CS1010E Lecture 6

Functions as Procedures

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Lecture Outline

- Defining procedures
- Function call statement / return statement
- Procedures for
  - Program output
  - Multiple function output
- Function output parameter
- Example: finding mean and variance

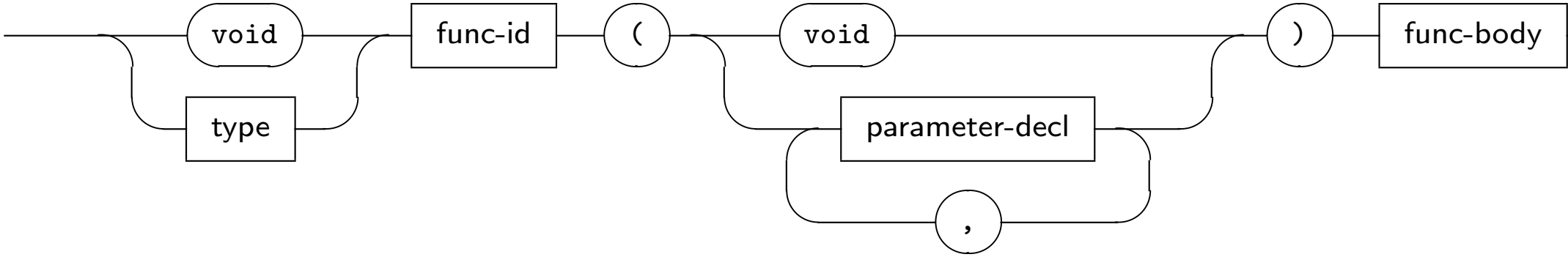
C Functions

- C function is used to define
  - value-returning function
  - procedure
- In general, a C function allows
  - multiple arguments or no arguments
  - one return value or none at all

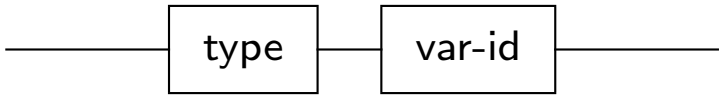
		# of arguments	
		0	multiple
# of return values	0	*rarely used*	*procedures*
	1	*rarely used*	*value-returning functions*

