Keeping Your CA212 Exercises

- Keep a special folder for CA212 exercises
- Grades will be affected by your exercises
- Tutors will award grades for up to date work on a week to week basis
- This forms a part of your continuous assessment.

W2   cont

Use Repetition Structures to Design and Implement Top-Down Stepwise Refinement of an Algorithm

Iteration

- *while* and counter controlled repetition.
- *while* and sentinel controlled repetition.
- *for* repetition

while Repetition Structure

- Programmer may specify that some lines of code are to be repeated while some *condition expression* is true

```
While there are more items on shopping list
   Purchase next item
   Cross off the list
Pay at checkout
```

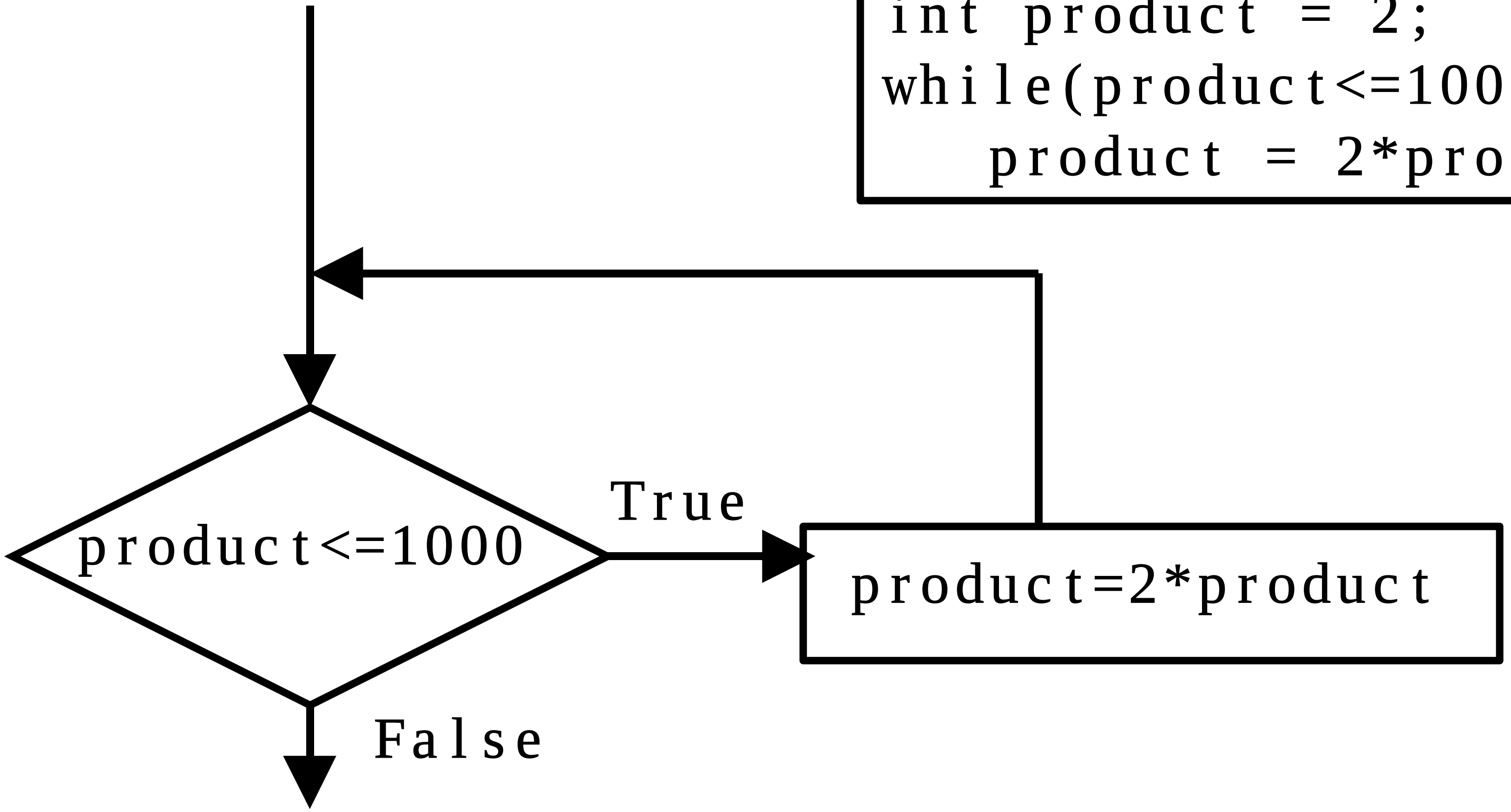
while Syntax

C++ Syntax: while (<condition>) <statement>

- Use the *while* keyword to implement a while loop.
- <statement> executes repeatedly until the value of <condition> is zero.
- The test takes place before <statement> executes. Thus, if <condition> evaluates to zero on the first pass, the loop does not execute.

while Example

```
int product = 2;
while(product<=1000)
    product = 2*product;
```



