COURSE CODE : DDWC 1223
KOD KURSUS

COURSE NAME : COMPUTER ORGANIZATION AND ASSEMBLY LANGUAGE
NAMA KURSUS *ORGANISASI KOMPUTER DAN BAHASA HIMPUNAN*

YEAR / PROGRAMME : 3 DDWC
TAHUN / PROGRAM

DURATION : 3 HOURS (INCLUDING SUBMISSION HOUR)
TEMPOH *3 JAM (TERMASUK MASA PENGHANTARAN)*

DATE : NOVEMBER 2020
TARIKH *NOVEMBER 2020*

INSTRUCTION / *ARAHAN:*

1. The question paper consists of **2 PARTS**: A and B.
   Kertas soalan terdiri daripada **2 BAHAGIAN**: A and B.

2. Answer **ALL** questions and write your answers on the answer sheet.
   Jawab **SEMUA** *soalan dan tulis jawapan anda pada kertas jawapan.*

3. Write a name, matric no., identity card no., course code, course name, section and lecturer name in the upper left corner on the answer sheet.
   Tulis nama, no. matrik, no. kad pengenalan, kod kursus, nama kursus, seksyen dan nama pensyarah di penjuru atas kiri kertas jawapan.

4. Each answer sheet must have a page number written at the bottom right corner.
   Setiap helai kertas jawapan mesti ditulis nombor muka surat pada bahagian bawah penjuru kanan.

5. Answers should be handwriting, neat and clear.
   Jawapan hendaklah ditulis tangan, kemas dan jelas menggunakan huruf cerai.

This examination paper consists of **18** pages including the cover.
Kertas soalan ini mengandungi **18** *muka surat termasuk kulit hadapan.*

ONLINE EXAMINATION RULES AND REGULATIONS
PERATURAN PEPERIKSAAN SECARA DALAM TALIAN

1. Student must carefully listen and follow instructions provided by invigilator.
   Pelajar mesti mendengar dan mengikuti arahan yang diberikan oleh pengawas peperiksaan dengan teliti.

2. Student is allowed to start examination only after confirmation of invigilator if all needed conditions are implemented.
   Pelajar dibenarkan memulakan peperiksaan hanya setelah pengesahan pengawas peperiksaan sekiranya semua syarat yang diperlukan telah dilaksanakan.

3. During all examination session student has to ensure, that he is alone in the room.
   Semasa semua sesi peperiksaan pelajar harus memastikan bahawa dia bersendirian di dalam bilik.

4. During all examination session student is not allowed to use any other devices, applications except other sites permitted by course lecturer.
   Sepanjang sesi peperiksaan pelajar tidak dibenarkan menggunakan peranti dan aplikasi lain kecuali yang dibenarkan oleh pensyarah kursus.

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   Selepas peperiksaan selesai, pelajar mesti memaklumkan kepada pengawas peperiksaan melalui platform komunikasi yang ditetapkan (contoh: Whatsapp dan lain-lain) mengenai peperiksaan yang telah selesai dan meninggalkan sesi peperiksaan selepas mendapat pengesahan daripada pengawas peperiksaan.

6. Any technical issues in submitting answers online have to be informed to respective lecturer within the given 30 minutes. Request for re-examination or appeal will not be entertain if complains are not made by students to their lecturers within the given 30 minutes.
   Sebarang masalah teknikal dalam menghantar jawapan secara dalam talian perlu dimaklumkan kepada pensyarah masing-masing dalam masa 30 minit yang diberikan. Permintaan untuk pemeriksaan semula atau rayuan tidak akan dilayan sekiranya aduan tidak dibuat oleh pelajar kepada pensyarah mereka dalam masa 30 minit yang diberikan.

7. During online examination, the integrity and honesty of the student is also tested. At any circumstances student is not allowed to cheat during examination session. If any kind of cheating behaviour is observed, UTM have a right to follow related terms and provisions stated in the respective Academic Regulations and apply needed measures.
   Semasa peperiksaan dalam talian, integriti dan kejujuran pelajar juga diuji. Walau apa pun keadaan pelajar tidak dibenarkan menipu semasa sesi peperiksaan. Sekiranya terdapat sebarang salah laku, UTM berhak untuk mengikuti terma yang dinyatakan dalam Peraturan Akademik.