Function Definition

function-definition



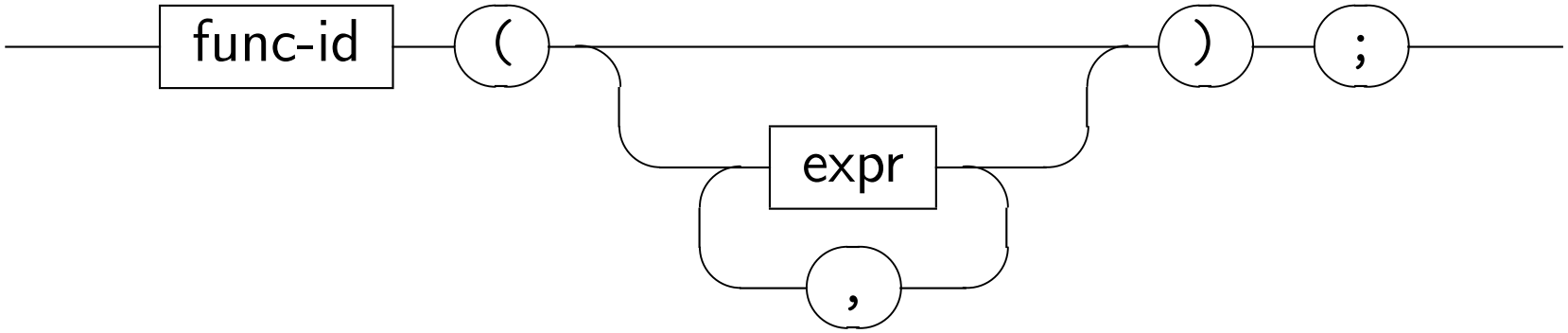
parameter-decl



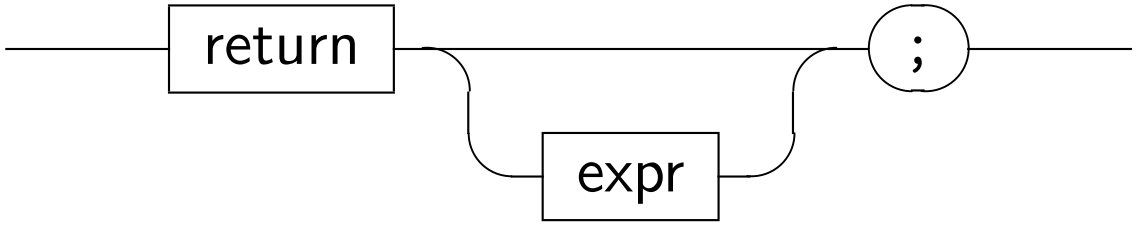
- type: type of return value; `void` if no return value
- func-id: meaningful function or parameter name
- parameter: parameter declaration; `void` for no parameters

Function Call and Return Statements

function-statement



return-statement



Procedure: Program Output

- Useful for complex printing tasks

```c
#include <stdio.h>

void printTriangle(int n);
void printRowOfStars(int n);

int main(void) {
   int n, i;

   printf("Enter n: ");
   scanf("%d", &n);

   for (i = n; i >= 1; i--) {
      printTriangle(i);
   }
   return 0;
}
```

```c
void printTriangle(int n) {
   int i, j;

   for (i = n; i > 0; i--) {
      printRowOfStars(i);
   }
   return;
}

void printRowOfStars(int n) {
   int i;

   for (i = 1; i <= n; i++) {
      printf("*");
   }
   printf("\n");
   return;
}
```

Procedure: Multiple Function Output

- A function can only return at most one value
- Example: Given a time duration (in seconds), compute the equivalent number of hours, minutes and seconds
- Solution #1: do-it-yourself!

```c
#include <stdio.h>

int main(void) {
   int t, h, m, s;

   printf("Enter duration (secs): ");
   scanf("%d", &t);

   h = t/3600;
   m = (t%3600)/60;
   s = t%60;

   printf("Duration: %d:%d:%d\n", h,m,s);

   return 0;
}
```

