CONDITIONALS AND BRANCHING

CS10003 PROGRAMMING AND DATA STRUCTURES

INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR

Data Types in C … a few more words

More Data Types in C

Some of the basic data types can be augmented by using certain data type qualifiers:

- short
- long

size qualifier

- signed
- unsigned

sign qualifier

Typical examples:

- short int (usually 2 bytes)
- long int (usually 4 bytes)
- unsigned int (usually 4 bytes, but no way to store + or -)

Some typical sizes (some of these can vary depending on type of machine)

Integer data type	#Bits	Minimum value	Maximum value
char	8	$-2^7 = -128$	$2^7-1 = 127$
short int	16	$-2^{15} = -32768$	$2^{15}-1 = 32767$
int	32	$-2^{31} = -2147483648$	$2^{31}-1 = 2147483647$
long int	32	$-2^{31} = -2147483648$	$2^{31}-1 = 2147483647$
long long int	64	$-2^{63} = -9223372036854775808$	$2^{63}-1 = 9223372036854775807$
unsigned char	8	0	$2^8-1 = 255$
unsigned short int	16	0	$2^{16}-1 = 65535$
unsigned int	32	0	$2^{32}-1 = 4294967295$
unsigned long int	32	0	$2^{32}-1 = 4294967295$
unsigned long long int	64	0	$2^{64}-1 = 18446744073709551615$

More on the char type

- Actually stored as an integer internally
- Each character has an integer code associated with it (ASCII code value, e.g., 65 for ‘A’, 97 for ‘a’)
- Internally, storing a character means storing its integer code
- The code of a character is represented by an 8-bit unit. An 8-bit unit can hold a total of 2^8=256 values. Some values of this 8-bit unit do not correspond to visible characters
- *No need to remember exact ASCII codes while programming*. Use the fact that ASCII codes of some important characters are contiguous (digits, lowercase alphabets, uppercase alphabets)

- All operations that are allowed on int are allowed on char
  - 32 + ‘a’ will evaluate to 32 + 97 (the integer ascii code of the character ‘a’) = 129
  - Same for other operators
    - Can switch on chars constants in switch, as they are integer constants

Another example

```
int a;
a = 'c' * 3 + 5;
printf("%d", a);
```

Will print 302 (99*3 + 5)

ASCII code of 'c' = 99

```
char c = 'A';
printf("%c = %d", c, c);
```

Will print A = 65

ASCII code of 'A' = 65

Assigning char to int is fine. But other way round is dangerous, as size of int is larger

Decimal	Hex	Binary	Character
32	20	00100000	SPACE
33	21	00100001	!
34	22	00100010	"
35	23	00100011	#
36	24	00100100	$
37	25	00100101	%
38	26	00100110	&
39	27	00100111	'
40	28	00101000	(
41	29	00101001	)
42	2a	00101010	*
43	2b	00101011	+
44	2c	00101100	,
45	2d	00101101	-
46	2e	00101110	.
47	2f	00101111	/
48	30	00110000	0
49	31	00110001	1
50	32	00110010	2

Decimal	Hex	Binary	Character
80	50	01010000	P
81	51	01010001	Q
82	52	01010010	R
83	53	01010011	S
84	54	01010100	T
85	55	01010101	U
86	56	01010110	V
87	57	01010111	W
88	58	01011000	X
89	59	01011001	Y
90	5a	01011010	Z
91	5b	01011011	[
92	5c	01011100	\
93	5d	01011101	]
94	5e	01011110	^
95	5f	01011111	_
96	60	01100000	`
97	61	01100001	a
98	62	01100010	b

51	33	00110011	3
52	34	00110100	4
53	35	00110101	5
54	36	00110110	6
55	37	00110111	7
56	38	00111000	8
57	39	00111001	9
58	3a	00111010	:
59	3b	00111011	;
60	3c	00111100	<
61	3d	00111101	=
62	3e	00111110	>
63	3f	00111111	?
64	40	01000000	@
65	41	01000001	A
66	42	01000010	B
67	43	01000011	C
68	44	01000100	D
69	45	01000101	E
70	46	01000110	F

