CS1100
Introduction to Programming

Control Structures

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Perfect Number Detection

- Perfect number – sum of proper divisors adds up to the number
- Pseudocode:
  - Read a number, A
  - Set the sum of divisors to 1
  - If A is divisible by 2, Add 2 to the sum of divisors
  - If A is divisible by 3, Add 3 to the sum of divisors

    …
  - If A is divisible by A/2, Add A/2 to the sum of divisors
  - If A is equal to the sum of divisors, A is a perfect number

Refining the Pseudocode

- Read a number, A
- Set the sum of divisors to 1
- Set B to 2
- While B is less than or equal to A/2
  - If A is divisible by B, Add B to the sum of divisors
  - Increment B by 1
- If A is equal to the sum of divisors, A is a perfect number

Perfect Number Detection

```
main ( ){
  int d=2, n, sum=1;
  scanf ("%d", &n);
  while (d <= (n/2)) {
     if (n%d == 0)
          sum += d;
    d++;
   }
  if (sum == n) printf ("%d is perfect\n", n);
  else printf ("%d is not perfect\n", n);
}
```

d<n will also do, but would do unnecessary work

Exercise: Modify to find the first *n* perfect numbers

for loops

- Counter controlled repetitions needs
  - Initial value for the counter
  - Modification of counter: i = i+1 or i = i–1, or any other arithmetic expression based on the problem, and
  - Final value for the counter
- ***for*** repetition structure provides for the programmer to specify all these
- Any statement written using ***for*** can be rewritten using ***while***
- Use of ***for*** helps make the program error free

The *for* construct

- General form:

  for (expr1; expr2; expr3) <statement>
- Semantics:
  - evaluate "expr1" - initialization operation(s)
  - repeat - evaluate expression "expr2" and
  - If "expr2" is true
    - execute "statement" and "expr3"
  - Else stop and exit the loop

Example Code with the *while* Construct

```
scanf("%d", &n);
value = 1;
printf ("current value is %d \n", value);
counter = 0;
while (counter <= n){
    value = 2 * value;
    printf ("current value is %d \n", value);
    counter = counter + 1;
}
```


Example Code with the *for* Construct

```
scanf("%d", &n);
value = 1;
for (count = 0; count <= n; count = count+1){
    if (count == 0) printf("value is %d \n",1);
    else{
        value = 2 * value;
        printf(value is %d \n", value);
    }
}
```

- Observe: a mistake in the earlier program is gone

Computing the Sum of the First 20 Odd Numbers

```
int i, j, sum;
sum = 0;
for (j = 1, i = 1; i <= 20; i = i+1){
        sum += j;
        j += 2;
}
```

Set *j* to the first odd number

i : Loop control variable

Termination condition

Increment sum by the i^{th} odd number

Set j to the next odd number

Calculating Compound Interest

$a = p(1 + r)^n$

```
#include<stdio.h>
#include<math.h>
main( ){
int yr;
double amt, principal = 1000.0, rate = .05;
printf("%4s%10s\n", "year", "Amount");
for (yr = 1; yr < = 10; yr++) {
    amt = principal * pow(1.0 + rate, yr);
    printf("%4d%10.2f\n", yr, amt);
}
```

String constants used to align heading and output data in a table

The *do-while* construct

- ***for*** and ***while*** check termination condition before each iteration of the loop body
- Sometimes - execute the statement and check for condition
- General form:

  do {<statement>} ***while*** (expr);
- Semantics:
  - execute the statement and check expr
  - if expr is true, re-execute statement else exit

An Example

```
#include<stdio.h>
int main( )
{
  int count = 1;
  do{
      printf("%d\n", count);
    }while(++count <= 10);
return 0;
}
```

Find the Square Root of a Number

- How do we find the square root of a given number N?
- We need to find the positive root of the polynomial $x^2 - N$
- Solve: $x^2 - N = 0$

Newton–Raphson Method

$f(x) = x^2 - N$

$$f'(x_n) = \frac{0 - f(x_n)}{(x_{n+1} - x_n)}$$

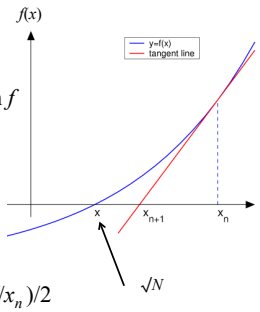
f' : the derivative of the function f

By simple algebra we can derive

$$x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)}$$

$x_{n+1} = x_n - (x_n^2 - N)/2x_n$

$= (x_n^2 + N)/2x_n = (x_n + N/x_n)/2$

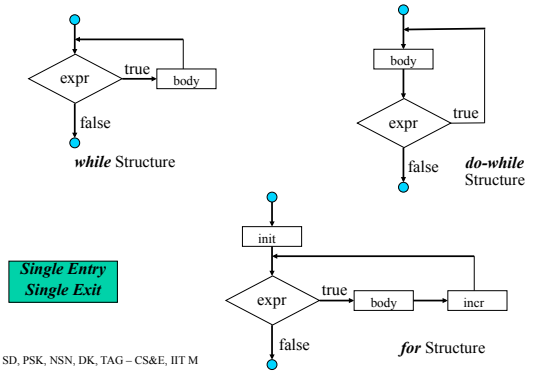


http://en.wikipedia.org/wiki/Newton's_method

Square Root of a Number

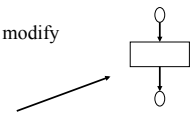
```
int n;
float prevGuess, currGuess, error, sqRoot;
scanf("%d", &n);
currGuess = (float) n/2 ; error = 0.0001;
do{
        prevGuess = currGuess;
        currGuess = (prevGuess + n/prevGuess)/2;
   }while(fabs(prevGuess – currGuess)>error);
sqRoot = currGuess;
printf("%f\n", sqRoot);
```


Repetition Structures



Structured Programming

- To produce programs that are
  - easier to develop, understand, test, modify
  - easier to get correctness proof
- Rules
  1. Begin with the "simplest flowchart"
  2. Any action box can be replaced by two action boxes in sequence
  3. Any action box can be replaced by any elementary structures (sequence, ***if***, ***if/else***, ***switch***, ***while***, ***do-while*** or ***for***)
  4. Rules 2 and 3 can be applied as many times as required and in any order



Break and Continue

- ***break*** – breaks out of the innermost loop or switch statement in which it occurs
- ***continue*** – starts the next iteration of the loop in which it occurs

An Example

```
#include<stdio.h>
main ( ){
    int i;
    for (i = 1; i < 10; i = i+1){
        if( i == 5)
            break; //continue;
        printf("%4d", i);
    }
}
```


Find a Smallest Positive Number

```
#include<stdio.h>
main ( ){
    int n=0, smallNum =  10000;
    printf("Enter Numbers (in the range 0 to 9999):\n");
    scanf("%d", &n);
    while (n >= 0){
        if(smallNum > n)   smallNum = n;
        scanf("%d",&n);
    }
    printf("Smallest number is %d\n",smallNum);
}
```


Exercises

- Write a program that reads in the entries of a 3x3 matrix, and prints it out in the form of a matrix. The entries could be floating point too.
- Write a program that reads in orders of two matrices and decides whether two such matrices can be multiplied. Print out the decision.
- Write a program that reads in two matrices, and multiplies them. Your output should be the two matrices and the resulting product matrix.