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CMPSCI 377 Sample Exam

This sample midterm is not to scale: there will be more short answer and true false questions.

1. Short Answer

a) Explain why modern operating systems use a hierarchical multi-level page tables

b) What does TLB stand for and how does it make a machine faster?

c) d) Explain the generational hypothesis.

2. Memory Management

Given the following code:

```
char *ptr = malloc (10)  
free ptr;  
free ptr;
```

The allocator you wrote for project two will probably crash. This is referred to as a “double free” and is actually a frequent programming error. Some allocators can handle this kind of error gracefully.

This is what my free code looks like (some details are omitted, but assume this works):

```
free(void *ptr){  
  
    BibopHeader *bbh  
    FreeObject *fo_ptr = (FreeObject *) ptr;  
  
    bbh= find_bbheader (ptr);  
  
    unsigned int num_objects = maxobjects(bbh); // Gives number of possible objects in page  
  
    // A  
    *((FreeObject **)fo_ptr) = bbh->_freeList;  
    bbh->_freeList = fo_ptr;  
    // B  
  
    bbh->_available++;  
  
    // Free and unlink the page if it is empty  
    free_page_if_empty(bbh);  
}
```

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I propose fixing double frees by changing the code between // A and // B to read:

```
unsigned int addr_free = (unsigned int) *((FreeObject **)fo_ptr);
unsigned int addr_bbh = (unsigned int) bbh;
if ((addr_free < addr_bbh) || (addr_free > addr_bbh+PAGESIZE)){
    *((FreeObject **)fo_ptr) = bbh->_freeList;
    bbh->_freeList = fo_ptr;
}
```

What is the logic behind this?

Does this work? Sometimes? Why or why not?

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3. Address Spaces

Consider a computer with the following properties:

- 32-bit addresses, byte addressing
- #define PAGE_SIZE = 256 = 2^8
- A page table entry occupies 4 bytes

Consider a program with valid addresses in two ranges:

0x00000000->0x00008000 and 0xffffbfff->0xffffffff are occupied.

Hint: 0x8000 is 2^{15} and $0xffffffff - 0xffffbfff = 0x4000 = 2^{14}$

a) If single level page tables are used, how much space does the table consume?

b) If a three level page table with 12 bits for level 1, 4 bits for level 2, and 8 bits for level 3, how much space is used?