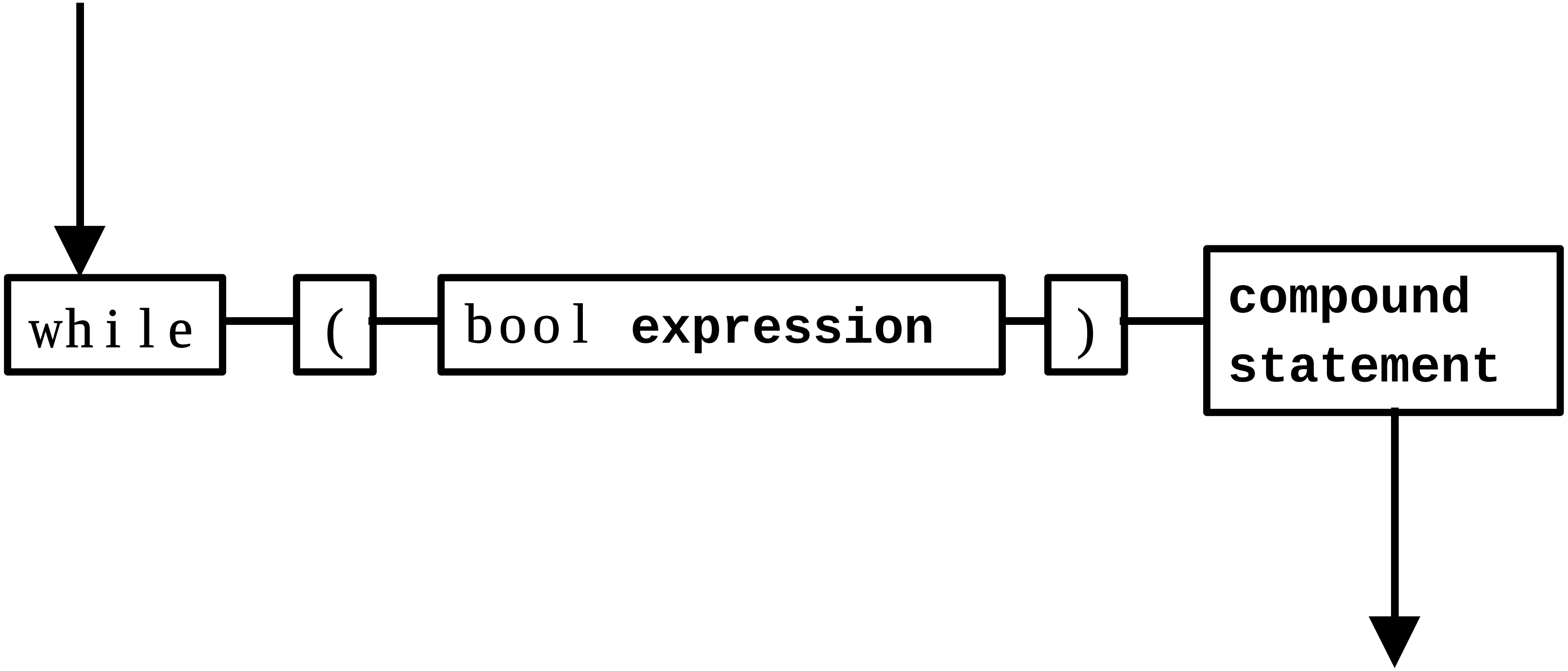
product<=1000

True

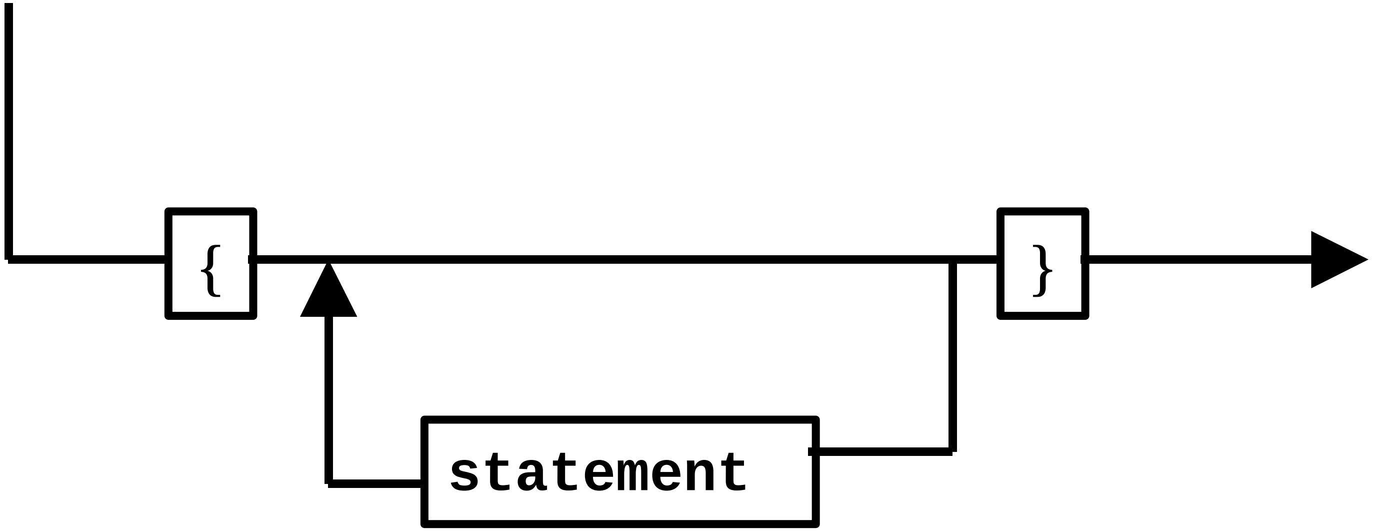
product=2*product

False

while Syntax Diagram



compound statement



Programming Errors

- Writing a condition which never evaluates to false will result in an infinite loop
- C and C++ are case-sensitive, do not write *While* where you intend to write *while*
- Do not put a ; after the condition, this will result in an infinite loop

Counter-Controlled Repetition

- Looking at several variations of a problem of finding the class-average of the programming exam grades

```
Set total to zero
Set grade counter to 1
while grade counter is less than or equal to 10
    input the next grade
    add the grade to the total
    add one to the counter
Set the class average to the total divided by 10
Print the class average
```

```
#include <iostream.h>
int main() {
  int total,       // sum of grades
     gradeCounter, // number of grades entered
     grade,        // one grade
     average;      // average of grades
     total = 0;                     // clear total
  gradeCounter = 1;                 // prepare to loop
  while ( gradeCounter <= 10 ) {       // loop 10 times
    cout << "Enter grade: ";          // prompt for input
    cin >> grade;                   // input grade
    total = total + grade;           // add grade to total
    gradeCounter = gradeCounter + 1;  // increment counter
  }
  average = total / 10;             // integer division
  cout << "Class average is " << average << endl;
  return 0;   // indicate program ended successfully
}
```

Programming Errors

- The counter-control variable will be off by 1 after the loop has completed, if you use it, you may get a bug!

Sentinel-Controlled Repetition

- We may not know in advance the size of the class, so the value of *gradeCounter* cannot be set in the code
- We wish to process an arbitrary number of grades each time the program is run

Stepwise Refinement

```
Initialise variables
Input the grades, sum them and count the grades
Calculate and print class average
```

```
Initialise total to 0
initialise counter to 0

Input first grade (possibly sentinel)
While user not entered sentinel
   add this grade to running total
   add 1 to grade counter
   input next grade (possibly sentinel)

if counter not equal to 0
   set average to total divided by counter
   print average
else
