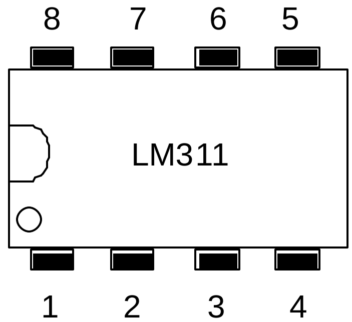
Physics 310
Lab 7 – Waveform Generators and Timers

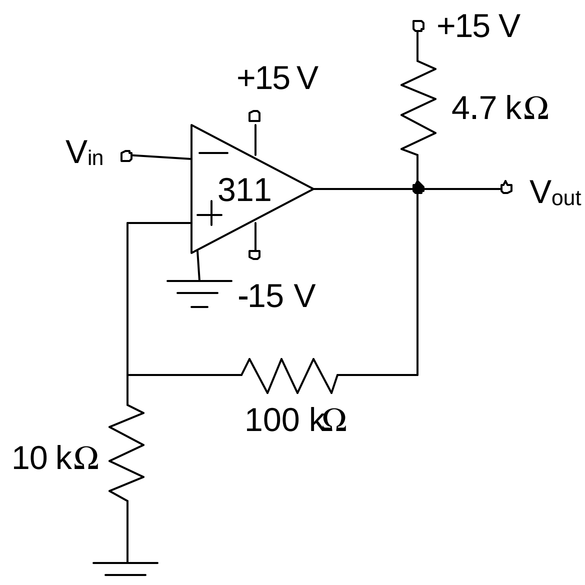
7-1. Waveform Shaping with a Schmitt Trigger

A. The LM311 is a voltage comparator. The pin connections are shown below.



1. "Ground"
2. Non-Inverting Input
3. Inverting Input
4. $-V_{CC}$
5. Balance
6. Balance/Strobe
7. Output
8. $+V_{CC}$

B. Construct the following circuit. Connect pin 1 to ground. Pins 5 and 6 are not used.



C. Input a 10-V amplitude sine wave with a frequency of about 1 kHz. Carefully draw the input, the output, and the reference voltage (the value at the non-inverting input) on the same time scale.

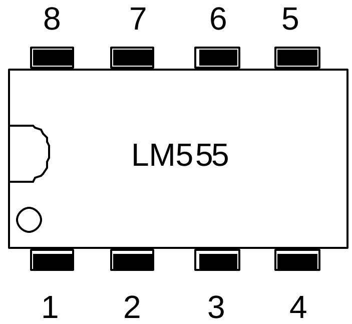
Question: Why does the value of the reference voltage change? Do the values of the reference voltage agree with what you expect?

D. Reconnect the so-called "ground" pin of the 311 to –15 V. Carefully draw the input, the output, and the reference voltage for this set up.

Question: What effect does changing the "ground" pin have?

7-2. Square-Wave Oscillator (Astable Oscillator)

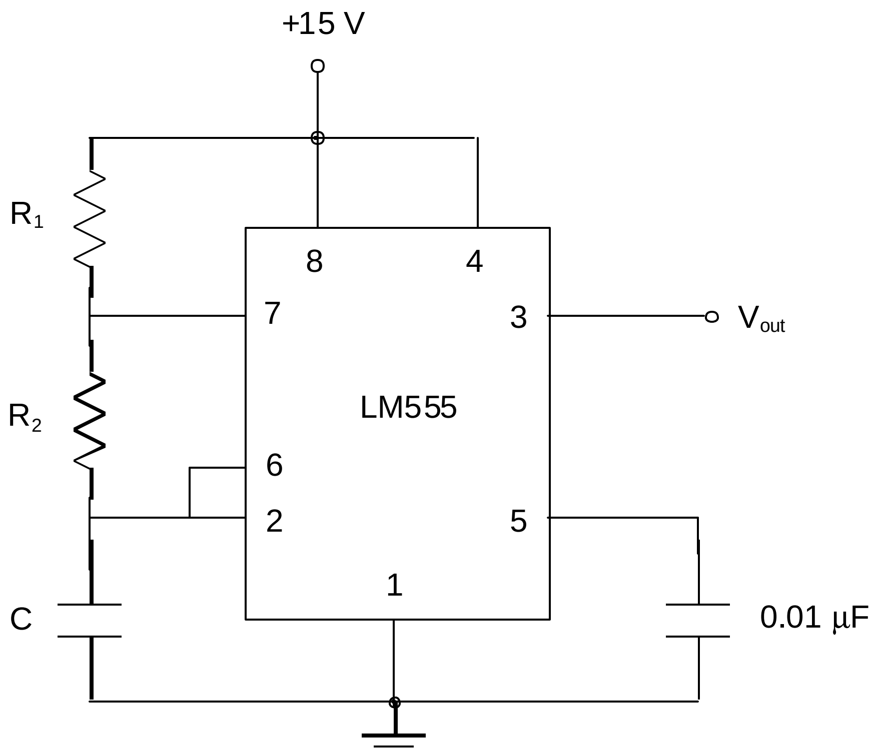
A. The LM555 is a very versatile timing IC. The pin connections are shown below.



