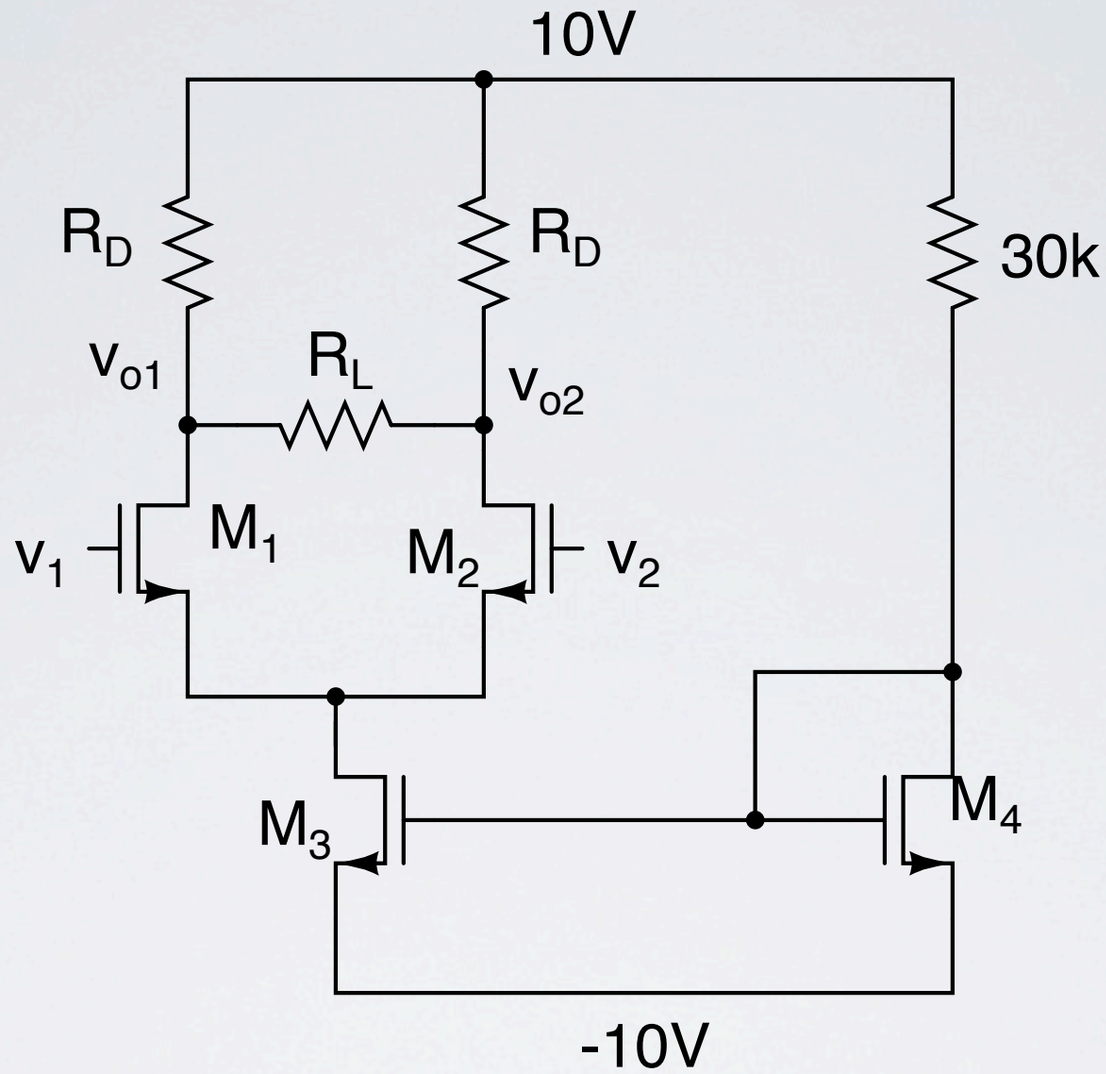