   print “no grades were entered”
```

```
#include <iostream.h>
#include <iomanip.h>
int main() {
   int total,        // sum of grades
       gradeCounter, // number of grades entered
       grade;        // one grade
   float average;    // number for average
   total = 0;
   gradeCounter = 0;
   cout << "Enter grade, -1 to end: ";     cin >> grade;
   while ( grade != -1 ) {
      total = total + grade;
      gradeCounter = gradeCounter + 1;
      cout << "Enter grade, -1 to end: ";
      cin >> grade;  }
   if ( gradeCounter != 0 ) {
      average = (float)total  / gradeCounter;   // note the cast here ! see type conversion slide
      cout << "Class average is " << setprecision( 2 )<< setiosflags( ios::fixed | ios::showpoint )
           << average << endl;   }
   else
      cout << "No grades were entered" << endl;
}
```

Programming Errors

- Do not choose a sentinel value which may be a legitimate input value for use inside the loop, we will not get to use it, the loop will exit
- Floating point arithmetic is done only approximately on computers
  - 1/3 cannot be represented precisely
- Do not test floating point numbers for equality, rather test the precision of their differences

Nested Control Structures

The School offers the CA101 programming course. You have been asked to summarise the results of the examinations. A **1** records a pass, a **2** records a fail. You are required to do the following

- Input each result after a prompt
- count the passes and fails
- Display in summary, number of passes and fails
- If more than 8 pass, print message ‘Raise tuition’

Our Observations on the Problem

- 10 test results each time, so counter-controlled loop is appropriate
- We can process only a 1 or a 2, of it is not a 1 we will assume it is a 2
- Two counters used, one for passes, one for fails
- After results are processed, must check for more than 8 passes

Stepwise Refinement of Pseudocode

```
Initialise variables

Input 10 grades and count passes and fails

Print summary and decide if fees should be raised
```

```
Initialise passes to 0
Initialise fails to 0
Initialise student counter to 1

while student counter less than or equal to 10
   input next exam result
   if student passed
      add one to passes
   else
      add one to fails
   add one to student counter

print number of passes
print number of fails
if more than 8 passes
   print ‘raise tuition’
```