99	63	01100011	c
100	64	01100100	d
101	65	01100101	e
102	66	01100110	f
103	67	01100111	g
104	68	01101000	h
105	69	01101001	i
106	6a	01101010	j
107	6b	01101011	k
108	6c	01101100	l
109	6d	01101101	m
110	6e	01101110	n
111	6f	01101111	o
112	70	01110000	p
113	71	01110001	q
114	72	01110010	r
115	73	01110011	s
116	74	01110100	t
117	75	01110101	u
118	76	01110110	v

Following a good style of writing programs

Good style of writing programs

- Programs have to be correct → Follow the C syntax correctly
- Programs should be understandable to others, not only to the writer → follow a good style
- A good style
  - A single statement in a line
  - Meaningful variable names, e.g., roll, count, price (instead of aa, b, c)
  - Indentation - leave some horizontal space (e.g., one tab-space) after opening a brace, till you close that brace
  - Comments
    - Single line comment // compute the interest
    - Multiple line comment /* this comment can span more than one line */

- Another guideline – before asking for user-input (e.g., using scanf, getchar), tell the user what input is expected (using a printf) – this is called a "prompt"

Conditionals

Branching / Conditionals: What do they do?

- Allow different sets of instructions to be executed depending on the outcome of a logical condition / test
- Whether the condition is TRUE (non-zero) or FALSE (zero)

How do we specify the condition?

Using relational operators.

- **Four relation operators:** <, <=, >, >=
- **Two equality operations:** ==, !=

Using logical operators / connectives.

- **Two logical connectives:** &&, | |
- **Unary negation operator:** !

EXAMPLES

(count <= 100)

((math+phys+chem) / 3 >= 60)

((sex == 'M') && (age >= 21))

((marks >== 80) && (marks < 90))

((balance > 5000) | | (no_of_trans > 25))

(!(grade == 'A'))

Branching: *The if Statement*

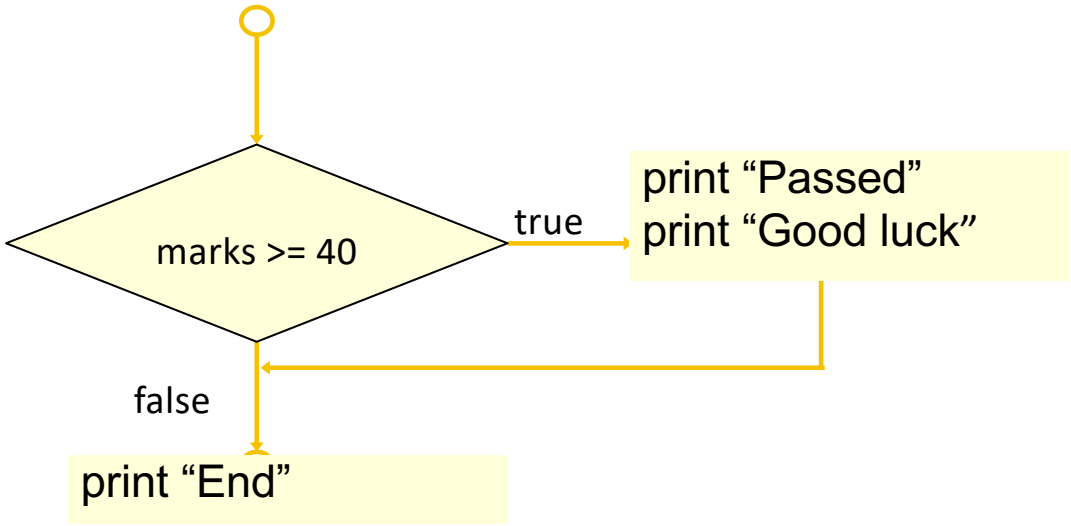
```
if (expression)
        statement;

if (expression) {
        Block of statements
}
```

if-block

Note: indentation (after opening a brace, leave some horizontal space in the following lines, till you close that brace)

The condition to be tested is any expression enclosed in parentheses. The expression is evaluated, and only if its value is true / non-zero, the if-block is executed.

