How to Analyze MPMS Data

Just in case, please save the files from time to time.

Copy data

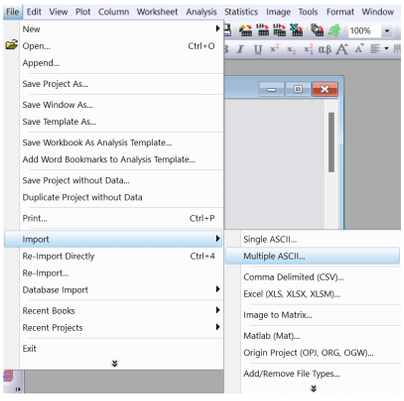
You can bring a hard drive or USB to copy data. Also, you can copy data by email on the Edge browser.

You can find the files in the folder icon from the taskbar. The Files' names are like "xxx-M-H_T.dat" or "xxx-M-T_H.dat". Normally, the size of the files is larger than 100kb.

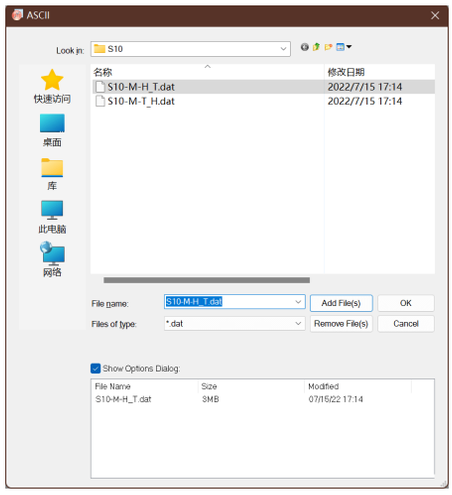
Import data

1. [File] → [Import] → [Multiple ASCII...]

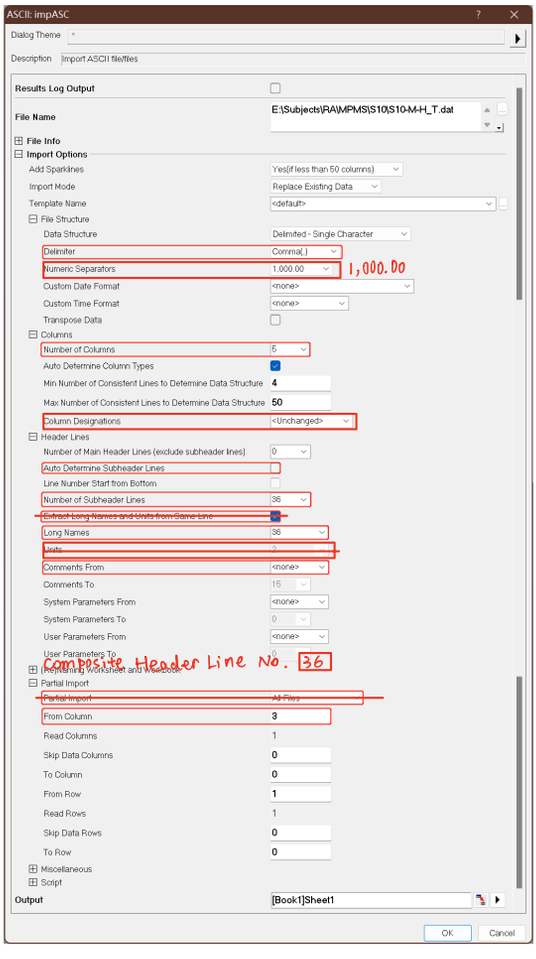
data →
import from file
→
Multiple ASCII.



2. Choose the files and click [Add File(s)] (or double click the files) → [OK]

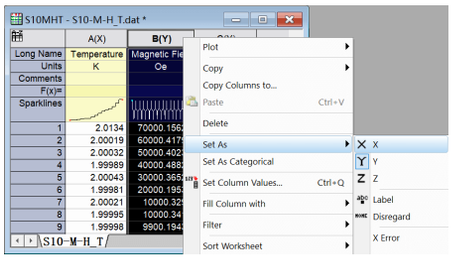


3. Set as follow → click [OK]
    - [File Structure]
        - Delimiter: Comma(,)
    - [Columns]
        - Number of Columns: 5
    - [Header Lines]
        - Auto Determine Subheader Lines: ×
        - Number of Subheader Lines: 36
        - Extract Long Name and Units from Same Line: ✓
        - Long Names: 36
        - Comments From: <none>
    - [Partial Import]
        - Partial Import: All Files
        - From Column: 3



Analyze M-H data

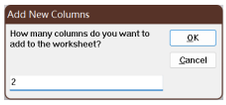
1. Choose the column of *Magnetic Field*, and set it as X



2. We tested many different temperature groups in our experiments (you can find that the *Sparkline* of *Temperature* is like a stair), and you first need to know how much data is in one set. (In our example, every 430 rows is a set)

