INFORMATIKA UMN

UMN
UNIVERSITAS MULTIMEDIA NUSANTARA

IF232
ALGORITHMS
&
DATA STRUCTURES

02

STRUCTURES, UNIONS, & ENUMERATIONS

DENNIS GUNAWAN

REVIEW

Arrays & Pointers:

Arrays

Pointers

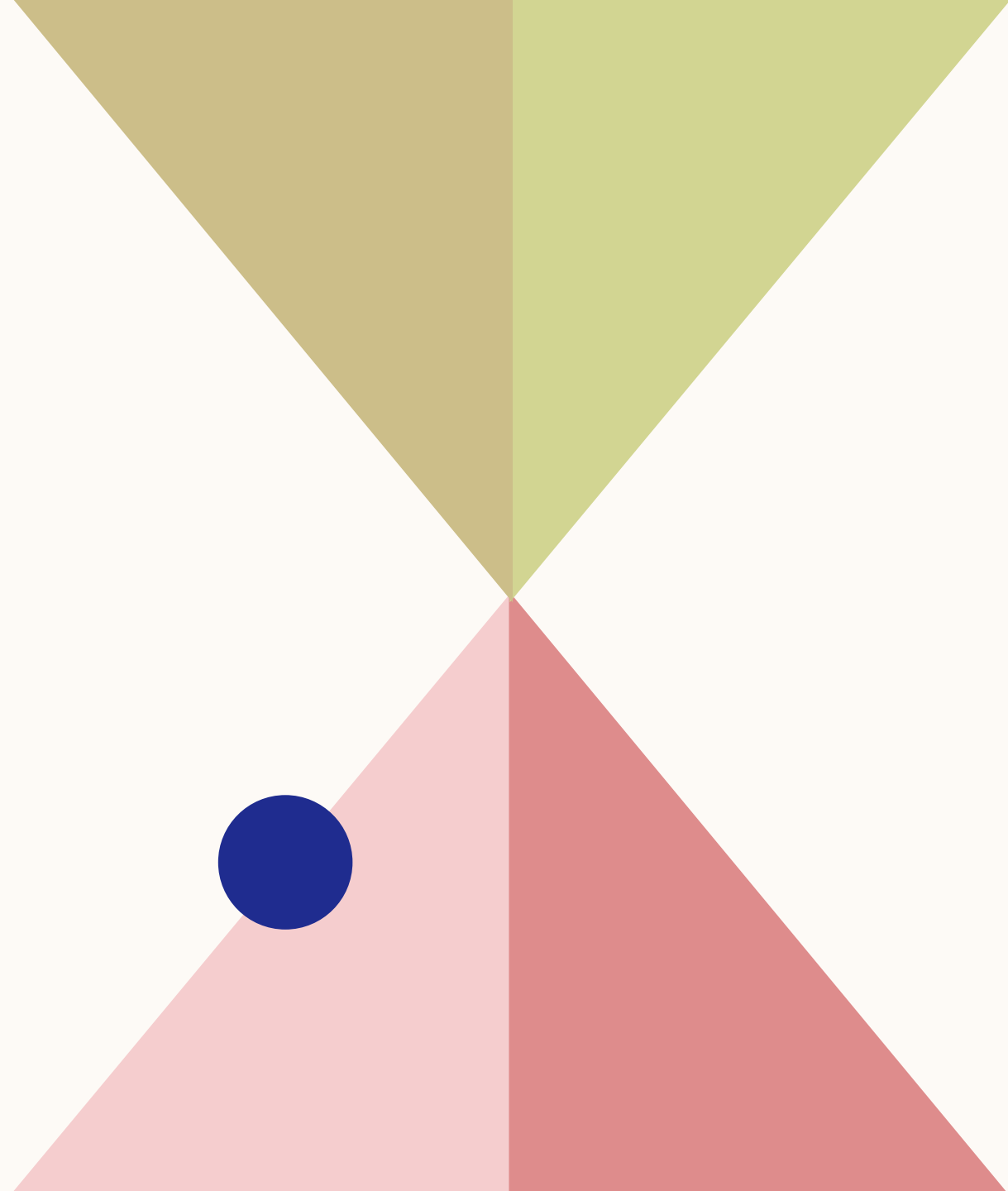
Strings

OUTLINE

Structures

Unions

Enumerations



STRUCTURES

- Collections of **related** variables under **one name**
- Structures may contain variables of many **different data types**
- Example: a **song** has **title**, **performer**, and **duration**