Note the position of the semi-colon.



A decision can be made on any expression.

zero :- false

nonzero :- true

```
if (marks>=40)  {
   printf(“Passed \n”);
   printf(“Good luck\n”);
}
printf (“End\n”) ;
```

Example: converting a character from lowercase to uppercase

```
int main()
{
        char c1;
        scanf("%c", &c1);
        /* convert to uppercase if lowercase, else leave as it is */
        if ( c1 >= 'a'  &&  c1<= 'z' )
                /* since ascii codes of uppercase letters are contiguous, the uppercase version of c1 will be as far
                   away from the ascii code of 'A' as it is from the ascii code of 'a' */
                c1 = 'A' + (c1 – 'a');
        printf(("The letter is %c\n", c1);
        return 0;
}
```

Only one executable statement inside the if-block, so braces are not essential (but better to use braces for clarity)

Branching: *if-else Statement*

```
if (expression) {
        Block of statements;
}
else {
        Block of statements;
}
```

if-block

else-block

Note: indentation (after opening a brace, leave some horizontal space in the following lines, till you close that brace)

If a block contains only one statement, the braces are not needed

Expression will be evaluated.

If expression is true / non-zero, the if-block will be executed.

If expression is false / zero, the else-block will be executed.

Example: checking if a character is a lowercase alphabet

```
int main()
{
        char c1;
        scanf("%c", &c1);
        /* the ascii code of c1 must lie between the ascii codes of 'a' and 'z' */
        if (c1 >= 'a' && c1<= 'z')
            printf("%c is a lowercase alphabet\n", c1);
        else
            printf("%c is not a lowercase alphabet\n", c1);
        return 0;
}
```

Branching: *if-else Statement*

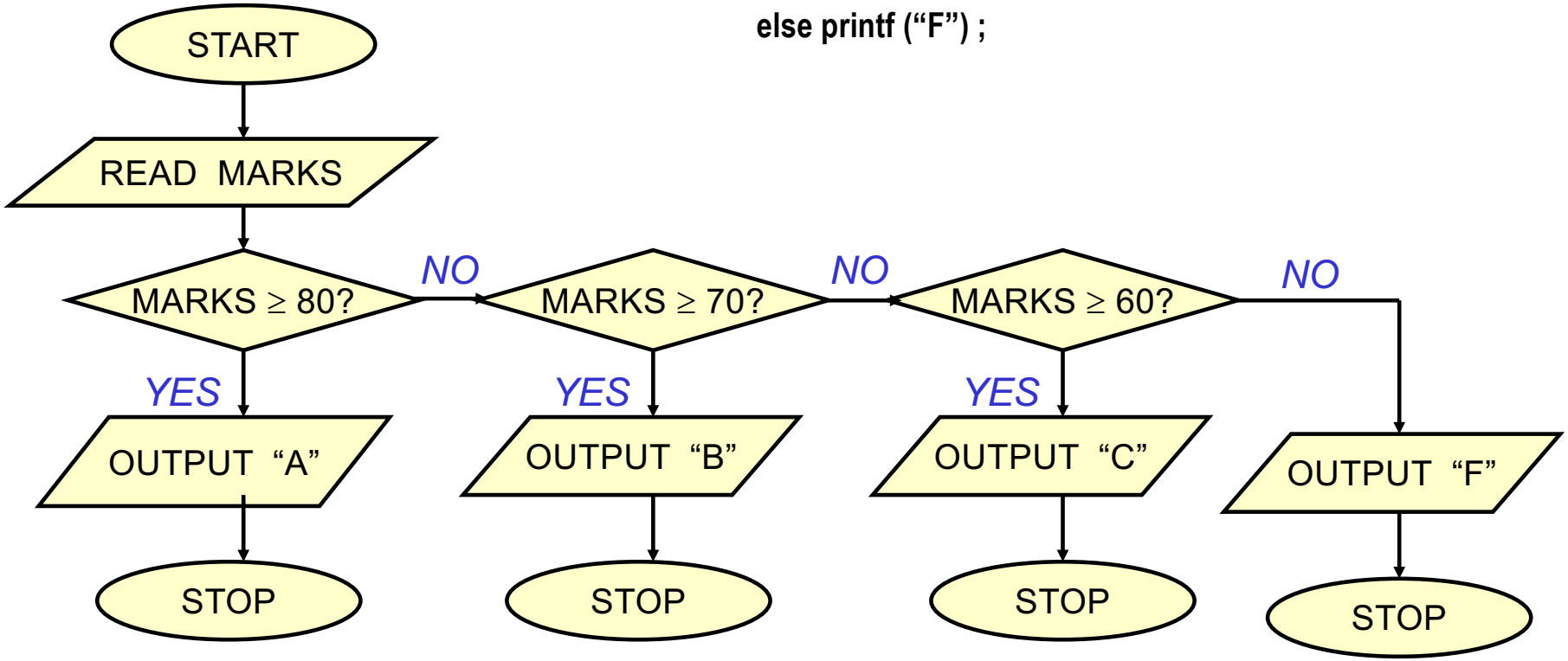
```
if (expression) {
        Block of statements;
}
else {
        Block of statements;
}
```

