

COMPUTER SCIENCE TRIPOS Part IB – 2023 – Paper 4

3 Concepts in Programming Languages (am21)

(a) A programmer reviewing a multi-file Java program containing

```
class A { protected final int a; public A() { a=3; }
        public int query() { return a; }}
class B extends A { protected final int b;
                    public B() { b=1; }
                    public int query() { return a*b; }}
```

reasons that `int q(A x) { return x.query(); }` “must always return 3”.

- (i) Giving reasons, agree or disagree with the programmer. [3 marks]
- (ii) Might appropriately inserting `final` change your answer? [2 marks]
- (iii) Give a name for the property being discussed, along with a brief statement of what it requires. [3 marks]

(b) A common bug-pattern can be exemplified in pseudo-Java by

```
class Database {
    private List<MyRecord> data;
    public void insert(MyRecord x) { data.add(x); }
    public void tidy() { /* may mutate items in data */ }
}
class User {
    public void foo(Database db) {
        var x = new MyRecord(...);
        int memo = x.field;
        db.insert(x); ...; db.tidy();
        assert (x.field == memo) raising "SomeOneIsConfused";
    }
}
```

- (i) Why might the programmer have added the assertion? [2 marks]
- (ii) Give two possible ways a “coding standards” document for the project could have protected against the assertion failing, in both cases summarising any modifications required to the above code. [6 marks]
- (iii) Name a language which provides a compile-time mechanism to express such coding-standard requirements. Indicate briefly, and in no particular syntax, the coding concept involved. [4 marks]