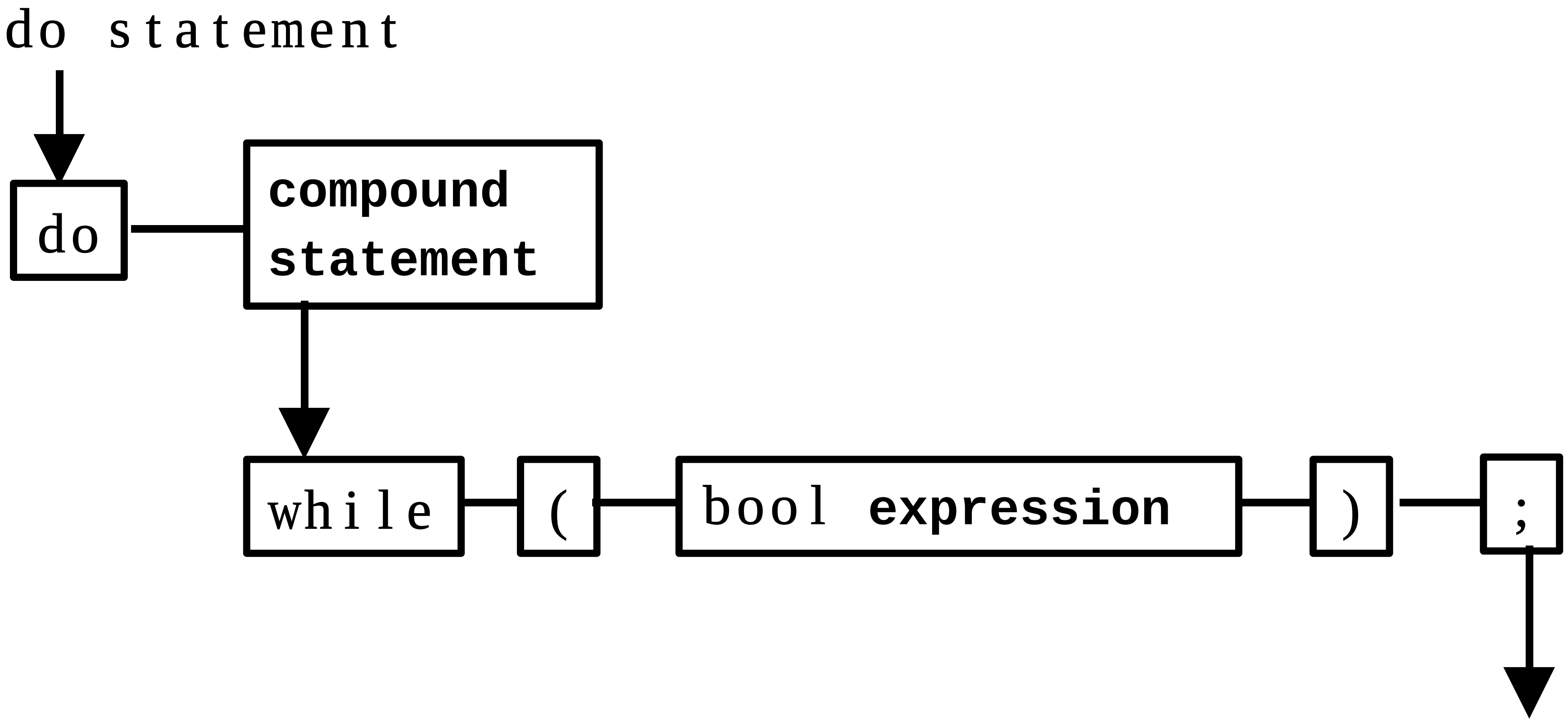
```
#include <iostream.h>
int main()   {
int passes = 0,          // number of passes
     failures = 0,        // number of failures
     studentCounter = 1,   // student counter
     result;              // one exam result
  while ( studentCounter <= 10 ) {
    cout << "Enter result (1=pass,2=fail): ";
    cin >> result;
    if ( result = = 1 )       // if/else nested in while
      passes = passes + 1;
    else
      failures = failures + 1;
    studentCounter = studentCounter + 1;
  }
  cout << "Passed " << passes << endl;
  cout << "Failed " << failures << endl;
  if ( passes > 8 )
    cout << "Raise tuition " << endl;    }
```