Excerpts from online final exam guidelines
Petikan daripada panduan peperiksaan akhir dalam talian
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SECTION A / *BAHAGIAN A*

30 MARKS / *30 MARKAH*

MULTIPLE CHOICE / *ANEKA PILIHAN*

Choose the most appropriate answer. Write your answer in the answer sheet provided.
Pilih satu jawapan yang paling tepat. Tulis jawapan anda pada kertas jawapan yang disediakan.

1. Which of the register of the processor is connected to memory bus?
   Daftar pemproses yang manakah yang disambungkan kepada bas memori?

   A)   Stack Pointer (SP)
   B)   Memory Address Register (MAR)
   C)   Instruction Pointer (IP)
   D)   EFLAGS

2. Suppose the CPU is executing **ADD [AX], BX**. Choose the **INCORRECT** statement that describes its execution.
   *Katakan CPU sedang melaksanakan **ADD [AX], BX**. Pilih penyataan yang **SALAH** yang menerangkan pelaksanaannya.*

   A)   There are five (5) basic steps in the Instruction Execute cycle.
        Terdapat lima (5) langkah asas dalam Kitar Laksana Arahan.

   B)   After the Instruction fetch step, the instruction is placed in the IR where it is then decoded.
        Selepas langkah kutip arahan, arahan diletakkan dalam IR di mana ia akan diterjemahkan.

   C)   The result of the execution is stored in a memory location.
        Hasil perlaksanaan disimpan dalam lokasi memori.

   D)   Pre-fetch cycle will not occur as the operand is not placed in the memory.
        Kitar pra-kutip tidak berlaku kerana operand tidak diletakan di dalam memori.

3. The 8-bits two's complement representation of -10_{10} is:
   Perwakilan 8-bit pelengkap dua bagi -10_{10} adalah:

   A)   11011001
   B)   11110110
   C)   11111100
   D)   00001010

4. If a computer uses signed-2's complement representation and 8-bit registers, what range of integers can this computer represent?

   Jika satu komputer menggunakan perwakilan pelengkap-2 bertanda dan daftar bersaiz 8-bit, apakah julat integer yang boleh diwakili oleh komputer ini?

   A)   -128 to 127
   B)   -127 to 127
   C)   -127 to 128
   D)   -128 t0 128

5. The DMA technique differs from the interrupt techniques by _____.

   Teknik DMA berbeza dengan teknik sampukan oleh _____.

   A)   The involvement of the processor for the I/O operation
        Penglibatan pemproses untuk operasi I/O.

   B)   A The method of accessing the I/O devices
        Kaedah mengakses peranti I/O.

   C)   The amount of data transfer possible
        Jumlah pemindahan data yang mungkin.

   D)   The involvement of the processor for the transfer of data to the memory.
        Penglibatan pemproses untuk memindahkan data ke memori.

6. What is the **CORRECT** sequence of time delays that happen during a data transfer from a disk to memory?

   *Apakah urutan masa kelewatan yang **BETUL** yang berlaku semasa pemindahan data dari cakera kepada ingatan?*

   A)   Seek time, access time, transfer time
        Masa carian, masa capaian, masa pemindahan

   B)   Access time, latency time, transfer time
        Masa capaian, masa pendam, masa pemindahan

   C)   Seek time, latency time, transfer time
        Masa carian, masa pendam, masa pemindahan

   D)   Latency time, access time, transfer time
        Masa pendam, masa capaian, masa pemindahan

7. The instruction used to cause unconditional jump is _____.

   Arahan yang digunakan untuk menyebabkan lompatan tanpa syarat adalah _____.

   A) JMP
   B) JG
   C) GOTO
   D) UJG

8. The address space of the IA-32 is _____.

   Ruang alamat bagi IA-32 adalah _____.

   A) 2^{16}
   B) 2^{32}
   C) 2^{64}
   D) 2^{8}

9. Four contiguous bytes in memory contain the hexadecimal values 12, 34, 56 and 78 in the order of increasing address. If these bytes are used to store a 32-bit integer in **little-endian** format, what is the integer? (Give your answer in hexadecimal.)

