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The Jack Programming Language
Standard Class Library

```
class Output {
   function void moveCursor(int i, int j)
   function void printChar(char c)
   function void printString(String s)
   function void printInt(int i)
   function void println()
   function void backSpace()
}
```

```
Class Keyboard {
   function char keyPressed()
   function char readChar()
   function String readLine(String message)
   function int readInt(String message)
}
```

```
Class Screen {
   function void clearScreen()
   function void setColor(boolean b)
   function void drawPixel(int x, int y)
   function void drawLine(int x1, int y1, int x2, int y2)
   function void drawRectangle(int x1, int y1, int x2, int y2)
   function void drawCircle(int x, int y, int r)
}
```

```
Class Array {
   function Array new(int size)
   method void dispose()
}
```

```
Class Sys {
   function void halt():
   function void error(int errorCode)
   function void wait(int duration)
}
```

```
Class String {
   constructor String new(int maxLength)
   method void   dispose()
   method int    length()
   method char   charAt(int j)
   method void   setCharAt(int j, char c)
   method String appendChar(char c)
   method void   eraseLastChar()
   method int    intValue()
   method void   setInt(int j)
   function char backSpace()
   function char doubleQuote()
   function char newLine()
}
```

```
class Math {
   function void init()
   function int abs(int x)
   function int multiply(int x, int y)
   function int divide(int x, int y)
   function int min(int x, int y)
   function int max(int x, int y)
   function int sqrt(int x)
}
```

Syntax: keywords

```
/** Procedural processing example */
class Main {
   /* Inputs some numbers and computes their average */
   function void main() {
     var Array a;
     var int length;
     var int i, sum;
     let length = Keyboard.readInt("How many numbers? ");
     let a = Array.new(length); // constructs the array
     let i = 0;
     while (i < length) {
        let a[i] = Keyboard.readInt("Enter a number: ");
        let sum = sum + a[i];
        let i = i + 1;
     }
     ...
}
```

Syntax elements:

- White space / comments
- keywords
- Symbols
- Constants
- Identifiers

class, constructor, method, function	Program components
int, boolean, char, void	Primitive types
var, static, field	Variable declarations
let, do, if, else, while, return	Statements
true, false, null	Constant values
this	Object reference

Syntax: symbols

```
/** Procedural processing example */
class Main {
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   function void main() {
     var Array a;
     var int length;
     var int i, sum;
     let length = Keyboard.readInt("How many numbers? ");
     let a = Array.new(length); // constructs the array
     let i = 0;
     while (i < length) {
        let a[i] = Keyboard.readInt("Enter a number: ");
        let sum = sum + a[i];
        let i = i + 1;
     }
     ...
}
```

Syntax elements:

- White space / comments
- keywords
- Symbols
- Constants
- Identifiers

() Used for grouping arithmetic expressions and for enclosing parameter-lists and argument-lists;	, Variable list separator;
[] Used for array indexing;	; Statement terminator;
{} Used for grouping program units and statements;	= Assignment and comparison operator;
	. Class membership;
	+ - * / & | ~ < > Operators.

1. Translate the following Java code into its equivalent Jack code.

```
int x = 3;
int y = 5;
int greatest;
if (x > y)
    greatest = x;
else
    greatest = y;
System.out.println(greatest);
```

Jack Code

```
class Main {
      // Entry point is main() function:
      // function == static

      function void main() {
            // Start with variable declaration
            var int x, y, greatest;

            // Assignment statements
            let x = 3;
            let y = 5;

            if(x > y) {
                  let greatest = x;
            } else {
                  let greatest = y;
            }

            // Make function/method call need keyword
'do'
            do Output.printInt(greatest);

            // Requires return statement
            return;
      }
}
```

2.

```
// Multiplies x * y
// (by summing x, y times)
int x = 2;
int y = 5;
int product = 0;
int n = 1;
while (n <= y)
{
    product += x;
    n++;
}
System.out.println("The product is "
        + product);
```

Jack Code

```
class Main {
        function void main() {
                var int x, y, product, n;
                let x = 2;
                let y = 5;
                let product = 0;
                let n = 1;

                // while(~(n >y))

                while(n - y < 1) {
                        let product = product + x;
                        let n = n + 1;
                }

                do Output.printString("The product is ");
                do Output.printInt(product);

                return;
        }
}
```

3. Write the Jack code that produces the following transaction with the user.
Note: the green text indicates input from the user.

```
Please enter number 1: 21
Please enter number 2: 19
Please enter number 3: 50

The average of the three numbers is: 30
```

Jack Code

```
class Main {
      function void main() {
            var int num1, num2, num3, sum, average;

            // Retrieve data from user
            let num1 = Keyboard.readInt("Enter number
1: ");
            let num2 = Keyboard.readInt("Enter number
2: ");
            let num3 = Keyboard.readInt("Enter number
3: ");

            // Calculate the average
            let sum = num1 + num2 + num3;
            let average = Math.divide(sum, 3);

            // Output
            do Output.printString("The average of the
three numbers is: ");
            do Output.printInt(average);

            return;
      }
}
```

