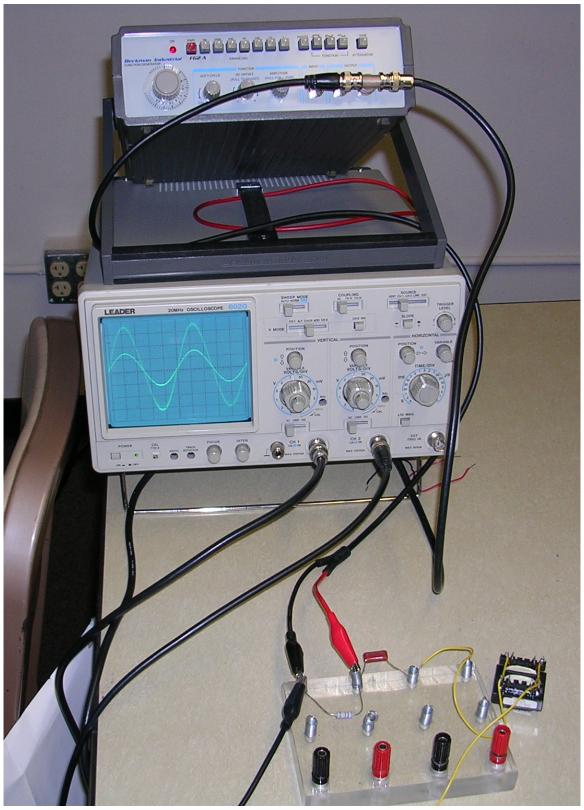
PH421: Equipment list for the series LRC circuit laboratory



Circuit breadboards: plastic blocks with 12 springs glued into them. BNC "T", BNC (FG-scope), BNC-aligator (FG-circuit), scope probe (scope-resistor), wires.

Capacitors: Ceramic capacitors. We use caps are labeled 104 K
$104 = 10*10^4$ pF $= 1*10^{4}*10^{-12} = 0.1\ \mu$F
Read XYZ – is XY * 10^Z picofarads ("puff"). K is temperature tolerance code.

Inductors are nominally 111 mH with both coils engaged. The inductance is the least "ideal" component. *L* measured at 10 kHz, and at low frequencies, the inductance is about 140 mH. Switching different inductors into the same circuit changes the resonance frequency, so they not identical. It is best to have students fit to *L*.

Resonance frequency is measured at about 1.3 kHz. Compare with model value,

$$f = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{140\times10^{-3}\times1\times10^{-7}}} = 1.34\,kHz$$

Resistors: 100 Ω (Brown/Black/Brown), or 200 Ω (Red/Black/Brown) give a good compromise between broadening (if *R* is too high) and loading down FG at resonance (if *R* is too low).

Function Generator (Beckman, model #): Use sine out, 1 kHz range. If the FG output is too large (>100 mV), the output impedance is too low and it becomes part of the circuit under investigation. The symptom is distortion of both input and output signals, especially near resonance. There are 2 FG attenuation controls: (i) a -20dB control at top right, and (ii) a pull-out function on the voltage amplitude control, bottom center. Both should be enabled for a voltage drive of about 10 – 20 mV amplitude. At this setting, the voltage across resistor is almost equal to V_{ext} at resonance (97%). At higher driving voltages, even 30 mV and certainly 100 mV, there is a loss of voltage at resonance (80% or more).

Oscilloscope:
(Either) **Rigol digital oscilloscope:** Ch 1 across all 3 elements, channel 2 across resistor. Trigger must average several traces, otherwise low-input signals become jumpy. Scope can be made to display p-p, rms, time difference between cursor, phase difference and almost anything you please. In this automated mode, it's important to make sure the students understand how to calculate phase differences in radians from phase differences in time.

(or) **Leader 8020 20 MHz analog oscilloscope:** Ch 1 across all 3 elements, channel 2 across resistor. Trigger on channel 1. The scope voltage controls must be calibrated (range knob all the way CW). Time base must be calibrated ("cal" knob all the way CW) to measure period, hence frequency, *from scope, not from the dial of the FG*. Check on FG for consistency. Students need to understand that they can "uncalibrate" for convenience, but must measure in calibrated mode.

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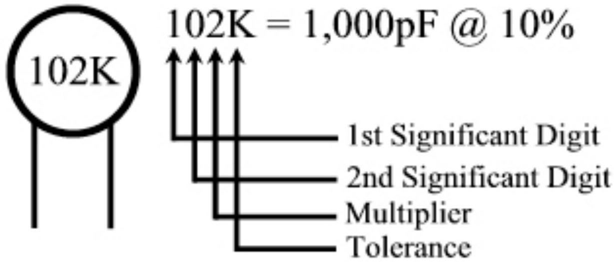
Grounds: It is critical to have a common ground for FG, scope and *R*, because we measure voltage across *R* to get *I*. Students commonly ground two places in the circuit and short out circuit elements.



Multiplier number	Multiply By (Additional Zeros)	Temp. Coeff. Code	Tolerance
0	1 (0)	C	±0.25pF
1	10 (1)	J	±5%
2	100 (2)	K	±10%
3	1,000 (3)	M	±20%
4	10,000 (4)	D	±0.5pF
5	100,000 (5)	Z	+80% / -20%
6	1,000,000 (6)		

Resistor Color Codes from http://educypedia.karadimov.info/electronics/electroniccalculatorsresistor.htm