Problem Solving using Conditionals

Rupesh Nasre.

Mentor TAs: Returaj, Akshay, Narayana, Sankaranarayanan, Ruheena, Pranshu, Dipanshu, Deepankar, Amit

IIT Madras
November 2022

Assignments are not enough!

- We need to make a decision: this way or the other.
- Finding the larger number
  - if x is less than y then y, otherwise x
- Finding if a roll number is from our department
  - if the first two letters are 'C' and 'S', then yes
- Will I pass this course?
  - If marks are equal to or above 40 then yes, otherwise GBY.

Conditionals

- Finding the larger number
  - if x is less than y then y, otherwise x

```c
#include <stdio.h>

int main() {
        int x, y;
        scanf("%d%d“, &x, &y);
        if (x < y)
                printf("%d is larger\n", y);
        else
                printf("%d is larger\n", x);
}
```

```c
#include <stdio.h>
int main() {
        int x, y;
        scanf("%d%d“, &x, &y);
        if (x < y) {
                printf("%d", y);
        } else {
                printf("%d", x);
        }
        printf(" is larger\n");
}
```

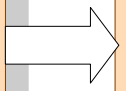
```c
printf("%d is larger\n", (x < y ? y : x));
```

Problem: Match blood groups

Four blood groups: A, B, O, C (assume AB as C)

What happens if I mistakenly use (bgone = bgtwo)?

```
scanf("%c%c", &bgone, &bgtwo);
if bgone is same as bgtwo then
        printf("Blood groups match.\n");
otherwise
        printf("It is a mismatch.\n");
```



```
scanf("%c%c", &bgone, &bgtwo);
if (bgone == bgtwo) {
        printf("Blood groups match.\n");
} else {
        printf("It is a mismatch.\n");
}
```

If O is a universal donor and C is a universal recipient, check if bgone can donate blood to bgtwo.

Allow blood group AB (instead of C). This can be done using char arrays.

Problem: Find your Bro!

- Finding if a roll number is from our department
  - if the first two letters are 'C' and 'S', then yes

```
scanf("%c%c%d%c%d“,
        &first, &second, &year,
        &prog, &classroll);
if (first == 'C') {
      if (second == 'S') {
            printf("Hi Bro!\n");
      } else {
            printf("Excuse me?\n");
      }
}
```

```
scanf("%c%c%d%c%d“,
        &first, &second, &year,
        &prog, &classroll);
if (first == 'C') {
      if (second == 'S') {
            printf("Hi Bro!\n");
} else {
      printf("Excuse me?\n");
}}
```

This **else** corresponds to which **if**?
The ambiguity is clearer if we remove braces.

Compile-time error

Problem: Find your Bro!

- Finding if a roll number is from our department
  - if the first two letters are 'C' and 'S', then yes

```
scanf("%c%c%d%c%d“,
        &first, &second, &year,
        &prog, &classroll);
if (first == 'C') {
      if (second == 'S') {
            printf("Hi Bro!\n");
      } else {
            printf("Excuse me?\n");
      }
}
```

else corresponds to the **second** if.

How do we modify the code so that the else corresponds to the first if?

Silent on EE, MS, ...

Removing these braces would make it equivalent to the left code.

```
scanf("%c%c%d%c%d“,
        &first, &second, &year,
        &prog, &classroll);
if (first == 'C') {
      if (second == 'S')
            printf("Hi Bro!\n");

} else
            printf("Excuse me?\n");
```

else corresponds to the **first** if.

And both the codes are incomplete.

Silent on CE, CH, ...

Problem: Find your Bro!

- Finding if a roll number is from our department
  - if the first two letters are 'C' and 'S', then yes

```
scanf("%c%c%d%c%d",
        &first, &second, &year,
        &prog, &classroll);
if (first == 'C')
      if (second == 'S')
            printf("Hi Bro!\n");
      else
            printf("Excuse me?\n");
 else
      printf("Excuse me?\n");
```

CS21B010
Hi Bro!

CE21B010
Excuse me?

MS21B010
Excuse me?

