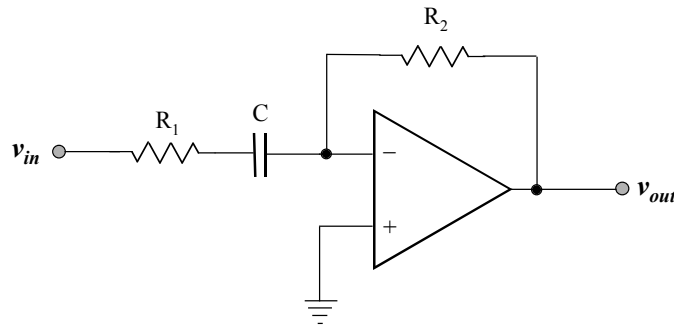


**Physics 623**  
**The Operational Amplifier: Lab worksheet**

*Please complete before coming to the lab on October 4*

1) In the lecture we have shown how to construct an integrator using an op-amp. With an op-amp it is possible to construct many mathematical operations. Another example is differentiation.

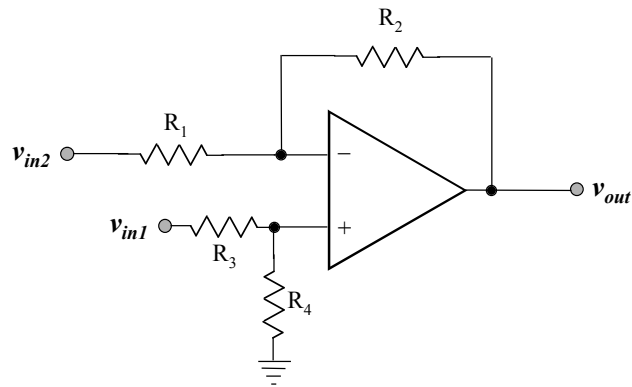
a) Find the relation between  $v_{in}$  and  $v_{out}$  for the below circuit.



b) Show that when  $R_1 \ll R_2$  the circuit works as a differentiator. Determine the differentiation error for the 741 op-amp.

2) With an op-amp, one can also construct a difference amplifier.

a) How does the output voltage relate to the two input voltages in the below circuit.



b) Show that when  $R_4/R_3=R_2/R_1$ , the circuit works as a difference amplifier. What is the voltage gain for a difference input?

3) In the below circuit, show that the current flowing through the load resistor,  $I_L$ , is independent of the load,  $R_L$ . What is  $V_{out}$ . This circuit constitutes a constant current source with a grounded load.