do while Repetition Structure

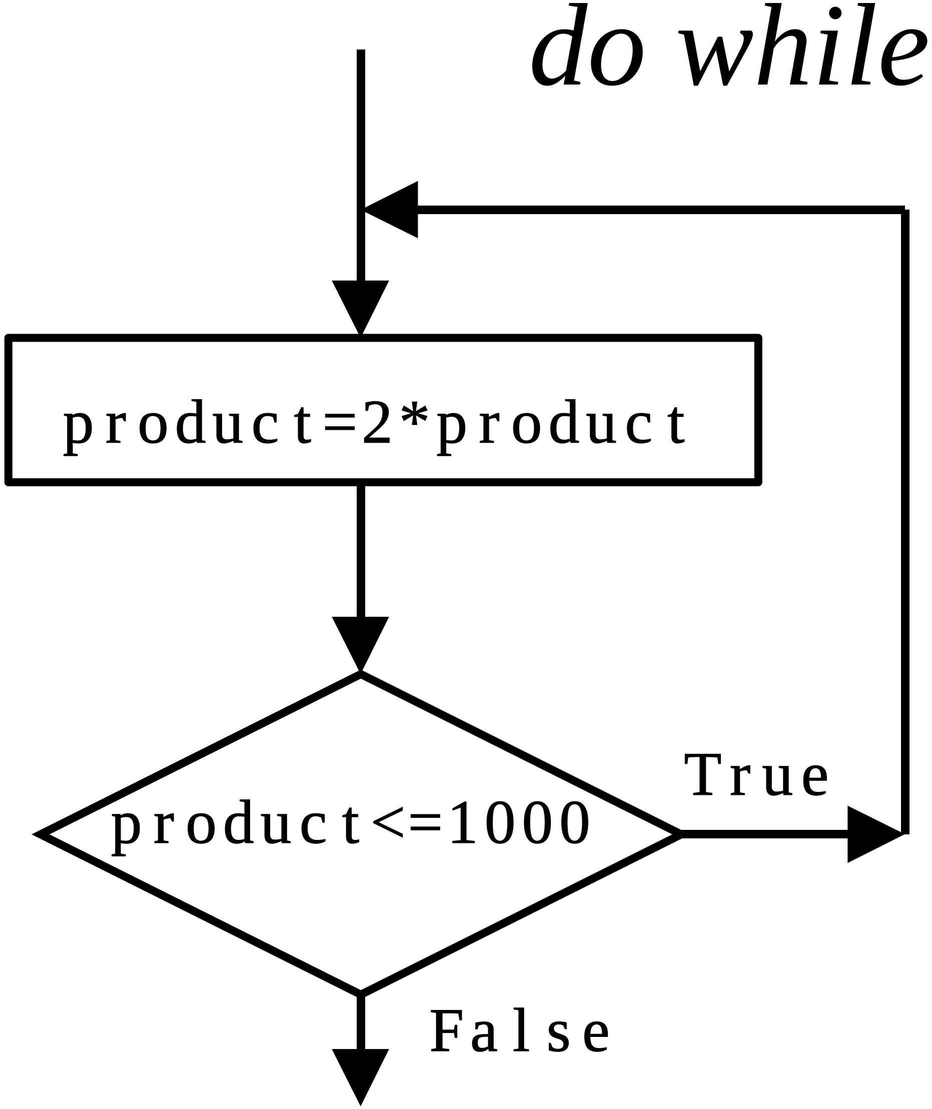
```
do <statement> while ( <condition> );
```

- The do statement implements a do ... while loop.
- <statement> is executed repeatedly as long as the value of <condition> remains non-zero.
- Since the condition is tested **after** each time the loop executes the <statement>, the loop will execute at least once.

do while Syntax Diagram



do while Example



```
int product = 2;
do
   product = 2*product;
while (product <= 1000);
```

Using *do while*

- This loop will cause the loop body to be executed **at least** once
- When programming advisable to use braces { } on loop body in order to eliminate confusion with *while* loop construct
- The conditional or boolean expression must evaluate false at some point in order for the loop to terminate