   *Empat bait berdampingan dalam memori mengandungi nilai perenambelasan 12, 34, 56 dan 78 dalam turutan peningkatan alamat. Sekiranya bait ini digunakan untuk menyimpan integer 32-bit dalam format **kecil-endian**, apakah integer tersebut? (Berikan jawapan anda dalam nombor perenambelasan.)*

   A) 1234h
   B) 12345678h
   C) 78563412h
   D) 3412h

10. Which of the following is **NOT** a legal instruction for the Intel Pentium CPU?

    *Manakah di antara berikut **BUKAN** arahan yang sah bagi Intel Pentium CPU?*

    A) shr eax, 4
    B) shrd eax, ebx,4
    C) sub [eax], [ebx]
    D) add ebx, [ebx]

11. The LEA mnemonic is used to _____.
    Mnemonik LEA digunakan untuk _____.

    A)   declare the values as global constants.
          menyatakan nilai-nilai sebagai pemalar global

    B)   load the values of operands onto an accumulator
          memuatkan nilai-nilai operand ke akumulator

    C)   store the outcome of the operation at a memory location
          simpan hasil daripada operasi di lokasi memori

    D)   load the effective address of an instruction
          memuatkan alamat efektif arahan

12. The division operation (DIV) in IA-32 is a single operand instruction, so _____.
    Operasi bahagi (DIV) dalam IA-32 adalah arahan operan tunggal, oleh itu _____.

    A)   the divisor is stored in the eax register
          pembahagi disimpan dalam daftar eax

    B)   the dividend is stored in the ebx register
          dividen disimpan dalam daftar ebx

    C)   the divisor is stored in the accumulator
          pembahagi disimpan dalam akumulator

    D)   the dividend is stored in the accumulator
          dividen disimpan dalam akumulator

Trace the following program fragment and answer questions 13 - 17.

Jejaki keratin aturcara berikut dan jawab soalan 13 - 17.

```
        .data
        Array1      DWORD  10000h, 20000h, 30000h, 40000h
        sum         DWORD  ?
        .code
        main PROC
                mov   edi, OFFSET Array1          ; ............... [1]
                mov   ecx, LENGTHOF Array1
                mov   eax, 0
        L1:
                add   eax, [edi]                  ; ............... [2]
                add   edi, TYPE Array1            ; ............... [3]
                loop  L1                          ; ............... [4]
                mov   sum, eax
                exit
                main ENDP
                END main
```

Note: Assume the program will be loaded into starting address 404000H for execution.

Anggapkan program ini akan dimuatkan ke dalam alamat permulaan 404000H untuk pelaksanaan.

13. What is the content of **edi** after the execution of instruction labeled [1]?

    *Apakah kandungan **edi** selepas pelaksanaan arahan bertanda [1]?*

    A)   0000 0000H

    B)   0001 0000H

    C)   0040 0000H

    D)   0040 4000H

14. **Loop** instruction [labeled 4] will be executed _____ times.

    *Arahan **Loop** [label 4] akan dilaksanakan sebanyak _____ kali.*

    A)   4   C)   2

    B)   3   D)   1

15. What is the content of register **eax** when statement labeled 2 is executed for the first time (that is during the first loop)?

    Apa yang kandungan daftar **eax** apabila penyataan berlabel 2 dilaksanakan buat kali pertama (iaitu semasa gelung pertama)?

    A)   0001 0000H
    B)   0040 4000H
    C)   0050 4000H
    D)   1040 4000H

16. What is the content of register **edi** when statement labeled 3 is executed for the second time (that is during the second loop)?

    *Apa yang kandungan daftar **edi** apabila penyataan berlabel 3 dilaksanakan buat kali kedua (iaitu semasa gelung kedua)?*

    A)   1040 4004H
    B)   0040 4004H
    C)   0040 4008H
    D)   1040 4000H

17. What will be the content of **sum** after the program completes execution?

    *Apakah kandungan **sum** selepas aturcara selesai dilaksanakan?*

    A)   504000H
    B)   0A0000H
    C)   100000H
    D)   404010H

Given the following partial data segment which starts at address **000200H** and answer question 18 to 20.

*Diberi sebahagian segmen data yang bermula pada alamat **000200H** dan jawapan soalan 18 hingga 20.*

```
.DATA
dval  DWORD 12345678h
array BYTE  00h, 10h, 20h, 30h
x     DWORD LENGTHOF dval
y     DWORD SIZEOF array
```