If a block contains only one statement, the braces are not needed

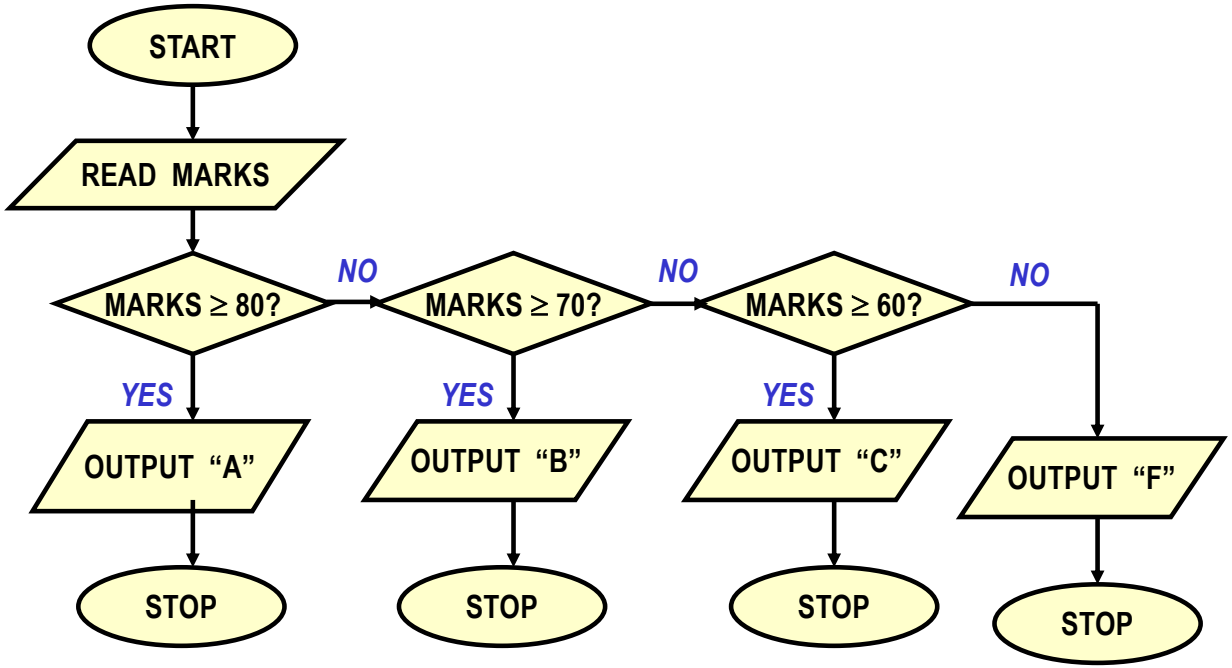
```
if (expression) {
    Block of statements;
}
else if  (expression) {
    Block of statements;
}
else {
    Block of statements;
}
```

