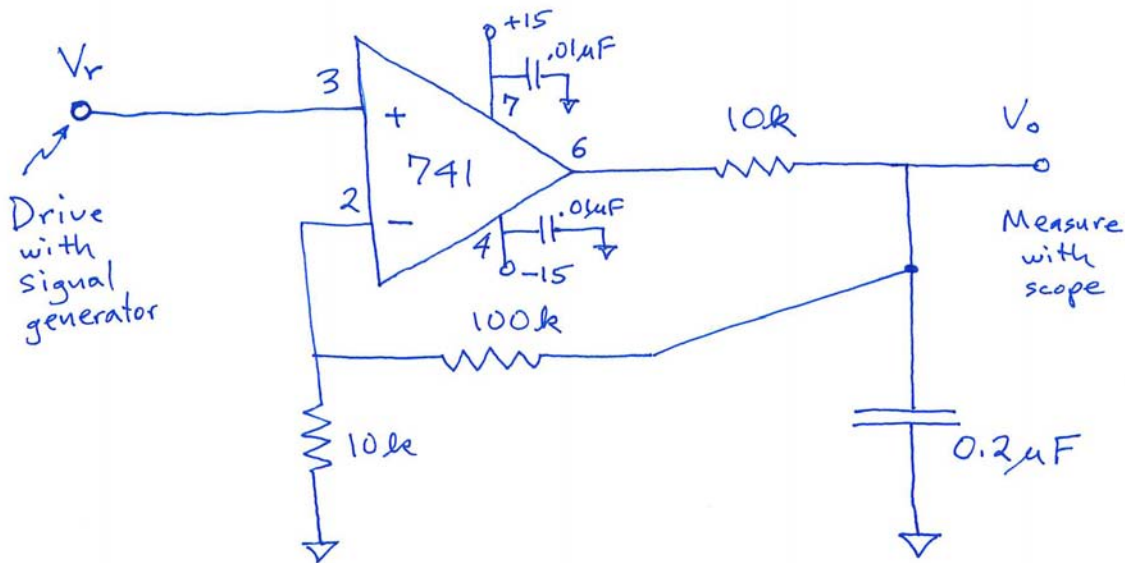## 2.14/2.140 Lab 4

Assigned: Week of Mar. 17, 2014
Due: Week of Mar. 31, in your lab session.

Lab 4 concerns the op-amp circuit shown below. You will use the NI myDAQ kit and protoboard to build and test this circuit, and compare your measured results against theory.

Build this circuit on the protoboard of your myDAQ kit. Be sure to connect power to the op amp and use the indicated bypass capacitors. For this circuit:

- Calculate the closed loop transfer function from reference V_r to output V_o. For this purpose, model the 741 op amp with the transfer function $V_{output}(s) = (6 \times 10^6/s)(v_+(s) - v_-(s))$, *i.e.*, $a(s) = 6 \times 10^6/s$, where V_{output} is the amplifier output voltage at pin 6.

- Analytically calculate the closed-loop step response. (Do not use any numerical program such as Matlab.)

- Make a carefully labeled and dimensioned Bode plot for the closed loop response. (Do not use any numerical program such as Matlab.)

- Use the scope and signal generator VIs in Labview to measure and plot the closed-loop step response. Compare with the analytical result from above.

- Use the scope and signal generator VIs in Labview to measure and plot the closed-loop frequency response. Compare with the analytical result from above.

Checkoff in lab session: In this week's lab session demonstrate to one of the teaching staff your working circuit and some experimental results. Progress shown in this checkoff will count towards half of your lab grade.

Answer sheets: At the start of your lab session during the week of March 31 you must submit your lab writeup, including the completed Lab 4 answer sheet. These write-ups are due at the start of the lab session, and will not be accepted late. Please include in your lab report clearly labeled answers and plots for all the questions above. This lab report will count towards half of your lab grade.

It is key that you submit your lab report on time at the start of the lab session.

2.14/2.140 Spring 2014 — Lab 4 Answer Sheet

Name: _____

Please complete this answer sheet and include it with your lab report. This will be the primary document that we will use to grade your work on Lab 4, so please be sure to fill in all requested information.

1. The closed-loop transfer function from reference V_r to output V_o is:

2. The closed-loop poles are located at:

   with natural frequency ω_n and ζ of:

3. An analytical expression for the closed loop step response is:

The following requested plots should be attached to this answer sheet:

1. A carefully labeled and dimensioned sketch of the analytical closed-loop step response. (This should be a hand-sketch. Do not use any numerical program such as Matlab.)

2. A carefully labeled and dimensioned Bode plot for the closed loop response. (This should be a hand-sketch. Do not use any numerical program such as Matlab.)

3. A well-scaled experimental step response acquired using the scope and signal generator VIs in Labview. List the measured ω_n and ζ on the basis of the step response and explain how these were measured. Compare with the analytical result from above.

4. A well-scaled experimental Bode plot of the frequency response acquired using the scope and signal generator VIs in Labview. List the measured ω_n and ζ on the basis of the frequency response and explain how these were measured. Compare with the analytical result from above.

2.14 / 2.140 Analysis and Design of Feedback Control Systems
Spring 2014