Part 1

1. What is the hit rate? Why is it that much?
Settings: placement policy = direct mapping,
number of blocks = 128, cache block size = 4 bytes(1 word), cache size = 512 bytes

The cache hit rate is 0%, with 2560 cache misses and 0 cache hits.
Dimensions of the matrix in file "iteration-array-bad-loop.s" is 4*64 (= 1024 bytes), which is twice bigger than the cache size, so it always overwrites the data and non of the data can be used again. The cache block size is 1 word, so only 1 element can be stored in the cache each time.

2. **How many compulsory misses? Why is it that much?**
A compulsory miss occurs the first time a program accesses data or instructions, cause there is no relevant content in the cache.
The number of compulsory misses is equal to the number of matrix elements, which is 4*64 = 256.

3. How are the compulsory misses affected when Block Size is changed from 4 bytes to 8 bytes? Why does it change?
Settings: placement policy = direct mapping,
number of blocks = 128, cache block size = 8 bytes(2 words), cache size = 1024 bytes

We can store 2 words in the cache at a time with the block size changed from 4 bytes to 8 bytes, so the number of compulsory misses becomes 128.

4. Change the block size back to 4 again, and change the mapping from "direct mapping" to "2-ways set associative"? Explain why the hit rate does or doesn't change.
Settings: placement policy = 2-ways set associative,
number of blocks = 128, cache block size = 4 bytes(1 word), cache size = 512 bytes

The cache hit rate remains unchanged. Changing placement policy won't affect the total cache size, and it is still smaller than the matrix size.

5. What cache size improves the hit rate? Why is the hit rate improved? Try with both "direct mapping" and "2-ways set associative".
Both for "direct mapping" and "2-ways set associative", when cache size is equal to 1024 bytes, the cache hit rate improves. There is enough space in the cache to store all the elements of the matrix in the first iteration.
The cache hit rate is 90% when the number of blocks is 256 and the cache block size is 4 bytes (cache size = 1024 bytes). And when we change the cache block size so that the cache block size is 8 and the number of blocks is 128, the cache hit rate is 95%.
There is no change in increasing the cache size further.

6. At this "optimal" cache size (question 5), and "direct mapping", what hit rates do you obtain by changing the Block size? Try with the sizes 4 bytes, 8 bytes and 16 bytes.

The results for 8 bytes is at 95% and 16 bytes is at 98%, but 4 bytes is 90%.

7. Show how the achieved hit rate (as shown by simulator) can be computed (by hand) for different block sizes for the "optimal" cache size you found in question 5. Hint: what is the size of a single element in the array?

Cache Hit Rate =
[Number of Iterations - (Matrix Size / Block Size)] / Number of Iterations * 100%

Part 2

1. Does the hit rate improve? Why (show computation)?

Settings: placement policy = direct mapping,
number of blocks = 128, cache block size = 4 bytes(1 word), cache size = 512 bytes

Nope, the hit rate is 0%. The cache can only store one element of the matrix at a time, and the cache size is smaller than the matrix size. Consequently, data overwrites occur in the cache, rendering it unusable in the next iteration.

2. Change the Block Size to 8 bytes? Does the hit rate improve? Why (show computation)?

Settings: placement policy = direct mapping,
number of blocks = 64, cache block size = 8 bytes(2 words), cache size = 512 bytes

Yes, the hit rate is 50%. The matrix size is still larger than the cache size, data overwrites occur, leading to an overall hit rate of 50%.

3. Change the Block Size to 16 bytes? Does the hit rate improve? Why (show computation)?

Settings: placement policy = direct mapping,
number of blocks = 32, cache block size = 16 bytes(4 words), cache size = 512 bytes

Yes, the hit rate is 75% because for every time we miss we load the whole row into the cache. So for every cache miss we will have 3 hits.

4. Change the Cache Size to 1024 bytes and Reset the Block Size to 4 bytes. What is the hit rate? Compute this hit rate by hand.

Settings: placement policy = direct mapping,
number of blocks = 256, cache block size = 4 bytes(1 word), cache size = 1024 bytes

The hit rate is 90%.

The Hit Rate = [(64*4*10) - (64*4/ 1)] / (64*4*10) * 100% = 90%

5. Change Block Size to 8 bytes. What is the hit rate? Compute this hit rate by hand.

Settings: placement policy = direct mapping,
number of blocks = 128, cache block size = 8 bytes(2 words), cache size = 1024 bytes

The hit rate is 95%.
The Hit Rate = [(64*4*10) - (64*4/ 2)] / (64*4*10) * 100% = 95%

6. Change Block Size to 16 bytes. What is the hit rate? Compute this hit rate by hand.

Settings: placement policy = direct mapping,
number of blocks = 64, cache block size = 16 bytes(4 words), cache size = 1024 bytes

The hit rate is 98%.
The Hit Rate = [(64*4*10) - (64*4/ 4)] / (64*4*10) * 100% = 98%

8. Can a perfect hit rate of 1.0 be achieved without changing the program? Why?

No. Because the cache always starts with an empty cache, there is at least one miss and it is impossible to achieve a perfect hit rate of 1.0.