STRUCTURE DEFINITIONS

- Syntax

```
struct [structure_tag]
{
    data_type member_var_name [,member_var_name,...];
    [data_type member_var_name [,member_var_name,...];]
} [structure_var_name];
```

- Defining variables of structure types

```
struct structure_tag
```

```
struct struct_tag struct_var_name [,struct_var_name,...];
```

STRUCTURE DEFINITIONS

```
struct song
{
    char title[50];
    char performer[35];
    int duration_ms;
};

struct song track1;
```

```
struct song
{
    char title[50];
    char performer[35];
    int duration_ms;
}track1;
```

```
struct
{
    char title[50];
    char performer[35];
    int duration_ms;
}track1;
```

INITIALIZING STRUCTURES

- Syntax

```
struct struct_tag struct_var_name = {value1, value2, ..., valuen};
```

- Example

```
struct song track1 = {“Friend Like Me”, “Ne-Yo”, 182000};
```

ACCESSING STRUCTURE MEMBERS

- Structure member operator: dot operator (.)
  - The structure member operator accesses a structure member via **the structure variable name**

```
printf("%s\n",track1.title);
printf("%s\n",track1.performer);
printf("%d\n",track1.duration_ms);
```

ACCESSING STRUCTURE MEMBERS

```c
struct song
{
    char title[50];
    char performer[35];
    int duration_ms;
};

int main()
{
    struct song track1 = {"Friend Like Me","Ne-Yo",182000};

    printf("Title          : %s\n",track1.title);
    printf("Performer      : %s\n",track1.performer);
    printf("Duration (ms)  : %d\n",track1.duration_ms);

    printf("\n[DG]");
    return 0;
}
```

```
Title          : Friend Like Me
Performer      : Ne-Yo
Duration (ms)  : 182000

[DG]
Process returned 0 (0x0)   execution time : 0.800 s
Press any key to continue.
```

ACCESSING STRUCTURE MEMBERS

- Structure pointer operator: arrow operator (->)
  - Consists of a minus (-) sign and a greater than (>) sign with no intervening spaces
  - The structure pointer operator accesses a structure member via **a pointer to the structure**

```
struct song *track1Ptr;

track1Ptr = &track1;

printf("%s\n",track1Ptr->title);
printf("%s\n",track1Ptr->performer);
printf("%d\n",track1Ptr->duration_ms);
```

```
(*track1Ptr).title
(*track1Ptr).performer
(*track1Ptr).duration_ms
```

?

ACCESSING STRUCTURE MEMBERS

```c
int main()
{
    struct song track1 = {"Friend Like Me","Ne-Yo",182000};
    struct song *track1Ptr;

    track1Ptr = &track1;

    printf("Title          : %s\n",track1Ptr->title);
    printf("Performer      : %s\n",track1Ptr->performer);
    printf("Duration (ms)  : %d\n",track1Ptr->duration_ms);

    printf("\n[DG]");
    return 0;
}
```

```c
struct song
{
    char title[50];
    char performer[35];
    int duration_ms;
};
```

```
Title          : Friend Like Me
Performer      : Ne-Yo
Duration (ms)  : 182000

[DG]
Process returned 0 (0x0)   execution time : 2.048 s
Press any key to continue.
```

GLOBAL SCOPE VS LOCAL SCOPE

```
[Local]  Song 1 : Friend Like Me
[Global] Song 2 : Part Of Your World

[DG]
Process returned 0 (0x0)   execution time : 1.017 s
Press any key to continue.
```

```c
struct song
{
    char title[50];
    char performer[35];
    int duration_ms;
};

struct song track2 = {"Part Of Your World","Jessie J",200000};

int main()
{
    struct song track1 = {"Friend Like Me","Ne-Yo",182000};

    printf("[Local]  Song 1 : %s\n",track1.title);
    printf("[Global] Song 2 : %s\n",track2.title);

    printf("\n[DG]");
    return 0;
}
```

