

**Physics 120A Final Exam - you have 120 minutes to finish!**

**First, breath. Next, please sign this sheet and sign and number all sheets used for this exam. Then set up your test board so that all power lines ( $\pm 15\text{ V}$  and  $+5\text{ V}$ ) and the ground are in place. Get your oscilloscope and wave generator running and display the input waveform in channel one of the oscilloscope as a reference. Only then begin.**

**Draw out each circuit (design) and show the instructor your work after you build (realization) it. Leave each circuit intact even if it has been checked off.**

**(1)** Design, showing relevant equation(s) and work, and realize a non-inverting op-amp circuit with a closed-loop gain of  $G \approx +40$  that works at DC and that amplifies a bipolar (both positive and negative going) signal. Demonstrate your circuit by showing a  $f = 10\text{ kHz}$  input signal and the corresponding output signal on the oscilloscope.

*Use these parts:*  
R = 47 k $\Omega$   
R = 1.2 k $\Omega$   
LF411 Op Amp

**(2)** Design, showing relevant equation(s) and work, and realize a single-pole high-pass filter with a cut-off frequency of  $f_{-3\text{ dB}} \approx 100\text{ Hz}$ . The filter is to be buffered at its output by the op-amp circuit from problem (1).

*Use all or some of these parts:*  
R = 47 k $\Omega$   
R = 470 k $\Omega$   
C = 0.033  $\mu\text{F}$

**(3)** Design and realize the support circuitry for a 7555 timer integrated circuit that produces an asymmetric square wave output with a period  $T \approx 1.5\text{ s}$ ;  $T = 0.69 \cdot (R_a + 2 \cdot R_b) \cdot C$ , with  $R_a = R_b$  the on/off duty cycle is approximately 2/3. Demonstrate the output on the oscilloscope.

*Use all or some of these parts:*  
R = 270 k $\Omega$  (2 supplied)  
R = 330 k $\Omega$  (2 supplied)  
R = 390 k $\Omega$  (2 supplied)  
C = 2.2  $\mu\text{F}$   
7555 IC

**(4)** Use the output from the timer you built in problem (3) to switch a power MOSFET from the non-conducting to the conducting state, with  $V_{\text{DD}} = +5\text{ V}$ , and drive a load current  $I_{\text{D}} \approx 100\text{ mA}$  so that it turns an incandescent lamp on and off with the above period T.

*Use all or some of these parts:*  
IRL510 MOSFET  
Incandescent lamp ( $R_{\text{lamp}} \approx 40\ \Omega$  when on) & holder  
R = 10 k $\Omega$   
R = 1.0 M $\Omega$

**(5a)** Design, showing relevant equations and work, and realize an inverting op-amp circuit with a closed-loop gain of  $G \approx -10$  that works at DC and amplifies a bipolar signal.

**(5b)** Add a single-pole low-pass filter with a cut-off frequency near  $f_{-3\text{ dB}} \approx 7\text{ kHz}$ .

Demonstrate your circuit with input signals in the 100 Hz to 100 kHz range together with the corresponding output signal on the oscilloscope.

*Use all or some of these parts:*  
R = 4.7 k $\Omega$   
R = 47 k $\Omega$   
C = 470 pF  
C = 330 pF  
LF411 Op Amp