18. Choose the **ILLEGAL** instruction based on the data definition given above.

    *Pilih arahan yang **TIDAK SAH** berdasarkan pentakrifan data berikut.*

    A)   mov al, BYTE PTR dval

    B)   mov al, dval

    C)   mov ax, WORD PTR dval

    D)   mov eax, dval

19. What are the values of **x** and **y**?

    *Apakah kandungan nilai **x** dan **y**.*

    A)   x = 4, y = 4

    B)   x = 4, y = 1

    C)   x = 1, y = 4

    D)   x = 1, y = 1

20. What is the address of **x**?

    *Apakah alamat **x**?*

    A)   000200H

    B)   000208H

    C)   000220H

    D)   000232H

SECTION B / *BAHAGIAN B*

70 MARKS / *70 MARKAH*

ANSWER ALL QUESTIONS / *JAWAB SEMUA SOALAN.*

QUESTION 1 / *SOALAN 1*

A digital computer has a memory unit with **16-bits** word size. One instruction is 1-word size. The instructions set consists of **62** different operations. The instructions set have **TWO (2)** format as shown in **Figure 1**. All instructions have an operation code part (opcode) and **TWO (2)** address field (also called operands) that consists of one for a memory address and one for a register address.

This particular system includes **12** general purpose, user addressable registers. Registers may be loaded directly from memory, and memory may be updated directly from registers. **Direct memory- to-memory data movement operations are not supported. Each instruction is store in one word of memory.**

*Komputer digital mempunyai satu unit ingatan dengan saiz perkataan adalah **16-bit**. Satu arahan adalah ukuran "1-word". Set arahannya terdiri daripada **62** operasi yang berbeza. Set arahan mempunyai **DUA (2)** format seperti ditunjukkan pada **Rajah 1**. Semua arahan mempunyai bahagian kod operasi (opcode) dan **DUA (2)** medan alamat (juga dipanggil operan) yang merangkumi satu alamat ingatan dan satu untuk alamat Daftar.*

*Sistem ini mempunyai **12** daftar tujuan umum yang boleh dialamatkan oleh pengguna. Daftar dapat dimuatkan terus dari ingatan, dan ingatan boleh dikemaskini secara langsung dari daftar. **Pergerakan data memori-ke-memori secara langsung tidak disokong. Setiap arahan disimpan dalam satu perkataan ingatan.***
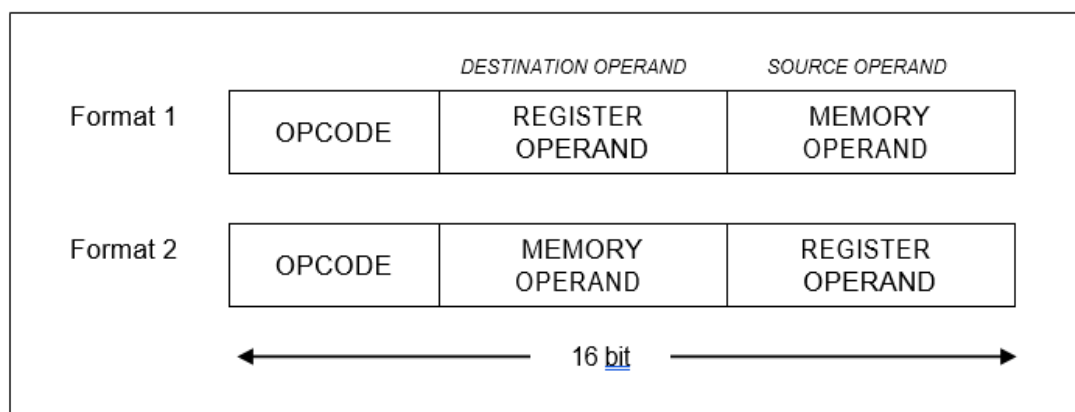

Figure 1 / **Rajah 1**

.

a) How many bits are needed for the opcode?   **[2 M]**
    Berapa bitkah diperlukan untuk kod operasi?

b) How many bits are needed to specify the register?   **[2 M]**
    Berapa bitkah diperlukan untuk menyatakan daftar?

c) How many bits are left for the memory parts of the instruction?   **[2 M]**
    Berapa bitkah yang tinggal untuk bahagian alamat arahan?

d) What is the maximum allowable size for the memory of this computer system? **[2 M]**
    Apakah saiz maksimum yang dibenarkan untuk alamat bagi sistem komputer ini?

e) What is the **largest** unsigned integer that can be accommodate in one word of the   **[2 M]**
    memory?
    *Apakah nilai integer tak bertanda **terbesar** yang boleh dimuatkan dalam satu perkataan memori?*

f) What is the **smallest** signed integer that can be accommodated in one word of the   **[2 M]**
    memory?
    *Apakah nilai integer bertanda **terkecil** yang boleh dimuatkan dalam satu perkataan memori?*