If first if condition is false, the second if condition is not evaluated.

We need both the elses.

- It would be nice if this repeated printf("Excuse me?\n"); is avoided.
- Can we make this work for small-case roll numbers also (cs21b010)?

Problem: Find your Bro!

- Finding if a roll number is from our department
  - if the first two letters are 'C' and 'S', then yes

```
scanf("%c%c%d%c%d",
        &first, &second, &year,
        &prog, &classroll);
if (first == 'C') {
      if (second == 'S')
            printf("Hi Bro!\n");
      else
            printf("Excuse me?\n");
} else
      printf("Excuse me?\n");
```

If first condition is false, the second condition is not evaluated.

```
scanf("%c%c%d%c%d",
      &first, &second, &year,
      &prog, &classroll);

if (first == 'C' && second == 'S')
      printf("Hi Bro!\n");
else
      printf("Excuse me?\n");
```

- It would be nice if this repeated printf("Excuse me?\n"); is avoided.
- Can we make this work for small-case roll numbers also (cs21b010)?

Problem: Find your Bro!

- Finding if a roll number is from our department
  - if the first two letters are 'C' and 'S', then yes

If first **||** condition is **true**, the second || condition is not evaluated.

If first **&&** condition is **false**, the second && condition is not evaluated.

```
if ((first == 'C' || first == 'c') &&
    (second == 'S' || second == 's'))
      printf("Hi Bro!\n");
else
      printf("Excuse me?\n");
```

This is called **short-circuiting**.

Extend this for only your batch: CS21B

```
if ((first == 'C' && second == 'S') ||
    (first == 'c' && second == 's'))
      printf("Hi Bro!\n");
else
      printf("Excuse me?\n");
```

Are these two codes equivalent?

- It would be nice if this repeated `printf("Excuse me?\n");` is avoided.
- Can we make this work for small-case roll numbers also (cs21b010)?

Problem: Find your Bro!

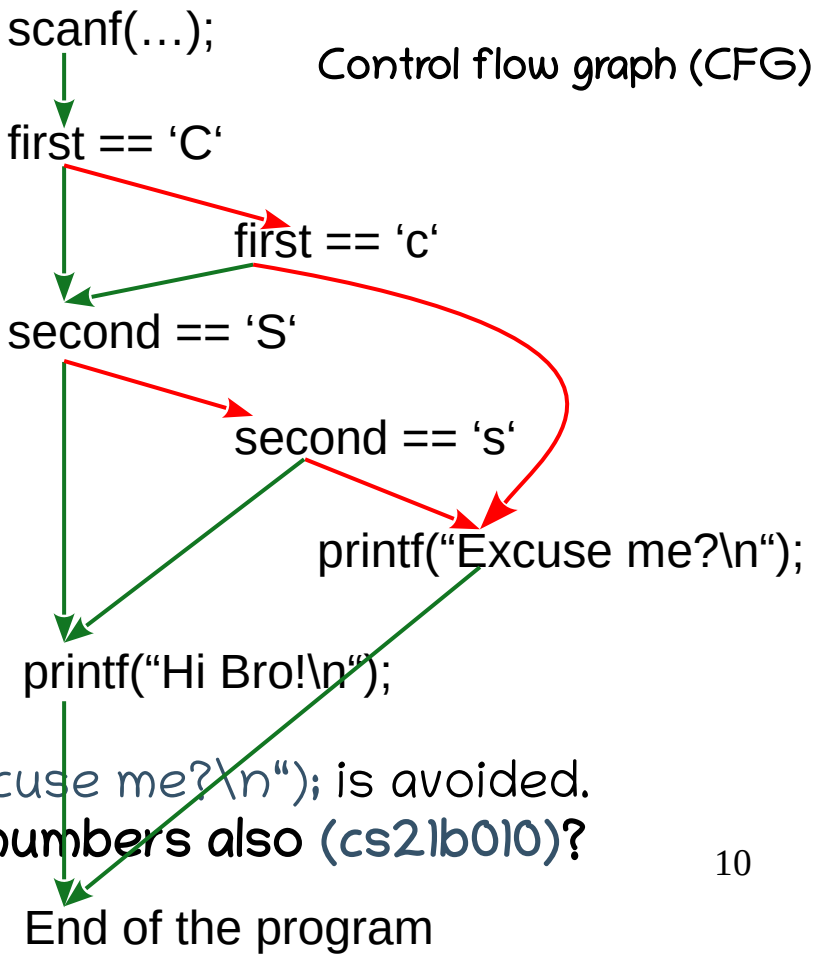
- Finding if a roll number is from our department
  - if the first two letters are 'C' and 'S', then yes