Grade Computation

```
if (marks >= 80) printf (“A”) ;
else if (marks >= 70) printf (“B”) ;
else if (marks >= 60) printf (“C”) ;
else printf (“F”) ;
```

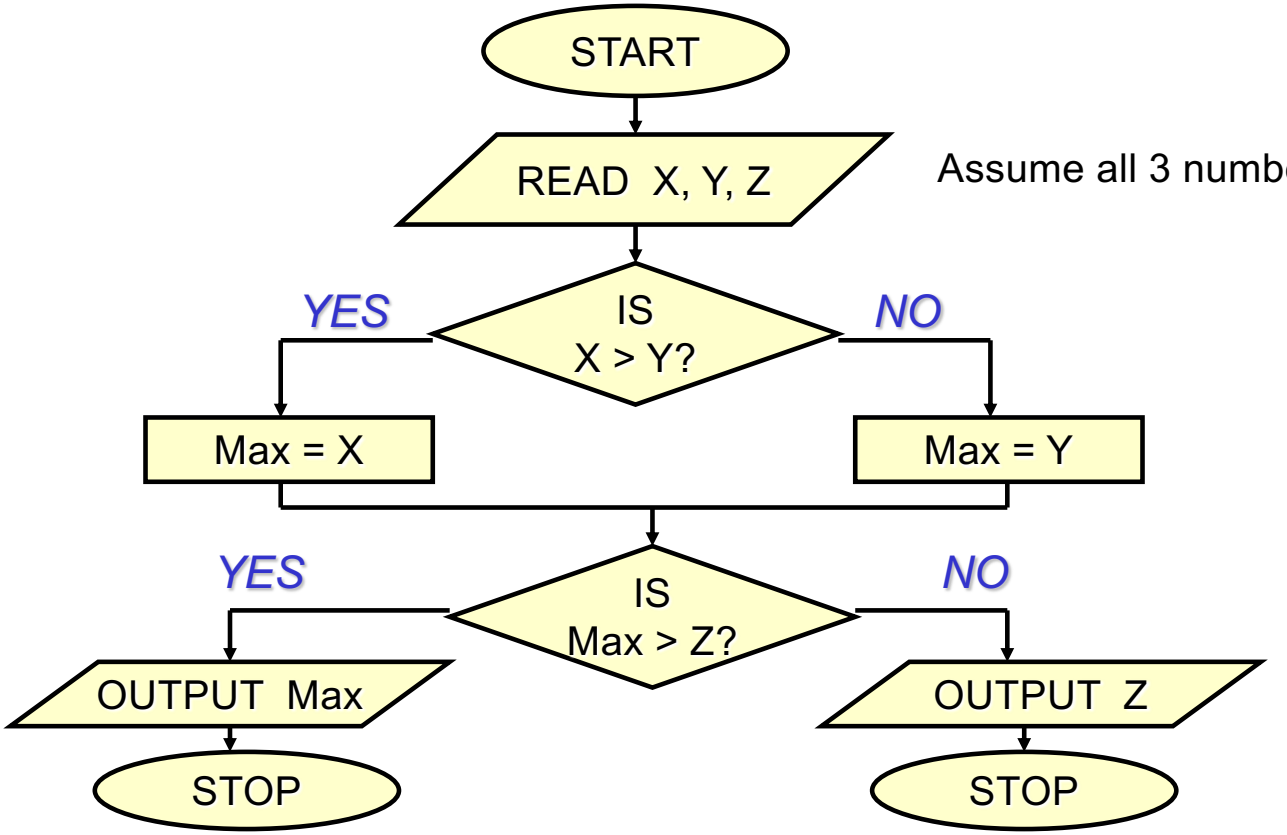


Grade Computation



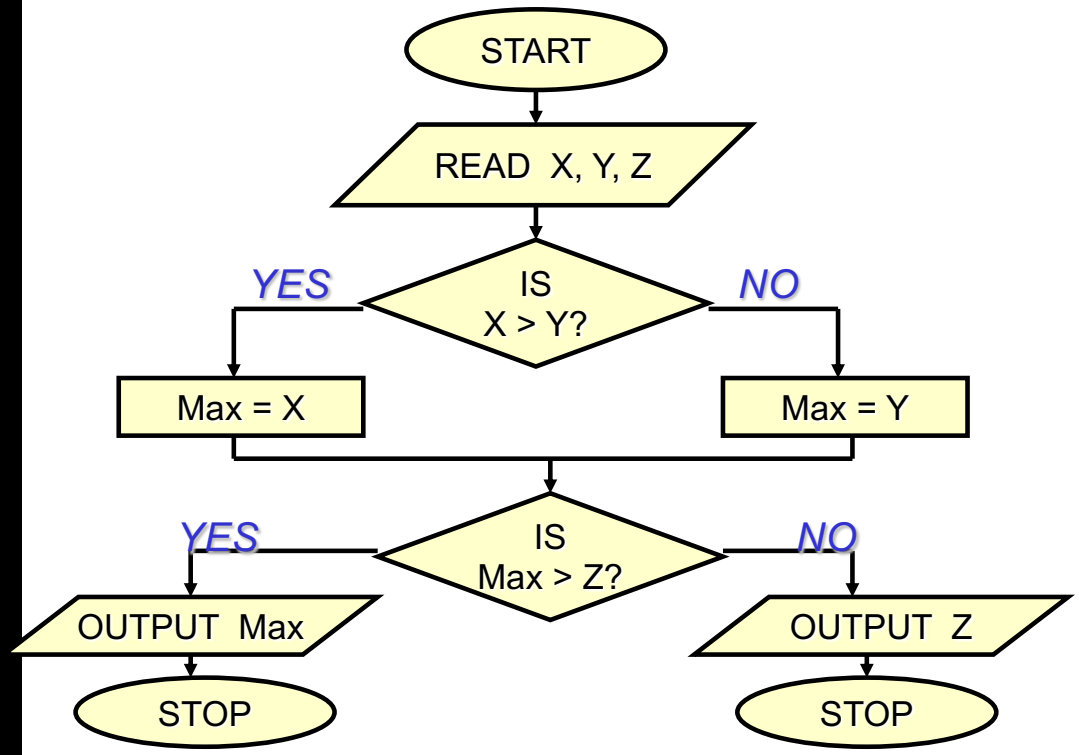

```
int main () {
    int marks;
    scanf ("%d", &marks) ;
    if (marks>= 80) {
       printf ("A: ") ;
       printf ("Good Job!") ;
    }
    else if (marks >= 70)  printf ("B ") ;
    else if (marks >= 60)  printf ("C ") ;
    else {
       printf ("F ") ;
    }
    return 0;
}
```

Largest of three numbers



Assume all 3 numbers are distinct

Assume all 3 numbers are distinct




```
int main () {
    int x, y, z, max;
    scanf ("%d%d%d",&x,&y,&z);
    if (x>y)
        max = x;
    else
        max = y;
    if (max > z)
        printf ("%d", max) ;
    else
        printf ("%d",z);
}
```

