Unix Systems Programming (CSE 3041)

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C Language Elements

Text Books

- **Jeri R. Hanly, & Elliot B. Koffman**
  Problem Solving and Program Design in C, 7th Edition
  Pearson Education
- **Kay A Robbins, & Steven Robbins**
  The Unix System Programming
  Communication,Concurrency, & Threads
  Pearson Education
- **Brain W. Kernighan, & Rob Pike**
  The Unix Programming Environment
  PHI

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- Each library has a standard header file whose name ends with the symbols .h.

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```
/*
 * Converts distances from miles to kilometers.
 */
```

standard header file

comment

preprocessor directive

```
#include <stdio.h>          /* printf, scanf definitions */
#define KMS_PER_MILE 1.609  /* conversion constant       */
```

constant

reserved word

```
int
main(void)
{
      double miles, /* distance in miles
```

variable

```
             kms;   /* equivalent distance in kilometers */
```

comment

standard identifier

```
      /* Get the distance in miles. */
      printf("Enter the distance in miles> ");
      scanf("%lf", &miles);

      /* Convert the distance to kilometers. */
      kms = KMS_PER_MILE * miles;
```

special symbol

```
      /* Display the distance in kilometers. */
      printf("That equals %f kilometers.\n", kms);
```

reserved word

punctuation

```
      return (0);
}
```

special symbol

Syntax Displays for Preprocessor Directives

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#include Directive for Defining Identifiers from Standard Libraries

SYNTAX: `#include <standard header file>`

EXAMPLES:

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

INTERPRETATION: `#include` directives tell the preprocessor where to find the meanings of standard identifiers used in the program. These meanings are collected in files called *standard header files*. The header file `stdio.h` contains information about standard input and output functions such as `scanf` and `printf`. Descriptions of common mathematical functions are found in the header file `math.h`. We will investigate header files associated with other standard libraries in later chapters.

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main Function Definition

SYNTAX:
```
int
main(void)
{
        function body
}
```

(continued)

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ANSI C RESERVED WORDS

auto	double	int	struct
break	else	long	switch
case	enum	register	typedef
char	extern	return	union
const	float	short	unsigned
continue	for	signed	void
default	goto	sizeof	volatile
do	if	static	while

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- Valid Identifiers : letter_1, letter_2, inches, cent, CENT_PER, Hello, variable

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Reserved Words	Standard Identifiers	User-Defined Identifiers
`int, void, double, return`	`printf, scanf`	`KMS_PER_MILE, main, miles, kms`

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- double miles; /* input - distance in miles. */
- double kms; /* output - distance in kilometers */

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Syntax Display for Declarations

SYNTAX:

```
int variable_list;
double variable_list;
char variable_list;
```

EXAMPLES:

```
int count,
    large;
double x, y, z;
char first_initial;
char ans;
```

INTERPRETATION: A memory cell is allocated for each name in the *variable_list*. The type of data (`double`, `int`, `char`) to be stored in each variable is specified at the beginning of the statement. One statement may extend over multiple lines. A single data type can appear in more than one variable declaration, so the following two declaration sections are equally acceptable ways of declaring the variables `rate`, `time`, and `age`.

```
double rate, time;
int age;
```

```
double   rate;
int      age;
double   time;
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- ’A’ ’z’ ’2’ ’9’ ’*’ ’:’ ’”’ ’ ’

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- In ASCII, the printable characters have codes from 32 (code for a blank or space) to 126 (code for the symbol $\sim$).
- The other codes represent nonprintable control characters. Sending a control character to an output device causes the device to perform a special operation such as returning the cursor to column one, advancing the cursor to the next line, or ringing a bell.

The ASCII Code

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The charts in this appendix show the following character sets: ASCII (American Standard Code for Information Interchange), EBCDIC (Extended Binary Coded Decimal Interchange Code), and CDC[†] Scientific. Only printable characters are shown. The integer code for each character is shown in decimal. For example, in ASCII, the code for 'A' is 65, and the code for 'z' is 122. The blank character is denoted by □.

