1. a. (5 points)
Calculate $v_1$.

![Diagram of a circuit with voltage sources and resistors](image)

b. (5 points)
Calculate $i_1$.

![Diagram of another circuit with voltage sources and resistors](image)
2. (30 points)

Derive an expression for $i_3$. The expression must not contain more than the circuit parameters $V_a, V_b, i_a, R_1, R_2,$ and $R_3$.

![Circuit Diagram]

3. (30 points)

a. Derive an expression for $i_2$. The expression must not contain more than the circuit parameters $\beta, V_a, i_a, R_1,$ and $R_2$.

![Circuit Diagram]

b. Make at least one consistency check (other than a units check) on your expression. Explain the consistency check clearly.

4. (30 points)

The op amp operates in the linear mode. Using an appropriate model of the op amp, derive an expression for $v_o$ in terms of not more than $i_s, R_1, R_2,$ and $R_3$.

![Circuit Diagram]