GLOBAL SCOPE VS LOCAL SCOPE

```c
int main()
{
    struct song
    {
        char title[50];
        char performer[35];
        int duration_ms;
    };

    struct song track1 = {"Friend Like Me","Ne-Yo",182000};

    printf("Title          : %s\n",track1.title);
    printf("Performer      : %s\n",track1.performer);
    printf("Duration (ms)  : %d\n",track1.duration_ms);

    printf("\n[DG]");
    return 0;
}
```

```
Title          : Friend Like Me
Performer      : Ne-Yo
Duration (ms)  : 182000

[DG]
Process returned 0 (0x0)   execution time : 0.977 s
Press any key to continue.
```

USING STRUCTURES WITH FUNCTIONS

- Structures may be passed to functions by passing individual structure members, by passing an entire structure, or by passing a pointer to a structure
- When structures or individual structure members are passed to a function, they are passed by value
- To pass a structure by reference (pointer), pass the address of the structure variable

USING STRUCTURES WITH FUNCTIONS

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

struct song
{
    char title[50];
    char performer[35];
    int duration_ms;
};

struct song newSong(char sTitle[], char sPerformer[], int sDuration)
{
    struct song s;

    strcpy(s.title,sTitle);
    strcpy(s.performer,sPerformer);
    s.duration_ms = sDuration;

    return s;
}
```

```c
int main()
{
    struct song track1 = newSong("Friend Like Me","Ne-Yo",182000);

    printf("Title          : %s\n",track1.title);
    printf("Performer      : %s\n",track1.performer);
    printf("Duration (ms)  : %d\n",track1.duration_ms);

    printf("\n[DG]");
    return 0;
}
```

```
Title          : Friend Like Me
Performer      : Ne-Yo
Duration (ms)  : 182000

[DG]
Process returned 0 (0x0)   execution time : 0.980 s
Press any key to continue.
```

USING STRUCTURES WITH FUNCTIONS

```c
#include <stdio.h>

struct song
{
    char title[50];
    char performer[35];
    int duration_ms;
};

void printSong(struct song s)
{
    printf("Title          : %s\n",s.title);
    printf("Performer      : %s\n",s.performer);
    printf("Duration (ms)  : %d\n",s.duration_ms);
}
```

```c
int main()
{
    struct song track1 = {"Friend Like Me","Ne-Yo",182000};

    printSong(track1);

    printf("\n[DG]");
    return 0;
}
```

```
Title          : Friend Like Me
Performer      : Ne-Yo
Duration (ms)  : 182000

[DG]
Process returned 0 (0x0)   execution time : 0.373 s
Press any key to continue.
```

USING STRUCTURES WITH FUNCTIONS

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

struct song
{
    char title[50];
    char performer[35];
    int duration_ms;
};

void newSong(struct song *s, char sTitle[], char sPerformer[], int sDuration)
{
    strcpy((*s).title,sTitle);
    strcpy(s->performer,sPerformer);
    (*s).duration_ms = sDuration;
}
```

```c
int main()
{
    struct song track1;

    newSong(&track1,"Friend Like Me","Ne-Yo",182000);

    printf("Title          : %s\n",track1.title);
    printf("Performer      : %s\n",track1.performer);
    printf("Duration (ms)  : %d\n",track1.duration_ms);

    printf("\n[DG]");
    return 0;
}
```

```
Title          : Friend Like Me
Performer      : Ne-Yo
Duration (ms)  : 182000

[DG]
Process returned 0 (0x0)   execution time : 0.918 s
Press any key to continue.
```

ARRAYS OF STRUCTURES

```c
int main()
{
    int i;
    struct song track[3] = {{"Friend Like Me","Ne-Yo",182000},
                            {"Part Of Your World","Jessie J",200000},
                            {"Zero To Hero","Ariana Grande",159000}};

    for(i = 0;i < 3;i++){
        printf("%-18s\t%-13s\t%d ms\n",track[i].title,
                                       track[i].performer,
                                       track[i].duration_ms);

    }

    printf("\n[DG]");
    return 0;
}
```

```c
struct song
{
    char title[50];
    char performer[35];
    int duration_ms;
};
```

```
Friend Like Me          Ne-Yo           182000 ms
Part Of Your World      Jessie J        200000 ms
Zero To Hero            Ariana Grande   159000 ms

[DG]
Process returned 0 (0x0)   execution time : 0.370 s
Press any key to continue.
```