Right Digit / Left Digit(s)	ASCII									
	0	1	2	3	4	5	6	7	8	9
3			□	!	"	#	$	%	&	'
4	(	)	*	+	,	–	.	/	0	1
5	2	3	4	5	6	7	8	9	:	;
6	<	=	>	?	@	A	B	C	D	E
7	F	G	H	I	J	K	L	M	N	O
8	P	Q	R	S	T	U	V	W	X	Y
9	Z	[	/	]	^	–	`	a	b	c
10	d	e	f	g	h	i	j	k	l	m
11	n	o	p	q	r	s	t	u	v	w
12	x	y	z	{	|	}				

Executable Statements

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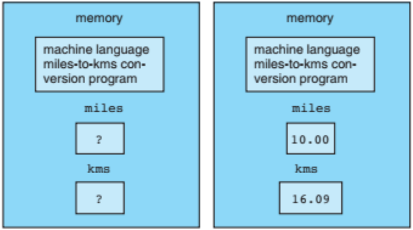

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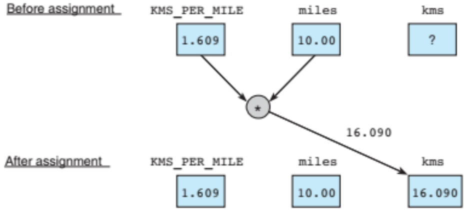

Assignment Statement

FORM: *variable* = *expression*;

EXAMPLE: `x = y + z + 2.0;`

INTERPRETATION: The *variable* before the assignment operator is assigned the value of the *expression* after it. The previous value of *variable* is destroyed. The *expression* can be a variable, a constant, or a combination of these connected by appropriate operators (for example, +, −, /, and *).

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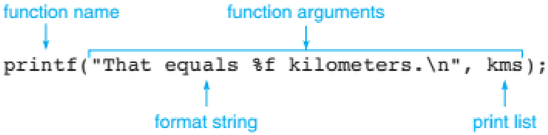

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- **newline escape sequence :** the character sequence \n, which is used in a format string to terminate an output line

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Placeholders in Format Strings

Placeholder	Variable Type	Function Use
%c	char	printf/scanf
%d	int	printf/scanf
%f	double	printf
%lf	double	scanf

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`%f`	`double`	`printf`
`%lf`	`double`	`scanf`

Syntax Display for printf Function Call

SYNTAX:

```
printf(format string, print list);
printf(format string);
```

EXAMPLES:

```
printf("I am %d years old, and my gpa is %f\n",
       age, gpa);
printf("Enter the object mass in grams> ");
```

INTERPRETATION: The `printf` function displays the value of its *format string* after substituting in left-to-right order the values of the expressions in the *print list* for their placeholders in the *format string* and after replacing escape sequences such as `\n` by their meanings.

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- In most cases the standard input device is the keyboard; consequently, the computer will attempt to store in miles whatever data the program user types at the keyboard.

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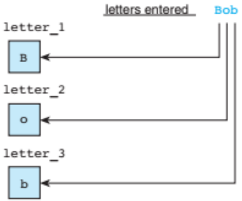

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Syntax Display for scanf Function Call

SYNTAX: `scanf(`*format string, input list*`);`

EXAMPLE: `scanf("%c%d", &first_initial, &age);`

INTERPRETATION: The `scanf` function copies into memory data typed at the keyboard by the program user during program execution. The *format string* is a quoted string of placeholders, one placeholder for each variable in the *input list*. Each `int`, `double`, or `char` variable in the *input list* is preceded by an ampersand (`&`). Commas are used to separate variable names. The order of the placeholders must correspond to the order of the variables in the *input list*.

You must enter data in the same order as the variables in the *input list*. You should insert one or more blank characters or carriage returns between numeric items. If you plan to insert blanks or carriage returns between character data, you must include a blank in the format string before the `%c` placeholder.