If first **||** condition is **true**, the second || condition is not evaluated.

If first **&&** condition is **false**, the second && condition is not evaluated.

```
if ((first == 'C' || first == 'c') &&
    (second == 'S' || second == 's'))
      printf("Hi Bro!\n");
else
      printf("Excuse me?\n");
```

This is called **short-circuiting**.



- It would be nice if this repeated printf("Excuse me?\n"); is avoided.
- **Can we make this work for small-case roll numbers also (cs21b010)?**

Problem: Find your Bro!

- Finding if a roll number is from our department
  - if the first two letters are 'C' and 'S', then yes

```
if ((first == 'C' && second == 'S') ||
    (first == 'c' && second == 's'))
       printf("Hi Bro!\n");
else
       printf("Excuse me?\n");
```

Draw control flow graph (CFG) for this code.

- It would be nice if this repeated printf("Excuse me?\n"); is avoided.
- **Can we make this work for small-case roll numbers also (cs21b010)?**

Problem: Lucky Cards!

- Four suites: Club C, Diamond D, Spade S, Heart H
- Each suite has 13 cards: A, 2, 3, ..., 9, T, J, Q, K
  - Lucky cards: SA, any H, DQ, DK, any 7

```
if ((suite == 'S' && card == 'A') ||
    (suite == 'H') ||
    (suite == 'D' && (card == 'Q' || card == 'K')) ||
    (card == '7'))
       printf("Lucky you!\n");
else
       printf("Better luck next time.\n");
```

```
if  suite is invalid or card is invalid
       printf("Invalid card\n");
else
    if ((suite == 'S' && card == 'A') ||
        (suite == 'H') ||
        (suite == 'D' && (card == 'Q' || card == 'K')) ||
        (card == '7'))
               printf("Lucky you!\n");
    else
               printf("Better luck next time.\n");
```

- For an input H0 or (*, the code should print "Invalid card".
- Support D10 (instead of DT). Can be done without char arrays.

Problem: Lucky Cards!

- Four suites: Club C, Diamond D, Spade S, Heart H
- Each suite has 13 cards: A, 2, 3, ..., 9, T, J, Q, K
  - Lucky cards: SA, any H, DQ, DK, any 7

```
if ((suite != 'C' && suite != 'D' &&
     suite != 'S' && suite != 'H' ) ||
    (card != 'A' && card != 'T' && card != 'J' &&
     card != 'Q' && card != 'K' &&
    ((int)card < '2'  ||   (int)card > '9')))
       printf("Invalid card\n");
else
```

```
if  suite is invalid or card is invalid
       printf("Invalid card\n");
else
    if ((suite == 'S' && card == 'A') ||
       (suite == 'H') ||
       (suite == 'D' && (card == 'Q' || card == 'K')) ||
       (card == '7'))
              printf("Lucky you!\n");
    else
              printf("Better luck next time.\n");
```

- For an input H0 or (*, the code should print "Invalid card".
- Support D10 (instead of DT). Can be done without char arrays.

Problem: Lucky Cards!

