EE 180 Homework 4

Schuyler Anne Tilney-Volk, Sean William Konz

TOTAL POINTS

99 / 100

QUESTION 1

10 pts

1.1 a) **3 / 3**

✓ **- 0 pts** Correct

1.2 b) **3 / 3**

✓ **- 0 pts** Correct

- 1 pts slight error

- 2 pts calculation error

1.3 c) **4 / 4**

- 0 pts Correct

✓ **- 0 pts** add more information see solution

QUESTION 2

10 pts

2.1 a) **5 / 5**

✓ **- 0 pts** Correct

- 0.5 pts slight error

- 2 pts error with approach

2.2 b) **4 / 5**

- 0 pts Correct

✓ **- 1 pts** calculation mistake

- 0.5 pts calculate for 1000 bytes

QUESTION 3

3 **15 / 15**

✓ **- 0 pts** Correct

- 2 pts add initiation time

- 2 pts check solution I/o bus time should be less

QUESTION 4

4 **20 / 20**

✓ **- 0 pts** Correct

- 10 pts only some part of the problem is solved

- 3 pts slightly off with I/O operations per sec

- 3 pts final answers not mentioned

QUESTION 5

45 pts

5.1 a) **7 / 7**

✓ **- 0 pts** Correct

- 2 pts double up calculation for platters

5.2 b) **7 / 7**

✓ **- 0 pts** Correct

- 1 pts small error

5.3 c) **7 / 7**

✓ **- 0 pts** Correct

- 1 pts controller overheadtime not considered

- 1 pts rotational delay time wrong

- 3 pts complete the solution

5.4 d) **6 / 6**

✓ **- 0 pts** Correct

- 0 pts based on your previous results

5.5 e) **6 / 6**

✓ **- 0 pts** Correct

- 0.5 pts marginal error

- 1 pts calculation mistake/ wrong approach

5.6 f) **6 / 6**

✓ **- 0 pts** Correct

- 2 pts wrong bandwidth

5.7 g) **6 / 6**

✓ **- 0 pts** Correct

- 1 pts provide more explanation

gradescope

EE180 - HW4

Sean Konz + Schuyler Tilney-Volk

1) a) Seek time + rot. latency + transfer time + controller delay

A: $11ms + \frac{1/2}{\left(\frac{7200}{60}\right)} + \frac{1024}{36\times10^6 B/s} + \frac{1024 \cdot 8}{500\times10^6 b/s}$

$= 11ms + 4.16ms + .0284ms + .016384ms$

$= 15.21ms$

B: $9ms + \frac{1/2}{\left(\frac{7200}{60}\right)} + \frac{1024}{32\times10^6 B/s} + \frac{1024 \cdot 8}{520\times10^6 b/s}$

$= 9ms + 4.16ms + .032ms + .015754ms$

$= 13.214ms$

b) Minimum time assumes no seek time or rotational latency

A: $\frac{2048}{36\times10^6 B/s} + \frac{2048 \cdot 8}{500\times10^6 b/s} = .000089657s = 8.9657\times10^{-5}s$

B: $\frac{2048}{32\times10^6 B/s} + \frac{2048 \cdot 8}{520\times10^6 b/s} = .000095508s = 9.5508\times10^{-5}s$

c) The dominant factor for performance in either disk is seek time since it contributes the most time for the avg read time. Seek time is dependent on access pattern, so we can improve this factor by reading larger sectors sequentially rather than moving the head around to different sectors. Alternative optimizations might be improved write location selection to prevent fragmentation.

1.1 a) 3 / 3

✓ **- 0 pts** Correct

gradescope

EE180 - HW4

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1.2 b) **3 / 3**

✓ **- 0 pts** Correct

- 1 pts slight error

- 2 pts calculation error

gradescope

EE180 - HW4

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1.3 c) **4 / 4**

- **- 0 pts** Correct

✓ **- 0 pts** add more information see solution

gradescope

2) Process 1byte of data: 1000 cycles   Clock 1×10^9 Hz

1 byte supplied every 0.02ms

$\rightarrow$ 20,000 cycles/.02ms

a) Poll occurs every 50 cycles

$\underbrace{20000 \text{ cycles} - 1000 \text{ cycles}}_{\text{Process Data}} = 19000$ cycles spent polling at 50 cycle intervals

need an extra polling iteration to detect the data, the cycles spent polling are $19000 + 50 = \underline{19050 \text{ cycles}}$.