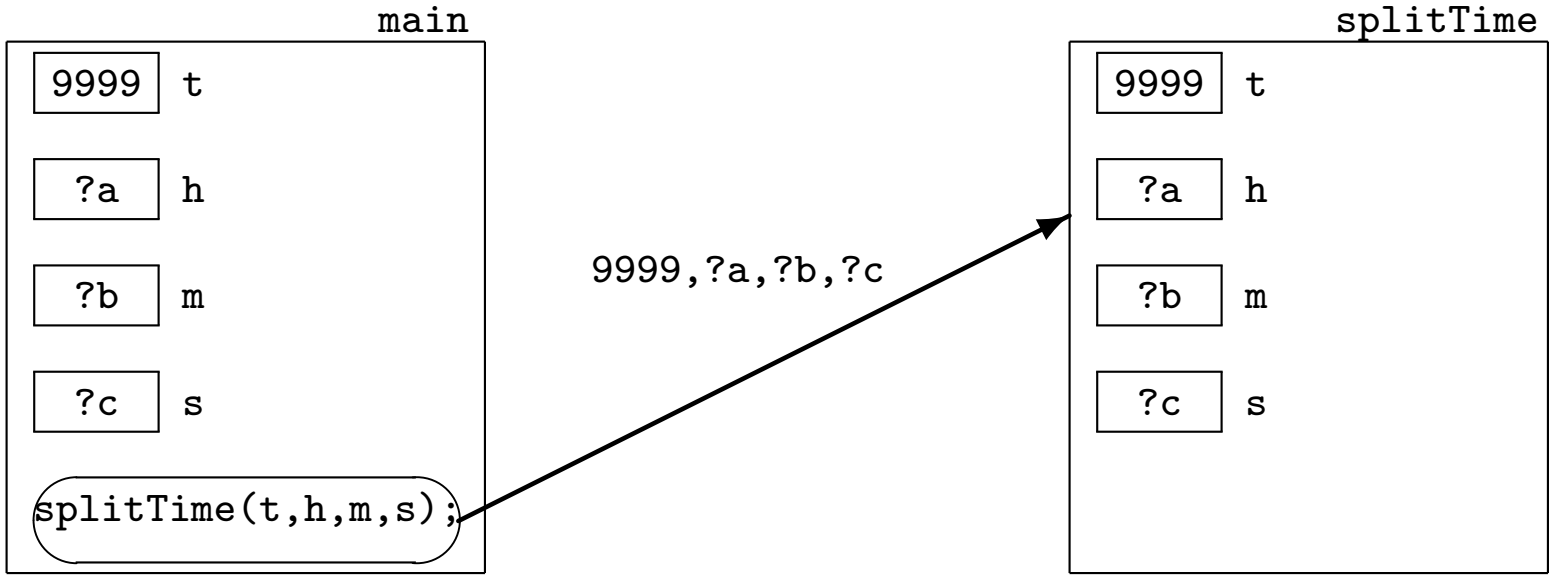
Procedure: Multiple Function Output

- Solution #2: Get a procedure to do it. Does this work?

```c
#include <stdio.h>

void splitTime(int t, int h, int m, int s);

int main(void) {
   int t, h, m, s;

   printf("Enter duration (secs): ");
   scanf("%d", &t);

   splitTime(t,h,m,s);
   printf("Duration: %d:%d:%d\n", h,m,s);
   return 0;
}

void splitTime(int t, int h, int m, int s) {
   h = t/3600;
   m = (t%3600)/60;
   s = t%60;
   return;
}
```