ARRAYS OF STRUCTURES

```c
int main()
{
    int i;
    struct song track[3];

    for(i = 0;i < 3;i++){
        scanf("%[^#]#%[^#]#%d",track[i].title,
                               track[i].performer,
                               &track[i].duration_ms);

        fflush(stdin);
    }

    printf("\n");

    for(i = 0;i < 3;i++){
        printf("%-18s\t%-13s\t%d ms\n",track[i].title,
                                       track[i].performer,
                                       track[i].duration_ms);

    }

    printf("\n[DG]");
    return 0;
}
```

```
Friend Like Me#Ne-Yo#182000
Part Of Your World#Jessie J#200000
Zero To Hero#Ariana Grande#159000

Friend Like Me          Ne-Yo           182000 ms
Part Of Your World      Jessie J        200000 ms
Zero To Hero            Ariana Grande   159000 ms

[DG]
Process returned 0 (0x0)   execution time : 51.201 s
Press any key to continue.
```

```c
struct song
{
    char title[50];
    char performer[35];
    int duration_ms;
};
```

NESTED STRUCTURES

```c
int main()
{
    int i;
    struct album album1 = {"We Love Disney",16};

    for(i = 0;i < 3;i++){
        scanf("%[^#]#%[^#]#%d",album1.track[i].title,
                               album1.track[i].performer,
                               &album1.track[i].duration_ms);
        fflush(stdin);
    }

    printf("\n\n%s\n\n",album1.title);

    for(i = 0;i < 3;i++){
        printf("%02d %-18s\t%-13s\t%d ms\n",i + 1,
                                            album1.track[i].title,
                                            album1.track[i].performer,
                                            album1.track[i].duration_ms);

    }

    printf("\n[DG]");
    return 0;
}
```

```
Friend Like Me#Ne-Yo#182000
Part Of Your World#Jessie J#200000
Zero To Hero#Ariana Grande#159000


We Love Disney

01 Friend Like Me       Ne-Yo           182000 ms
02 Part Of Your World   Jessie J        200000 ms
03 Zero To Hero         Ariana Grande   159000 ms

[DG]
Process returned 0 (0x0)
Press any key to continue.
```

```c
struct song
{
    char title[50];
    char performer[35];
    int duration_ms;
};

struct album
{
    char title[50];
    int numberOfSongs;
    struct song track[3];
};
```

TYPEDEF

- The keyword **typedef** provides a mechanism for creating synonyms (or aliases) for previously defined data types
- Names for structure types are often defined with **typedef** to create shorter type names
- C programmers often use **typedef** to define a structure type, so a structure tag is not required

TYPEDEF

```c
struct song
{
    char title[50];
    char performer[35];
    int duration_ms;
};

typedef struct song playlist;
```

```c
typedef struct
{
    char title[50];
    char performer[35];
    int duration_ms;
} playlist;
```

```c
int main()
{
    playlist track1 = {"Friend Like Me","Ne-Yo",182000};

    printf("Title          : %s\n",track1.title);
    printf("Performer      : %s\n",track1.performer);
    printf("Duration (ms)  : %d\n",track1.duration_ms);

    printf("\n[DG]");
    return 0;
}
```

UNIONS

- A derived data type with members that **share the same storage space**
- A union shares the space instead of wasting storage on variables that are not being used
- The number of bytes used to store a union must be at least enough to hold the largest member
- In most cases, unions contain two or more data types

UNIONS

- Syntax

```
union [union_tag]
{
    data_type member_var_name [,member_var_name,...];
    [data_type member_var_name [,member_var_name,...];]
} [union_var_name];
```

- Defining variables of union types

```
union union_tag union_var_name;
```

UNIONS

```c
#include <stdio.h>

union data
{
    short number;
    char c[2];
};

int main()
{
    union data d;

    d.number = 17479;
    printf("Number    : %d\n",d.number);
    printf("c[1]c[0]  : %c%c\n",d.c[1],d.c[0]);

    printf("\n[DG]");
    return 0;
}
```

union	d															
member 1	number															
member 2	c[1]								c[0]							
bit	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1
value	0	1	0	0	0	1	0	0	0	1	0	0	0	1	1	1

```
Number    : 17479
c[1]c[0]  : DG

[DG]
Process returned 0 (0x0)   execution time : 1.466 s
Press any key to continue.
```

