On my honor, I have not given, nor received, nor witnessed any unauthorized assistance on this work.

Print name and sign: _____

Question:	1	2	3	Total
Points:	12	8	10	30
Score:				

1. (6 points) When we virtualize memory, we have three primary goals (listed below). Provide a (brief!) explanation of each goal with respect to memory virtualization.

   (a) (2 points) transparency

   (b) (2 points) efficiency

   (c) (2 points) protection

2. Assume a system is using base and bounds with the following system characteristics:

   - a 1KB (1024 bytes) virtual address space
   - a base register set to 10000
   - a bounds register set to 100

   For each of the **virtual addresses**, give the corresponding physical memory location or state that it would generate a fault.

   (a) (2 points) 0 _____

   (b) (2 points) 99 _____

   (c) (2 points) 100 _____

   (d) (2 points) 1000 _____

3. Consider a system uses segmentation and has 2 segments:

   - segment 0 for code and a positive growing heap (grows towards higher addresses)
   - segment 1 for a negatively-growing stack (grows towards smaller addresses).

   This system has a virtual address space size of only 128 bytes, and there is only 1K of physical memory.

   Below is a memory trace from a program. In particular, the trace tells you which virtual address (VA) was accessed (in both hex and decimal), and then whether or not the access was valid or not, and what segment the virtual address tried to access (thus, you **do not** need to map these addresses to segments yourself).

   If valid, the physical address (in both hex and decimal) are reported. Magically, this program kept running after memory-access violations, and thus we have a long trace.

```
VA 0x0000006c (decimal: 108) --> VALID in SEG1: 0x000003ec (decimal: 1004)
VA 0x0000001d (decimal: 29) --> VALID in SEG0: 0x0000021d (decimal: 541)
VA 0x00000050 (decimal: 80) --> SEGMENTATION VIOLATION (SEG1)
VA 0x0000001e (decimal: 30) --> SEGMENTATION VIOLATION (SEG0)
VA 0x00000058 (decimal: 88) --> VALID in SEG1: 0x000003d8 (decimal: 984)
VA 0x00000061 (decimal: 97) --> VALID in SEG1: 0x000003e1 (decimal: 993)
VA 0x00000035 (decimal: 53) --> SEGMENTATION VIOLATION (SEG0)
VA 0x00000021 (decimal: 33) --> SEGMENTATION VIOLATION (SEG0)
VA 0x00000064 (decimal: 100) --> VALID in SEG1: 0x000003e4 (decimal: 996)
VA 0x0000003d (decimal: 61) --> SEGMENTATION VIOLATION (SEG0)
VA 0x0000000c (decimal: 12) --> VALID in SEG0: 0x0000020c (decimal: 524)
VA 0x00000005 (decimal: 5) --> VALID in SEG0: 0x00000205 (decimal: 517)
VA 0x0000002f (decimal: 47) --> SEGMENTATION VIOLATION (SEG0)
```

   (a) (2 points) From this trace, what was the base register of segment 0 set to? _____

   (b) (2 points) From this trace, what was the bounds register of segment 0 set to? _____

   (c) (2 points) From this trace, what was the base register of segment 1 set to? _____

   (d) (2 points) From this trace, what was the bounds register of segment 1 set to?

   Hint: You cannot state a precise value. Give a range. _____

(e) (2 points) The mechanism of segmentation often leads to **external fragmentation**. Explain what fragmentation is and how it occurs.