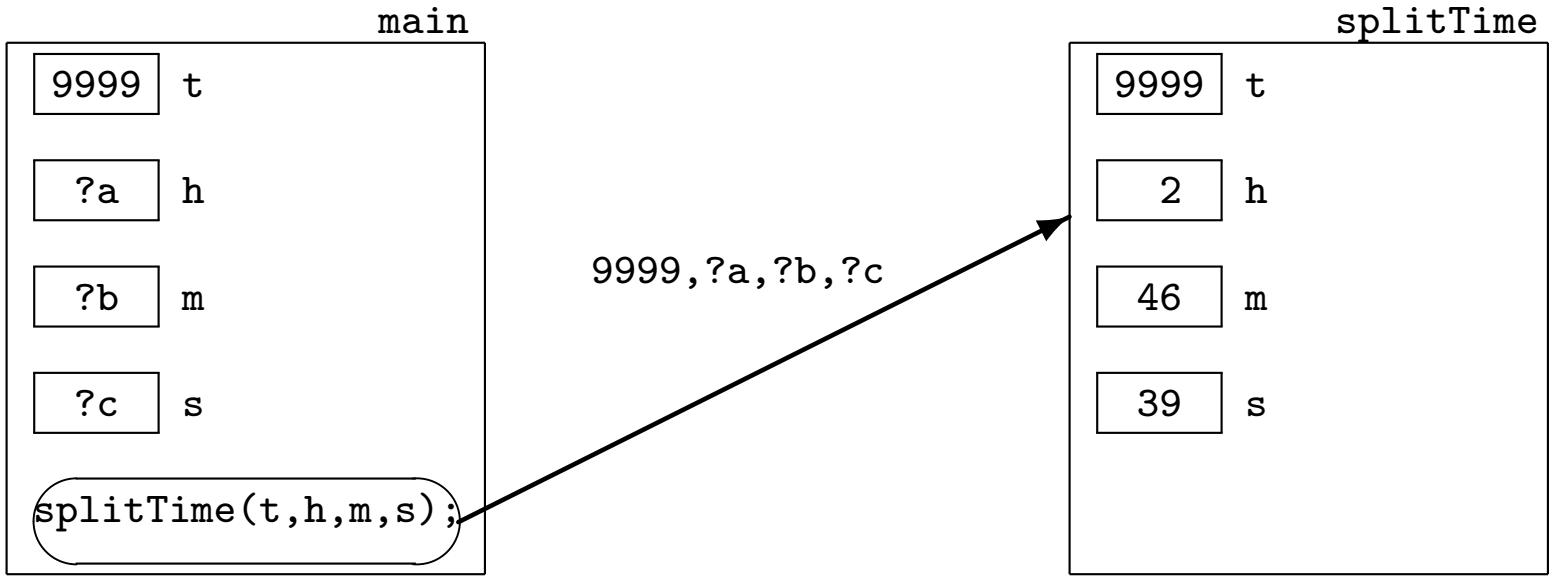
Pass-by-Value Revisited

- Recall pass-by-value



Pass-by-Value Revisited

- Just before `splitTime` function returns



- What happens to the variables in the `main` function?

Variable Access Across Functions

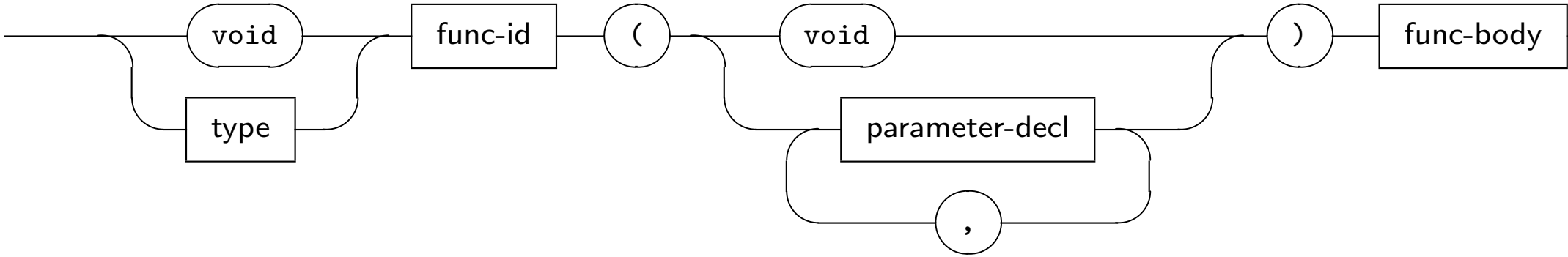
- To enable function output via the parameters, use the "into" way of variable access (e.g. `scanf`)

```
int main(void) {
   int t, h, m, s;

   printf("Enter duration (secs): ");
   scanf("%d", &t);

   splitTime(t,&h,&m,&s);

   printf("Duration: %d:%d:%d\n", h,m,s);

   return 0;
}
```

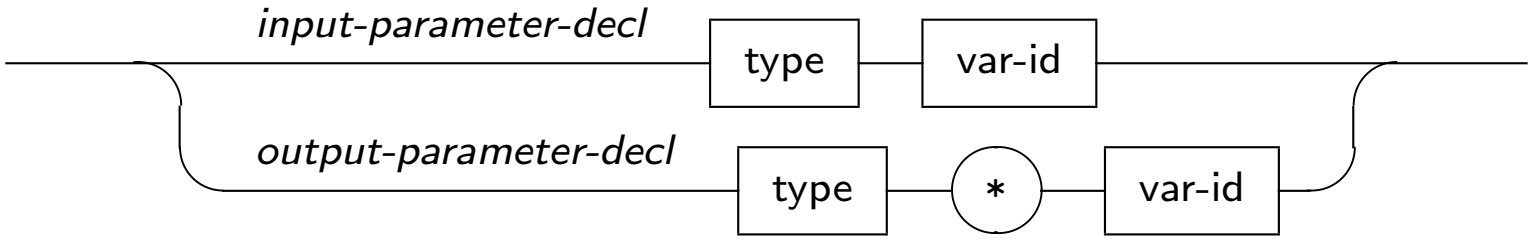
- How to define parameters of the `splitTime` function?

