

$$\begin{aligned}
 &\bullet C_{\text{total}} = c_1 s_1 + c_2 s_2 + c_3 s_3 \leq 15000 \\
 &15000 = 1.25 \times 512 + .2 \times 32000 + .0002 * s_3 \\
 &15000 = 640 + 6400 + .0002 * s_3 \\
 &.0002 * s_3 = 15000 - 640 - 6400 \\
 &\quad = 7960 / .0002 \\
 &\quad = 39800000 \times 10^{-6} \\
 &\quad \mathbf{s_3 = 39.8}
 \end{aligned}$$

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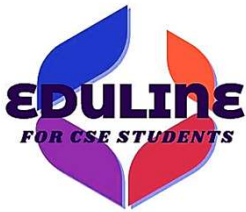
$$\begin{aligned}
 &\mathbf{T_{eff}} = h_1 t_1 + (1 - h_1) h_2 t_2 + (1 - h_1)(1 - h_2) h_3 t_3 \\
 &\mathbf{T_{eff}} = h_1 t_1 + (1 - h_1) h_2 t_2 + (1 - h_1)(1 - h_2) h_3 t_3 \leq 850 \text{ ns} \\
 &850 \times 10^{-9} = .98 \times 25 \times 10^{-9} + .02 * .99 * \mathbf{t_2} + .02 * .01 * 1 * 4 * 10^{-3} \\
 &850 \times 10^{-9} = 24.5 \times 10^{-9} + .0198 \mathbf{t_2} + .0008 \times 10^{-3} \\
 &.0198 \mathbf{t_2} = 850 \times 10^{-9} - 24.5 \times 10^{-9} - .0008 \times 10^{-3} \\
 &\quad = 825.5 \times 10^{-9} - .0008 \times 10^{-3} \\
 &\quad = 825.5 \times 10^{-9} - 800 \times 10^{-9} \\
 &\quad = 25.5 \times 10^{-9} \\
 &\quad = 25.5 \times 10^{-9} / .0198 \\
 &\quad \mathbf{t_2 = 1287 \times 10^{-9}}
 \end{aligned}$$

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# Important Problematic Questions for University Exam



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## MODULE 1

**Q1:**

A benchmark program is run on a 40 MHz processor. The executed program consists of 100,000 instruction executions, with the following instruction mix and clock cycle count:

Instruction Type	Instruction Count	Cycles per Instruction
Integer arithmetic	45.000	1
Data transfer	32.000	2
Floating point	15.000	2
Control transfer	8000	2

Determine the effective CPI, MIPS rate, and execution time for this program.

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Clock speed of the Processor = 40 MHz

Instruction Type	Instruction Count	Cycles per Instruction	cycles
Integer arithmetic	45,000	1	45000
Data transfer	32,000	2	64000
Floating point	15,000	2	30000
Control transfer	8000	2	16000

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- Total no: of cycles required to execute complete program

$$\rightarrow 45000 + 64000 + 30000 + 16000$$

$$\rightarrow 155000 \text{ cycles}$$

$$C = 155000 \text{ cycles}$$

- Effective CPI =  $C/I_c$

$$\rightarrow 155000 / 100000$$

$$CPI = 1.55$$

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**Q2:**

Consider the design of a three level memory hierarchy with the following specifications for memory characteristics:

Memory level	Access time	Capacity	Cost/Kbyte
Cache	$t_1 = 25 \text{ ns}$	$s_1 = 512 \text{ Kbytes}$	$c_1 = \$1.25$
Main Memory	$t_2 = 903 \text{ ns}$	$s_2 = 32 \text{ Mbytes}$	$c_2 = \$0.2$
Disk array	$t_3 = 4 \text{ ms}$	$s_3 = 39.8 \text{ Gbytes}$	$c_3 = \$0.0002$

Hit ratio of cache memory is  $h_1 = 0.98$  and a hit ratio of main memory is  $h_2 = 0.9$ .

- Calculate the effective access time.
- Calculate the total memory cost.