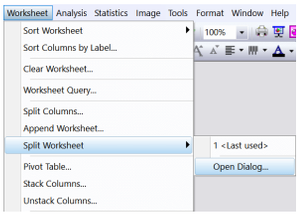
	A(X1)	B(X2)	C(Y2)
Long Name	Temperature	Magnetic Field	Moment
Units	K	Oe	emu
Comments			
F(x)=			
Sparklines			
425	1.99987	20000.46289	0.02847
426	2.00018	30000.46289	0.03053
427	1.99979	40000.17188	0.0314
428	2.00012	50000.24219	0.03188
429	1.99996	60000.46484	0.0322
430	1.99997	70000.32031	0.03243
431	4.9999	69999.55469	0.0326
432	5.00029	60000.41797	0.0324
433	4.99967	50000.30859	0.03212
434	4.99997	40000.25781	0.03171
435	5.00013	30000.29297	0.03109

3. Press [ctrl]+[D], Add 2 new columns

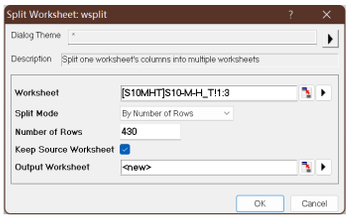


4. Choose all columns → [Worksheet] → [Split Worksheet] → [Open Dialog]

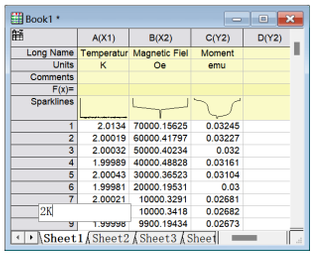
	A(X1)	B(X2)	C(Y2)	D(Y2)	E(Y2)
Long Name	Temperature	Magnetic Field	Moment		
Units	K	Oe	emu		
Comments					
F(x)=					
Sparklines					
1	2.0134	70000.15625	0.03245		
2	2.00019	60000.41797	0.03227		
3	2.00032	50000.40234	0.032		
4	1.99989	40000.48828	0.03161		
5	2.00043	30000.36523	0.03104		



5. Setting
   - Split Mode: By Number of Rows
   - Change the *Number of Rows*
   - Click [OK]

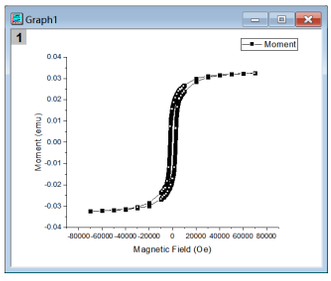


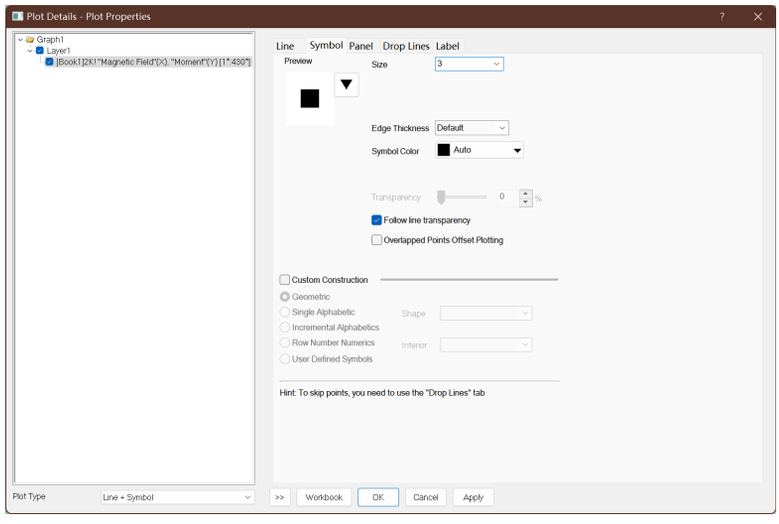
6. Double click the sheet title to rename each sheet according to temperature

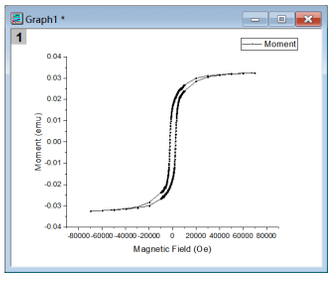


7. Choose the columns of *Magnetic Field* and *Moment*, click [Line + Symbol Graph] () to plot it.

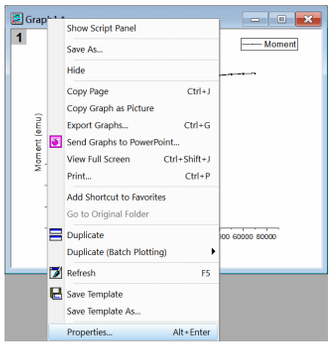
8. Double click the curve to open *Plot Details* dialog, you can reduce the marker size here

