



OOP with Java

8. Loops

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- Sometimes, we need to carry out the same command again and again in a program.

- Sometimes, we need to carry out the same command again and again in a program.
- Instead of copying the same code multiple times, we may wrap it into a *loop*.

Listing: Vertical Ball Throw: $t = 0, 0.2, 0.4, \dots, 2.2, \text{ and } 2.2\text{s}$.

```
/**
 * A ball is thrown vertically upwards into the air by a 1.8m tall person<br/>
 * with velocity 10m/s. Where is it after t=0,02,...,2.2 seconds?<br/>
 *  $x(t) = x_0 + v_0 * t - 0.5 * g * t^2$ 
 */
public class VerticalBallThrowMultiple {

    /** The main routine
     * @param args
     *     we ignore this parameter for now */
    public static final void main(String[] args) {
        double x0 = 1.8d; // initial vertical position
        double v0 = 10d; // initial velocity upwards
        double g = 9.80665d; // free fall acceleration downwards

        double t = 0.0d; // set the time to 0s
        System.out.println(x0 + (v0 * t) - 0.5d * g * t * t); // prints 1.8
        t = 0.2d; // set the time to 0.2s
        System.out.println(x0 + (v0 * t) - 0.5d * g * t * t); // prints 3.6038669999999997
        t = 0.4d; // set the time to 0.4s
        System.out.println(x0 + (v0 * t) - 0.5d * g * t * t); // prints 5.015468
        t = 0.6d; // set the time to 0.6s
        System.out.println(x0 + (v0 * t) - 0.5d * g * t * t); // prints 6.034803
        t = 0.8d; // set the time to 0.8s
        System.out.println(x0 + (v0 * t) - 0.5d * g * t * t); // prints 6.6618720000000001
        t = 1.0d; // set the time to 1.0s
        System.out.println(x0 + (v0 * t) - 0.5d * g * t * t); // prints 6.8966750000000001
        t = 1.2d; // set the time to 1.2s
        System.out.println(x0 + (v0 * t) - 0.5d * g * t * t); // prints 6.7392120000000001
        t = 1.4d; // set the time to 1.4s
        System.out.println(x0 + (v0 * t) - 0.5d * g * t * t); // prints 6.1894830000000003
        t = 1.6d; // set the time to 1.6s
        System.out.println(x0 + (v0 * t) - 0.5d * g * t * t); // prints 5.2474880000000001
        t = 1.8d; // set the time to 1.8s
        System.out.println(x0 + (v0 * t) - 0.5d * g * t * t); // prints 3.9132270000000001
        t = 2.0d; // set the time to 2.0s
        System.out.println(x0 + (v0 * t) - 0.5d * g * t * t); // prints 2.1867000000000002
        t = 2.2d; // set the time to 2.2s
        System.out.println(x0 + (v0 * t) - 0.5d * g * t * t); // prints 0.067906999999999816
    }
}
```

- The most basic loop in Java is a *for loop*

Listing: The structure of *for loop*

```
for( [counter variable initialization]; [loop condition]; [counter increment]) {  
    // loop body  
}
```

- The (optional) first element `[counter variable initialization]` can be used to allocate and initialize a counter variable. It is executed *before* the loop begins.
- The (optional) second element `[loop condition]` is an expression which is checked before each loop iteration. Only if it is `true`, the `loop body` is executed.
- If there is no loop condition, the loop will loop for ever.
- The (optional) third element `counter increment` can be used to increase or decrease the loop counter. It is executed after each loop iteration.
- The `loop body` may contain any command or statement, including conditionals and other loops.

Listing: Vertical Ball Throw: $t = 0, 0.2, 0.4, \dots, 2.2$, and $2.2s$.

```
/**
 * A ball is thrown vertically upwards into the air by a 1.8m tall person<br/>
 * with velocity 10m/s. Where is it after  $t=0,0.2,\dots,2.2$  seconds?<br/>
 *  $x(t) = x_0 + v_0 * t - 0.5 * g * t^2$ 
 */
public class VerticalBallThrowForLoop {

    /** The main routine
     * @param args
     *     we ignore this parameter for now */
    public static final void main(String[] args) {
        double x0 = 1.8d; // initial vertical position
        double v0 = 10d; // initial velocity upwards
        double g = 9.80665d; // free fall acceleration downwards

        for (double t = 0.0d; t <= 2.2d; t += 0.2d) { // using double counter: imprecision accumulates
            System.out.println(x0 + (v0 * t) - 0.5d * g * t * t); // prints the current position
        }
    }
}
```