ENUMERATIONS

- A set of **integer enumeration constants represented by identifiers**
- Values in an enumeration start with 0, unless specified otherwise, and incremented by 1

ENUMERATIONS

- Syntax

```
enum [enum_tag]
{
    member1, member2, ..., membern
} [enum_var_name];
```

- Defining variables of enumeration types

```
enum enum_tag enum_var_name;
```

ENUMERATIONS

- Examples

```
enum months
{
    JAN, FEB, MAR, APR, MAY, JUN, JUL, AUG, SEP, OCT, NOV, DEC
};
```

```
enum months
{
    JAN = 1, FEB, MAR, APR, MAY, JUN, JUL, AUG, SEP, OCT, NOV, DEC
};
```

ENUMERATIONS

```c
#include <stdio.h>

enum months
{
    JAN = 1, FEB, MAR, APR, MAY, JUN, JUL, AUG, SEP, OCT, NOV, DEC
};

int main()
{
    enum months month;
    char *monthName[13] = {"",
                           "January", "February", "March", "April",
                           "May", "June", "July", "August",
                           "September", "October", "November", "December"};

    for(month = JAN;month <= DEC;month++){
        printf("Month %2d: %s\n",month,monthName[month]);
    }

    printf("\n[DG]");
    return 0;
}
```

```
Month  1: January
Month  2: February
Month  3: March
Month  4: April
Month  5: May
Month  6: June
Month  7: July
Month  8: August
Month  9: September
Month 10: October
Month 11: November
Month 12: December

[DG]
Process returned 0 (0x0)
Press any key to continue.
```

PRACTICE

EXERCISES

1. Find the error in each of the following program segments and correct the error.

   a.

```
struct person{
    char lastName[15];
    char firstName[15];
    int age;
}

person d;
```

EXERCISES

1. Find the error in each of the following program segments and correct the error.

   b.

```
struct card{
    char *face;
    char *suit;
}

struct card c, *cPtr, cards[13];

cPtr = &c;

printf("%s\n",*cPtr->face);
printf("%s\n",cards.face);
```

EXERCISES

1. Find the error in each of the following program segments and correct the error.

   c.

```
union values{
    char w;
    float x;
    double y;
};

union values v = {1.27};
```

EXERCISES

2. Given the following struct and variable definitions.

```
struct customer{
    char lastName[15];
    char firstName[15];
    int customerNumber;
    struct{
        char phoneNumber[11];
        char address[50];
        char city[15];
        char state[3];
        char zipCode[6];
    } personal;
} customerRecord, *customerPtr;

customerPtr = &customerRecord;
```

EXERCISES

2. Write an expression that accesses the struct members in each of the following parts.

    a. Member `lastName` of struct `customerRecord`
    b. Member `firstName` of the struct pointed to by `customerPtr`
    c. Member `phoneNumber` of member `personal` of struct `customerRecord`
    d. Member `zipCode` of member `personal` of the struct pointed to by `customerPtr`

EXERCISES

3. What is the value of X?

```c
#include <stdio.h>

int multiple(int num)
{
    int mask = 1, mult = 1, i;

    for(i = 1; i <= 10; ++i, mask <<= 1){
        if((num & mask) != 0){
            mult = 0;
            break;
        }
    }

    return mult;
}
```

```c
int main()
{
    int y;

    puts("Enter an integer between 1 and 32000: ");
    scanf("%d", &y);

    if(multiple(y)){
        printf("%d is a multiple of X\n",y);
    }
    else{
        printf("%d is not a multiple of X\n",y);
    }

    return 0;
}
```

EXERCISES

4. What does the following program do?

```c
#include <stdio.h>

int mystery(unsigned int bits)
{
    unsigned int mask = 1 << 31;
    unsigned int total = 0, i;

    for(i = 1; i <= 32; ++i, bits <<= 1){
        if((bits & mask) == mask){
            ++total;
        }
    }

    return !(total % 2) ? 1 : 0;
}
```

```c
int main()
{
    unsigned int x;

    puts("Enter an integer: ");
    scanf("%u",&x);

    printf("The result is %d\n",mystery(x));

    return 0;
}
```

EXERCISES

5. Define a **structure** type named **long_lat** that would be appropriate for storing longitude or latitude values. Include components named **degrees** (an **integer**), **minutes** (an **integer**), and **direction** (**one of the characters** 'N', 'S', 'E', or 'W').