$\therefore$ Each byte takes $19050 + 1000 = 20050$ cycles

so the total operation takes $1000 \cdot 20{,}050 = \underline{2.005\times10^7 \text{ cycles}}$

b) $1000 + 200 = 1200$ cycles to process each byte

20000 cycles per .02ms so 18800 cycles free for each byte of data processed

$\therefore 18800 \cdot 1000 = 1.88\times10^7$ cycles

2.1 a) **5 / 5**

✓ **- 0 pts** Correct

- 0.5 pts slight error

- 2 pts error with approach

gradescope

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∴ Each byte takes 19050 + 1000 = 20050 cycles

so the total operation takes 1000 · 20,050 = 2.005×10^7 cycles

b) 1000 + 200 = 1200 cycles to process each byte

20000 cycles per .02ms so 18800 cycles free for each byte of data processed

∴ 18800 · 1000 = 1.88×10^7 cycles

2.2 b) **4 / 5**

- **- 0 pts** Correct
- ✓ **- 1 pts** **calculation mistake**
- **- 0.5 pts** calculate for 1000 bytes

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3) Memory System: write: read: 4words/8cycles = $16B \cdot \left(\frac{200 \times 10^6}{8}\right) = 400MB/s$

I/O Bus: 6 MB/s

DMA: 1.5ms latency for all I/O operations

Disks: 4MB/s latency, 20ms delay

Since the Disk bandwidth is the slowest, we can ignore all other component bandwidth times, since any other latency will be negligible in the I/O Bus and memory System.

Total Time = Init + Seek time + Rotational Latency + Transfer

$= 1.5ms + 20ms + \frac{32KB}{4 MB/s}$

$= 21.5ms + 8ms = \boxed{29.5ms}$

3 **15 / 15**

✓ **- 0 pts** Correct

- 2 pts add initiation time

- 2 pts check solution I/o bus time should be less

gradescope

4) 50 disks for 5 I/O Bus, 10 disks/Bus and 10 disks/DMA

Each disk will have the same transfer time since components are constant, but block size is variable now

Transfer Time = Init + Seek Time + Rot. Latency + Transfer

$$= 21.5ms + \frac{B}{4MB/s}$$

To saturate the I/O Bus, the Data being transferred must exceed the bandwidth of the I/O Bus or DMA.

The DMA has a bandwidth of 6MB/s.

Since the DMA serves 10 disks here, all transferring blocks of size B, then the required data transfer bandwidth must be greater than or equal to 6MB/s to saturate

$$\frac{10B}{21.5ms + \frac{B}{4MB/s}} \geq 6MB/s \rightarrow 10B \geq (21.5ms)(6MB/s) + \frac{3}{2}B$$

$$\frac{17}{2}B \geq .129 MB \rightarrow B \geq .01517647MB$$

$$\underline{B \geq 15.2KB}$$

Since the block size must be a power of 2, the block size is $\underline{16KB}$ in order to saturate all the I/O Busses.