Another program for finding largest of three numbers

```
int main()  {
   int  a,b,c;
   scanf ("%d%d%d", &a, &b, &c);

   if ((a >= b) && (a >= c))
      printf ("\n The largest number is: %d", a);

   if ((b >= a) && (b >= c))
      printf ("\n The largest number is: %d", b);

  if ((c >= a) && (c >= b))
      printf ("\n The largest number is: %d", c);

  return 0;
}
```

There are many different ways to write the same program correctly

Confusing Equality (==) and Assignment (=) Operators

Dangerous error

- Does not ordinarily cause syntax errors.
- Any expression that produces a value can be used in control structures.
- Nonzero values are true, zero values are false.

Example:

```
if ( payCode == 4 )
   printf( "You get a bonus!\n" );

if ( payCode = 4 )
   printf( "You get a bonus!\n" );
```

X

Dangling else problem

if (exp1) if (exp2) stmta else stmtb

```
if (exp1) {

   if (exp2)
         stmta
   else
         stmtb

}
```

OR

```
if (exp1)  {

   if (exp2)
         stmta
}
else
         stmtb
```

?

X

An “else” clause is associated with the closest preceding unmatched “if”.

Which one is the correct interpretation?

Example – wrong program

```
int main()
{
    int x;
    scanf("%d", &x);
    if (x >= 0)
        if (x <= 100)
          printf("ABC\n");
    else
        printf("XYZ\n");
    return 0;
}
```

Print "ABC" if a number is between 0 and 100, or "XYZ" if it is –ve. Do not print anything in other cases.

Outputs for different inputs

```
150
XYZ
```

Not what we want, should not have printed anything

```
-20
```

Not what we want, should have printed XYZ

Example - Correct Program

```
int main()
{
    int x;
    scanf("%d", &x);
    if (x >= 0)
    {
        if (x <= 100)
            printf("ABC\n");
    }
    else
        printf("XYZ\n");
    return 0;
}
```

Outputs for different inputs

```
150
```

```
-20
XYZ
```

More examples

```
if e1 s1
else if e2 s2
```

```
if e1 s1
else { if e2 s2 }
```

```
if e1 s1
else if e2 s2
else s3
```

?

```
if e1 s1
else { if e2 s2
          else s3 }
```

```
if e1 if e2 s1
else s2
else s3
```

```
if e1 { if e2 s1
          else s2 }
else s3
```

```
if e1 if e2 s1
else s2
```

```
if e1 { if e2 s1
          else s2 }
```

While programming, it is always good to explicitly give the { and } to avoid any mistakes

The Conditional Operator ?:

This makes use of an expression that is either true or false. An appropriate value is selected, depending on the outcome of the logical expression.

Example:

```
interest =    (balance>5000) ?  balance*0.2  :  balance*0.1;
```

Returns a value

Equivalent to:

```
if (balance > 5000)
        interest = balance * 0.2;
else
        interest = balance * 0.1;
```

More Examples

```
if (  (a >10) && (b < 5) )
        x = a + b;
else x = 0;
```

```
x = ((a > 10) && (b < 5)) ? a + b : 0
```

```
if (marks >= 60)
     printf("Passed \n");
else printf("Failed \n");
```

```
(marks >= 60) ? printf("Passed \n") : printf("Failed \n");
```

The *switch* statement

This causes a particular group of statements to be chosen from several available groups.

