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1 Internal representation. [10 points.]

Construct an AST for the following C program:

```c
double sumorprod(a, n, i)
    double a[100];
    int n;
    int i;
{
    double acc;
    int j;
    if (i == 0)
    {
        acc = 0.0;
        for (j=0; j < 100; j++)
            acc += a[j];
    }
    return acc;
}
```
2. Control Flow Graphs. [20 points.]

For each of the following two flow graphs, determine whether it is reducible or irreducible. If it is reducible show the reduction by intervals and clearly indicate each component of each interval. If the graph is irreducible, explain why.

(A) 

(B)
3. **Static Single Assignment. [20 points.]**
   (a) Transform the following program into SSA form

   ```
   x=a
   if (x==b) then
     y=c
   else
     y=d
   end if
   j=1
   if (x==e) then
     i=1
     s=0
     while (i<100) {
       s=s+i
       i=i+1
     }
   else
     j=j+1
   end if
   return j
   ```

   (b) Apply dead-code elimination based on the SSA program. Explain (briefly) the algorithm you use and show the result.
4. Data flow analysis. [20 points.]
For the following flow graph, compute the reaching definitions in sets. Use the tables below in your computations.

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```

(1) a = 1
(2) b = 2
(3) c = a + b
(4) d = c - a
(5) d = b * d
(6) d = a + b
(7) e = e + 1
(8) b = a + b
(9) e = c - a
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5. Data flow analysis [20 points]

Which data flow analysis problems can be used to detect uninitialized uses of local variables in a procedure on (a) some path from the initial node, and (b) all paths from the initial node? Explain.
6. Dependence Analysis [20 points]

Compute the dependence graph and the direction vectors for the following loop.

```
do i=1,n
    S1 a=a+1
    S2 y=a^2
    S3 z(i)=y+v(i)
    S4 a=x(i+1)+x(i-1)
    S5 x(i)=w(i)+1
    S6 w(i+1)=x(i)+1
end do
```
7. Dominators [20 points]

a) Prove that if $a$ and $b$ are two dominators of $n$, then either $a \ dom b$ or $b \ dom a$ must hold.

b) Prove that if a definition $d$ is in $IN[B]$, then there is some acyclic path from the block containing $d$ to $B$ such that $d$ is in the IN’s and OUT’s all along that path.