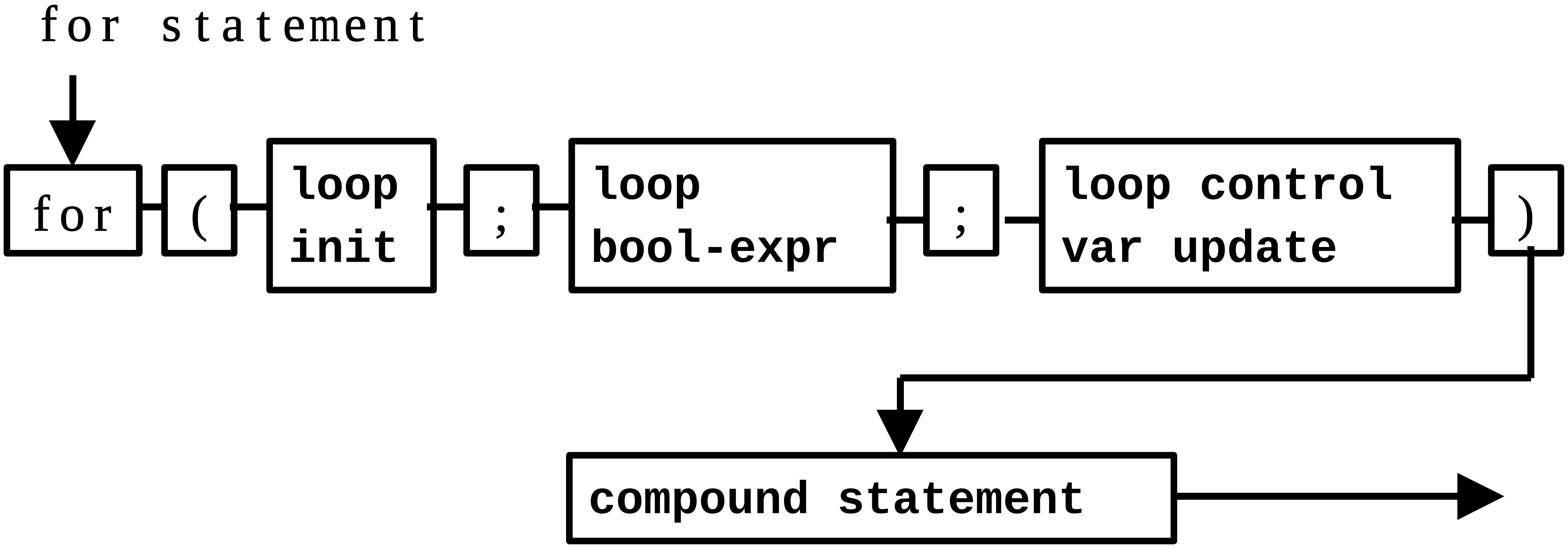
Example *do while* program

```
#include <iostream.h>
int main()
{
   int counter = 1;
   do {
      cout << counter << "  ";
   } while ( ++counter <= 10 );
   cout << endl;
   return 0;
}
```