Listing: Vertical Ball Throw: $t = 0, 0.2, 0.4, \dots, 2.2$, and $2.2s$.

```
/**
 * A ball is thrown vertically upwards into the air by a 1.8m tall person<br/>
 * with velocity 10m/s. Where is it after  $t=0,0.2,\dots,2.2$  seconds?<br/>
 *  $x(t) = x_0 + v_0 * t - 0.5 * g * t^2$ 
 */
public class VerticalBallThrowForLoopBetter1 {

    /** The main routine
     * @param args
     *     we ignore this parameter for now */
    public static final void main(String[] args) {
        double x0 = 1.8d; // initial vertical position
        double v0 = 10d; // initial velocity upwards
        double g = 9.80665d; // free fall acceleration downwards

        for (int i = 0; i < 12; i++) { // using an integer for counting
            double t = 0.2d * i; // and multiplying it by 0.2 is more accurate
            System.out.println(x0 + (v0 * t) - 0.5d * g * t * t); // prints the current position
        }
    }
}
```


Listing: Vertical Ball Throw: $t = 0, 0.2, 0.4, \dots, 2.2$, and $2.2s$.

```
/**
 * A ball is thrown vertically upwards into the air by a 1.8m tall person<br/>
 * with velocity 10m/s. Where is it after  $t=0,0.2,\dots,2.2$  seconds?<br/>
 *  $x(t) = x_0 + v_0 * t - 0.5 * g * t^2$ 
 */
public class VerticalBallThrowForLoopBetter2 {

    /** The main routine
     * @param args
     *     we ignore this parameter for now */
    public static final void main(String[] args) {
        double x0 = 1.8d; // initial vertical position
        double v0 = 10d; // initial velocity upwards
        double g = 9.80665d; // free fall acceleration downwards

        for (int i = -1; ++i < 12; ) { // using an integer for counting
            double t = 0.2d * i; // and multiplying it by 0.2 is more accurate
            System.out.println(x0 + (v0 * t) - 0.5d * g * t * t); // prints the current position
        }
    }
}
```

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- There are two more keywords that can be used to control loop:
 - `break` exits the current loop immediately
 - `continue` jumps to the next iteration (executing the incremental and condition checking code of the loop header, if any)
- Normally, we would avoid using these keywords, because they make the code harder to read. . .

Listing: Vertical Ball Throw: $t = 0, 0.2, 0.4, \dots, 2.2,$ and $2.2s$.

```
/**
 * A ball is thrown vertically upwards into the air by a 1.8m tall person<br/>
 * with velocity 10m/s. Where is it after  $t=0,0.2,\dots,2.2$  seconds?<br/>
 *  $x(t) = x_0 + v_0 * t - 0.5 * g * t^2$ 
 */
public class VerticalBallThrowForLoopStrange1 {

    /** The main routine
     * @param args
     * we ignore this parameter for now */
    public static final void main(String[] args) {
        double x0 = 1.8d; // initial vertical position
        double v0 = 10d; // initial velocity upwards
        double g = 9.80665d; // free fall acceleration downwards

        for (int i = 0;;) { // using an integer for counting, but no loop condition
            double t = 0.2d * i; // and multiplying it by 0.2 is more accurate
            System.out.println(x0 + (v0 * t) - 0.5d * g * t * t); // prints the current position
            if (++i >= 12) { // the actual loop condition
                break; // exit the for loop if above condition is met
            }
        }
    }
}
```

Listing: Vertical Ball Throw: $t = 0, 0.2, 0.4, \dots, 2.2$, and $2.2s$.

```
/**
 * A ball is thrown vertically upwards into the air by a 1.8m tall person<br/>
 * with velocity 10m/s. Where is it after  $t = 0, 0.2, \dots, 2.2$  seconds?<br/>
 *  $x(t) = x_0 + v_0 * t - 0.5 * g * t^2$ 
 */
public class VerticalBallThrowForLoopStrange2 {

    /** The main routine
     * @param args
     *     we ignore this parameter for now */
    public static final void main(String[] args) {
        double x0 = 1.8d; // initial vertical position
        double v0 = 10d; // initial velocity upwards
        double g = 9.80665d; // free fall acceleration downwards

        for (int i = 0;;) { // using an integer for counting, but no loop condition
            double t = 0.2d * i; // and multiplying it by 0.2 is more accurate
            System.out.println(x0 + (v0 * t) - 0.5d * g * t * t); // prints the current position
            if (++i < 12) { // this is the continuation condition
                continue; // jump to next loop iteration
            }
            break; // exit the for loop: happens if "continue" was not reached above
        }
    }
}
```

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- `while (condition)` loops are loops with any type of (Boolean) `condition` expression
- The `condition` is checked before every iteration
- (notice, however, that `while (condition){ ... }` is basically equivalent to `for(; condition;){ ... }` ... but it's kind of ugly to use `for` loops like this...)

