1. Sketch: VOUT WRT VIN and VRL WRT VIN for VREF = 0V

2. Find TON, DUTY CYCLE (%), VRL = VP * D and VRL (DVM) for:
   - VREF = -7V, -6V, -5V, -4V, -3V, -2V, -1V, 0V
   - +1V, +2V, +3V, +4V, +5V, +6V, +7V

3. Find VREF for 80% and 20% DUTY CYCLE. Sketch VRL, WRT, VIN

4. Demo
1. SET UP THE CIRCUIT WITH PIN #'S LABELED
2. FIND VREF FOR EACH OPAMP
3. FIND VIN FOR EACH LED TO TURN ON AND OFF
   MEASURE VDIFF FOR EACH OPAMP FOR THE VARIOUS
   CONDITIONS OF THE LED'S (JUST ON / JUST OFF)
4. FIND RANGE OF VIN FOR EACH LED ON AND OFF
5. DEMO
1. SET UP CIRCUIT WITH PIN #'S LABELED
2. FIND VREF FOR UPPER AND LOWER OPAMPS
3. FIND VIN FOR EACH LED TO TURN ON/OFF
4. CALCULATE VREF FOR EACH OPAMP, USING
   THE VALUES SHOWN IN THE ABOVE CIRCUIT ONLY

OP-13
ELECTRONIC CKTS

\[ \text{RF/R8} = 2 \quad \text{ALTERNATE VALUES} \quad 20K \text{ OR } 10K \]
\[ \text{RF/R10} = 1 \quad 10K, 5K \]

**TABULATE**

1. VIN, V1, V2, V3, V4, V5, \( \Rightarrow \) AC(Vp-p), AC(RMS), DC
2. VOUT: AC(Vp-p), AC(RMS), DC VALUE
3. SKETCH VOUT WAVEFORM (1) CRO DC COUPLED
   (2) CRO AC COUPLED. LABEL ZERO VOLT REFERENCE
4. PHASE OF VOUT WRT V4, V1, V2
5. DEMO

**OP-14**
RF/R8 = 1  USE 20K OR 10K
RF/R9 = 2  USE 10K, 5K OR 20K, 10K
R7/R6 = R5/R4 = 2  USE 100K, 49.9K

TABULATE: (I.D. OPAMP USED & PIN #’S)
1. V1, V2, V3, V4
2. VOUT AC AND DC VALUES, SKETCH, VIN, VOUT WAVEFORM (LABEL AC & DC VALUES) CRO DC COUPLED
3. PHASE OF VOUT WRT VIN (USE AC COUPLING)
4. DEMO