MACQUARIE
University

Department of Computing

ITEC625 Fundamentals of Computer Science
Workshop - Control Structures

Learning outcomes

This weeks workshop is about understanding control structures, namely conditions and loops.

1. **boolean expressions**

   Write boolean expressions to check each of the following. You may assume all relevant variables are already declared and initialized to some value.

   (a) if an integer n is in the range 1 to 100 (inclusive on both sides)

   Solution:

   ```
   n >= 1 && n <= 100
   ```

   (b) if an integer n is in the range 1 to 100 (inclusive on right side only)

   Solution:

   ```
   n > 1 && n <= 100
   ```

   (c) if an integer n is in the range 1 to 100 (inclusive on left side only)

   Solution:

   ```
   n >= 1 && n < 100
   ```

   (d) if an integer n is in the range 1 to 100 (exclusive on both sides)

   Solution:

   ```
   n > 1 && n < 100
   ```

   (e) if an integer n is divisible by integer a but not by integer b

   Solution:

   ```
   n % a == 0 && n % b != 0
   ```

(f) if integer n is either an even number that is more than 20 or an odd number that is less than 5.

Solution:

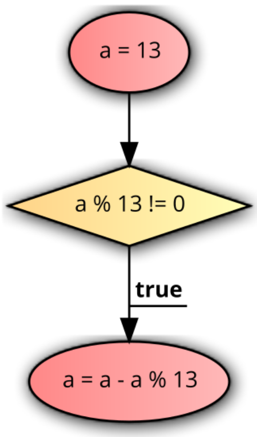
```
(n%2 == 0 && n >= 20) || (n%2 != 0 && n < 5)
```

2. **Flowcharts**

Draw flowcharts for each of the following codes. In which cases will your program result in a Variable may not have been initialized error? Are there any other mistakes in the program?

(a)

```
int a = 13;
if(a % 13 != 0) {
        a = a - a % 13;
}
```

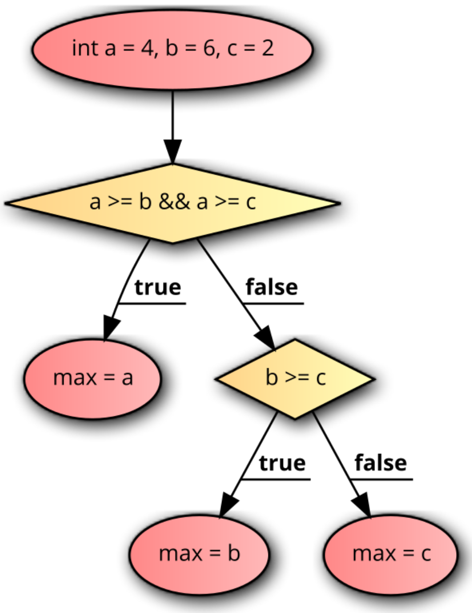


Solution:

Program does not result in variable may not be initialized since all leaves of the flowchart end up in a value being assigned to a.

(b)

```
int max;
int a = 4, b = 6, c = 2;
if(a >= b && a >= c) {
        max = a;
}
else if(b >= c) {
        max = b;
}
else {
        max = c;
}
```

