1 Control Graph, Dominator and Post-Domintor (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.

```java
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:

\[a \ b \ a \ b \ c \ d \ c \ b \ a \ b \ c \ b.\]

Assume the initial lookup table is:

<table>
<thead>
<tr>
<th>Context</th>
<th>Prediction</th>
</tr>
</thead>
<tbody>
<tr>
<td>ab</td>
<td>a</td>
</tr>
<tr>
<td>bc</td>
<td>a</td>
</tr>
<tr>
<td>cd</td>
<td>b</td>
</tr>
</tbody>
</table>

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)
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;

(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,

1. if (...) 
2. if (...) 
3. s0;
4. if (...) 
5. s1
6. s2;
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.