Notes on Kirchhoff's Laws uncertainty calculations

The uncertainty of Metex DMM

DC voltmeter (all ranges) $\pm$0.5% of rdg + 1 dgt => $\pm$(1/2 percent of reading + one digit)

DC ammeter (200 mA setting) $\pm$1.2% of rdg + 1 dgt => $\pm$(1.2 percent of reading + one digit)

Voltage uncertainty calculations

Sample data table for measured potentials (with calculated DMM uncertainties)

Loop1 Potentials $V \pm \delta V$ (V)	Loop2 Potentials $V \pm \delta V$ (V)	Loop3 Potentials $V \pm \delta V$ (V)
V_{fa} - **1.548** $\pm$ **0.009**	V_{bc} - $\pm$	V_{fa} - **1.548** $\pm$
V_{ab} - **-0.342** $\pm$ **0.003**	V_{cd} - $\pm$	V_{ab} **-0.3432**
V_{be} - **-0.712** $\pm$ **0.005**	V_{de} - $\pm$	V_{bc} - **-1.568**
V_{ef} - **-0.490** $\pm$ **0.003V**	V_{eb} - $\pm$	V_{cd} - **0.384**
$\sum V_{loop} \pm \delta V_{loop}$ **0.004** $\pm$ below*	$\sum V_{loop} \pm \delta V_{loop}$	V_{de} **0.467**
xxxxxxxxxxxxxxxxxxx	xxxxxxxxxxxxxxxxxxx	V_{ef} **-0.490**
xxxxxxxxxxxxxxxxxxx	xxxxxxxxxxxxxxxxxxx	$\sum V_{loop} \pm \delta V_{loop}$

Loop 1 uncertainties (How to Do)

$\delta V_{fa} = \pm[1.548 \times 0.005 + 0.001]V = \pm[0.00774 + 0.001]V = \pm 0.00874V = \pm \mathbf{0.009V}$

$\delta V_{ab} = \pm[0.342 \times 0.005 + 0.001]V = \pm[0.00171 + 0.001]V = \pm 0.00271V = \pm \mathbf{0.003V}$

$\delta V_{be} = \pm[0.712 \times 0.005 + 0.001]V = \pm[0.00356 + 0.001]V = \pm 0.00456V = \pm \mathbf{0.005V}$

$\delta V_{ef} = \pm[0.490 \times 0.005 + 0.001]V = \pm[0.00245 + 0.001]V = \pm 0.00345V = \pm \mathbf{0.003V}$

Uncertainties are of a sum (i.e., Kirchhoff's Voltage law) are to be added in quadrature

$$\delta V_{loop1} = \pm\sqrt{(0.009)^2 + (0.003)^2 + (0.005)^2 + (0.003)^2}\,V = \pm 0.0114V = \pm 0.01V$$

This uncertainty and the ones above should be added to data table (with correct significant figures) you turn in with lab report

*** Thus we see for final <u>loop one sum</u> plus uncertainty** $\sum V_{loop1} \pm \delta V_{loop1} = 0.00 \pm 0.01V$

Similar calculations should be done for loop 2 (which would also cover loop 3). To save you work you can use loop 1 values in loops 2 and 3 as long as you match similar values. Therefore only 4 calculations needed.

Notes on Kirchhoff's Laws uncertainty calculations

Current uncertainties calculations

Sample data for current values (without DMM uncertainties)

	Measured-(DMM) $Current \pm \delta Current$ **(A)**	Calculated **(A)**	% Difference
I_1	**0.0306** ± value calculated below	0.0329	
I_2	**0.0195** ± value calculated below	0.0217	
I_3	**0.0496** ± value calculated below	0.0547	

Uncertainty calculation for current: See DMM ammeter (200mA) uncertainty above:

$$\delta I_1 = \pm[0.0306 \times 0.012 + 0.0001]A = \pm[0.000367 + 0.0001]A = \pm[0.000467]A = \pm 0.0005A$$

$$\delta I_2 = \pm[0.0195 \times 0.012 + 0.0001]A = \pm[0.000234 + 0.0001]A = \pm[0.000334]A = \pm 0.0003A$$

$$\delta I_3 = \pm[0.0496 \times 0.012 + 0.0001]A = \pm[0.000595 + 0.0001]A = \pm[0.000695]A = \pm 0.0007A$$

These uncertainties should be added to data table (like above) that you turn in with lab report

Since Kirchhoff's current law states that the amount if current going into a junction is the same as the current out of a junction you are interested in whether

$$I_1 \pm \delta I_1 + I_2 \pm \delta I_2 = I_3 \pm \delta I_3$$

Using currents and uncertainty values from data above we see (adding uncertainties in quadrature)

$$0.0306 \pm 0.0005A + 0.0195 \pm 0.0003A = [0.0306+0.0195] \pm \sqrt{(0.0005)^2 + (0.0003)^2}\ ]A$$

$I_1 \pm \delta I_1 + I_2 \pm \delta I_2 = 0.0501 \pm 0.00058A = 0.0501 \pm 0.0006A$ ➔ $0.0495A < I_1 + I_2 < 0.0507A$

The measured value for I_3 was 0.0496 ± 0.0007A. ➔ $0.0489A < I_3 < 0.0503A$

Is $I_1 \pm \delta I_1 + I_2 \pm \delta I_2$ equal to $I_3 \pm \delta I_3$ when uncertainty is considered? Yes since results overlap.

Comments on results. The data sheet that you fill out are not the results. Your results are taken from the data sheets (and the uncertainties determined) and should answer the following questions:

1) *Are the sum the voltages around any closed loop equal to zero* (when uncertainty is considered)

2) *Are the sum of the currents going into a junction the same as the current coming out of a junction* (when uncertainty is considered.

If you give only the data sheet as your results you will be penalized!!!!