1. Ground
2. Trigger
3. Output
4. Reset
5. Control Voltage
6. Threshold
7. Discharge
8. $+V_{CC}$

B. Construct the following circuit choosing the components to get a frequency (f) of about 1 kHz and a duty cycle (*D.C.*) of about 30%. R_1 should be greater than 1 kΩ and R_2 greater than about 5 kΩ, but neither should be much above 10's of kΩ.

$$f = 1.44/(R_1 + 2R_2)C_1 \qquad D.C. = R_2/(R_1 + 2R_2)$$



C. Measure the frequency and duty cycle of the output. Recall that for the 555, the duty cycle is conventionally defined as the ratio of output's Lo time during one cycle to period.

Question: How do the frequency and duty cycle compare with the expected values?

D. Sketch the output and the voltage across the capacitor on the same time scale.

Question: Explain the operation of the circuit. (What is happening to the capacitor at different times? What determines when the output changes?)

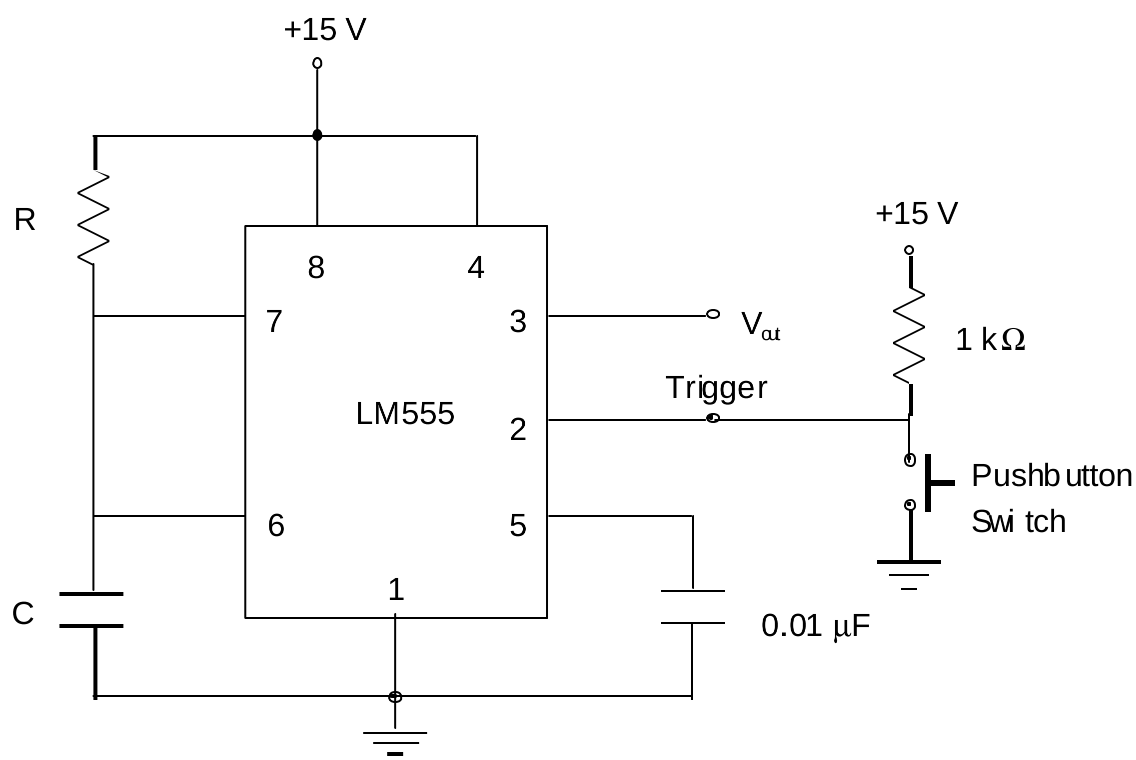
E. Turn the circuit into a voltage controlled oscillator (VCO) by disconnecting the capacitor from pin 5 and connecting that pin to the wiper of a 10-kΩ potentiometer with the ends attached to ground and +15 V.