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**Effective access time**

$$\begin{aligned}
 T_{eff} &= h_1 t_1 + (1 - h_1) h_2 t_2 + (1 - h_1)(1 - h_2) h_3 t_3 \\
 &= 0.98 * 25 \times 10^{-9} + 0.02 * .9 * 903 \times 10^{-9} + 0.02 * .1 * 1 * 4 \times 10^{-3} \\
 &= 24.5 \times 10^{-9} + 16.254 \times 10^{-9} + .008 \times 10^{-3} \\
 &= 40.754 \times 10^{-9} + .008 \times 10^{-3} \\
 &= 40.754 \times 10^{-9} + 8000 \times 10^{-9} \\
 &= 8040.754 \times 10^{-9} \\
 &= \mathbf{8.04 \mu sec.}
 \end{aligned}$$

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$$\begin{aligned}\text{Total cost} &= C_1S_1 + C_2S_2 + C_3S_3 \\ &= 1.25 \times 512 + 0.2 \times 32 \times 10^3 + 39.8 \times 0.0002 \times 10^6 \\ &= 640 + 6400 + 7960 \\ &= \text{\$15000}\end{aligned}$$

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## MODULE 4

### Q1:

Consider the execution of a program of **15,000 instructions** by a **linear pipeline** processor with a **clock rate of 25 Mhz**. Assume that the instruction pipeline has **five stages** and that **one instruction is issued per clock cycle**. The penalties due to branch instructions and out-of sequence executions are ignored.

- Calculate the speedup factor using this pipeline to execute the program as compared with the use of an equivalent non-pipelined processor with an equal amount of flow-through delay.
- what are the efficiency and throughput of this pipelined processor?

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**Ans:**

Information we get are :

- ☞  $n = 15,000$  instructions or tasks.
- ☞  $f = 25 \text{ MHz}$ .
- ☞  $k = 5$  stages.
- ☞ 1-issued processor.

The Speedup ( $S_k$ ), Efficiency, ( $E_k$ ), and Throughput ( $H_k$ ) factors are :

$$\begin{aligned}
 S_k &= \frac{T_1}{T_k} = \frac{nk\tau}{k\tau + (n-1)\tau} & H_k &= \frac{nf}{k + (n-1)} & E_k &= \frac{S_k}{k} \\
 &= \frac{nk}{k + (n-1)} & &= \frac{(15,000)(25)}{5 + (15,000-1)} & &= \frac{4,999}{5} \\
 &= \frac{(15,000)(5)}{5 + (15,000-1)} & &= \frac{375,000}{15,004} & &= 0,999 \\
 &= \frac{75,000}{15,004} & &= 24,99 \text{ MIPS} & & \\
 &= 4,999 & & & &
 \end{aligned}$$

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**Q2:**

Suppose the time delay of 4 stage are  $\tau_1 = 60\text{ns}$ ,  $\tau_2 = 50\text{ns}$ ,  $\tau_3 = 90\text{ns}$ ,  $\tau_4 = 80\text{ns}$  and the interface latch has a delay of  $d = 10\text{ns}$ . Find the clock period and frequency of this pipeline?

$$\tau = \tau_{\max} + d = 90 \times 10^{-9} + 10 \times 10^{-9} = 100 \times 10^{-9}$$

This means that the clock frequency of the pipeline can be set to

$$f = \frac{1}{\tau} = \frac{1}{100 \times 10^{-9}} = 10 \text{ MHz}$$

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**Q3:**

Determine the frequency of the pipeline if the stage delays are  $\tau_1 = 3\text{ns}$ ,  $\tau_2 = \tau_3 = 5\text{ns}$  and  $\tau_4 = 8\text{ns}$  and the latch delay is  $1\text{ns}$ .

$$\tau_{\max} = 8\text{ns}$$

$$d = 1\text{ns}$$

$$\tau = \tau_{\max} + d = 8 \times 10^{-9} + 1 \times 10^{-9} = 9 \times 10^{-9}$$

$$f = \frac{1}{\tau} = \frac{1}{9 \times 10^{-9}} = 111.11\text{ MHz}$$