4. Write the Jack code that produces the following transaction with the user.
   Note: the green text indicates input from the user.

```
Please enter your birth year...
1934
You are 85 years old.

Please enter a future age...
100
You will be 100 in the year 2034.
```

Jack Code

```
class Main {
      function void main() {
            var int birthYear, currentAge, futureAge,
futureYear;

            // Get birth year and print current age
            let birthYear = Keyboard.readInt("Enter
your birth year: ");
            let currentAge = 2020 - birthYear;
            do Output.printString("You are ");
            do Output.printInt(currentAge);
            do Output.printString(" years old");

            // Get future age and print year
            do Output.println();
            let futureAge = Keyboard.readInt("Enter a
future age: ");
            let futureYear = birthYear + futureAge;
            do Output.printString("You will be ");
            do Output.printInt(futureAge);
            do Output.printString(" in the year ");
            do Output.printInt(futureYear);

            return;
      }
}
```

5. Translate the entire Main class (written in Java) into its Jack equivalent.

```java
public class Main {

    public static void main(String[] args)
    {
        System.out.println(mult(5, 4));
    }

    static int mult(int x, int y)
    {
        int sum = 0;
        int n = 1;
        while (n <= y)
        {
            sum += x;
            n++;
        }
        return sum;
    }
}
```

Jack Code

```
class Main {
	function void main() {
		var int x, y;

		// Initialize
		let x = 5;
		let y = 4;

		// Print product
		do Output.printInt(Main.mult(x, y));

		return;
	}

	function int mult(int x, int y) {
		var int sum, n;
		let sum = 0;
		let n = 1;
		while(n - y < 1) {
			let sum = sum + x;
			let n = n + 1;
		}

		return sum;
	}
}
```

6. Convert the following Java class (Fraction.java) into its Jack equivalent (two files/classes named Fraction.jack and Main.jack).

```java
public class Fraction {

    private int numerator, denominator;
    Fraction(int x, int y) {
        numerator = x;
        denominator = y;
    }
    int getNumerator() { return numerator; }
    int getDenominator() { return denominator; }

    void print() {
        System.out.println(numerator + "/" + denominator);
    }

    Fraction plus(Fraction other) {
        // Cross-multiply, no reduction/simplification
        int num = numerator * other.denominator +
                other.numerator * denominator;
        int den = denominator * other.denominator;
        return new Fraction(num, den);
    }

    public static void main(String[] args) {
        Fraction f1, f2, f3;
        f1 = new Fraction(2, 3);
        f2 = new Fraction(1, 5);
        f3 = f1.plus(f2);
        f3.print();
    }
}
```

Jack Code

```
// Lab 10 Question 6
class Main {
	function void main() {
		var Fraction f1, f2, f3;
		let f1 = Fraction.new(2, 3);
		let f2 = Fraction.new(1, 5);
		let f3 = f1.plus(f2);
		do f3.print();

		return;
	}
}


class Fraction {
	field int numerator, denominator;

	constructor Fraction new(int a, int b) {
		let numerator = a;
		let denominator = b;
		return this;
	}
```

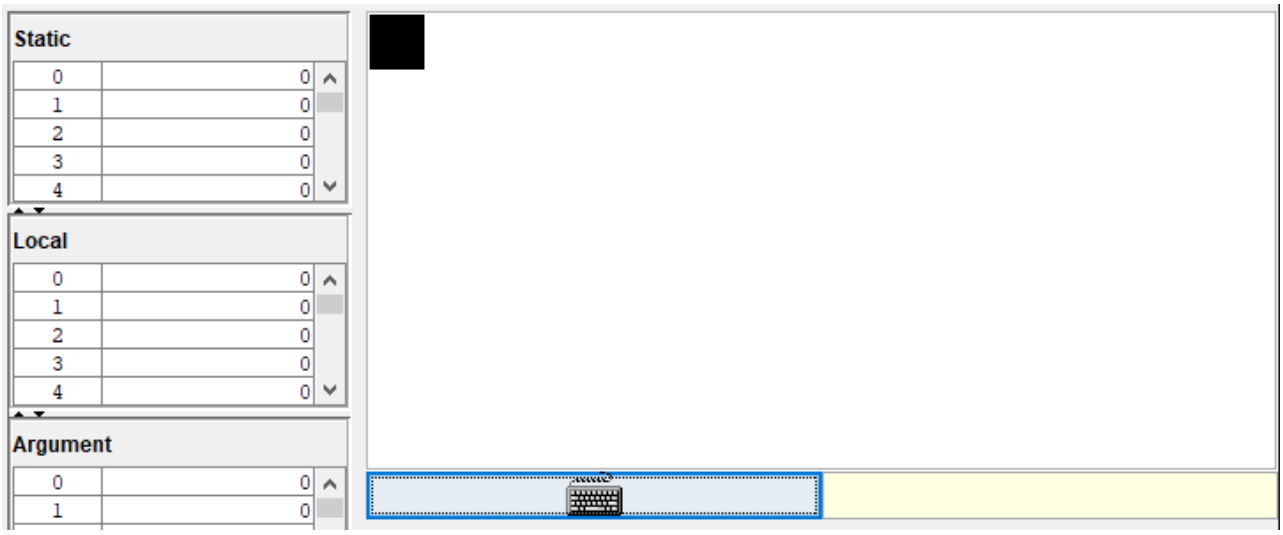
```
      // Getters
      method int getNumerator() { return numerator; }
      method int getDenominator() { return denominator; }

      method Fraction plus(Fraction other) {
            var int sum;
            let sum = (numerator * other.getDenominator()) +
                  (other.getNumerator() * denominator);
            return Fraction.new(sum, denominator * other.getDenominator());
      }

      // Print
      method void print() {
            do Output.printInt(numerator);
            do Output.printString("/");
            do Output.printInt(denominator);
            return;
      }
}
```