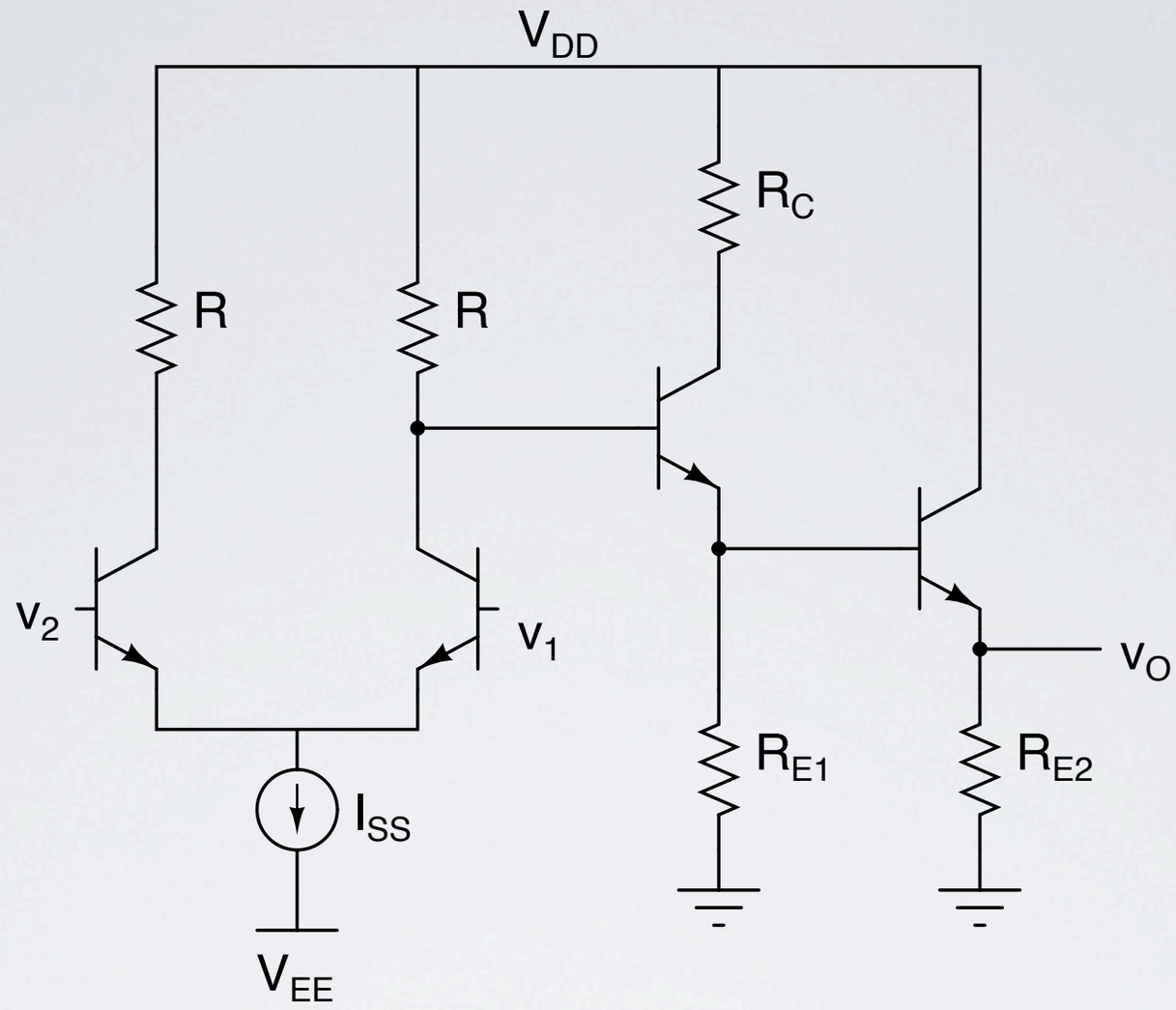
PRACTICE PROBLEMS

