COMS W4115
Programming Languages and Translators
Homework Assignment 2

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Due April 23rd, 2007
at 1:10 PM (beginning of class)

Submit solution on paper (no email). Please write your name clearly on the paper.

Do this assignment alone. You may consult the instructor and the TAs, but not other students.

1. For each of the following lambda expressions, write its normal form or explain why it does not have one.

   (a) $+ \ 1 \ 2$

   (b) $\lambda x \,.\, + \ x \ 3$

   (c) $(\lambda x \,.\, + \ x \ 3)\ 5$

   (d) $(\lambda x \,.\, \lambda y \,.\, * \ (+ \ x \ 2) \ y)\ 2$

   (e) $(\lambda x \,.\, \lambda y \,.\, * \ (+ \ x \ 2) \ y)\ 2 \ 3$

   (f) $(\lambda x \,.\, x \ x)(\lambda x \,.\, x \ x)$

2. Consider the following C-like program.

```
int w = 3;
int x = 10;

int incw() { return ++w; }
int incx() { return ++x; }

void foo(y, z){
  printf("%d\n", y + y);
  x = 1;
  printf("%d\n", z);
}

int main() {
  foo(incw(), incx());
  return 0;
}
```

   What does it print if the language uses

   (a) Applicative-order evaluation?

   (b) Normal-order evaluation?

3. In an assembly-language-like notation (e.g., use MIPS or a pseudocode of your own choosing), write what a good optimizing compiler would produce for the following two `switch` statements. Assume they are in separate functions (i.e., compiled separately).

```
switch (a) {
case 1: x = 3; break;
case 2: x += 5; break;
case 3: y = 15; break;
case 4: z = 20; break;
case 5: x = z + 23; break;
default: x = 28; break;
}

switch (b) {
case 1: p = 3; break;
case 10: p = 5; break;
case 100: q += 15; break;
case 1000: r = q + 20; break;
default: r = 25; break;
}
```

4. For a 32-bit little-endian processor with the usual alignment rules, show the memory layout and size in bytes of the following C types.

```
union {
  struct {
     char b; /* 8-bit */
     int a;  /* 32-bit */
  } s;
  short c;   /* 16-bit */
} u1;

struct {
  char a;
  short b;
  int c;
  char d;
} s1;

struct {
  char a;
  char d;
  short b;
  int c;
} s2;
```