Question: How does raising the voltage at pin 5 affect the frequency?

7-3. One-Shot (Monostable Operation)

A. Construct the following circuit with components that will make the output will stay high for a time (Δt) long enough to measure accurately with a stopwatch (several seconds). The value of R should be larger than 5 kΩ.

$$\Delta t = 1.1\, RC$$



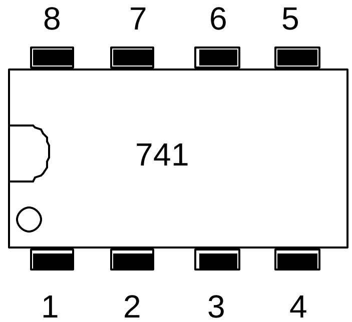
B. Connect output through an LED and a 1-kΩ resistor to ground to give a visual indication of how long the timer is on.

C. The timer should start when the button is pushed dropping the trigger from +15 V to ground. Use a stopwatch to measure how long the LED stays on. If the timer stays on too long, it can be reset by momentarily connecting pin 4 to ground.

Question: How does the measured time (make several measurements and take the average) compare with the expected value?

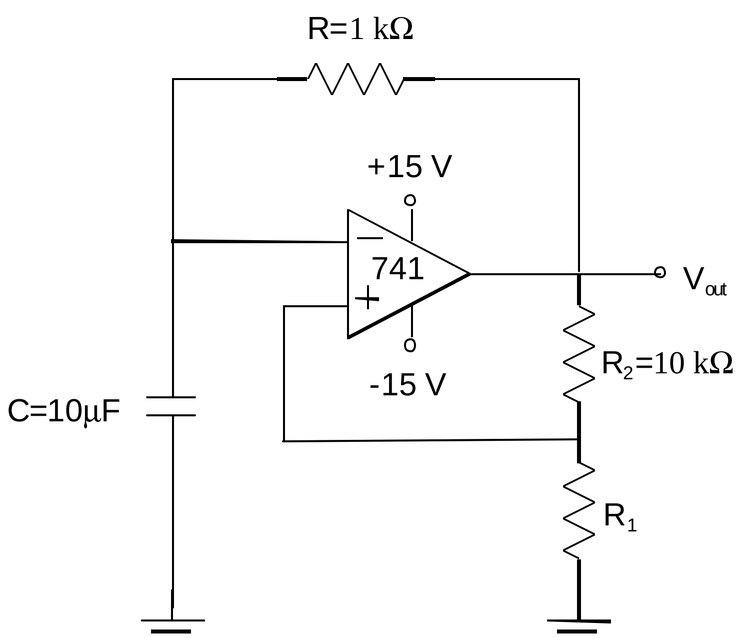
7-4. Op-Amp Oscillator

A. The pin connections of the 741 op amp are shown below.



1. Offset Null
2. Inverting Input
3. Non-Inverting Input
4. $-V_{CC}$
5. Offset Null
6. Output
7. $+V_{CC}$
8. No Connection

B. Construct the following circuit with R_1=10 kΩ.



C. Carefully draw the output, the capacitor voltage, and the reference voltage (the value at the non-inverting input) on the same time scale.

Question: How does the op-amp oscillator work?

D. Measure the frequency of the output with R_1=10 kΩ and with R_1=1 kΩ.

Question: How does the measured frequencies compare with the expected values? (Note: the book gives an approximate expression for the particular resistors it selected, the more general expression is $f = \dfrac{1}{2RC\ln\left(2\dfrac{R_2}{R_1}+1\right)}$.)