7. Write a Jack program that will display a square (30 pixels x 30 pixels), starting in the top-left (x=0, y=0) of the screen, then moving around the edge of the screen clockwise (e.g. along the top edge, then right edge, bottom edge, left edge) until it gets back to the origin.

   The square should move by itself, with a short wait between each movement.



Jack Code

```
class Main {
	function void main() {
		var int x, y;
		// !(x > 510)
		// !(y > 255)
		let x = 0;
		let y = 0;
		while(true) {
			// go right
			while(x < 495) {
				do Screen.setColor(true);
				do Screen.drawRectangle(x, y, x+30, y+30);
				do Sys.wait(250);
				do Screen.setColor(false);
				do Screen.drawRectangle(x, y, x+30, y+30);
				let x = x + 15;
			}

			// turn down
			let x = x - 15;
			let y = y + 15;
			do Screen.setColor(true);
			do Screen.drawRectangle(x, y, x+30, y+30);
			do Sys.wait(250);
			do Screen.setColor(false);
			do Screen.drawRectangle(x, y, x+30, y+30);
			let y = y + 15;

			// go down
			while(y < 230) {
				do Screen.setColor(true);
				do Screen.drawRectangle(x, y, x+30, y+30);
				do Sys.wait(250);
				do Screen.setColor(false);
				do Screen.drawRectangle(x, y, x+30, y+30);
				let y = y + 15;
			}

			// turn left
			let y = y - 15;
			let x = x - 15;
			do Screen.setColor(true);
			do Screen.drawRectangle(x, y, x+30, y+30);
			do Sys.wait(250);
			do Screen.setColor(false);
			do Screen.drawRectangle(x, y, x+30, y+30);
			let x = x - 15;

			// go left
			while(~(x < 0)) {
				do Screen.setColor(true);
```

```
                        do Screen.drawRectangle(x, y, x+30, y+30);
                        do Sys.wait(250);
                        do Screen.setColor(false);
                        do Screen.drawRectangle(x, y, x+30, y+30);
                        let x = x - 15;
                  }

                  // turn up
                  let x = x + 15;
                  let y = y - 15;
                  do Screen.setColor(true);
                  do Screen.drawRectangle(x, y, x+30, y+30);
                  do Sys.wait(250);
                  do Screen.setColor(false);
                  do Screen.drawRectangle(x, y, x+30, y+30);
                  let y = y - 15;

                  // go up
                  while(~(y < 0)) {
                        do Screen.setColor(true);
                        do Screen.drawRectangle(x, y, x+30, y+30);
                        do Sys.wait(250);
                        do Screen.setColor(false);
                        do Screen.drawRectangle(x, y, x+30, y+30);
                        let y = y - 15;
                  }
                  let y = 0;
            }
            return;
      }
}
```

Summative Questions:

8. When we execute a Jack program, the first subroutine that starts running is:
   The Main.main function

9. Can a subroutine in one Jack class access field variables of another Jack class?
   Not with out getters

10. Which Jack classes should have a method for disposing objects?
    All classes that designate memory deallocation for their objects

11. What does the keyword "this" implicitly refer to? (Select all that apply)

    a) In constructors: the current object

    (b) In functions: the current object

    (c) In methods: the current object

    d) In Main.main: the current object

12. Which of the following are true about Jack classes? (Select all that apply)

    a) A Jack class must have a constructor

    b) A Jack class can contain either methods, or functions, but not both

    (c) Each Jack class must be stored in a separate file

    d) Each Jack class must have a subroutine named "main"