INEL 4202 - Exam 3 - April 2013

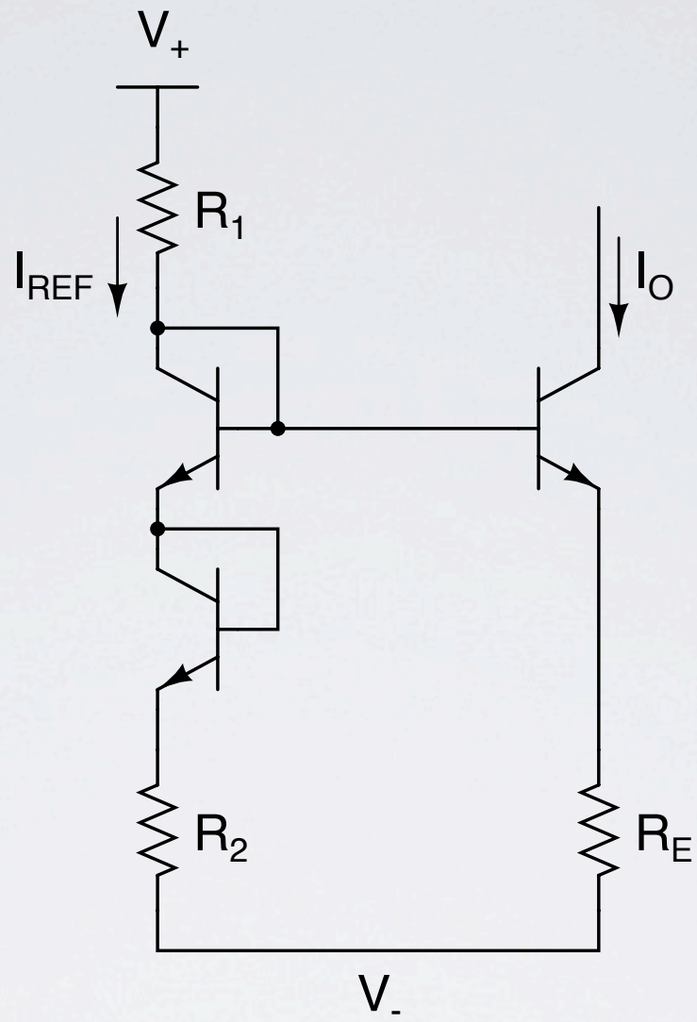


Assume $K_{n1}=K_{n2}=0.1mA/V^2$, $K_{n3}=K_{n4}=0.3mA/V^2$, $R_D=16k$, $V_{th}=1V$, $r_O=inf$. Find

1) dc currents
2) differential gain
3) common-mode gain v_{o1}/v_{CM}
4) R_{in} and R_{out}



Find an expression for the differential gain.

