Programming Languages G22.2110 Summer 2007
Final Exam

8/2/2007

1. Pointer arithmetic ($20 = 10 \cdot 2$ points)
   Consider the following C variable declarations:

   ```
   long long p[3][3];
   long long (*q)[3] = &p[2];
   long long *r = &p[2][2];
   ```

   Assume that the array `p` starts at address `1000`, and that `sizeof(long long) == 8` and `sizeof(int) == 4`. What are the numeric values of each of the following expressions?

   1a. (2 points) `q`

   1b. (2 points) `q + 1`

   1c. (2 points) `q - 1`

   1d. (2 points) `q - p`

   1e. (2 points) `(long long*)q - (long long*)p`

   1f. (2 points) `(int*)q - (int*)p`

   1g. (2 points) `r`

   1h. (2 points) `r + 1`

   1i. (2 points) `r - &p[2][0]`

   1j. (2 points) `r - &p[1][0]`

2. Type equivalence and compatibility ($20 = 5 \cdot 4$ points)

   2a. (4 points) Give an example of two types that are structurally equivalent but not name equivalent.

   2b. (4 points) Give an example of two types that are not structurally equivalent.

   2c. (4 points) Give an example of two types such that one is compatible with the other, but they are not equivalent.

   2d. (4 points) Is type compatibility symmetric? In other words, if type A is compatible with type B, does that imply that type B is also compatible with type A? Briefly explain your answer.

   2e. (4 points) Is type compatibility transitive? In other words, if type A is compatible with type B, and type B is compatible with type C, does that imply that type A is also compatible with type C? Briefly explain your answer.

3. Virtual method dispatch ($20 = 5 \cdot 4$ points)
Consider the following Java definitions:

```
interface I { public void a(); public void c(); }
class S { public void a() {} void b() {} }
class T extends S { public void c() {} }
class U extends T implements I { public void a() {} }
class V extends S { public void a() {} void d() {} }
class W extends V implements I { public void c() {} }
```

3a. (4 points) What is the vtable of class `S`?

3b. (4 points) What is the vtable of class `T`?

3c. (4 points) What is the vtable of class `U`?

3d. (4 points) What is the vtable of class `V`?

3e. (4 points) What is the vtable of class `W`?

4. Type inference ($20 = 3 + 3 + 3 + 11$ points)
Consider the following SML function:

```
fun q (_, x, 1) = x | q (s, y, n) = s (y, q (s, y, n - 1));
```

4a. (3 points) What is the result of "`q (op *, 2.0, 4);`"?

4b. (3 points) What is the result of "`q (op +, 2.0, 4);`"?

4c. (3 points) What is the type of `q`?

4d. (11 points) Show the type inference steps for `q`.

5. Parameter passing modes ($20 = 4 \cdot 5$ points)
Consider the following program in pseudo-C:

```
char x[3];
int y;
void f(char@ z) {
  y--;
  z = 'd';
  x[2] = x[1];
}
int main() {
  x[0] = 'a', x[1] = 'b', x[2] = 'c';
  y = 1;
  f(x[y]);
  printf("%c %c %c\n", x[0], x[1], x[2]);
}
```

5a. (5 points) What does the program print if `z` is passed by value?

5b. (5 points) What does the program print if `z` is passed by value-result?

5c. (5 points) What does the program print if `z` is passed by reference?

5d. (5 points) What does the program print if `z` is passed by name?
