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 (± 15 V and + 5 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 check off.*

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

Use these parts:
R = 47 kΩ
R = 1.2 kΩ
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 $f_{-3\ dB}$ ≈ 100 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 kΩ
R = 470 kΩ
C = 0.033 µF

(3) Design and realize the support circuitry for a 7555 timer integrated circuit that produces an asymmetric square wave output with a period T ≈ 1.5 s; T = 0.69*(R_a+2*R_b)*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 kΩ (2 supplied)
R = 330 kΩ (2 supplied)
R = 390 kΩ (2 supplied)
C = 2.2 µF
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_{DD} = +5 V, and drive a load current I_D ≈ 100 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_{lamp} ≈ 40 Ω when on) & holder
R = 10 kΩ
R = 1.0 MΩ

(5a) Design, showing relevant equations and work, and realize an inverting op-amp circuit with a closed-loop gain of G ≈ – 10 that works at DC and amplifies a bipolar signal.
(5b) Add a single-pole low-pass filter with a cut-off frequency near $f_{-3\ dB}$ ≈ 7 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 kΩ
R = 47 kΩ
C = 470 pF
C = 330 pF
LF411 Op Amp