- Four suites: Club C, Diamond D, Spade S, Heart H
- Each suite has 13 cards: A, 2, 3, ..., 9, T, J, Q, K
  - Lucky cards: SA, any H, DQ, DK, any 7

```
if (!((suite == 'C' || suite == 'D' ||
       suite == 'S' || suite == 'H' ) &&
      (card == 'A' || card == 'T' || card == 'J' ||
       card == 'Q' || card == 'K') &&
      ((int)card >= '2' && (int)card <= '9')))
       printf("Invalid card\n");
else
```

De Morgan's Law
!(x && y) == (!x || !y)

```
if      (suite is valid and card is valid)
        printf("Invalid card\n");
else
    if ((suite == 'S' && card == 'A') ||
        (suite == 'H') ||
        (suite == 'D' && (card == 'Q' || card == 'K')) ||
        (card == '7'))
            printf("Lucky you!\n");
    else
            printf("Better luck next time.\n");
```

- For an input H0 or (*, the code should print "Invalid card".
- Support D10 (instead of DT). Can be done without char arrays.

Problem: ISD Code to Country

When conditions use equality over constant integers, C provides an alternative: switch-case.

```
scanf("%d", &isd);
if (isd == 91) printf("India\n");
else if (isd == 1) printf("US-Canada\n");
else if (isd == 61) printf("Australia\n");
else if (...) ...
else
    printf("Unknown ISD code\n");
```

is equivalent to

```
scanf("%d", &isd);
if (isd == 91) printf("India\n");
else if (isd == 1) printf("US-Canada\n");
    else if (isd == 61) printf("Australia\n");
        else if (...) ...
            else
                printf("Unknown ISD code\n");
```

Correctness-wise, the order of conditions does not matter.
Performance-wise, the more frequent conditions should appear first.
(e.g., if most queries are about India, that should be the first condition)

- Given ISD code, find the country.

91: India, 1: US, 93: Afghanistan, 61: Australia, 55: Brazil, 1: Canada, 86: China, 20: Egypt, 49: Germany, 39: Italy, 218: Libya, 850: N Korea, 92: Pakistan, 7: Russia, 82: S Korea, 94: Sri Lanka, 380: Ukraine

Problem: ISD Code to Country

```
scanf("%d", &isd);
if (isd == 91) printf("India\n");
else if (isd == 1) printf("US-Canada\n");
else if (isd == 61) printf("Australia\n");
else if (...) ...
else
    printf("Unknown ISD code\n");
```

is equivalent to

```
scanf("%d", &isd);
switch (isd) {
    case 91: printf("India\n"); break;
    case 1: printf("US-Canada\n"); break;
    case 61: printf("Australia\n"); break;
    case ...: ...
    default: printf("Unknown ISD code\n");
}
```

Future Connect:
break is also used to come out of loops.

When condit … over constant integers, C … witch-case.

```
91
India
```

```
91
India
```

- Given ISD code, find the cou…

91: India, 1: US, 93: Afghanistan, 61: … , 1: Canada, 86: China, 20: Egypt, 49: Ge… 8: Libya, 850: N Korea, 92: Pakistan, 7: Ru… ea, 94: Sri Lanka, 380: Ukraine

Problem: ISD Code to Country

Why this complication? Is there a use of such a behavior?

```
1
US-Canada
Australia

91
India
```

```
scanf("%d", &isd);
switch (isd) {
        case 91: printf("India\n"); break;
        case 1: printf("US-Canada\n"); break;
        case 61: printf("Australia\n"); break;
        case ...: ...
        default: printf("Unknown ISD code\n");
}
```

When conditions use equality over constant integers, C provides an alternative: switch-case.

- Given ISD code, find the country.

91: India, 1: US, 93: Afghanistan, 61: Australia, 55: Brazil, 1: Canada, 86: China, 20: Egypt, 49: Germany, 39: Italy, 218: Libya, 850: N Korea, 92: Pakistan, 7: Russia, 82: S Korea, 94: Sri Lanka, 380: Ukraine

Problem: Seating Arrangement

Why this complication? Is there a use of such a behavior?