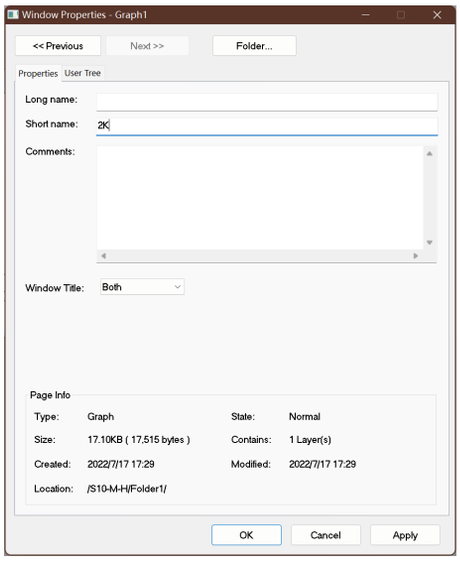




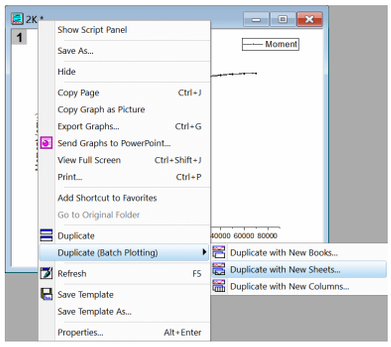


9. Right click the title of the plot window → [Properties] → Rename short name in the pop out window according to the temperature → [OK]

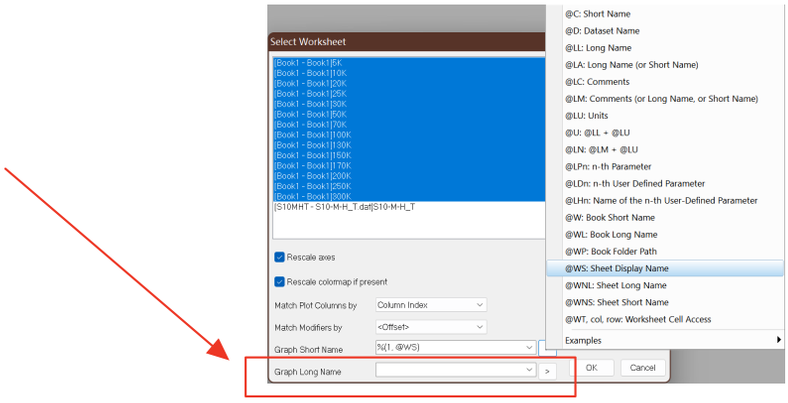




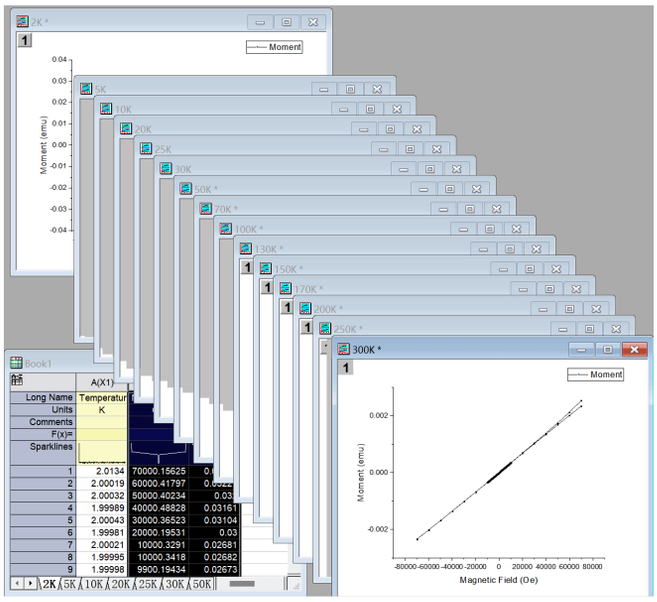
10. Right click the title of the plot window → [Duplicate (Batch Plotting)] → [Duplicate with New Sheets...]



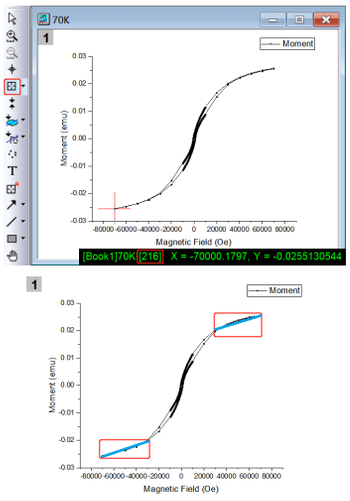
11. Setting
    - Select all worksheets you want to plot
    - Set Graph Short Name as *Sheet Display Name*
    - Set Graph Long Name as *blank*
    - Click [OK]