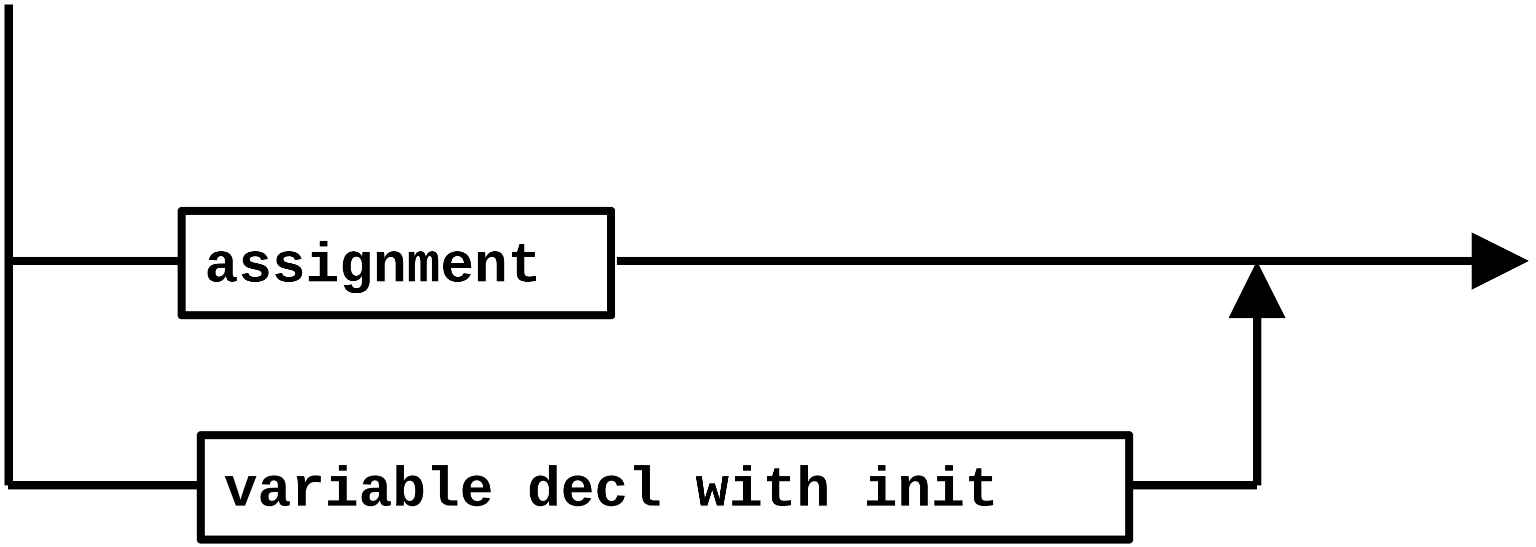
for Repetition Structure

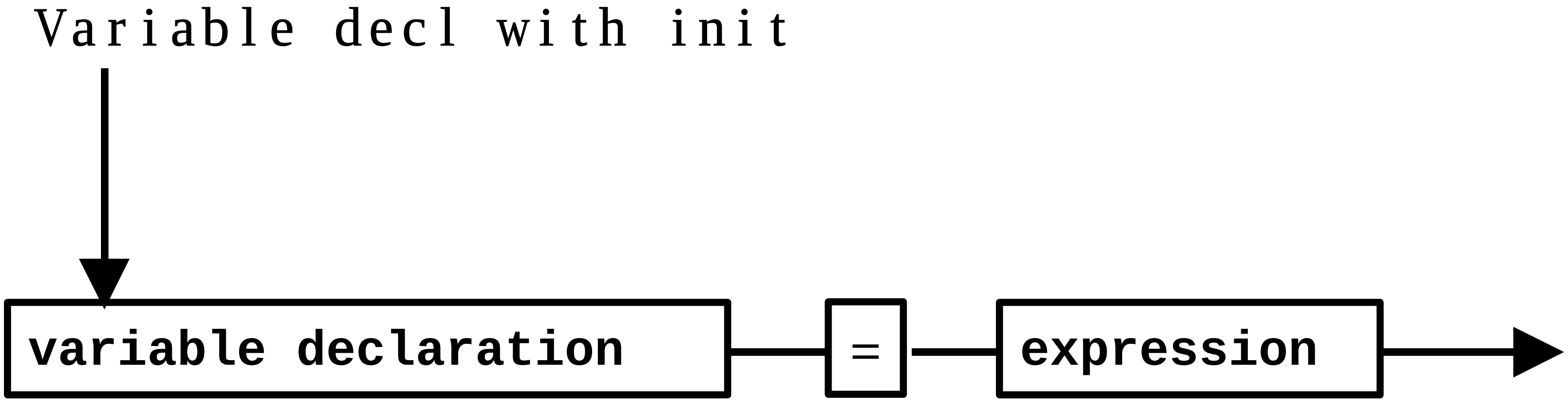
- Handles counter controlled repetition within the language
- Initialisation, test and increment all handled in one place

