Boolean Expressions for Simplification

1. F1(A,B,C,D) = AB¬C + A¬BC + ¬ABC + ABC + ¬A¬BC D + A¬B¬CD

2. F2(A,B,C,D) = (A+¬B+C)(¬A+B+¬C+D)(A+C+D)(¬B+¬C+¬D)

3. F3 = Σm(0,2,3,8,9,11,12,14)

4. F4 = (A+B¬C)(¬A+C+¬D) + BC¬D + A¬BD

5. F5 = ¬(A⊕B)C + (A⊕C)D

6. F6 = Σm(1,4,5,7,10,13)

7. F7 = (A+¬B+C+D)(¬A+B+¬C)(A+B+¬D)

8. F8 = A¬BC + AB¬C + ¬ABC + ¬A¬B¬C D + ABC

9. F9 = Σm(2,3,6,7,10,11,14,15)

10. F10 = AB + A¬C + ¬ACD + B¬CD + ¬BC

11. F11 = Σm(0,5,9,12)

12. F12 = (A⊕B)(C+¬D) + ¬AB¬C

Combinational Circuit

**Question 1 — 2-bit Multiplier (multi-output, K-map per output)**

Design a combinational circuit that multiplies two unsigned 2-bit numbers A=A1A0 and B=B1B0. The product P is 4 bits P3P2P1P0.  
  
Tasks:  
1. Write the full truth table (16 input rows → 4 output bits).  
2. For each output bit P3,P2,P1,P0: write the canonical minterm SOP, fill 4×4 K-maps, find minimal SOP.  
3. Show Boolean-algebra simplifications where helpful.  
4. Draw the final gate-level schematic for all outputs.

**Question 2 — Design Y = 3X + 1 for 3-bit unsigned X**

Design a combinational circuit that accepts a 3-bit unsigned input X=X2X1X0 and produces output Y such that Y = 3X + 1.  
  
Tasks:  
1. Produce the truth table (8 rows).  
2. Use K-maps to find minimal expressions for each output bit.  
3. Provide simplified Boolean expressions and the final gate schematic.

**Question 3 — Incrementer (3-bit, modulo 8)**

Design a combinational circuit which, given 3-bit input n=xyz, outputs a 3-bit result abc equal to n+1 modulo 8 (i.e., 111 → 000).  
  
Tasks:  
1. Produce truth table for all 8 inputs.  
2. Derive minimal expressions for a,b,c using K-maps.  
3. Give Boolean-algebra simplification and draw the gate schematic.

**Question 4 — Priority / Reservation System**

Specification: Suppose three operator stations provide stop signals s1,s2,s3 and additional signals wIN,wOUT. You must design logic outputs: Ready (true if none of the stop signals are asserted), Reset (true if any stop signal is asserted), and a Warning output that combines local and neighbor warnings according to a spec.  
  
Tasks:  
1. From the verbal specification, write precise Boolean specs for each output.  
2. Produce truth tables.