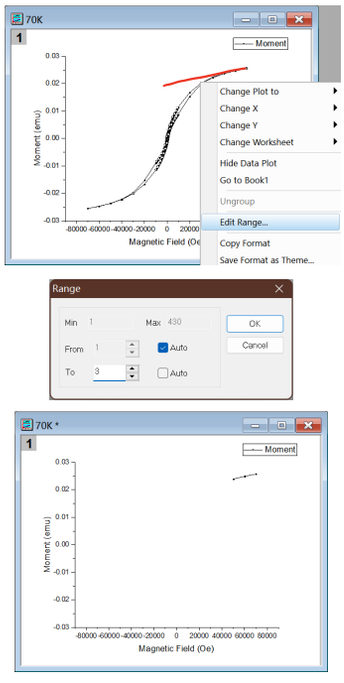
12. You can see the end of the graphs are not saturated, this may due to paramagnet or diamagnet of the environment (tape, tissue, holder, etc.). We need to correct them.



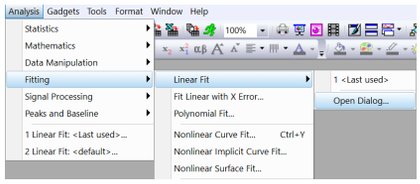
13. By using *Data Reader* ( ), you can find the index of the data points. Choose the points from the region of *straight-line-like* (either the left part or the right part of the hysteresis loop are both okay).



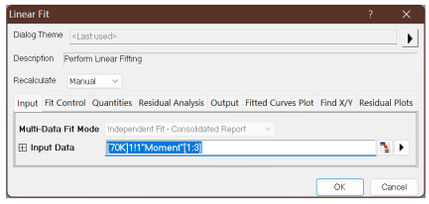
14. Right click on the curve → [Edit Range] → input the range
    - Disable *Auto*, then you can input the index you choose
    - Able *Auto* will automatically use the min or max index



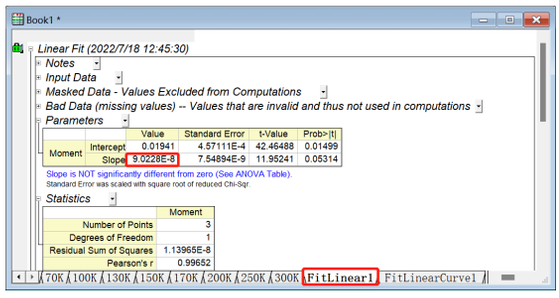
15. [Analysis] → [Fitting] → [Linear Fit] → [Open Dialog] (if you have done this step before, you can click [Analysis] → [Linear Fit: <Last used>...] next time)



16. Click [OK] in the pop-up window

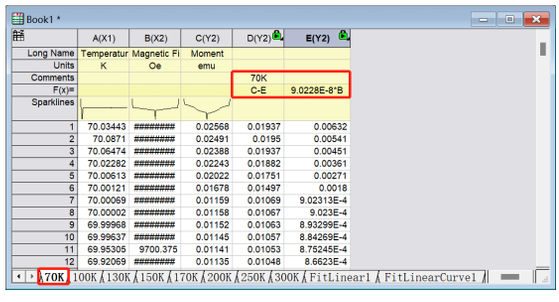


17. Copy (press [ctrl]+[C]) the *Slope* of the fitting line in the *FitLinear* sheet

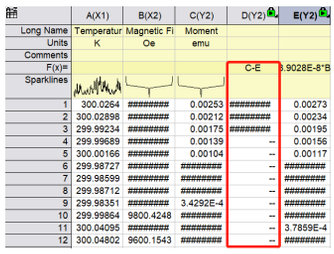


18. Set the function in the temperature set sheet

- Click the *Function* row (F(x)=) of a new column that we created before and paste (press [ctrl]+[V]) the slope, then times it with the *Magnetic Field* column (you can find the example in the E column in the following image). For convenience, we call this column as *Excess* column
- In another *Function* row of a new column, please use the *Moment* column minus the *Excess* column, and this is the *Corrected Moment* column (you can find the example in the D column in the following image)
- Input the temperature in the *Comments* row in the *Corrected Moment* column



- Sometimes, you might find that the program cannot calculate all data

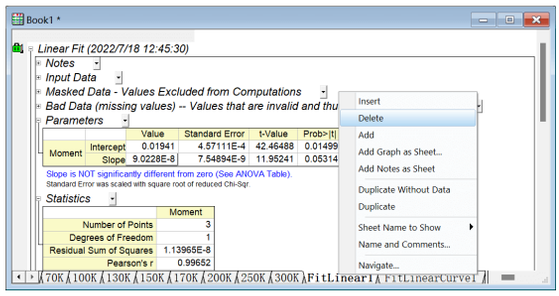


Please replace the *Function* row with any constant number, and then re-input the formula ("###" means ellipsis, you can expand the width of the column, then the data can be seen)