Listing: Vertical Ball Throw: $t = 0, 0.2, 0.4, \dots, 2.2$, and $2.2s$.

```
/**
 * A ball is thrown vertically upwards into the air by a 1.8m tall person<br/>
 * with velocity 10m/s. Where is it after  $t=0,0.2,\dots,2.2$  seconds?<br/>
 *  $x(t) = x_0 + v_0 * t - 0.5 * g * t^2$ 
 */
public class VerticalBallThrowWhileLoop1 {

    /** The main routine
     * @param args
     *     we ignore this parameter for now */
    public static final void main(String[] args) {
        double x0 = 1.8d; // initial vertical position
        double v0 = 10d; // initial velocity upwards
        double g = 9.80665d; // free fall acceleration downwards

        int i = 0;
        while (i < 12) { // the condition is checked at the top of the loop
            double t = 0.2d * i;
            System.out.println(x0 + (v0 * t) - 0.5d * g * t * t); // prints the current position
            i++; // increase counter
        }
    }
}
```

Listing: Vertical Ball Throw: $t = 0, 0.2, 0.4, \dots, 2.2, \text{ and } 2.2s$.

```
/**
 * A ball is thrown vertically upwards into the air by a 1.8m tall person<br/>
 * with velocity 10m/s. Where is it after  $t=0,0.2,\dots,2.2$  seconds?<br/>
 *  $x(t) = x_0 + v_0 * t - 0.5 * g * t^2$ 
 */
public class VerticalBallThrowWhileLoop2 {

    /** The main routine
     * @param args
     * we ignore this parameter for now */
    public static final void main(String[] args) {
        double x0 = 1.8d; // initial vertical position
        double v0 = 10d; // initial velocity upwards
        double g = 9.80665d; // free fall acceleration downwards

        int i = -1;
        while (++i < 12) { // the condition is checked at the top of the loop
            double t = 0.2d * i;
            System.out.println(x0 + (v0 * t) - 0.5d * g * t * t); // prints the current position
        }
    }
}
```

Listing: Vertical Ball Throw with reading t from stdin

```
import java.util.Scanner;

/**
 * A ball is thrown vertically upwards into the air by a  $x_0$ m tall person<br/>
 * with velocity  $v_0$ m/s. Where is it after  $t$  seconds?<br/>
 *  $x(t) = x_0 + v_0 * t - 0.5 * g * t^2$ <br/>
 * Allow user to enter arbitrarily many values for  $t$ 
 */
public class VerticalBallThrowWhileLoopSystemIn {

    /** The main routine
     * @param args
     * we ignore this parameter for now */
    public static final void main(String[] args) {
        double x0 = 1.8d; // initial vertical position
        double v0 = 10d; // initial velocity upwards
        double g = 9.80665d; // free fall acceleration downwards

        Scanner scanner = new Scanner(System.in); // initiate reading from System.in, ignore for now

        System.err.println("Keep entering times t, hit ctrl-d to exit."); //NON-NLS-1$
        while (scanner.hasNext()) { // until stdin was closed with ctrl-d (or end has been reached)
            double t = scanner.nextDouble(); // read next number from stdin
            System.out.print("position at x("); //NON-NLS-1$
            System.out.print(t); // print t
            System.out.print(")="); //NON-NLS-1$
            double xt = x0 + (v0 * t) - 0.5d * g * t * t; //  $x(t) = x_0 + v_0 * t - 0.5 * g * t^2$ 
            System.out.println((xt > 0d) ? xt : 0d); // prints result and makes sure the ball stops at ground
        }
    }
}
```

- `do { ...} while (condition)` loops are similar to `while` loops

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- The `condition` is checked *after* every iteration and another iteration is only performed if `condition` evaluates to true

- `do { ...} while (condition)` loops are similar to `while` loops
- The `condition` is checked *after* every iteration and another iteration is only performed if `condition` evaluates to true
- do-while loops always perform at least one iteration

Listing: Vertical Ball Throw: $t = 0, 0.2, 0.4, \dots, 2.2$, and $2.2s$.

```
/**
 * A ball is thrown vertically upwards into the air by a 1.8m tall person<br/>
 * with velocity 10m/s. Where is it after  $t=0,0.2,\dots,2.2$  seconds?<br/>
 *  $x(t) = x_0 + v_0 * t - 0.5 * g * t^2$ 
 */
public class VerticalBallThrowDoWhileLoop {

    /** The main routine
     * @param args
     *     we ignore this parameter for now */
    public static final void main(String[] args) {
        double x0 = 1.8d; // initial vertical position
        double v0 = 10d; // initial velocity upwards
        double g = 9.80665d; // free fall acceleration downwards

        int i = 0;
        do { // using an integer for counting
            double t = 0.2d * i; // and multiplying it by 0.2 is more accurate
            System.out.println(x0 + (v0 * t) - 0.5d * g * t * t); // prints the current position
            i++;
        } while (i < 12); // the condition is checked at the bottom of the loop
    }
}
```

- We have learned how to repeat actions in a program.
- We have learned three types of loops for this purpose: for, while, and do-while loops.
- We have learned the special key words `break` and `continue` which can also be used to control loops
- We now know the most basic control flow primitives to structure programs which process input data

谢谢

Thank you

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Caspar David Friedrich, "Der Wanderer über dem Nebelmeer", 1818
http://en.wikipedia.org/wiki/Wanderer_above_the_Sea_of_Fog