All busses are saturated, so they run at full bandwidth:

Total Bandwidth: $5 \cdot 6MB/s = \underline{30 MB/s}$

Block size is 16KB/operation. ∴ total I/O operations per second:

$$\frac{30 MB/s}{16KB/op} = \underline{1875 \frac{ops}{s}}$$

4 **20 / 20**

- ✓ **- 0 pts** Correct
- **- 10 pts** only some part of the problem is solved
- **- 3 pts** slightly off with I/O operations per sec
- **- 3 pts** final answers not mentioned

5) 15000 RPM   424 sectors/track   512 B/sector, 12 platters, 14,100 cylinders

Seek time = 5.6ms   DMA overhead = 0.5ms   cylinders = $\frac{\text{Tracks}}{\text{Head}}$

a)

Total capacity = 12 Platters $\cdot$ 2 $\frac{\text{Heads}}{\text{Platter}} \cdot 14100 \frac{\text{Tracks}}{\text{Head}} \cdot 424 \frac{\text{Sectors}}{\text{Track}} \cdot 512 \frac{\text{B}}{\text{Sector}}$

= 73,462,579,200

= $\underline{68.42 \text{ GB}}$

b) rotates at 15000RPM

for each rotation, each head passes 424 sectors, which is 424 sectors $\cdot$ 512 $\frac{B}{\text{Sector}}$

= 217,088 $\frac{B}{\text{rev}}$

15000 RPM → 250 rev/s

$217088 \frac{B}{\text{rev}} \cdot 250 \frac{\text{rev}}{s} = 54,272,000 \text{ B/s}$

$= \underline{54.3 \text{ MB/s}}$

c) Essentially time to access the correct sector, but not to transfer any data

Time = Seek time + Rot. Latency + Overhead

$= 5.6\text{ms} + \frac{0.5}{\left(\frac{15000}{60}\right)} + 0.5\text{ms}$

$= 5.6\text{ms} + 2\text{ms} + 0.5\text{ms} = \underline{8.1\text{ms}}$

5.1 a) **7 / 7**

✓ **- 0 pts** Correct

- 2 pts double up calculation for platters

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5) 15000 RPM 424 sectors/track 512 B/sector, 12 platters, 14,100 cylinders

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gradescope

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5.3 c) **7 / 7**

✓ **- 0 pts** Correct

- 1 pts controller overheadtime not considered

- 1 pts rotational delay time wrong

- 3 pts complete the solution

gradescope

d) b = disk bandwidth
t = Avg access time

$$\text{Transfer time} = \frac{\text{Block}}{b} + t = \frac{64KB}{b} + t$$

∴ effective Bandwidth

$$= \frac{\text{Block size}}{\text{time}} = \boxed{\frac{64KB}{t + \frac{64KB}{b}}}$$

e) Disk bandwidth = 54.3 MB/s (from (b))

to saturate, sum of disk bandwidth must exceed Bus bandwidth

$$\frac{160 \text{ MB/s}}{54.3 \text{ MB/s}} = 2.9466 \text{ drives} \approx 3 \text{ drives}$$ Assuming data is being read continuously

∴ Without assuming a block size, It's possible to saturate the I/O bus with 3 drives

5.4 d) **6 / 6**

✓ **- 0 pts** Correct

- 0 pts based on your previous results

gradescope

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5.5 e) **6 / 6**

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- 0.5 pts marginal error

- 1 pts calculation mistake/ wrong approach

gradescope

f) Memory processor transfer rate: $\frac{4 \cdot 64 \text{ bits} \cdot}{8 \text{cycles}} = 4B/\text{cycle}$

M-P Bandwidth: $150 \times 10^6 \frac{\text{cycle}}{s} \cdot \frac{4B}{\text{cycle}} = \underline{600 MB/s}$

each I/O Bus has 160MB/s bandwidth, so the memory-processor Bus can handle

$$\frac{600 MB/s}{160 MB/s} = 3.75 \text{ I/O Busses to saturate}$$

round up to 4 I/O Busses to saturate the memory processor bus

g) Routing all I/O operations through the cache will put strain on the system because of the size of these blocks. since I/O often occurs in larger data transfer blocks, The entire data block from I/O being sent to the cache can overwrite cached data that is currently being utilized, but the entire block from I/O is unlikely to be needed all at once.

5.6 f) **6 / 6**

✓ **- 0 pts** Correct

- 2 pts wrong bandwidth

gradescope

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5.7 g) **6 / 6**

✓ **- 0 pts** Correct

- 1 pts provide more explanation

gradescope