Function Output Parameter

function-definition



parameter-decl



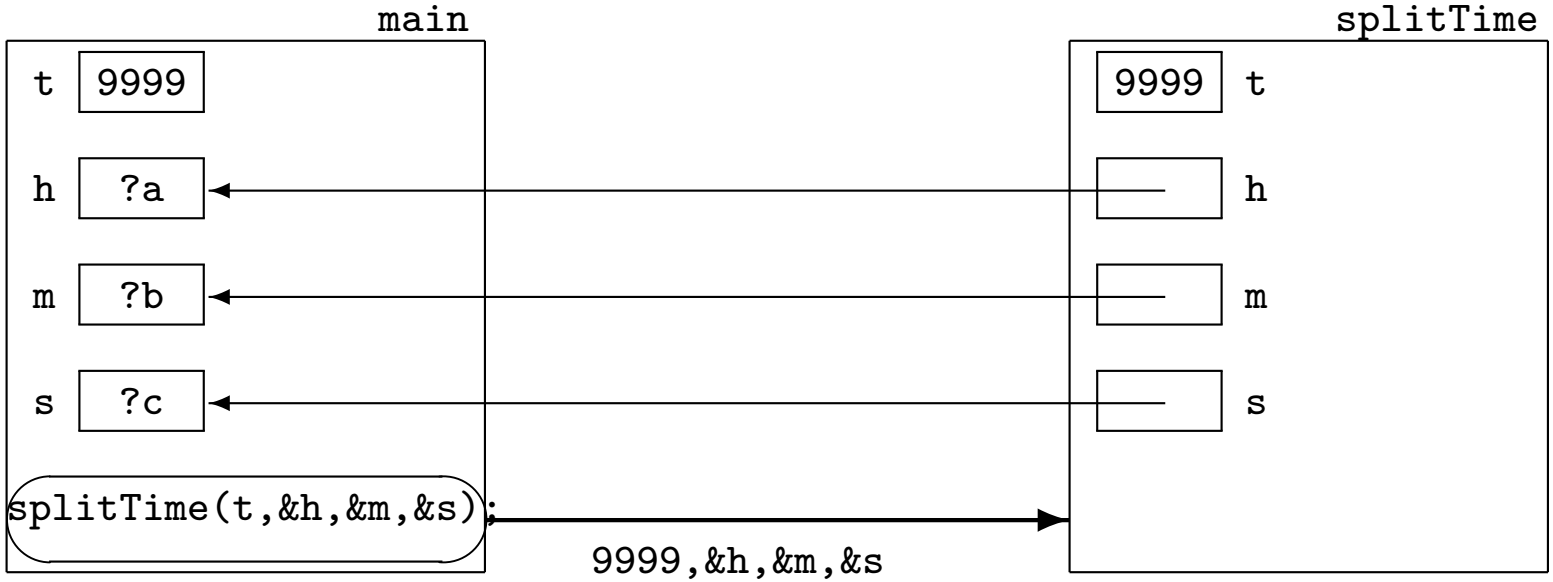
Function Output Parameter

- Output parameter declared with * in the function header
- Output parameter accessed using * in the function body

```
/*
   Function splitTime takes t in seconds, splits and
   outputs the hours, minutes and seconds through the
   output parameters h, m and s.

   Precondition: t >= 0
*/
void splitTime(int t, int *h, int *m, int *s) {
   *h = t/3600;
   *m = (t%3600)/60;
   *s = t%60;

   return;
}
```