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Syntax Display for return Statement

SYNTAX: `return` *expression*`;`

EXAMPLE: `return (0);`

INTERPRETATION: The `return` statement transfers control from a function back to the activator of the function. For function `main`, control is transferred back to the operating system. The value of *expression* is returned as the result of the function execution.

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{
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Program Comment

SYNTAX: `/* comment text */`

EXAMPLES:

```
/* This is a one-line or partial-line comment */
/*
 * This is a multiple-line comment in which the stars
 * not immediately preceded or followed by slashes
 * have no special syntactic significance, but simply
 * help the comment to stand out as a block. This
 * style is often used to document the purpose of a
 * program.
 */
```

INTERPRETATION: A slash-star indicates the start of a comment; a star-slash indicates the end of a comment. Comments are listed with the program but are otherwise ignored by the C compiler. A comment may be put in a C program anywhere a blank space would be valid.

Note: ANSI C does not permit the placement of one comment inside another.

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- Before you implement each step in the initial algorithm, you should write a comment that summarizes the purpose of the algorithm step.
- This comment should describe what the step does rather than simply restate the step in English.For example, the comment

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/*
 * Programmer: William Bell    Date completed: May 9, 2003
 * Instructor: Janet Smith     Class: CIS61
 *
 * Calculates and displays the area and circumference of a
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 * Calculates and displays the area and circumference of a
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```

```
/* Convert the distance to kilometers. */
kms = KMS_PER_MILE * miles;
```

is more descriptive and hence preferable to

```
/* Multiply KMS_PER_MILE by miles and store result in kms. */
kms = KMS_PER_MILE * miles;
```

Practice Questions ???

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1. Change the following comments so they are syntactically correct.

```
/* This is a comment? *\
/* This one /* seems like a comment */ doesn't it */
```

2. Correct the syntax errors in the following program, and rewrite the program so that it follows our style conventions. What does each statement of your corrected program do? What output does it display?

```
/*
 * Calculate and display the difference of two input values
 *)
#include <stdio.h>
int
main(void) {int X, /* first input value */ x, /* second
  input value */
sum; /* sum of inputs */
scanf("%i%i"; X; x); X + x = sum;
printf("%d + %d = %d\n"; X; x; sum); return (0);}
```

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Arithmetic Operator	Meaning	Examples
+	addition	`5 + 2 is 7` `5.0 + 2.0 is 7.0`
-	subtraction	`5 - 2 is 3` `5.0 - 2.0 is 3.0`
*	multiplication	`5 * 2 is 10` `5.0 * 2.0 is 10.0`
/	division	`5.0 / 2.0 is 2.5` `5 / 2 is 2`
%	remainder	`5 % 2 is 1`

Mixed-Type Assignment Statement

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- An expression that has operands of both type int and double is a mixed-type expression. The data type of such a mixed-type expression will be double.

