1 Control Graph, Dominator and Post-Dominator (25p)

(a) Construct the control flow graph for the below code snippet. Please also list the dominators and immediate post-dominators for 3, 5, 6, 7, 8, and 17.

1. n=input();
2. s=0;
3. if (n>10)
   4. return;
5. while (n>0) {
   6. if (s>10) {
      7. while (n>0) {
   8.     s=s-n;
   9.     n=n-1;
   10. }
   11. break;
   12. }
13. s=s+2;
14. n=n-1;
15. }
16. if (s>0 &&
17.     s%2==0) {
18.     s=s+1;
19. }

(b) Prove that a statement has only one immediate post-dominator (8p).

2 Program Dependence Graph (20p)

Build the program dependence graph for the code in problem 1. If the graph is too crowded, you can separate it to two subgraphs: data dependence graph and control dependence graph.
3 Trace Compression (10p)
Let a plain text string be
\texttt{a b a b c d c b a b c b}.
Assume the initial lookup table is
\begin{center}
\begin{tabular}{|c|c|}
\hline
Context & Prediction \\
\hline
ab & a \\
bc & a \\
cd & b \\
\hline
\end{tabular}
\end{center}
Use FCM-2 to compress the string. The final compressed string and the final lookup table are required. Intermediate steps are not required but encouraged.

4 Path Profiling (25p)
\begin{verbatim}
1. if (p1)
2.    s0;
3. while (p2) {
4.   if (p3) {
5.     s1;
6.     continue;
7.   }
8.   while (p4) {
9.     s2;
10.    s3;
11. }
12. }
13. if (p5)
14.    s4;
\end{verbatim}
(a) Construct the path enumeration graph for the above program. Show the path encoding.
(b) Show the final instrumented program, executing which collects the path profile.

5 Predicate Tracing (20p)
Predicate tracing is a control flow tracing technique that records the branch outcomes of predicates. For example,
\begin{verbatim}
1. if (...) 
2.   if (...) 
3.    s0;
4.   if (...) 
5.    s1 
6.    s2;
\end{verbatim}
The trace 1 2 3 4 6 for the above program can be represented as T T F. Three bits are needed.

(a) Please list the challenges for making the above idea work on real world programs. You can assume C or Java languages.

(b) Sketch solutions to such challenges.

Using examples is encouraged.