QUESTION 2 / *SOALAN 2*

a) Multiple clock cycles are required to perform Memory Read operation (as shown in **Figure 2**
    below). Based on the timing diagram given, write a sequence of steps involved in a Memory
    Read operation.   **[4 M]**
    *Berbilang kitaran jam berbilang diperlukan untuk melakukan operasi Bacaan Ingatan (seperti
    yang ditunjukkan dalam **Rajah 2** di bawah). Berdasarkan gambarajah masa yang diberikan,
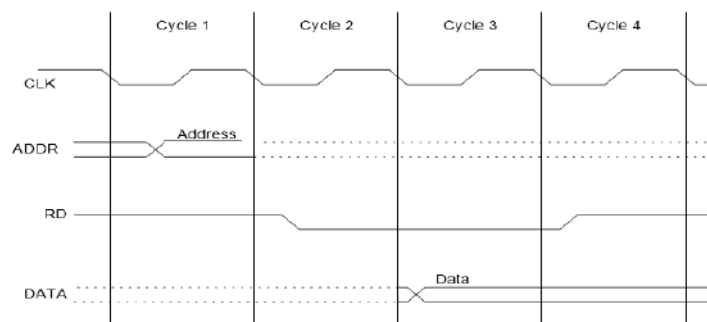   tulis jujukan langkah yang terlibat dalam satu operasi Baca Ingatan.*

Figure 2 / *Rajah 2*

b) In order to execute a program, instruction must be transferred from memory along a bus to the CPU. If the bus has 16 data lines, at most two bytes (16 bit) can be transferred at a time. How many memory accesses would be needed in this case to transfer a 64-bit instruction from memory to the CPU. **[2 M]**

Untuk melaksanakan satu arahan aturcara, arahan mesti dipindahkan dari ingatan utama ke CPU melalui bas. Jika sesuatu bas itu mempunyai 16 talian data, sebanyak dua bait (16 bit) data boleh dipindahkan pada satu masa. Berapa banyak capaian ingatan diperlukan dalam kes ini untuk memindahkan arahan 64-bit dari CPU.

c) Suppose we have a magnetic disk (resembling an IBM Microdrive) with the following parameters:

Katakan kita mempunyai cakera magnetik (menyerupai sebuah IBM Microdrive) dengan parameter berikut:

Average seek time / *masa carian purata*	12 ms
Rotation rate / *kadar pusingan*	3600 RPM
Transfer rate / *kadar pemindahan*	3.5 MB/sec
Number of sectors per track / *bilangan sektor setiap trek*	64
Sector size / *Saiz sektor*	512 bytes

Answer the following questions / *Jawab soalan berikut:*

(i) What is the average time to read a single sector? **[2 M]**
Apakah masa purata untuk membaca satu sektor yang tunggal?

(ii) What is the average time to read 8 KB in 16 consecutive sectors in the same cylinder? **[2 M]**
Apakah masa purata untuk membaca 8 KB 16 sektor berturut-turut dalam silinder yang sama?

QUESTION 3 / *SOALAN 3*

a) What is the content of register AX, DX and CF flag (in hexadecimal value) after the execution of the following program fragment?

Apakah kandungan daftar AX, DX, dan bendera CF (dalam nilai heksadesimal) selepas perlaksanaan keratan aturcara berikut?

After execution/ *Selepas perlaksanaan:*

```
MOV   AX, 0F00Fh
MOV   DX, 0ADADh
SHR   AX, 3
ROR   DX, 4
```

AX = _____ [2 M]

DX = _____ [2 M]

CF = _____ [1 M]

b) Implement the following **WHILE LOOP** into assembly language code: **[4 M]**

*Implemen **WHILE LOOP** berikut kepada bahasa himpunan:*

```
while (ebx <= num){
      ebx = ebx + 10; num = num - 2
}
```

c) Implement the following **IF statement** in assembly language. All values are **32-bit unsigned integers**. **[4 M]**

*Implemen **penyataan IF** berikut dalam bahasa himpunan. Semua nilai adalah **32-bit integer tak-bertanda**.*

```
if (var1 <= var2) {
      var3 = 10;
}else {
      var3 = 60;
      var4 = 70;
}
var1 = var1 / var3
```

QUESTION 4 / *SOALAN 4*

a) Suppose AX =13h, BX = 10h and CX = 19h, what is the value of **AX, BX, CF** and **OF** after the following program fragment is executed?