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m = 3;
n = 2;
p = 2.0;
x = m / p;
y = m / n;
```

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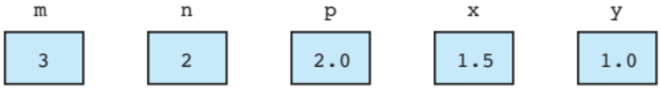

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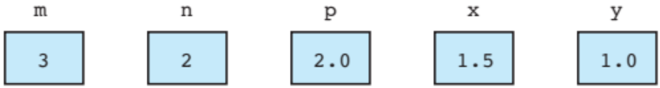

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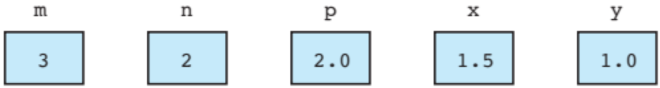

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- The expression in the assignment statements
  $x = 9 * 0.5;$
  $n = 9 * 0.5;$
  evaluates to the real number 4.5.

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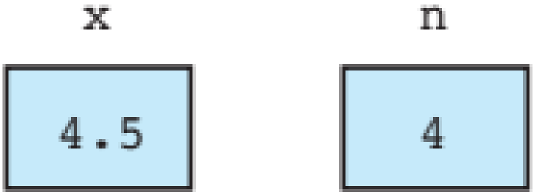

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- You can perform arithmetic operations on characters. For example, the expression 'A' + 1 adds 1 to the code for 'A' and its value is the next character after 'A' which is 'B' in ASCII.

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Mathematical Formula	C Expression
1. $b^2 - 4ac$	`b * b - 4 * a * c`
2. $a + b - c$	`a + b - c`
3. $\frac{a+b}{c+d}$	`(a + b) / (c + d)`
4. $\frac{1}{1+x^2}$	`1 / (1 + x * x)`
5. $a \times -(b + c)$	`a * -(b + c)`

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Value	Format	Displayed Output	Value	Format	Displayed Output
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`3.14159`	`%3.2f`	`3.14`	`3.14159`	`%5.1f`	`▮▮3.1`
`3.14159`	`%5.3f`	`3.142`	`3.14159`	`%8.5f`	`▮3.14159`
`.1234`	`%4.2f`	`0.12`	`-.006`	`%4.2f`	`-0.01`
`-.006`	`%8.3f`	`▮▮-0.006`	`-.006`	`%8.5f`	`-0.00600`
`-.006`	`%.3f`	`-0.006`	`-3.14159`	`%.4f`	`-3.1416`

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- In most systems, this association can be accomplished relatively easily through input/output redirection using operating system commands.

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- For example, in the UNIX® and MS-DOS® operating systems, you can instruct your program to take its input from file mydata.txt instead of from the keyboard by placing the symbols $\langle$ mydata.txt at the end of the command line that causes your compiled and linked program to execute.

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- **Output Redirection**
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- which takes program input from data file mydata.txt and sends program output to output file myoutput.txt.

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- **Logic errors** occur when a program follows a faulty algorithm. Because logic errors usually do not cause run-time errors and do not display error messages,they are very difficult to detect.

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- **PROBLEM :**
- You are drafting software for the machines placed at the front of supermarkets to convert change to personalized credit slips. In this draft, the user will manually enter the number of each kind of coin in the collection, but in the final version, these counts will be provided by code that interfaces with the counting devices in the machine.

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- **ANALYSIS:**
- To solve this problem, you need to get the customer's initials to use in personalizing the credit slip along with the count of each type of coin (dollars, quarters, dimes,nickels, pennies). From the counts, you can determine the total value of the coins in cents. Once you have that figure, you can do an integer division using 100 as the divisor to get the dollar value; the remainder of this division will be the leftover change. In the data requirements, list the total value in cents (total_cents) as a program variable, because it is needed as part of the computation process but is not a required problem output.

DATA REQUIREMENTS

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- Problem Inputs

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  char first, middle, last /* a customer's initials */

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- Problem Inputs
  char first, middle, last /* a customer's initials */
  int dollars /* number of dollars */

DATA REQUIREMENTS

- Problem Inputs
  char first, middle, last /* a customer's initials */
  int dollars /* number of dollars */
  int quarters /* number of quarters */

DATA REQUIREMENTS

- Problem Inputs
  char first, middle, last /* a customer's initials */
  int dollars /* number of dollars */
  int quarters /* number of quarters */
  int dimes /* number of dimes */

DATA REQUIREMENTS

- Problem Inputs
  char first, middle, last /* a customer's initials */
  int dollars /* number of dollars */
  int quarters /* number of quarters */
  int dimes /* number of dimes */
  int nickels /* number of nickels */

DATA REQUIREMENTS

- Problem Inputs
  char first, middle, last /* a customer's initials */
  int dollars /* number of dollars */
  int quarters /* number of quarters */
  int dimes /* number of dimes */
  int nickels /* number of nickels */
  int pennies /* number of pennies

DATA REQUIREMENTS

- Problem Inputs