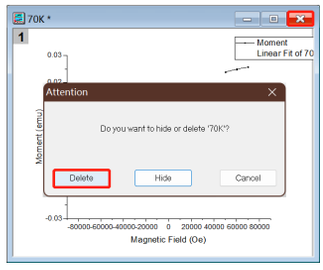
	A(X1)	B(X2)	C(Y2)	D(Y2)	E(Y2)
Long Name	Temperatur	Magnetic Fi	Moment		
Units	K	Oe	emu		
Comments					
F(x)=				0	9028E-8*B
Sparklines					
1	300.0264	########	0.00253	0	0.00273
2	300.02898	########	0.00212	0	0.00234
3	299.99234	########	0.00175	0	0.00195
4	299.99689	########	0.00139	0	0.00156
5	300.00166	########	0.00104	0	0.00117
6	299.98727	########	########	0	########
7	299.98599	########	########	0	########
8	299.98712	########	########	0	########
9	299.98351	########	3.4292E-4	0	########
10	299.99864	9800.4248	########	0	########
11	300.04095	########	########	0	3.7859E-4
12	300.04802	9600.1543	########	0	########

	A(X1)	B(X2)	C(Y2)	D(Y2)	E(Y2)
Long Name	Temperatur	Magnetic Fi	Moment		
Units	K	Oe	emu		
Comments					
F(x)=				C-E	9028E-8*B
Sparklines					
1	300.0264	########	0.00253	########	0.00273
2	300.02898	########	0.00212	########	0.00234
3	299.99234	########	0.00175	########	0.00195
4	299.99689	########	0.00139	########	0.00156
5	300.00166	########	0.00104	########	0.00117
6	299.98727	########	########	########	########
7	299.98599	########	########	########	########
8	299.98712	########	########	########	########
9	299.98351	########	3.4292E-4	########	########
10	299.99864	9800.4248	########	########	########
11	300.04095	########	########	########	3.7859E-4
12	300.04802	9600.1543	########	########	########

19. To make it simple and clear, we can delete the *FitLinear* sheet and the *FitLinearCurve* sheet that we will not use anymore

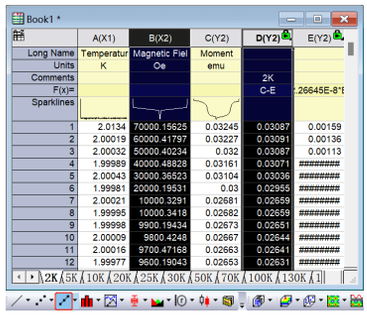


20. Close and delete the figure window

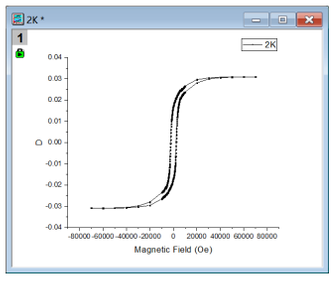


21. Repeat step 13~20 for all temperature sets

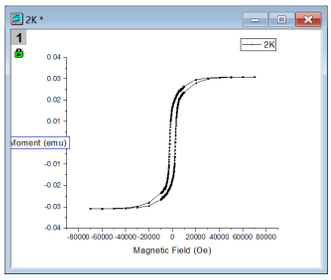
22. Choose the Magnetic Field column as well as Corrected Moment column and then plot it



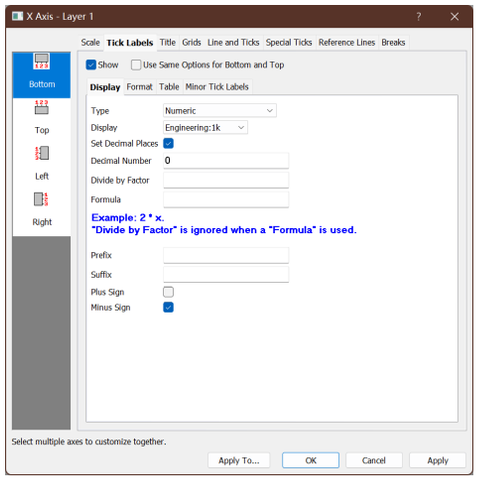
23. You can see the *Legend* show the *Comments* that we input before, please reduce the size of the marker and rename the title of the figure window