*Andaikan AX =13h, BX = 10h and CX = 19h, apakah nilai **AX, BX, CF** dan **OF** selepas keratan aturcara ini dilaksanakan?*

```
        CMP    AL,BL
        JA     BR1
        CMP    BL,CL
        JBE    NEXT
BR1:    INC    AX
NEXT:   ADD    AX, BX
        NEG    BX
```

AX = _____ **[2 M]**

BX = _____ **[2 M]**

CF = _____ **[1 M]**

OF = _____ **[1 M]**

b) Indicate the content of registers (in hex value) after the execution of the following program fragments:

Tunjukkan kandungan daftar (dalam nilai heksa) selepas perlaksanaan keratan aturcara berikut:

```
        MOV    BX, 7888h
        ADD    BX, 1000h
        MOV    CX, 9FFFh
        CMP    BX, CX
        JNC    Next
        ADD    BX, 4000h
Next:   SUB    CX, 250h
```

BX = _____ **[2 M]**

CX = _____ **[2 M]**

CF = _____ **[1 M]**

SF = _____ **[1 M]**

c) Refer to the following program fragments.

Rujuk keratan aturcara berikut:

```
.data
      Value1      byte  23h, 30h, 40h, 50h
      Value2      word  2010h, 3010h, 400h, 50h
      Value3      dword 20000h, 30000h, 40000h,500000h
      total word  ?
.code
main proc
      mov   esi, 2
      mov   al, Value1 [esi]        ............ [1]
      mov   bx, Value2 [esi * 2]    ............ [2]
      mov   ecx, Value3 [esi * 4]   ............ [3]
```

Suppose the address of the data segment starts at address 605000H. What is the effective address of the source operand for instruction [1], [2] and [3]? Show your calculation.   **[3 M]**

Andaikan alamat segmen data bermula pada alamat 605000H. Apakah alamat efektif bagi operan sumber bagi arahan [1], [2] dan [3]? Tunjukkan pengiraan anda.

QUESTION 5 / *SOALAN 5*

Projection for monthly income and expenses of Aaron Kwak for the first half of Year 2020 is given in Table 1. However, due to Covid-19 pandemic Aaron is forced to work from home for 4 months starting from March to June 2020 with a 25% pay cut.

Unjuran pendapatan dan perbelanjaan bulanan bagi Aaron Kwak untuk separuh tahun pertama Tahun 2020 adalah seperti di Jadual 1. Walau bagaimanapun, pun, disebabkan pandemik Covid-19 Aaron terpaksa bekerja dari rumah selama 4 bulan mulai bulan Mac hingga June 2020 dengan potongan gaji sebanyak 25%.

Table 1 / *Jadual 1*

Month / *Bulan*	Jan	Feb	March	April	May	June
Income / *Pendapatan* (RM)	7500	9200	10500	11000	13000	13500
Expenses / *Perbelanjaan* (RM)	700	1028	580	760	980	1250
Savings / *Simpanan* (RM)	?	?	?	?	?	?

a) Give suitable data declaration statements for Income, Expenses and Savings.   **[3 M]**

Berikan penyataan deklarasi data bagi Income, Expenses dan Savings.

b) Write a complete Intel IA32 Assembly Language program that calculates: **[17 M]**
   (i) Income for the month of March, April, May and June after the 25% pay cut
   (ii) Savings for each month (January until June 2020)
   (iii) Total saving (form January until June 2020)

Your program **MUST** use **LOOP** instructions. You are required to produce output as stated below. Refer to Appendix B for Procedure calls.

Tulis satu aturcara Bahasa Himpunan Intel IA32 yang mengira:
   (i) Pendapatan untuk bulan Mac, April, Mei dan Jun selepas potongan sebanyak 25%.
   (ii) Simpanan untuk setiap bulan (Januari hingga Jun 2020)
   (iii) Jumlah simpanan (Jumlah dari Januari hingga Jun 2020)

Program anda **MESTI** menggunakan arahan **LOOP** Anda perlu menghasilkan output seperti yang dinyatakan di bawah. Rujuk Appendiks B untuk panggilan Prosedur.

