2 Algorithms II (FMS)

(a) Briefly explain the concurrency keywords “spawn”, “sync” and “parallel for”.

(b) Define what a “determinacy race” is and list the precise circumstances under which one may occur.

(c) In less than 10 lines of pseudocode, give a clear example of a determinacy race (but not the same example as in the textbook or the course handout) and briefly explain why it is one.

(d) Do any of the two following pseudocode functions contain determinacy races? Justify and explain your answer for each of the two pieces of code.

```python
def fibonacci(n):
    if n <= 1:
        return n
    else:
        x = spawn fibonacci(n - 1)
        y = fibonacci(n - 2)
        sync
        return x + y

def matrixMultiply(A, B):
    # PRECONDITION: A and B are square matrices of the same size
    n = A.rows
    let C be a new n x n matrix
    parallel for i = 1 to n:
        parallel for j = 1 to n:
            C[i,j] = 0
            for k = 1 to n:
    return C
```

(e) Give an example of a circumstance in which a multithreaded algorithm containing a determinacy race might still be correct. For each of the races you found and discussed in (d), if any, state whether this circumstance applies.