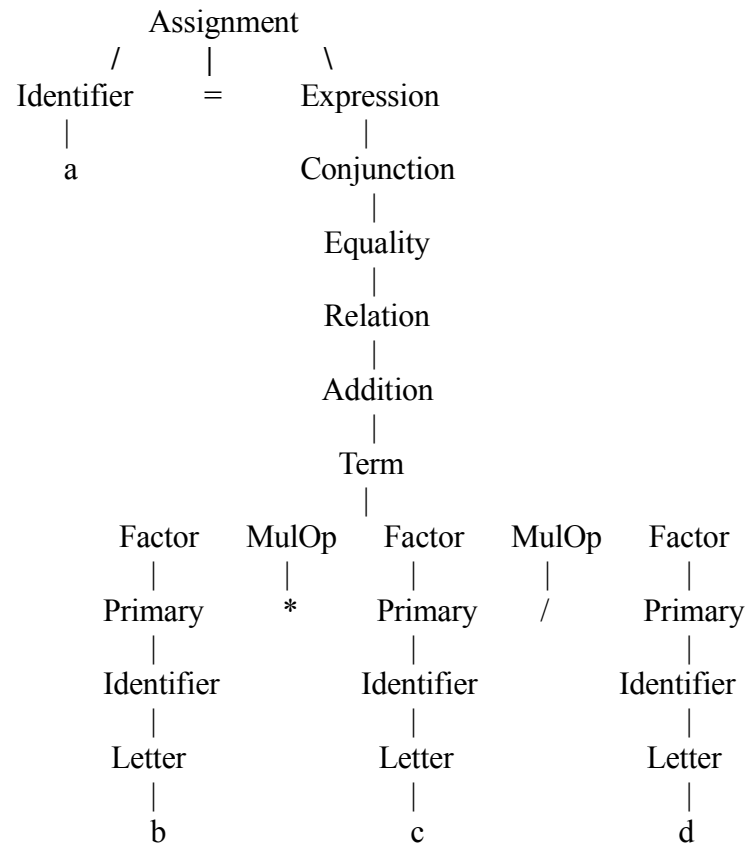
Identifier → *Letter* *Digit* *Letter*
 → *Letter* *Digit* i
 → *Letter* 2 i
 → a 2 i

2.5

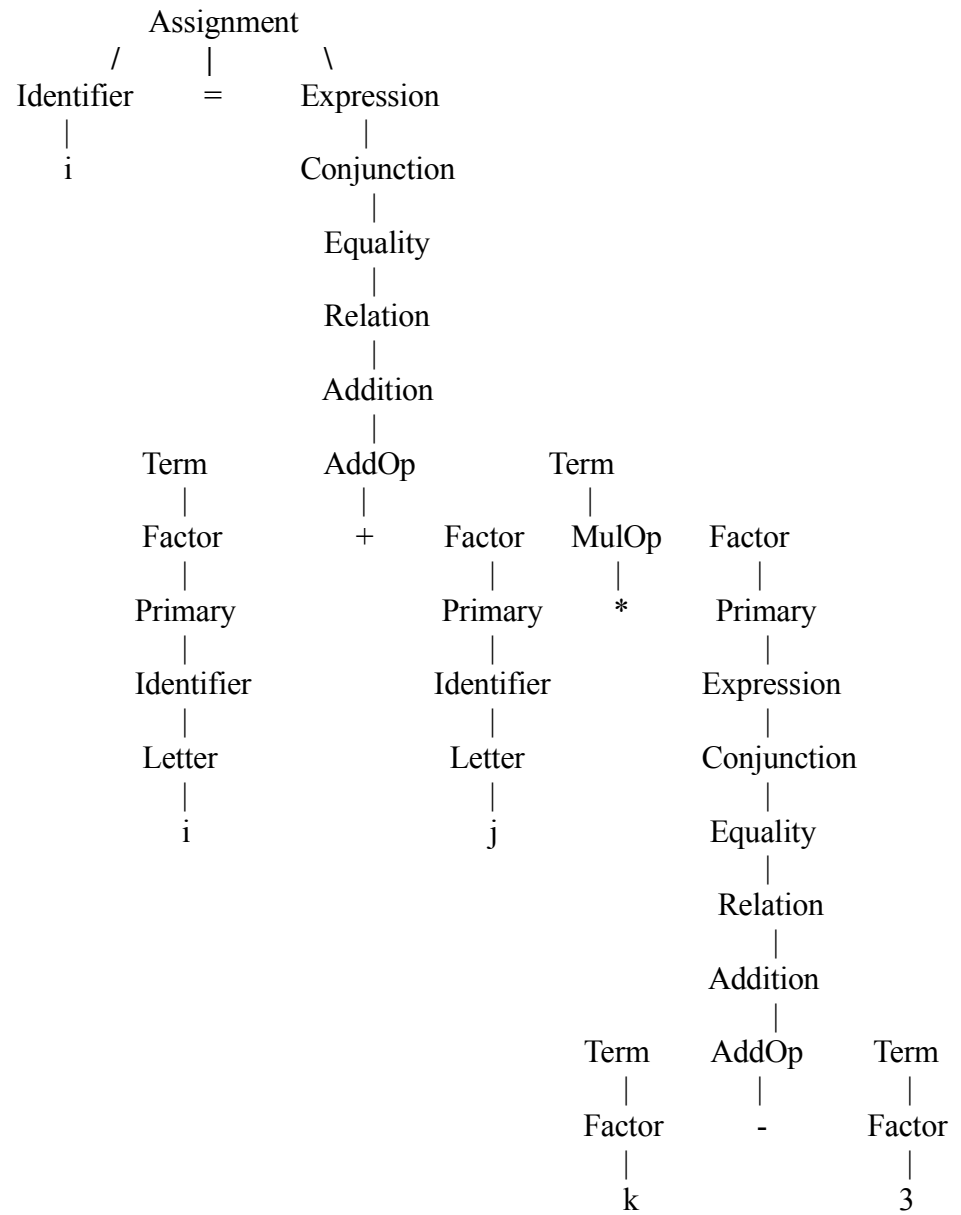
(a)



(b)

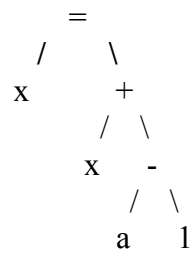


(c)



2.20

(a)



(b)

$$\begin{array}{c} = \\ / \quad \backslash \\ \mathbf{a} \quad * \\ / \quad \backslash \\ \mathbf{b} \quad / \\ / \quad \backslash \\ \mathbf{c} \quad \mathbf{d} \end{array}$$

(c)

$$\begin{array}{c} = \\ / \quad \backslash \\ \mathbf{i} \quad + \\ / \quad \backslash \\ \mathbf{i} \quad - \\ / \quad \backslash \\ * \quad 3 \\ / \quad \backslash \\ \mathbf{j} \quad \mathbf{k} \end{array}$$