Avoids repetition of common processing.

```
21
CRC
19
CRC
18
Raman
17
Ramanujan
```

```
scanf("%d", &batch);
switch (batch) {
        case 19:
        case 21: printf("CRC\n"); break;

        case 18: printf("Raman\n"); break;

        case 20:
        default: printf("Ramanujan\n"); break;
}
```

Problem: Year-wise Courses

```
scanf("%d", &batch);
printf("You should have completed ");
switch (batch) {
        case 18: printf("Prof. Ethics, Internship ");
        case 19: printf("Compilers, PoP, OS, ");
        case 20: printf("LMC, FCSD, COA, DAA, OOAIA, ");
        case 21: printf("CS1111, DM\n");
}
```

```
19
You should have completed Compilers, PoP, OS, LMC, FCSD, COA, DAA, OOAIA, CS1111, DM
```

- Given a year of admission, print the core courses that should have been completed.

Two uses of fallthrough

```
scanf("%d", &batch);
switch (batch) {
        case 19:
        case 21: printf("CRC\n"); break;

        case 18: printf("Raman\n"); break;

        case 20:
        default: printf("Ramanujan\n"); break;
}
```

When there is many-to-one mapping

Multiple cases map to one processing.

Examples

- Case-insensitive processing
- Mobile number to name mapping
- Issued book to roll number mapping
- Problem to algorithm mapping (DAA)

```
scanf("%d", &batch);
printf("You should have completed ");
switch (batch) {
        case 18: printf("Prof. Ethics, Internship");
        case 19: printf("Compilers, PoP, OS, ");
        case 20: printf("LMC, FCSD, COA, OOAIA, ");
        case 21: printf("CS1111, DM\n");
}
```

When there is subsumption of processing

A case subsumes another's processing.

Examples

- Eligibility of quarters based on seniority
- Finding all taller than a given student
- Constraints in normal forms (Databases)
- Properties of various languages (LMC)
- Duff's device

Problem: Month Days

```
scanf("%d“, &month);
switch (month) {
        case 1: case 3: case 5: case 7: case 8:
        case 10: case 12: printf("31\n"); break;
        case 4: case 6: case 9: case 11: printf("30\n"); break;
        case 2: printf("28 or 29\n"); break;
        default: printf("Invalid month %d\n", month);
}
```

```
if (month == 1 || month == 3 || month == 5 || month == 7 ||
    month == 8 || month == 10 || month == 12)
        printf("31\n");
else if (month == 4 || month == 6 || month == 9 || month == 11)
        printf("30\n");
else if (month == 2)
        printf("28 or 29\n");
else printf("Invalid month %d\n", month);
```

Given a month 1..12, print the number of days in that month.

Old Problem: Lucky Cards!

- Four suites: Club C, Diamond D, Spade S, Heart H
- Each suite has 13 cards: A, 2, 3, ..., 9, T, J, Q, K
  - Lucky cards: SA, any H, DQ, DK, any 7

```
if (!((suite == 'C' || suite == 'D' ||
       suite == 'S' || suite == 'H' ) &&
      (card == 'A' || card == 'T' || card == 'J' ||
       card == 'Q' || card == 'K') &&
      ((int)card >= '2' && (int)card <= '9')))
      printf("Invalid card\n");
else
      // check luck.
```

Nested switch

```
switch (suite) {
  case 'C': case 'D': case 'S': case 'H':
  switch (card) {
      case 'A': case 'T': case 'J': case 'Q':
      case 'K': case '2': case '3': case '4':
      case '5': case '6': case '7': case '8':
      case '9': // check luck.
      default: printf("Invalid card\n");
  }
  default: printf("Invalid card\n");
}
```

Restrictions on cases

```
scanf("%f", &weight);
switch (weight) {
        case 19.2: ...
        case 21.5: ...
        default: ...
}
```

```
int final = 18, prefinal = 19,
    sophomore = 20, freshies = 21;
scanf("%d", &batch);
switch (batch) {
        case final: ...
        case prefinal: ...
        case sophomore: ...
        case freshies: ...
        default: ...
}
```

Wh… …ntegers, C provides an alternative: switch-case.

```
#define final 18
#define prefinal 19
#define sophomore 20
#define freshies 21
scanf("%d", &batch);
switch (batch) {
        case final: ...
        case prefinal: ...
        case sophomore: ...
        case freshies: ...
        default: ...
}
```

```
enum {final = 18, prefinal = 19,
    sophomore = 20, freshies = 21};

scanf("%d", &batch);
switch (batch) {
        case final: ...
        case prefinal: ...
        case sophomore: ...
        case freshies: ...
        default: ...
}
```

