Xiaoting Wang, 406267
Wensheng Zhang, 405521

Aufgabe 3

```
                    ⟨x ≥ 0⟩
                    ⟨x ≥ 0 ∧ −x = −x ∧ x = x⟩
res = -x;
                    ⟨x ≥ 0 ∧ res = −x ∧ x = x⟩
c = x;
                    ⟨x ≥ 0 ∧ res = −x ∧ c = x⟩
                    ⟨res = x · x − 2 · ∑_{k=0}^{c} k ∧ c ≥ 0⟩
while (c > 0)
                    ⟨res = x · x − 2 · ∑_{k=0}^{c} k ∧ c ≥ 0 ∧ c > 0⟩
                    ⟨res + 2 · (c − 1) = x · x − 2 · ∑_{k=0}^{(c−1)} k ∧ (c − 1) ≥ 0⟩
  res = res + 2 * c;
                    ⟨res = x · x − 2 · ∑_{k=0}^{(c−1)} k ∧ (c − 1) ≥ 0⟩
  c = c - 1;
                    ⟨res = x · x − 2 · ∑_{k=0}^{c} k ∧ c ≥ 0⟩
}
                    ⟨res = x · x − 2 · ∑_{k=0}^{c} k ∧ c ≥ 0 ∧ ¬(c > 0)⟩
                    ⟨res = x · x⟩
```

Aufgabe 5

a)

```
                    ⟨q ≥ 1⟩
                    ⟨q ≥ 1 ∧ q = q ∧ x = p ∧ y = 1⟩
n = q;
                    ⟨q ≥ 1 ∧ n = q ∧ p = p ∧ y = 1⟩
x = p;
                    ⟨q ≥ 1 ∧ n = q ∧ x = p ∧ 1 = 1⟩
y = 1;
                    ⟨q ≥ 1 ∧ n = q ∧ x = p ∧ y = 1⟩
                    ⟨p^q = x^n · y ∧ n ≥ 1⟩
while (n > 1){
                    ⟨p^q = x^n · y ∧ n ≥ 1 ∧ n > 1⟩
  if (n % 2 == 0){
                    ⟨p^q = x^n · y ∧ n ≥ 1 ∧ n > 1 ∧ n mod 2 = 0⟩
                    ⟨p^q = (x · x)^{⌊n/2⌋} · y ∧ ⌊n/2⌋ ≥ 1⟩
    x = x * x;
                    ⟨p^q = x^{⌊n/2⌋} · y ∧ ⌊n/2⌋ ≥ 1⟩
    n = n / 2;
                    ⟨p^q = x^n · y ∧ n ≥ 1⟩
  } else {
                    ⟨p^q = x^n · y ∧ n ≥ 1 ∧ n > 1 ∧ ¬(n mod 2 = 0)⟩
                    ⟨p^q = (x · x)^{⌊(n−1)/2⌋} · (x · y) ∧ ⌊(n−1)/2⌋ ≥ 1⟩
    y = x * y;
                    ⟨p^q = (x · x)^{⌊(n−1)/2⌋} · y ∧ ⌊(n−1)/2⌋ ≥ 1⟩
    x = x * x;
                    ⟨p^q = x^{⌊(n−1)/2⌋} · y ∧ ⌊(n−1)/2⌋ ≥ 1⟩
    n = (n-1) / 2;
                    ⟨p^q = x^n · y ∧ n ≥ 1⟩
  }
                    ⟨p^q = x^n · y ∧ n ≥ 1⟩
}
                    ⟨p^q = x^n · y ∧ n ≥ 1 ∧ ¬(n > 1)⟩
                    ⟨p^q = x · y⟩
x = x * y;
                    ⟨p^q = x⟩
```

b)

$V = \mathtt{n}$, denn: $\mathtt{n} > 1 \implies \mathtt{n} \geq 0$

```
1                   ⟨n = m ∧ n > 1⟩
2                   ⟨n < m⟩
3   if (n % 2 == 0){
4                   ⟨n < m ∧ n > 1 ∧ n mod 2 = 0⟩
5                   ⟨⌊n/2⌋ < m⟩
6     x = x * x;
7                   ⟨⌊n/2⌋ < m⟩
8     n = n / 2;
9                   ⟨n < m⟩
10  } else {
11                  ⟨n < m ∧ n > 1 ∧ ¬(n mod 2 = 0)⟩
12    y = x * y;
13                  ⟨⌊(n−1)/2⌋ < m⟩
14    x = x * x;
15                  ⟨⌊(n−1)/2⌋ < m⟩
16    n = (n-1) / 2;
17                  ⟨n < m⟩
18  }
19                  ⟨n < m⟩
20
```

Aufgabe 7

```
1  public class BubbleSort {
2    public static void sort(int[] a) {
3      int tmp;
4      for (int i = a.length - 1; i > 0; i--){
5        for (int j = 0; j < i; j++){
6          if (a[j] > a[j+1]){
7            tmp = a[j+1];
8            a[j+1] = a[j];
9            a[j] = tmp;
10         }
11       }
12     }
13   }
14 }
15
```

Aufgabe 9

a)

```
1                   ⟨true⟩
2                   ⟨true ∧ 0 = 0 ∧ false = false⟩
3   i = 1;
4                   ⟨true ∧ i = 0 ∧ false = false⟩
5   res = false;
6                   ⟨true ∧ i = 0 ∧ res = false⟩
7                   ⟨res = x ∈ {a[j] | 0 ≤ j < i} ∧ i ≤ a.length⟩
8   while (i < a.length){
9                   ⟨res = x ∈ {a[j] | 0 ≤ j < i} ∧ i ≤ a.length ∧ i < a.length⟩
10    if (x == a[i]){
11                  ⟨res = x ∈ {a[j] | 0 ≤ j < i} ∧ i ≤ a.length ∧ i < a.length ∧ x = a[i]⟩
12                  ⟨true = x ∈ {a[j] | 0 ≤ j < i + 1} ∧ i + 1 ≤ a.length⟩
13      res = true;
14                  ⟨res = x ∈ {a[j] | 0 ≤ j < i + 1} ∧ i + 1 ≤ a.length⟩
15    }
16                  ⟨res = x ∈ {a[j] | 0 ≤ j < i + 1} ∧ i + 1 ≤ a.length⟩
```

Xiaoting Wang, 406267
Wensheng Zhang, 405521

```
17      i = i + 1;
18                      ⟨res = x ∈ {a[j] | 0 ≤ j < i} ∧ i ≤ a.length⟩
19    }
20                      ⟨res = x ∈ {a[j] | 0 ≤ j < i} ∧ i ≤ a.length ∧ ¬(i < a.length)⟩
21                      ⟨res = x ∈ {a[j] | 0 ≤ j < a.length − 1}⟩
22
```

b)

$V = \texttt{a.length} - \texttt{i}$, denn: $\texttt{i} < \texttt{a.length} \Longrightarrow \texttt{a.length} - \texttt{i} \geq 0$

```
1                       ⟨a.length − i = m ∧ i < a.length⟩
2                       ⟨a.length − (i + 1) < m⟩
3     if (x == a[i]){
4                       ⟨a.length − (i + 1) < m ∧ x = a[i]⟩
5                       ⟨a.length − (i + 1) < m⟩
6       res = true;
7                       ⟨a.length − (i + 1) < m⟩
8     }
9                       ⟨a.length − (i + 1) < m⟩
10      i = i + 1;
11                      ⟨a.length − i < m⟩
12
```