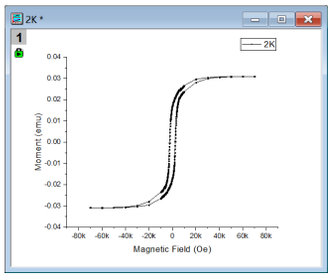


24. Double click the title of the Y axis to rename it as "Moment (emu)"

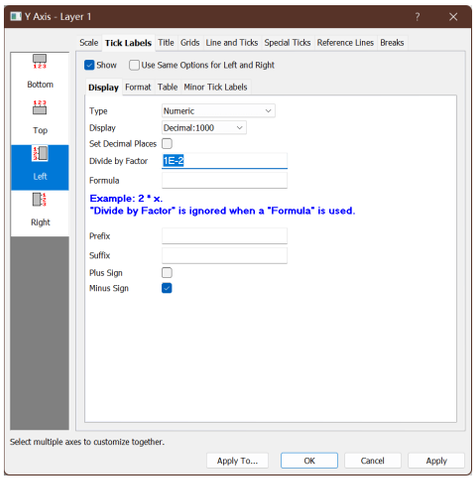


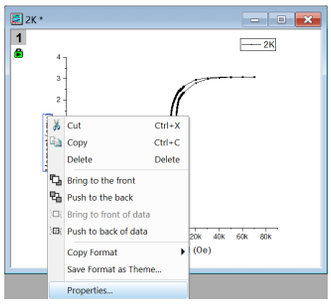
25. Also, you can double click other elements in the window to modify them, please have a try.
    - For example, you can double click the *Tick Labels* (number) of the X axis to change its format

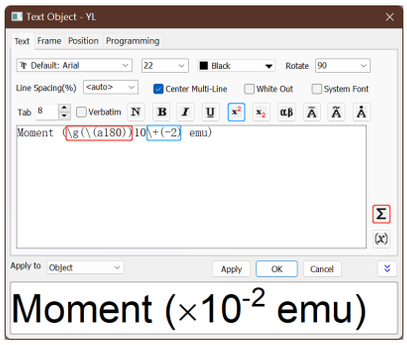


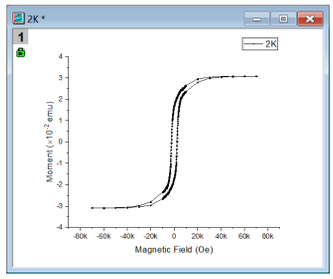


    - For example, you can double click the number of the *Tick Labels* of the Y axis to change its format, and then modify the unit of the Y axis title

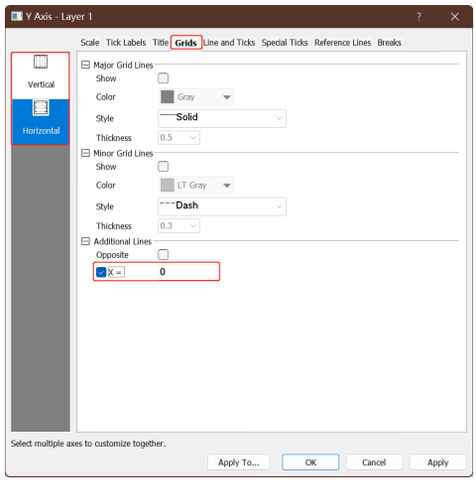


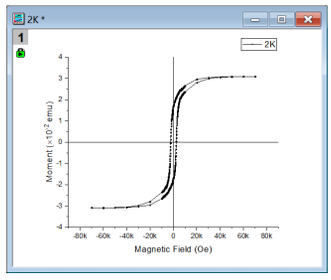




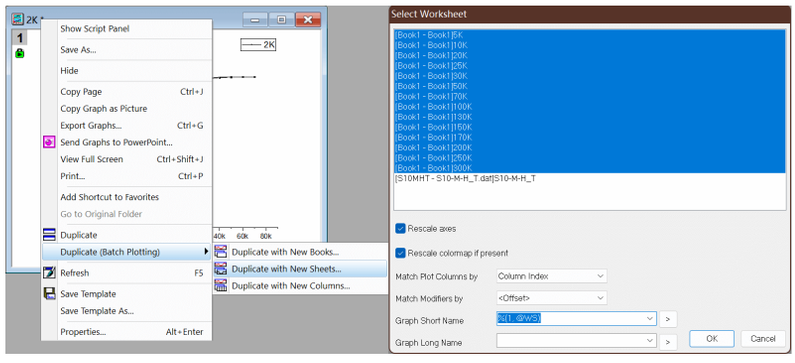


- Also, please remember to create the line of "X = 0" and "Y = 0" in the *Grids* interface

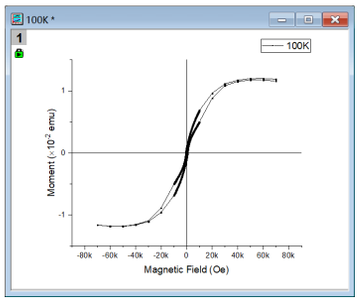


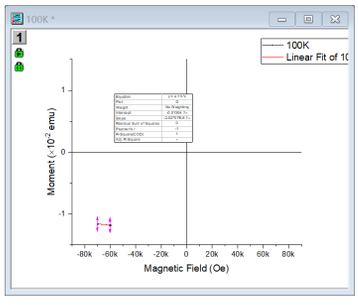


26. After modifying the figure window, please duplicate it

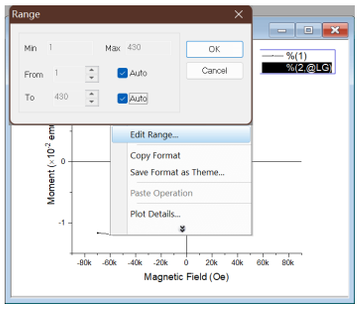


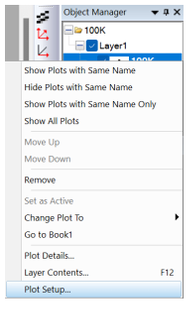
27. Some corrections might not that good, you can redo the process again in this step