  char first, middle, last /* a customer's initials */
  int dollars /* number of dollars */
  int quarters /* number of quarters */
  int dimes /* number of dimes */
  int nickels /* number of nickels */
  int pennies /* number of pennies
  Problem Outputs

DATA REQUIREMENTS

- Problem Inputs
  char first, middle, last /* a customer's initials */
  int dollars /* number of dollars */
  int quarters /* number of quarters */
  int dimes /* number of dimes */
  int nickels /* number of nickels */
  int pennies /* number of pennies
  Problem Outputs
  int total_dollars /* total dollar value */

DATA REQUIREMENTS

- Problem Inputs
  char first, middle, last /* a customer's initials */
  int dollars /* number of dollars */
  int quarters /* number of quarters */
  int dimes /* number of dimes */
  int nickels /* number of nickels */
  int pennies /* number of pennies
  Problem Outputs
  int total_dollars /* total dollar value */
  int change /* leftover change */

DATA REQUIREMENTS

- Problem Inputs
  char first, middle, last /* a customer's initials */
  int dollars /* number of dollars */
  int quarters /* number of quarters */
  int dimes /* number of dimes */
  int nickels /* number of nickels */
  int pennies /* number of pennies
  Problem Outputs
  int total_dollars /* total dollar value */
  int change /* leftover change */
  Additional Program Variables

DATA REQUIREMENTS

- Problem Inputs
  char first, middle, last /* a customer's initials */
  int dollars /* number of dollars */
  int quarters /* number of quarters */
  int dimes /* number of dimes */
  int nickels /* number of nickels */
  int pennies /* number of pennies
  Problem Outputs
  int total_dollars /* total dollar value */
  int change /* leftover change */
  Additional Program Variables
  int total_cents /* total value in cents */

DESIGN

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- INITIAL ALGORITHM

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  1. Get and display the customer's initials.

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  2. Get the count of each kind of coin.

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  1. Get and display the customer's initials.
  2. Get the count of each kind of coin.
  3. Compute the total value in cents.

DESIGN

- INITIAL ALGORITHM
  1. Get and display the customer's initials.
  2. Get the count of each kind of coin.
  3. Compute the total value in cents.
  4. Find the value in dollars and change.

DESIGN

- INITIAL ALGORITHM
  1. Get and display the customer's initials.
  2. Get the count of each kind of coin.
  3. Compute the total value in cents.
  4. Find the value in dollars and change.
  5. Display the value in dollars and change.

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- INITIAL ALGORITHM
  1. Get and display the customer's initials.
  2. Get the count of each kind of coin.
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  Steps 3 and 4 may need refinement. Their refinements are:

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  Steps 3 and 4 may need refinement. Their refinements are:
  Step 3 Refinement 3.1 Find the equivalent value of each kind of coin in pennies and add these values.

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- INITIAL ALGORITHM
  1. Get and display the customer's initials.
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  1. Get and display the customer's initials.
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  Steps 3 and 4 may need refinement. Their refinements are:
  Step 3 Refinement 3.1 Find the equivalent value of each kind of coin in pennies and add these values.
  Step 4 Refinement
  4.1 total_dollars is the integer quotient of total_cents and 100.

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- INITIAL ALGORITHM

  1. Get and display the customer's initials.
  2. Get the count of each kind of coin.
  3. Compute the total value in cents.
  4. Find the value in dollars and change.
  5. Display the value in dollars and change.

  Steps 3 and 4 may need refinement. Their refinements are:

  Step 3 Refinement 3.1 Find the equivalent value of each kind of coin in pennies and add these values.

  Step 4 Refinement

  4.1 total_dollars is the integer quotient of total_cents and 100.

  4.2 change is the integer remainder of total_cents and 100.

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- INITIAL ALGORITHM
  1. Get and display the customer's initials.
  2. Get the count of each kind of coin.
  3. Compute the total value in cents.
  4. Find the value in dollars and change.
  5. Display the value in dollars and change.

  Steps 3 and 4 may need refinement. Their refinements are:
  Step 3 Refinement 3.1 Find the equivalent value of each kind of coin in pennies and add these values.
  Step 4 Refinement
  4.1 total_dollars is the integer quotient of total_cents and 100.
  4.2 change is the integer remainder of total_cents and 100.

IMPLEMENTATION

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- Now Write the C Program.