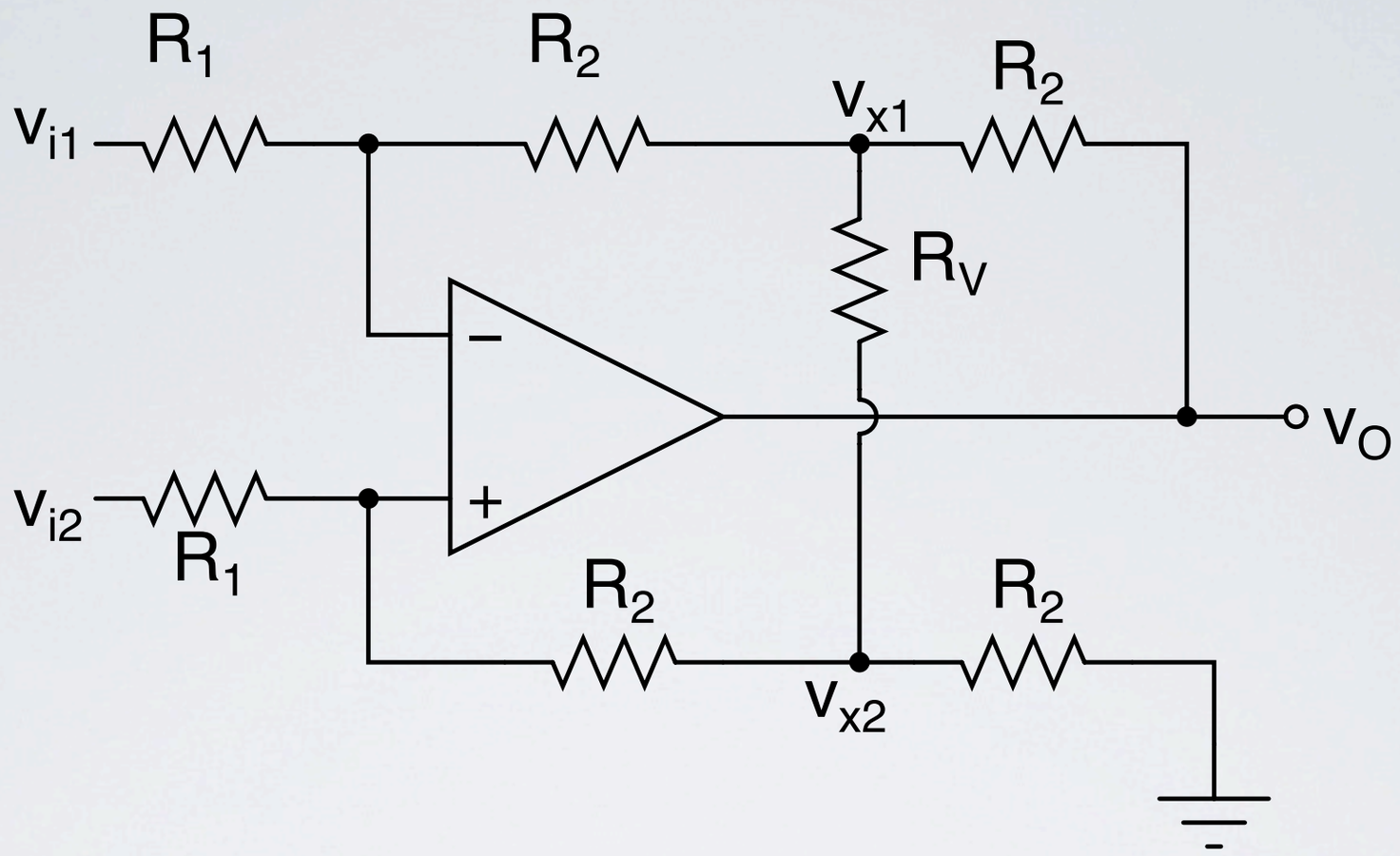


Find

a) an expression for I_O in terms of the bias voltages and resistor values

b) Show that if $R_1 = R_2$ and $I_O = I_{ref}$ then $I_O = (V_+ - V_-)/2R_E$

c) for $V_+ = -V_- = 5V$, design the circuit so that $I_O = 0.5uA$



For the above circuit, show that the output voltage is given by

$$v_O = \frac{2R_2}{R_1}\left(1 + \frac{R_2}{R_v}\right)(v_{i2} - v_{i1})$$

The opamp is ideal.

$$
\begin{aligned}
v_- &= v_+ = x \\
\frac{v_{i1} - x}{R_1} &= \frac{x - v_{x1}}{R_2} \Rightarrow v_{x1} = -\frac{R_2}{R_1} v_{i1} + x(1 + R_2/R_1) \\
\frac{v_{i2} - x}{R_1} &= \frac{x - v_{x2}}{R_2} \Rightarrow -v_{x2} = \frac{R_2}{R_1} v_{i2} - x(1 + R_2/R_1) \\
v_{x1} - v_{x2} &= -\frac{R_2}{R_1} v_{i1} + x(1 + R_2/R_1) + \frac{R_2}{R_1} v_{i2} - x(1 + R_2/R_1) \\
&= -\frac{R_2}{R_1} (v_{i1} - v_{i2}) \\
\frac{x - v_{x1}}{R_2} &= \frac{v_{x1} - v_O}{R_2} + \frac{v_{x1} - v_{x2}}{R_v} \Rightarrow x = 2v_{x1} - v_O + \frac{R_2}{R_v}(v_{x1} - v_{x2}) \\
\frac{x - v_{x2}}{R_2} &= -\frac{v_{x1} - v_{x2}}{R_v} + \frac{v_{x2}}{R_2} \Rightarrow x = 2v_{x2} - \frac{R_2}{R_v}(v_{x1} - v_{x2}) \\
2v_{x1} - v_O + \frac{R_2}{R_v}(v_{x1} - v_{x2}) &= 2v_{x2} - \frac{R_2}{R_v}(v_{x1} - v_{x2}) \\
v_O &= 2\left(1 + \frac{R_2}{R_v}\right)(v_{x1} - v_{x2}) \\
v_O &= \frac{2R_2}{R_1}\left(1 + \frac{R_2}{R_v}\right)(v_{i2} - v_{i1})
\end{aligned}
$$