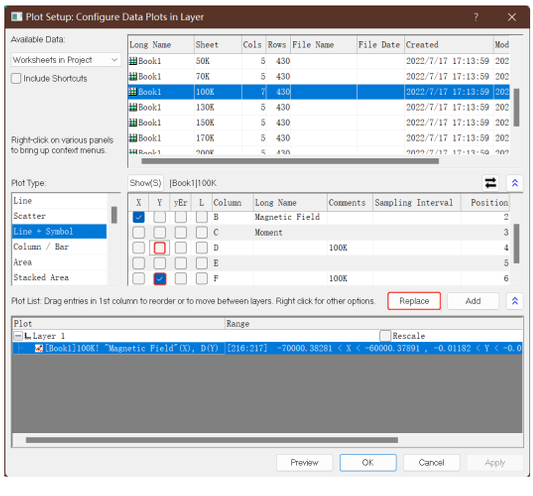


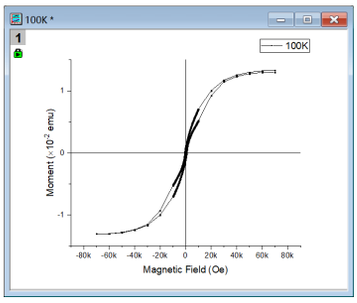


	A(X1)	B(X2)	C(Y2)	D(Y2)	E(Y2)	F(Y2)	G(Y2)
Long Name	Temperatur	Magnetic Fi	Moment				
Units	K	Oe	emu				
Comments				100K		100K	
F(x)=				C-E	1.19088E-7*B	D-G	-2.02707E-8*B
Sparklines							
1	99.93016	########	0.02022	0.01188	0.00834	0.0133	-0.00142
2	100.02075	########	0.01916	0.01201	0.00715	0.01323	-0.00122
3	99.98338	########	0.01794	0.01199	0.00595	0.013	-0.00101
4	99.95409	########	0.0165	0.01174	0.00476	0.01255	-8.10833E-4
5	99.97415	########	0.01472	0.01115	0.00357	0.01176	-6.08126E-4

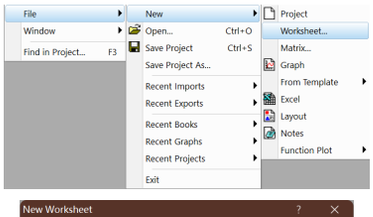


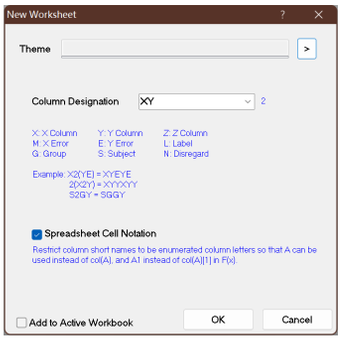






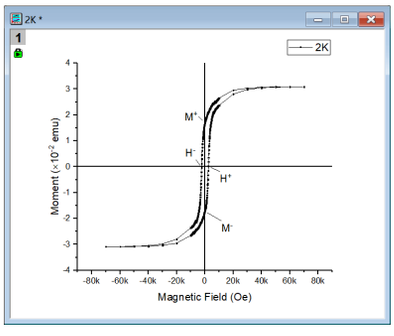
28. [File] → [New] → [Worksheet] → [OK]



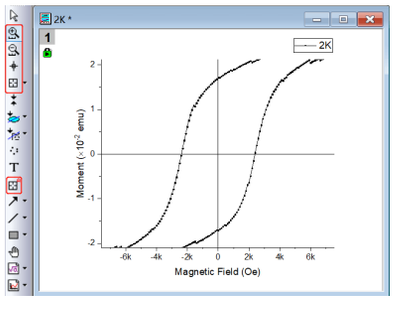


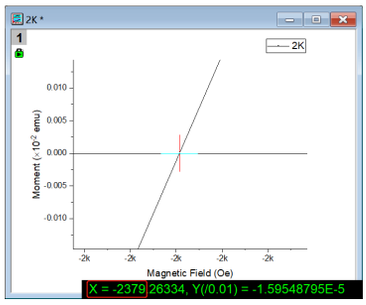
29. Please input the title, unit, formula (and the temperatures) as following
    - Formula
        - $H_c = (abs(H^-) + abs(H^+))/2$
        - $H_{eb} = (H^- + H^+)/2$
        - $M_r = (M^- + M^+)/2$