Function Output Parameter

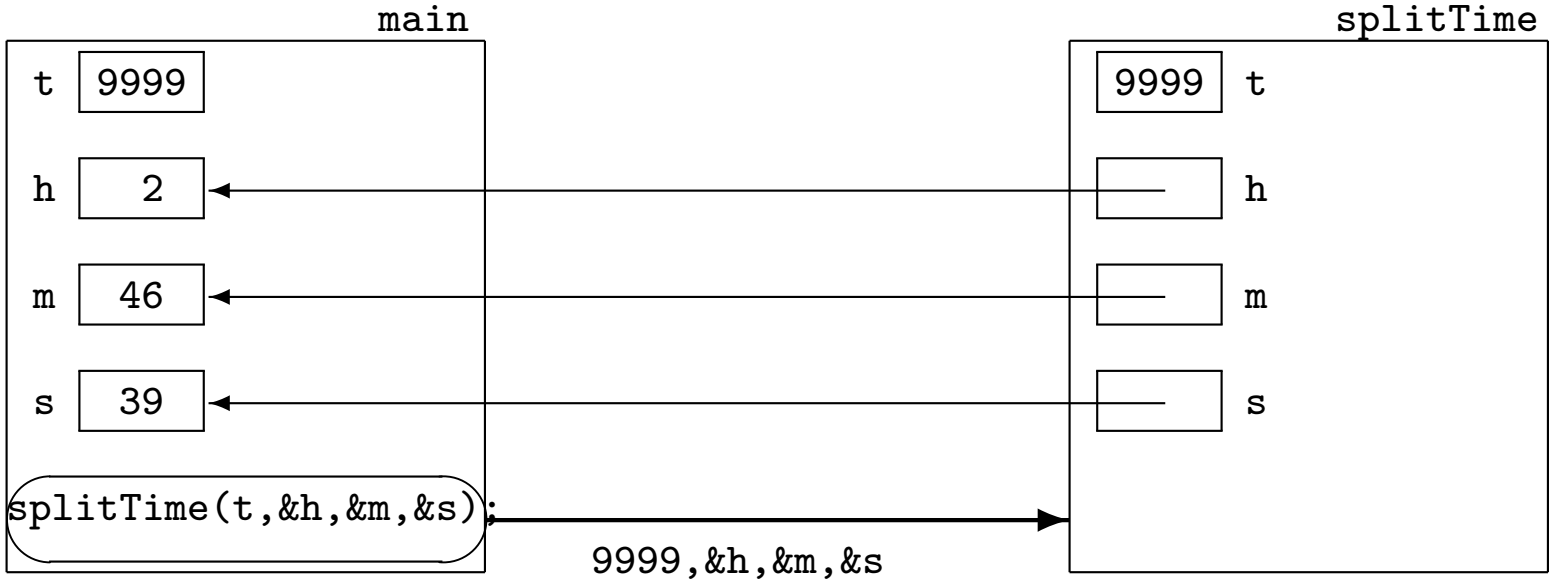
- Calling `splitTime` with function output parameters



- Passing `&h`, `&m` and `&s` to `splitTime` gives it access to variables `h`, `m` and `s` in `main`

Function Output Parameter

- Just before `splitTime` function returns



- Values are "returned" through the function output parameters; does not violate lexical scoping

Example: Swapping Variable Contents

- Using `main` function to swap the contents of two variables

```c
#include <stdio.h>

int main(void) {
    int x, y, temp;

    printf("Enter x and y: ");
    scanf("%d%d", &x, &y);

    temp = x;
    x = y;
    y = temp;

    printf("x=%d; y=%d\n", x, y);

    return 0;
}
```

