This assignment contains 3 questions, for a total of 8 points. It is OK to write/draw by hand and then scan (or take a photo of) your answer, and then upload that scan/photo.

**Q1** (3 pts): Consider the control-flow graph (CFG) shown below. For each node, describe the immediate dominator of that node. Based on this information, describe all back edges in the graph. For each back edge, describe its natural loop — specifically, (1) the header of that loop, and (2) the set of nodes in that loop.

**Q2** (2 pts): Suppose node 2 from the above CFG contains instruction \( x = 3.14 \times 3.14 \). Further, suppose that \( x \) does not appear in any other instruction in the CFG. Can a compiler move this loop-invariant instruction from node 2 to node 1 in the CFG? Justify your answer.

**Q3** (3 pts): Consider the CFG below and Live Variables data-flow analysis for it. Show what variables are in sets OUT\[ENTRY\], OUT[1], ..., OUT[5]. (Note that, by definition, OUT[EXIT] = \( \emptyset \).) Based on your results, identify all dead code instructions—that is, each instruction that assigns to a variable that is not live immediately after the instruction.