- **Uses “switch” statement and “case” labels.**
- **Syntax of the “switch” statement:**

```
switch (expression)  {
    case expression-1: { …….. }
    case expression-2: { …….. }

    case expression-m: { …….. }
    default: { …….. }
}
```

Syntax of switch statement

```
switch (expression)  {
    case const-expr-1: S-1
    case const-expr-2: S-2
       :
    case const-expr-m: S-m
    default: S
}
```

- expression is any integer-valued expression
- const-expr-1, const-expr-2,…are any constant integer-valued expressions
  - Values must be distinct
- S-1, S-2, …,S-m, S are statements/compound statements
- Default is optional, and can come anywhere (not necessarily at the end as shown)

Behavior of switch

```
switch (expression)  {
        case const-expr-1: S-1
        case const-expr-2: S-2
    :
        case const-expr-m: S-m
        default: S
}
```

- expression is first evaluated
- It is then compared with const-expr-1, const-expr-2,…for equality in order
- If it matches any one, all statements from that point till the end of the switch are executed (including statements for default, if present)
  - Use break statements if you do not want this (see example)
- Statements corresponding to default, if present, are executed if no other expression matches

Examples

```
switch ( letter ) {
        case 'A':
                printf ("First letter \n");
                break;
        case 'Z':
                printf ("Last letter \n");
                break;
        default :
                printf ("Middle letter \n");
                break;
}
```

Will print this statement for all letters other than A or Z

Examples

```
switch ( choice = getchar( ) ) {
    case 'r' :
    case 'R': printf("Red");
              break;
    case 'b' :
    case 'B' : printf("Blue");
               break;
    case 'g' :
    case 'G': printf("Green");
               break;
    default: printf("Black");
}
```

Since there isn't a **break** *statement here, the control passes to the next statement* (printf) *without checking the next condition.*

Another way

```
switch  ( choice = toupper( getchar( ) ) )  {
            case 'R':   printf ("RED \n");
                                break;
            case 'G':   printf ("GREEN \n");
                                break;
            case 'B':   printf ("BLUE \n");
                                break;
            default:    printf ("Invalid choice \n");
}
```

Rounding a Digit

```
switch (digit)   {
                        case 0:
                        case 1:
                        case 2:
                        case 3:
                        case 4: result = 0; printf (“Round down\n”); break;
                        case 5:
                        case 6:
                        case 7:
                        case 8:
                        case 9: result = 10; printf(“Round up\n”); break;
}
```

Evaluating expressions

```
int main () {
      int operand1, operand2;
      int result = 0;
      char operation ;
      /* Get the input values */
      printf (“Enter operand1 :”);
      scanf(“%d”,&operand1) ;
      printf (“Enter operation :”);
      scanf (“\n%c”,&operation);
      printf (“Enter operand 2 :”);
      scanf (“%d”, &operand2);
      switch (operation)    {
      case ‘+’ :
            result=operand1+operand2;
             break;
      case ‘-’ :
            result=operand1-operand2;
            break;
      case ‘*’ :
            result=operand1*operand2;
            break;
      case ‘/’ :
            if (operand2 !=0)
                result=operand1/operand2;
            else
                printf(“Divide by 0 error”);
            break;
      default:
            printf(“Invalid operation\n”);
           return;
      }
      printf (“The answer is %d\n”,result);
      return 0;
}
```

Practice Problems

1. Read in 3 integers and print a message if any one of them is equal to the sum of the other two.
2. Read in the coordinates of two points and print the equation of the line joining them in y = mx +c form.
3. Read in the coordinates of 3 points in 2-d plane and check if they are collinear. Print a suitable message.
4. Read in the coordinates of a point, and the center and radius of a circle. Check and print if the point is inside or outside the circle.
5. Read in the coefficients a, b, c of the quadratic equation $ax^2 + bx + c = 0$, and print its roots nicely (for imaginary roots, print in x + iy form)
6. Suppose the digits 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 are mapped to the lowercase letters a, b, c, d, e, f, g, h, i, j respectively. Read in a single digit integer as a character (using %c in scanf) and print its corresponding lowercase letter. Do this both using switch and without using switch (two programs). Do not use any ascii code value directly.
7. Suppose that you have to print the grades of a student, with >= 90 marks getting EX, 80-89 getting A, 70-79 getting B, 60-69 getting C, 50-59 getting D, 35-49 getting P and <30 getting F. Read in the marks of a student and print his/her grade.