Example: Swapping Variable Contents

- Using a swap function

```c
#include <stdio.h>

void swap(int *x, int *y);

int main(void) {
   int x, y;

   printf("Enter x and y: ");
   scanf("%d%d", &x, &y);

   swap(&x,&y);

   printf("x=%d; y=%d\n", x, y);

   return 0;
}
```

```c
void swap(int *x, int *y) {
   int temp;

   temp = *x;
   *x = *y;
   *y = temp;

   return;
}
```

Example: Finding Mean and Standard Deviation

- Example: Given n ($\geq$ 0) non-negative floating-point values, find the mean μ and standard deviation σ

$$\mu = \frac{\sum x_i}{n}$$

$$\sigma = \sqrt{\frac{\sum({x_i}^2) - \frac{(\sum x_i)^2}{n}}{n}}$$

- Finding μ and σ requires the sum $\sum x_i$, as well as sum of squares $\sum({x_i}^2)$
- Use sentinel-controlled input to read values

Using only the `main` function

```c
#include <stdio.h>
#include <math.h>

int main(void) {
    int n=0;
    double data, sum=0, sumSq=0, mean, stdev;

    scanf("%lf", &data);
    while (data >= 0) {
        sum = sum + data;
        sumSq = sumSq + (data * data);
        n++;
        scanf("%lf", &data);
    }

    if (n > 0) {
        mean = sum/n;
        stdev = sqrt((sumSq - (sum*sum/n))/(n));
        printf("mean=%f; stdev=%f\n", mean, stdev);
    } else {
        printf("No data\n");
    }

    return 0;
}
```

Modularizing `readData`

```c
#include <stdio.h>
#include <math.h>

void readData(int *n, double *sum, double *sumSq);

int main(void) {
    int n=0;
    double sum=0, sumSq=0, mean, stdev;

    readData(&n,&sum,&sumSq);

    if (n > 0) {
        mean = sum/n;
        stdev = sqrt((sumSq - (sum*sum/n))/(n));
        printf("mean=%f; stdev=%f\n", mean, stdev);
    } else {
        printf("No data\n");
    }

    return 0;
}
```

Modularizing readData

```
   readData reads values until a sentinel (< 0) and outputs
   n (no. of values read), sum and sumSq (sum of square values)

   Precondition: none
   Postcondition: n >= 0, sum >= 0, sumSq >= 0
*/
void readData(int *n, double *sum, double *sumSq) {
   double data;

   *n = 0; *sum = 0; *sumSq = 0;
   scanf("%lf", &data);
   while (data >= 0) {
      *sum = *sum + data;
      *sumSq = *sumSq + (data*data);
      (*n)++;

      scanf("%lf", &data);
   }

   return;
}
```

Modularizing `findStats`

```c
#include <stdio.h>
#include <math.h>

void readData(int *n, double *sum, double *sumSq);
void findStat(int n, double sum, double sumSq,
              double *mean, double *stdev);

int main(void)
{
   int n=0;
   double sum=0, sumSq=0, mean, stdev;

   readData(&n,&sum,&sumSq);

   if (n > 0) {
      findStat(n,sum,sumSq,&mean,&stdev);
      printf("mean=%f; stdev=%f\n", mean, stdev);
   } else {
      printf("No data\n");
   }

   return 0;
}
```

Modularizing `findStats`

```
/*
   findStats outputs the mean and stdev of n values
   given sum and sumSq (sum of square values).

   Precondition: n > 0
*/
void findStat(int n,
              double sum, double sumSq,
              double *mean, double *stdev) {
   *mean = sum / n;
   *stdev = sqrt((sumSq - (sum*sum)/n)/(n));

   return;
}
```

Lecture Summary

- Application of user-defined functions as value-returning functions or procedures
- Use of function output parameters to simulate "multiple return values"
  - Are value-returning functions that return a single value no longer necessary?
  - How about function compositions?

```
double cos(double x);
double sqrt(double x);
```

allows the following expression to be defined:

```
sqrt((b * b) + (c * c) -
     (2 * b * c * cos(alpha * PI / 180)));
```