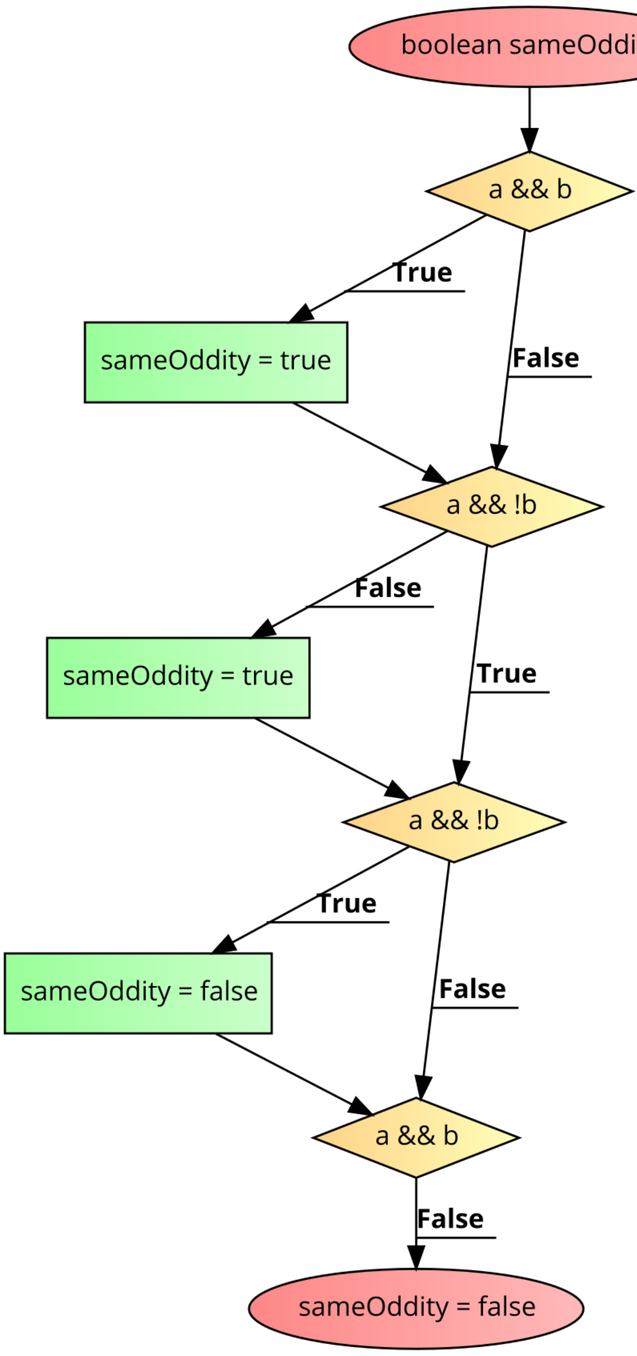


Solution:

Program does not result in variable may not be initialized since all leaves of the flowchart end up in a value being assigned to `max`.

(c)

```
boolean sameOddity;
if(a && b) {
        sameOddity = true;
}
if(!a && !b) {
        sameOddity = true;
}
if(a && !b) {
        sameOddity = false;
}
if(!a && b) {
        sameOddity = false;
}
```



Solution:

Program results in variable may not be initialized since one path of the flowchart end up in a value being assigned to `sameOddity` (when none of the boolean expressions are true).

3. **Tracing control structures - 1** Trace the following code and determine the value of result.

```
int a = 114;
int result = 0;
while(a != 0) {
        if(a % 2 == 1) {
                result = result + 1;
        }
        a = a / 2;
}
```

Solution: result = 4 (number of 1s in the binary version of 114)

4. **Tracing control structures - 2** Trace the following code and determine the value of result.

```
int x = 2;
int n = 8;
int result = 1;
for(int i=1; i <= n; i++) {
        result = result * x;
}
```

Solution: result = 256 (256 = 2 to the power of 8). The program calculates x^n.

5. **Tracing control structures - 3** Trace the following code and determine the value of result.

```
int a = 23, b = 49;
int result = 0, power = 1;

while (a != 0 || b != 0) {
  int bit1 = a % 2;
  int bit2 = b % 2;
  if (bit1 != bit2) {
    result = result + power;
  }
  power = power * 2;
  a = a / 2;
  b = b / 2;
}
```

Solution: result = 38 (outcome of a XOR b)

6. **Writing control structures - 1**

Consider there are three variables, `low, high, interval` such that:

- `low` $\leq$ `high`, and,
- `interval` ≥ 0

Write a piece of code that computes the following value, and stores it in a variable `sum`.

```
low + (low + interval) + (low + 2*interval) + ... high


* note that it might not go all the way to high
```

For example,

```
low = 3, high = 15, interval = 4 -> sum = 3+7+11+15 = 36
low = 1, high = 8, interval = 5 -> sum = 1+6 = 7
low = -18, high = 20, interval = 12 -> sum = -18+-6+6+18 = 0
```

Solution:

```
int sum = 0;
for(int i=low; i<=high; i+=interval) {
        sum = sum + i;
}
```

7. **Writing control structures - 2**

   Given an integer $n \geq 1$, write a piece of code that adds integers from 1 to n with the additional constraints that -

   a. any multiple of 5 should not be added, unless the number is also a multiple of 10, in which case, we should add twice of that number to the sum.

   For example,

```
n = 12, sumNot5 = 1+2+3+4+6+7+8+9+2*10+11+12 = 83
```

Solution:

```
int sumNot5 = 0;
for(int i=1; i<=n; i++) {
        if(i%5 != 0) {
                sumNot5 = sumNot5 + i;
        }
        else if(i%10 == 0) {
                sumNot5 = sumNot5 + 2*i;
        }
}
```

8. **(ADVANCED) Writing control structures - 3**

   In the lecture we discussed how to determine if a given integer is prime or not. The snippet is provided below:

```
boolean isPrime = true;
for(int i=2; i*i<=n && isPrime; i++) {
        if(n%i==0) {
                isPrime = false;
        }
}
```

The first few primes are:

```
prime 0: 2
prime 1: 3
prime 2: 5
prime 3: 7
prime 4: 11
prime 5: 13
```

(In C-base languages - including Java - we number everything starting at zero).

Given an integer $k \geq 0$, write a piece of code that computes prime k.

For example,

```
k = 5 -> 13
k = 10 -> 31
k = 45 -> 199
k = 1000 -> 7927
```

Solution:

```
int n = 2;
int result = n;
if (k > 0) {
  for (int p=0; p<=k; n++) {
    boolean isPrime = true;
    for (int i=2; i*i<=n && isPrime; i++) {
      if (n%i==0) {
        isPrime = false;
      }
    }
    if (isPrime) {
      p++;
    }
  }
  n--; //the last time
}
```