1. Hardware Upgrade

1.1: 2 points

1 point for a correct answer.
1 point for adequate work - using the access time weighted by hit rate probabilities formula.

Average memory access time =
\[
T_{TLB} + (1 - P_{TLBMiss}) [T_{Cache} + P_{CacheMiss} T_{DRAM}] + \\
P_{TLBMiss} [2T_{DRAM} + (1 - P_{Fault}) [T_{Cache} + P_{CacheMiss} T_{DRAM}] + P_{Fault} T_{HDD}]
\]

Let Int1 = 6, Int2 = 3. Then,

\[
T_{avg} = 1 + (1 - .01) [1 + .01 \times 160] + .01 \times [2 \times 160 + (1 - .00002) [1 + .01 \times 160] + .00002 \times 13 \times 10^6]
\]

\[
T_{avg} = 9.4\text{ns}
\]

1.2: 2 points

1 point for choosing A, B, and C (all three must be chosen). No points awarded in this section if this answer is wrong.
1 point for the correct memory access time calculation.

Average memory access time =
\[
T_{TLB} + (1 - P_{TLBMiss}) [T_{Cache} + P_{CacheMiss} T_{DRAM}] + \\
P_{TLBMiss} [2T_{DRAM} + (1 - P_{Fault}) [T_{Cache} + P_{CacheMiss} T_{DRAM}] + P_{Fault} [T_{SSD} + P_{SSDMiss} T_{HDD}]]
\]

Let Int1 = 6, Int2 = 3. Then,

\[
T_{avg} = 1 + (1 - .01) [1 + .01 \times 160] + .01 \times [2 \times 160 + (1 - .00001) [1 + .01 \times 160] + .00001 \times [16 \times 1000 + 1 \times 7 \times 10^6]]
\]

\[
T_{avg} = 6.87\text{ns}
\]

2. Raid by RAID

2.1: 1 point

1 point for a correct answer.

4000 tracks * 6000 sectors * 512 bytes * 5 disks \(\approx\) 572.2\(\text{GiB}\)

2.2: 2 points

1 point for accessing disks 0, 2, 3, 4, and 5.
1 point for reconstructing disk 1 by XORing bits from the other disks.
2.3: 2 points

1 point for a correct answer.

Writing to block 0 access Disk 0 and Disk 5 (for parity). So, we must eliminate any writes to blocks that access these disks.

0: Obviously writes to Disk 0.
4: Parity writes to Disk 5.
8: Ok.
21: Ok.
24: Writes to Disk 5.
26: Parity writes to Disk 0.
30: Writes to Disk 0.
38: Ok.
32: Parity writes to Disk 5.

Valid blocks: 8, 21, 38.

3. Elevator

Let Int1 = 6, Int2 = 3.
Request order: 5, 23, 9, 14, 2, 20, 4, 10, 12, 16, 30
Initial floor: 11

3.1: 2 points

2 points for a correct answer.

To calculate, sum the pairwise differences between floors.

\[
\begin{align*}
&| 11 - 5 | + | 5 - 23 | + | 23 - 9 | + | 9 - 14 | + | 14 - 2 | + | 2 - 20 | + | 20 - 4 | + | 4 - 10 | \\
&+ | 10 - 12 | + | 12 - 16 | + | 16 - 30 | \\
&= 115 \text{ floors}
\end{align*}
\]

3.2: 2 points

2 points for a correct answer.

The next floor is the closest floor (for ties, earliest and closest floor).

\[
\begin{align*}
&| 11 - 10 | + | 10 - 9 | + | 9 - 12 | + | 12 - 14 | + | 14 - 16 | + | 16 - 20 | + | 20 - 23 | + | \\
&23 - 30 | + | 30 - 5 | + | 5 - 4 | + | 4 - 2 | \\
&= 51 \text{ floors}
\end{align*}
\]
3.3: 2 points

2 points for a correct answer (We accepted LOOK or C-LOOK for this).

C-LOOK: The next floor is the closest increasing floor (restarts at lowest floor when it reaches the end).

\[
\begin{align*}
| 11 - 12 | & + | 12 - 14 | + | 14 - 16 | + | 16 - 20 | + | 20 - 23 | + | 23 - 30 | + | 30 - 2 | + | 2 - 4 | + | 4 - 5 | + | 5 - 9 | + | 9 - 10 | \\
= 55 \text{ floors}
\end{align*}
\]

LOOK: The next floor is the closest increasing floor (goes reverse when it reaches the end).

\[
\begin{align*}
| 11 - 12 | & + | 12 - 14 | + | 14 - 16 | + | 16 - 20 | + | 20 - 23 | + | 23 - 30 | + | 30 - 10 | + | 10 - 9 | + | 9 - 5 | + | 5 - 4 | + | 4 - 2 | \\
= 47 \text{ floors}
\end{align*}
\]