   The following are a structure type to represent a geographic location and a variable of this hierarchical structure type.

```
typedef struct
{
    char place[20];
    long_lat longitude, latitude;
} location_t;

location_t resort;
```

EXERCISES

5. Given that the values shown have been stored in **resort**.

`.place`	Hawaii\0		
`.longitude`	158	0	W
`.latitude`	21	30	N

Complete the following table.

Reference	Data Type of Reference	Value
resort.latitude	long_lat	21 30 'N'
resort.place	…	…
resort.longitude.direction	…	…
…	…	30
resort.place[3]	…	…

LAB

EXERCISES

1. Write a program to read and display the information about all the students in a class. Use structures and functions.

```
1. Add student
2. Display student details
3. Display grade average

0. Exit

Menu: 1
```

```
ID          : 001
Name        : Ethan William
Assignment  : 83
Mid Exam    : 72
Final Exam  : 78
```

```
1. Add student
2. Display student details
3. Display grade average

0. Exit

Menu: 1
```

```
ID          : 002
Name        : Jacob Oliver
Assignment  : 91
Mid Exam    : 84
Final Exam  : 86
```

EXERCISES

1. Write a program to read and display the information about all the students in a class. Use structures and functions.

```
1. Add student
2. Display student details
3. Display grade average

0. Exit

Menu: 2
```

Final Grade:

A	85 – 100	C+	60 – 64.99
A-	80 – 84.99	C	55 – 59.99
B+	75 – 79.99	D	45 – 54.99
B	70 – 74.99	E	0 – 44.99
B-	65 – 69.99		

Final Score:
30% * Assignment +
30% * Mid Exam +
40% * Final Exam

ID	Name	Assignment	Mid Exam	Final Exam	Final Score	Final Grade
001	Ethan William	83	72	78	77.70	B+
002	Jacob Oliver	91	84	86	86.90	A

EXERCISES

1. Write a program to read and display the information about all the students in a class. Use structures and functions.

```
1. Add student
2. Display student details
3. Display grade average

0. Exit

Menu: 3
```

```
Assignment : 87.00
Mid Exam   : 78.00
Final Exam : 82.00
Final Score: 82.30
```

```
1. Add student
2. Display student details
3. Display grade average

0. Exit

Menu: 1
```

```
ID         : 003
Name       : Liam Mason
Assignment : 75
Mid Exam   : 67
Final Exam : 65
```

EXERCISES

1. Write a program to read and display the information about all the students in a class. Use structures and functions.

```
1. Add student
2. Display student details
3. Display grade average

0. Exit

Menu: 2
```

Final Grade:

A	85 – 100	C+	60 – 64.99
A-	80 – 84.99	C	55 – 59.99
B+	75 – 79.99	D	45 – 54.99
B	70 – 74.99	E	0 – 44.99
B-	65 – 69.99		

Final Score:
30% * Assignment +
30% * Mid Exam +
40% * Final Exam

ID	Name	Assignment	Mid Exam	Final Exam	Final Score	Final Grade
001	Ethan William	83	72	78	77.70	B+
002	Jacob Oliver	91	84	86	86.90	A
003	Liam Mason	75	67	65	68.60	B-

EXERCISES

1. Write a program to read and display the information about all the students in a class. Use structures and functions.

```
1. Add student
2. Display student details
3. Display grade average

0. Exit

Menu: 3
```

```
Assignment : 83.00
Mid Exam   : 74.33
Final Exam : 76.33
Final Score: 77.73
```

REFERENCES

- Deitel, P. and Harvey Deitel (2022), C How to Program (9th Edition), Pearson Education.
- Thareja, R. (2014), Data Structures Using C (2nd Edition), India: Oxford University Press.

NEXT

File Processing:

Data Hierarchy

Files and Streams

Sequential-Access File Processing

VISION

To become an **outstanding** undergraduate Computer Science program that produces **international-minded** graduates who are **competent** in software engineering and have **entrepreneurial spirit** and **noble character**.

MISSION

1. To conduct studies with the best technology and curriculum, supported by professional lecturer
2. To conduct research in Informatics to promote science and technology
3. To deliver science-and-technology-based society services to implement science and technology

Without hard work,
nothing grows but weeds.

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Have patience.
All things are difficult before they become easy.