Q1: Multilevel Index 20 points
1. 1st level index requires $\left\lceil \frac{50,000}{30} \right\rceil = 1667$ blocks.
2. 2nd level index requires $\left\lceil \frac{1667}{30} \right\rceil = 56$ blocks.
3. 3rd level index requires $\left\lceil \frac{56}{30} \right\rceil = 2$ blocks.
4. 4th level index requires 1 block which has only 2 entries.

Q2: Extendible hashed file a) b) c)

• Q2.a) 15 points
• Q2.b) 5 points

No. Each time you double the directory, the pointer always points to the corresponding data.

• Q2.c) 20 points

![Diagram](image)

Figure 2: Q2.c

Q3: Directory size 20 points

There are $\lceil N/B \rceil$ buckets. The directory size will be minimum if $2^d = \lceil N/B \rceil$. Solving for $d$, we get $d = \lceil \log_2 \lceil N/B \rceil \rceil$. So the smallest possible directory size is $2^{\lceil \log_2 \lceil N/B \rceil \rceil}$.

Q4: B+ Tree 20 points
Figure 3: Q4