for Syntax Diagram

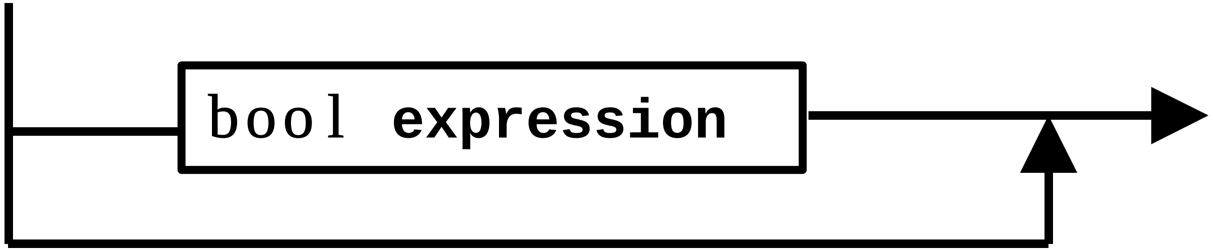


loop init

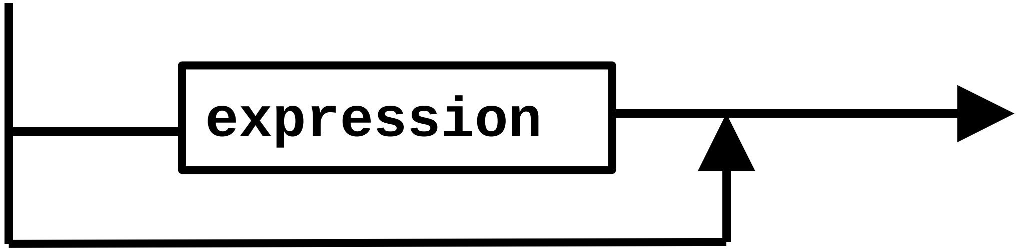



Variable decl with init
variable declaration
=
expression

loop bool-expr



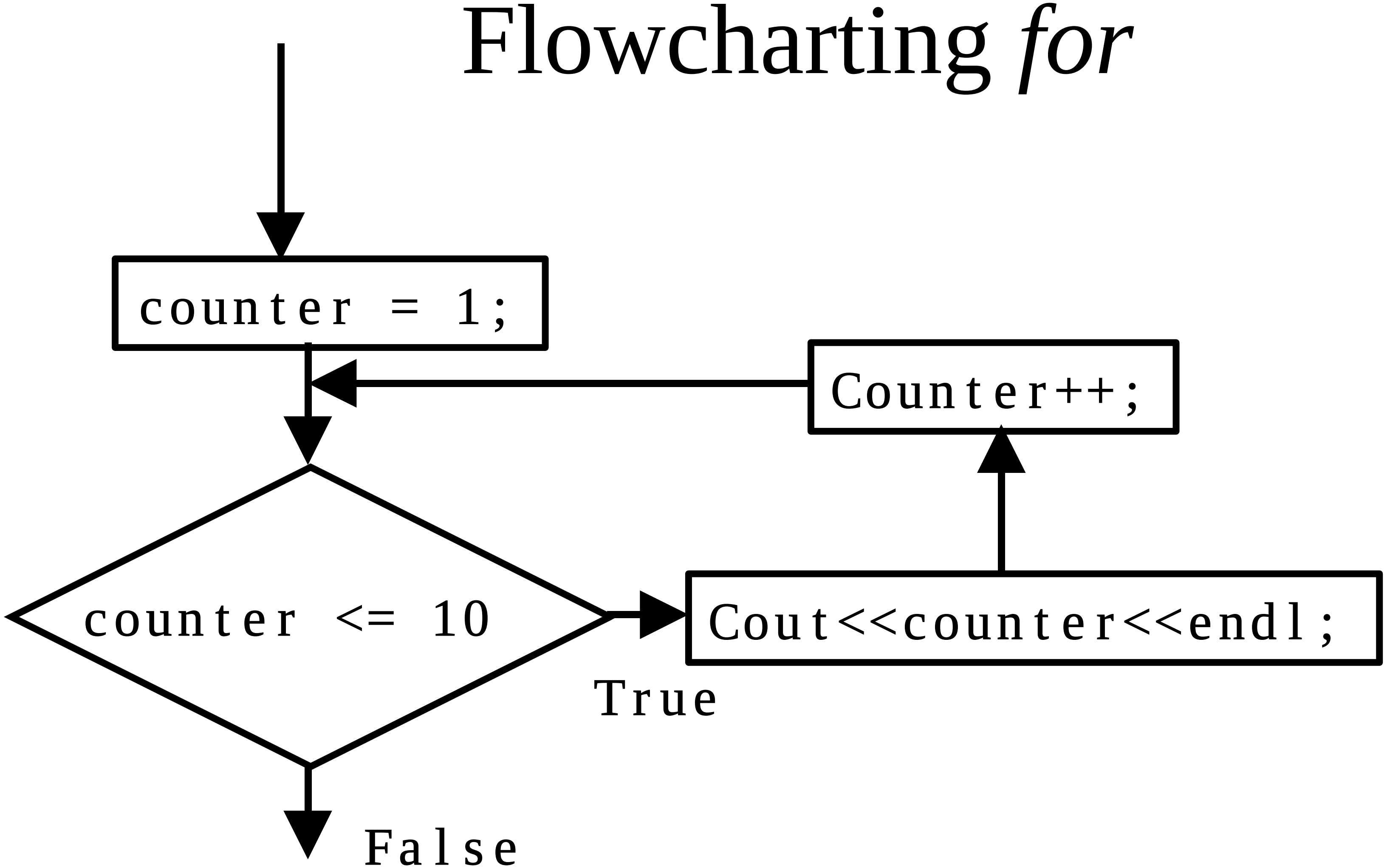
loop control var update



for Example

```
// Counter-controlled repetition with the for structure
#include <iostream.h>
main()
{
  // Initialization, repetition condition, and incrementing
  // are all included in the for structure header.
  for (int counter = 1; counter <= 10; counter++)
    cout << counter << endl;
  return 0;
}
```

Flowcharting *for*



counter = 1;

counter <= 10

True

Cout<<counter<<endl;

Counter++;

False

```
// Calculating compound interest
#include <iostream.h>
#include <iomanip.h>
#include <math.h>
main()
{
  double amount, principal = 1000.0, rate = .05;
  cout << "Year" << setw(21) << "Amount on deposit" << endl;
  for (int year = 1; year <= 10; year++) {
    amount = principal * pow(1.0 + rate, year);
    cout << setw(4) << year
         << setiosflags(ios::fixed | ios::showpoint)
         << setw(21) << setprecision(2) << amount << endl;
  }
  return 0;
}
```

Compare *while* and *do while*

```
#include <iostream.h>
main(){
  int counter, grade, total, average;
  total = 0;
  counter = 1;
  while (counter <= 10) {
    cout << "Enter grade: ";
    cin >> grade;
    total = total + grade;
    counter = counter + 1;
  }
  average = total / 10;          // integer division
  cout << "Class average is " << average << endl;
  return 0;   // indicate program ended
successfully
}
```

Counter controlled repetition.

```
#include <iostream.h>
main(){
  float average;              /* new data type */
  int counter, grade, total;
  total = 0;
  counter = 0;
  cout<<"Enter grade, -1 to end: ";
  cin>>grade;
  while (grade != -1) {
     total = total + grade;
     counter = counter + 1;
     cout<<"Enter grade, -1 to end: ";
     cout<<grade;
  }
if (counter != 0) {
    average = (float) total / counter;
    cout<<"Class average is %.2f", average;
  }
  else
    cout"No grades were entered\n";
  return 0;   /* indicate program ended successfully */
}
```

Sentinel controlled repetition.

Workshop/Tutorial Exercises

- Do exercise 2.16
  - Hint: uses a sentinel controlled loop
- Do exercise 2.20
  - Hint: combines
    - iteration (while, do while, for)
    - selection (if)