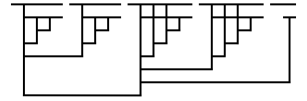# CMSC330 Fall 2025 Quiz 4

Proctoring TA: _____   **Name:** _____

Section Number: _____   **UID:** _____

Problem 1: Lambda Calc   [Total 6 pts]

For each of the following expressions (a-c), select its beta normal form (BNF) or the alpha equivalent to its BNF.

(a) $(\lambda j.jj)(\lambda q.q)$?   [1 pts]

   (A) $(\lambda q.q)(\lambda q.q)$ (B) q (C) j (D) $\lambda j.j$ (E) has no BNF (F) None of the other options

(b) $(\lambda j.\lambda q.jq)(\lambda l.qlq)(\lambda m.j)$?   [1 pts]

   (A) $q(\lambda m.q)q$ (B) $q\,q$ (C) $\lambda g.(\lambda l.q\,l\,q)\,g$ (D) has no BNF (E) None of the other options

(c) $(\lambda a.\lambda b.ab)(\lambda x.xx)(\lambda y.yy)$?   [1 pts]

   (A) $\lambda b.(\lambda x.xx)$ (B) has no BNF (C) $b\,b$ (D) $\lambda x.xx$ (E) None of the other options

Scratch space:

(d) Reduce the following lambda expression to its beta normal form, one step (beta reduction) at a time. Then, draw a box around your final answer: [3 pts]
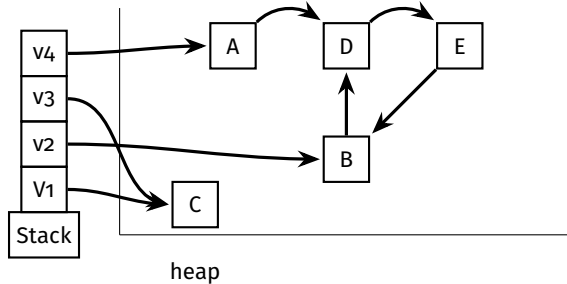
$(\lambda a.\lambda b.bab)\ (\lambda x.\lambda x.x)\ (\lambda a.a)$

Problem 2: Garbage Collection

Suppose that $v4$, $v3$ and $v2$ are popped off the stack. Draw the stack and heap after this occurs if we are using the **reference counting** garbage collection technique.

heap

heap

Problem 3: Rust Ownership and references

If there is no owner (because the value has been dropped) put "None". Assume that we are asking about ownership **during** execution.

```
fn get_char(input: &String) -> char {
    // Mark 4
    input.chars().last().unwrap()
}

fn string_uppercase(mut muty: String) {
    // Mark 5
    muty = muty.to_uppercase();
    println!("{muty}");
}

fn main() {
    let data = String::from("Hello");
    // Mark 1
    get_char(&data);
    // Mark 2
    string_uppercase(data);
    // Mark 3
}
```

Who is the owner of the String with contents "Hello" at Mark 1?

Who is the owner of the String with contents "Hello" at Mark 2?

Who is the owner of the String with contents "Hello" at Mark 3?

Who is the owner of the String with contents "Hello" at Mark 4?

Who is the owner of the String with contents "Hello" at Mark 5?