Exercise 1

Consider the Java class `IntegerInterval` that represents an interval of integer values.

```java
class IntegerInterval {
    int getLowerBound() { ... }
    int getUpperBound() { ... }
    void doSomething (int i) { ... }
}
```

The methods of the class `IntegerInterval` have the following specifications:

- `getLowerBound()`:
  - `@pre: true; @post: 0 <= getLowerBound() < getUpperBound()`
- `getUpperBound()`:
  - `@pre: true; @post: 0 <= getLowerBound() < getUpperBound()`
- `doSomething (int i)`:
  - `@pre: getLowerBound() <= i < getUpperBound(); @post: true;`

Additionally, consider the class `NegativeIntegerInterval` that extends `IntegerInterval` as follows.

```java
class NegativeIntegerInterval extends IntegerInterval {
    void doSomething (int i) {
        super.doSomething (-i);
    }
}
```

The method `doSomething` in the class `NegativeIntegerInterval` has the following specification:

- `doSomething(int i)`:
  - `@pre: this.getLowerBound() <= -i < this.getUpperBound(); @post: true;`

Consider the class `Run` that uses the `NegativeIntegerInterval` class as follows.

```java
class Run {
    public static void main (String[] a) {
        IntegerInterval c = new NegativeIntegerInterval();
        c.doSomething(-42);
        c.doSomething(42);
    }
}
```

Analyze the code and identify whether contract violations may occur during run-time.
Exercise 2
Let $n, m \in \mathbb{N}_0$. Are the following Hoare Triples valid? Provide a proof in the Hoare Calculus and explain in each proof step which axiom or rule has been applied.

1. $\{ m = 2 \cdot n + 1 \} n = 2 \cdot n; \{ m = n + 1 \}$
2. $\{ m \geq n \} \text{if}(m > n) n = n + 1 \text{else} m = m + 1 \{ m \geq n \}$
3. $\{ m = n \} \text{while}(m \geq n) m = m + 1 \{ m = m + n \}$

Exercise 3
Consider the following program $P$:

```plaintext
1 m = 0;
2 while (x >= y) {
3     m = m + 1;
4     x = x - y;
5 }
```

Let $x, y, m \in \mathbb{N}_0$. Write down the basic paths and the verification conditions for the Hoare Triple

$$\{ x \geq 0 \land y > 0 \land x_0 = x \} P \{ m = x_0/y \}$$

Compute the weakest preconditions and conclude if the program is correct with respect to its specification or not. Remember: $x/y$ stands for integer division.

Exercise 4
Consider the following program $P$:

```plaintext
1 m = 0;
2 while (x >= y) {
3     m = m + 1;
4     x = x - y;
5 }
```

Let $x, y, m \in \mathbb{N}_0$. Prove that the Hoare Triple

$$\{ x \geq 0 \land y > 0 \land x_0 = x \} P \{ m = x_0/y \}$$

is valid. Therefore, find a suitable loop invariant for the while loop in $P$ and give a proof in the Hoare Calculus. Remember: $x/y$ stands for integer division.