

Name (PRINTED):	_____		
University ID #:	_____		
Circle your TA's name:	David	Brandon	
Circle your discussion time:	10:00	11:00	12:00

CMSC 330

Exam #2

Fall 2008

Do not open this exam until you are told. Read these instructions:

1. This is a closed book exam. **No notes or other aids are allowed.**
2. **You must turn in your exam immediately when time is called at the end.**
3. This exam contains 9 pages, including this one. **Make sure you have all the pages.** Each question's point value is next to its number. **Write your name on the top of all pages before starting the exam.**
4. In order to be eligible for as much partial credit as possible, show all of your work for each problem, and **clearly indicate** your answers. Credit **cannot** be given for illegible answers.
5. If you finish at least 15 minutes early, bring your exam to the front when you are finished; otherwise, wait until the end of the exam to turn it in. Please be as quiet as possible.
6. If you have a question, raise your hand. If you feel an exam question assumes something that is not written, write it down on your exam sheet. Barring some unforeseen error on the exam, however, you shouldn't need to do this at all, so be careful when making assumptions.
7. If you need scratch paper during the exam, please raise your hand. Scratch paper must be turned in with your exam, with your name and ID number written on it. Scratch paper **will not** be graded.
8. Small syntax errors will be ignored in any code you have to write on this exam, as long as the concepts are correct.
9. The Campus Senate has adopted a policy asking students to include the following handwritten statement on each examination and assignment in every course: "*I pledge on my honor that I have not given or received any unauthorized assistance on this examination.*" Therefore, **just before turning in your exam**, you are requested to write this pledge **in full** and **sign it** below:

Good luck!

1	2	3	4	Total

1. [25 pts.] **Short Answer.**

- a. [4 pts.] List the free variables of the following OCaml function
- `f`
- :

```
let f a y =  
  let g z = a + b + z in  
  let w = (g a) * z in  
  w + b
```

Answer: `z, b`

- b. [4 pts.] Given an expression
- `e1; e2`
- in OCaml, the OCaml compiler will issue a warning if
- `e1`
- does not have type
- `unit`
- . Explain the rationale behind this warning.

Answer: The type `unit` (and corresponding value `()`) indicate an uninteresting result. If `e1` produces a non-`unit` value, that suggests the result may be meaningful. But `e1; e2` throws away the result of computing `e1`. Hence if the compiler sees that `e1` produces a meaningful result that is then discarded, it suggests you might have some bug in your program, because you're performing computation and then throwing away the result.

- c. [4 pts.] In class, I said that everyone basically agrees it is a bad idea to use call-by-name as a parameter passing mechanism in an imperative language. Explain why.

Answer: Under call-by-name, it is very hard to predict when a parameter will be evaluated, since it will not happen until that parameter is actually used. This makes it extremely difficult to determine the order that side effects occur in, which in turn makes it hard to predict the behavior of a program.

- d. [8 pts.] Apply beta reduction to the following lambda calculus term until no more reductions are possible. Show each individual step of beta reduction (i.e., don't skip steps).

$(\lambda x.\lambda y.\lambda z.z\ x\ y)\ (\lambda a.a)\ (\lambda b.\lambda c.b)\ (\lambda d.\lambda e.e)$

Answer:

$$\begin{aligned}(\lambda x.\lambda y.\lambda z.z\ x\ y)\ (\lambda a.a)\ (\lambda b.\lambda c.b)\ (\lambda d.\lambda e.e) &\rightarrow (\lambda y.\lambda z.z\ (\lambda a.a)\ y)\ (\lambda b.\lambda c.b)\ (\lambda d.\lambda e.e) \\ &\rightarrow (\lambda z.z\ (\lambda a.a)\ (\lambda b.\lambda c.b))\ (\lambda d.\lambda e.e) \\ &\rightarrow (\lambda d.\lambda e.e)\ (\lambda a.a)\ (\lambda b.\lambda c.b) \\ &\rightarrow (\lambda e.e)\ (\lambda b.\lambda c.b) \\ &\rightarrow (\lambda b.\lambda c.b)\end{aligned}$$