#define

To see preprocessed output: gcc -E file.c

```c
#include <stdio.h>
int main() {
#define FSTR "%d"
        int yearofbirth;
        scanf(FSTR, &yearofbirth);
        int age = (2022 – yearofbirth);
        printf(FSTR, age);
}
```

```c
#include <stdio.h>
#define output printf
#define input scanf

int main() {
#define FSTR "%d"
        int yearofbirth;
        input(FSTR, &yearofbirth);
        int age = (2022 – yearofbirth);
        output(FSTR, age);
}
```

```c
#include <stdio.h>
#define allmain                         \
int main() {                            \
        int yearofbirth;                \
        scanf("%d", &yearofbirth);      \
        int age = (2022 – yearofbirth); \
        printf("%d", age);              \
}

allmain
```

```c
#include <stdio.h>
#define _ main
#define __ _
#define BEGIN (
#define END )
#define _a int
#define __a "%d"
_a _ BEGIN END {
  _a a;
  scanf BEGIN __a, &a END;
  _a a_ = BEGIN 2022 - a END;
  printf BEGIN __a, a_ END;
}
```

The interested may take a look at the IOCCC.

Uses of #define

```c
#include <stdio.h>

#define PLUS(x, y)      x + y

int main() {
      printf("%d + %d = %d\n", 5, 6, PLUS(5, 6));
      printf("%d + %d = %d\n", 3, 7, PLUS(3, 7));
}
```

```c
#include <stdio.h>
#define DEBUG   0
#define dprintf if (DEBUG) printf

int main() {
        dprintf("Start of main\n");
        int n = 5;
        n = n - 1;
        printf("n = %d\n", n);
        dprintf("End of main\n");
}
```

```c
#include <stdio.h>

#define SQ(x)   x*x

int main() {
        if (SQ(3) == 9)
            printf("(2+3)*(2+3) = %d\n", SQ(2+3));
}
```

```c
#include <stdio.h>
#define log(x)  printf(x)
#define ERROR(x)        {                       \
        if (x == 0) ;                           \
        else if (x == 1) log("Warning\n");      \
        else if (x == 2) log("Error\n");        \
        else log("Serious error\n");            \
}
int main() {
        // some code
        if (x < y) ERROR(1);
}
```

Problem: Mini Calculator

```
scanf("%d%c%d“, &x, &op, &y);
switch (op) {
      case '+': printf("%d\n", x + y); break;
      case '-': printf("%d\n", x - y); break;
      case '*': printf("%d\n", x * y); break;
      case '/': if (y != 0) printf("%d\n", x / y);
                else printf("Division by zero error\n");
                break;
      default: printf("Invalid operator %c\n", op);
}
```

Future Connect:
To support full-fledged expressions (such as 3 – 4 * 5 / (6 + 7)), we will need a stack.

Given an expression num#num, print its value. # is +, -, *, /.

Borrowed from Meghana Nasre‘s slides.

Week	Problems	Tools
✓ 0	Solve equations, find weighted sum.	Data types, expressions, assignments
✓ 1	Find max, convert marks to grade.	Conditionals, logical expressions
2	Find weighted sum for all students.	Loops
3	Encrypt and decrypt a secret message.	Character arrays
4	Our first game: Tic-tac-toe	2D arrays
5	Making game modular, reuse.	Functions
6	Find Hemachandra/Fibonacci numbers.	Recursion
7	Encrypt and decrypt many messages.	Dynamic memory, pointers
8	Maintain student records.	Aggregate data types
9	Search and sort student records.	Searching and sorting algorithms
A	Reduce memory wastage.	Linked lists
B	Implement token system in banks.	Queues
C	IRCTC-like ticket booking system	File handling
D	Putting it all together	All the above

Summary

- if, if else, nested if
- Logical expressions with && and II
- switch-case
- #define
- Problem Solving with conditionals