

APPENDIX C

INSTRUMENTS USED IN THE PHYSICS 321 LABORATORY

The instruments we use in the laboratory provide or measure DC and AC voltages and/or currents. The tables below list the specifications for devices actually used in the Physics 321 Laboratory. These tables are followed by a discussion of the general properties of instruments which provide these functions.

SUBSTITUTION OR DECADE BOXES

RESISTANCE	ACCURACY
General Radio	0.05 %
Eico	0.5 %
Heathkit Substitution Box	10 %
Heathkit Decade Box	0.5 %
CAPACITANCE	
Eico	1 %
INDUCTANCE	
General Radio	1 %

DC POWER SUPPLY - Lambda Model LPD-421FM

Floating Output	Outputs can be at $\pm 300\text{V}$ off ground
Maximum Voltage	20 V
Maximum Current	1.7 A
Polarity	Either positive or negative terminal can be grounded
Voltage Regulation	0.01% + 1 mV for line voltage 105 to 132 V_{RMS} 0.01% + 1 mV for 0 to 1.7A load current
Current Regulation	5 mA for line voltage 105 to 132 V_{RMS} 5 mA for 0 to 20V output voltage
Ripple and Noise	500 μV_{RMS}
Voltage Temperature Coefficient	$\pm (0.015 \% + 0.5\text{mV})/^\circ\text{C}$

FUNCTION GENERATOR - Wavetek Model 180

Floating Output	Ground need not be at either output terminal
Maximum Voltage	HI output: 20 Vpp into an open circuit 10 Vpp into a 50 ohm load LO output: 1 Vpp into a 50 ohm load TTL output: Square wave drives up to 20 TTL loads
Voltage Offset	HI output: $\pm 5V$ into a 50 ohm load LO output: $\pm 1V$ into a 50 ohm load
Output Impedance	HI and LO output: 50 ohms TTL output is 3 NANDs ORed
Frequency range	0.1Hz to 2 MHz in 7 range steps
Waveform	sine, square, and triangle for HI and LO outputs
Distortion	time symmetry $\leq \pm 1\%$ on all but 1 MHz range Typically $\leq 0.5\%$ for sine waves on all ranges square wave rise time < 75 ns triangle wave linearity $> 99\%$ up to 200 kHz

VOLT-OHM-MILLIAMMETER (VOM) - Simpson Model 270

Floating Input	Inputs can be $\pm 1kV$ off the case potential		
Galvanometer	$r_g = 5000$ ohms (50 μA full scale)		
DC Voltage	sensitivity = 20,000 ohms/V (50 μA FS) ranges are 0 to 0.25, 2.5, 10, 50, 250, and 1000 V FS accuracy $\leq \pm 1.75\%$ of reading		
DC Current	sensitivity = 0.252 ohm-A (0.25 V FS) ranges are 50 μA and 1, 10, 100, and 500 mA FS accuracy $\leq \pm 1.75\%$ of reading		
AC Voltage	sensitivity = 5,000 ohms/V (200 μA FS) ranges are 0 to 0.25, 2.5, 10, 50, 250, and 1000V FS accuracy $\leq \pm 3.0\%$ of reading for $V_{pp} > 0.4$ V average reading calibrated in sine wave RMS		
DC Resistance	accuracy $\leq \pm 1.75^\circ$ of arc ranges are		
	Rx1	0 to 2 k	12 Ω center
	Rx100	0 to 200 k Ω	1200 Ω center
	Rx10,000	0 to 20 M Ω	120 k Ω center
	open circuit		
	nominal output voltage: 1.5 V on Rx1 and Rx100 7.5 V on Rx10,000		
	maximum output current: 160 mA on Rx1 1.3 mA on Rx100 0.3 mA on Rx10,000		

DIGITAL MULTIMETER (DMM) - Keithley Model 175 & 178

	Model 175	Model 178
DC Voltage:		
Ranges (volts FS)	0.2, 2, 20, 200, 1000	2, 20, 200, 1200
Input impedance	10 M Ω or 11 M Ω (depending on range)	10 M Ω
Accuracy	$\pm (0.03 \% + 1 \text{ digit})$	$\pm (0.04 \% + 1 \text{ digit})$
AC Voltage:	True RMS	Average Reading Calibrated for sinewave RMS.
Ranges (volts FS)	0.2, 2, 20, 200, 750	2, 20, 200, 1000
Input impedance	10 M Ω or 11 M Ω shunted by $< 75 \text{ pf}$	1 M Ω shunted by $< 75 \text{ pf}$
Accuracy (f $< 20\text{kHz}$)	$\pm (1 \% + 40 \text{ digits})$	$\pm (0.3 \% + 15 \text{ digits})$
DC Resistance		
Ranges	200 Ω – 2M Ω	2 k Ω – 20 M Ω
Accuracy	$\pm (0.05 \% + 1 \text{ or } 2 \text{ digits})$	$\pm (0.04 \% + 1 \text{ digit})$
Current	1 mA (200 Ω , 2k Ω), 10 μA (20 k Ω , 200 k Ω), 0.1 μA (2 M Ω)	2 volts/(R Full Scale)

ELECTROMETER - Keithley Model 610B or 610C

Non-floating Input	one side grounded
DC Voltage	input impedance = $10^{14} \Omega$ shunted by 20 pF ranges are 1 mV to 100V FS in 11 x1 and x3 steps accuracy = $\pm 1\%$ or reading
DC Current	input impedance 10 Ω to $10^{11} \Omega$ – drops 1V FS on x1 ranges are 0.3 to 10^{-14} A FS in 28 steps (multiplier is 100 to 0.001) accuracy = $\pm 2 \%$ of reading (0.3 to 10^{-11})A FS $\pm 4 \%$ of reading (3×10^{-12} to 10^{-14})A FS