Sample Output / *Contoh Output*

```
.............O U T P U T.............
    Month 1  savings  =  RM 6730
    Month 2  savings  =  RM 8132
    Month 3  savings  =  RM 7300
    Month 4  savings  =  RM 7850
    Month 5  savings  =  RM 9150
    Month 6  savings  =  RM 9625
    -------------------------------------------
     Total saving is  =  RM 48787
    -------------------------------------------
```

END OF QUESTIONS / *SOALAN TAMAT*

APPENDIX A

ASCII TABLE / *JADUAL ASCII*

Dec	Hex	Char	Dec	Hex	Char	Dec	Hex	Char	Dec	Hex	Char
0	00	Null	32	20	Space	64	40	@	96	60	`
1	01	Start of heading	33	21	!	65	41	A	97	61	a
2	02	Start of text	34	22	"	66	42	B	98	62	b
3	03	End of text	35	23	#	67	43	C	99	63	c
4	04	End of transmit	36	24	$	68	44	D	100	64	d
5	05	Enquiry	37	25	%	69	45	E	101	65	e
6	06	Acknowledge	38	26	&	70	46	F	102	66	f
7	07	Audible bell	39	27	'	71	47	G	103	67	g
8	08	Backspace	40	28	(	72	48	H	104	68	h
9	09	Horizontal tab	41	29	)	73	49	I	105	69	i
10	0A	Line feed	42	2A	*	74	4A	J	106	6A	j
11	0B	Vertical tab	43	2B	+	75	4B	K	107	6B	k
12	0C	Form feed	44	2C	,	76	4C	L	108	6C	l
13	0D	Carriage return	45	2D	−	77	4D	M	109	6D	m
14	0E	Shift out	46	2E	.	78	4E	N	110	6E	n
15	0F	Shift in	47	2F	/	79	4F	O	111	6F	o
16	10	Data link escape	48	30	0	80	50	P	112	70	p
17	11	Device control 1	49	31	1	81	51	Q	113	71	q
18	12	Device control 2	50	32	2	82	52	R	114	72	r
19	13	Device control 3	51	33	3	83	53	S	115	73	s
20	14	Device control 4	52	34	4	84	54	T	116	74	t
21	15	Neg. acknowledge	53	35	5	85	55	U	117	75	u
22	16	Synchronous idle	54	36	6	86	56	V	118	76	v
23	17	End trans. block	55	37	7	87	57	W	119	77	w
24	18	Cancel	56	38	8	88	58	X	120	78	x
25	19	End of medium	57	39	9	89	59	Y	121	79	y
26	1A	Substitution	58	3A	:	90	5A	Z	122	7A	z
27	1B	Escape	59	3B	;	91	5B	[	123	7B	{
28	1C	File separator	60	3C	<	92	5C	\	124	7C	|
29	1D	Group separator	61	3D	=	93	5D	]	125	7D	}
30	1E	Record separator	62	3E	>	94	5E	^	126	7E	~
31	1F	Unit separator	63	3F	?	95	5F		127	7F	□

APPENDIX B

Link library Irvine32.lib

1. Dumpling Registers and Memory

Procedure	Description
DumpRegs	Writes EAX, EBX, ECX, and EDX on first line in hexadecimal Writes ESI, EDI, EBP, and ESP on second line in hexadecimal Writes EIP, EFLAGS, CF, SF, ZF, and OF on third line
DumpMem	Writes a range of memory to standard output in hexadecimal ESI = starting address ECX = number of elements to write EBX = element size (1, 2, or 4)

2. Input Procedures: ReadInt, ReadChar, ReadString, Dec

Procedure	Description
ReadChar	Reads a char from keyboard and returns it in the AL register. The character is NOT echoed on the screen.
ReadHex	Reads a 32-bit hex integer and returns it in the EAX register. Reading stops when the user presses the [Enter] key. No leading spaces. No error checking is performed.
ReadInt	Reads a 32-bit signed integer and returns it in EAX. Leading spaces are ignored. Optional + or – is allowed. Error checking is performed (error message) for invalid input.
ReadDec	Reads a 32-bit unsigned integer and returns it in EAX.
ReadString	Reads a string of characters from keyboard. Additional null-character is inserted at the end of the string. EDX = address of array where input characters are stored. ECX = maximum characters to be read + 1 (for null byte) Return EAX = count of non-null characters read.

3. Output Procedures: Clrscr, WriteInt, WriteHex, WriteString, WriteHex, WriteInt, WriteDec, WriteBin

Procedure	Description
Clrscr	Clears screen, locates cursor at upper left corner.
Crlf	Writes end of line sequence (CR,LF) to standard output.