Optimising Compilers (tmj32)

The following excerpt from a program in C-style code is optimised with a compiler using code-motion transformations. The function `read()` returns a signed integer from the user.

```
10:   a = read();
11:   b = read();
12:   p = &a;
13:   q = &b;
14:   r = &p;
15:   if (read() > 0) {
16:      a = b + 5;
17:   } else {
18:      i = 0;
19:      while (i < 10) {
20:         c = b + 5;
21:         **r += *q;
22:         i += 1;
23:      }
24:      a += c;
25:   }
26:   print(a);
```

(a) Describe loop-invariant code motion (LICM) and which expression(s) in the loop above it should move. [2 marks]

(b) Describe a simple data-flow analysis and a way of using it to identify loop-invariant expressions. Use this to analyse the code above. [5 marks]

(c) Explain whether all expressions described in Part (a) are found through the analysis in Part (b). [2 marks]

(d) Describe an analysis that can aid in making LICM more precise in this example. [3 marks]

(e) Apply the analysis from Part (d) to the code above and redo the analysis from Part (b) to show which expressions described in Part (a) are now found. [4 marks]

(f) Describe another code motion transformation that could be applied to the code after LICM and show the final code after its application. [4 marks]