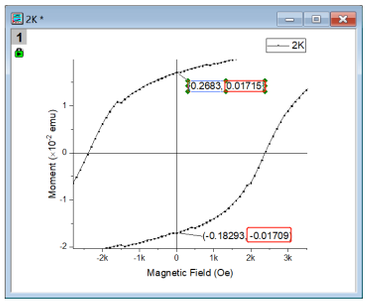
	A(X)	B(Y)	C(Y)	D(Y)	E(Y)	F(Y)	G(Y)	H(Y)
Long Name	Temperature	H-	H+	M-	M+	Hc	Heb	Mr
Units	K					Oe	Oe	emu
Comments								
F(x)=						(abs(B)+abs(C))/2	(B+C)/2	(D+E)/2
1	2							
2	5							
3	10							
4	20							
5	25							



30. Use *Scale In* ( ) and *Scale Out* ( ) to zoom in or zoom out, press [ctrl]+[R] to resize the view. Use *Screen Reader* ( ) to read H^- and H^+, use Data Reader ( ) or Annotation (, choose the point then press [enter]) to read M^- and M^+. And then please record them in the worksheet that we created

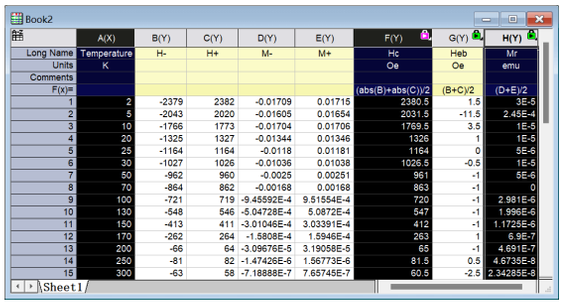




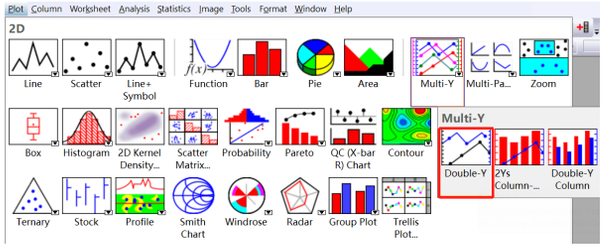


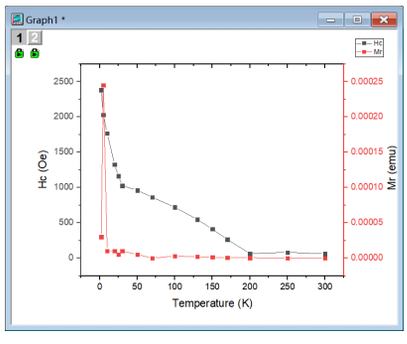
	A(X)	B(Y)	C(Y)	D(Y)	E(Y)	F(Y)	G(Y)	H(Y)
Long Name	Temperature	H-	H+	M-	M+	Hc	Heb	Mr
Units	K					Oe	Oe	emu
Comments								
F(x)=						(abs(B)+abs(C))/2	(B+C)/2	(D+E)/2
1	2	-2379	2382	-0.01709	0.01715	2380.5	1.5	3E-5
2	5	-2043	2020	-0.01605	0.01654	2031.5	-11.5	2.45E-4
3	10	-1766	1773	-0.01704	0.01706	1769.5	3.5	1E-5
4	20	-1325	1327	-0.01344	0.01346	1326	1	1E-5
5	25	-1164	1164	-0.0118	0.01181	1164	0	5E-6

31. Choose the columns of Temperature, H_c, and M_r $\rightarrow$ [Plot] $\rightarrow$ [Multi-Y] $\rightarrow$ [Double-Y]

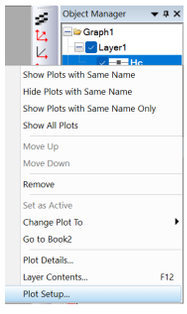


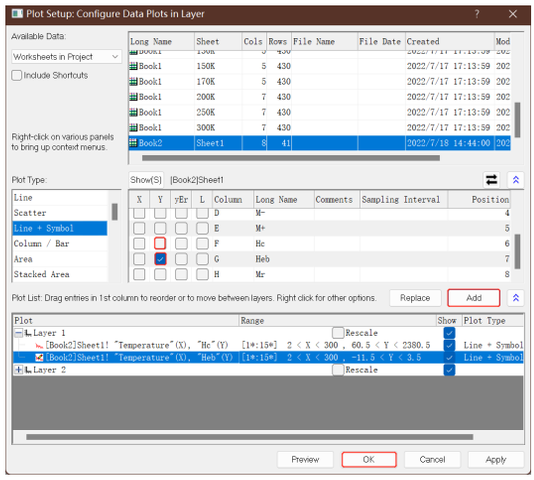
	A(X)	B(Y)	C(Y)	D(Y)	E(Y)	F(Y)	G(Y)	H(Y)
Long Name	Temperature	H-	H+	M-	M+	Hc	Heb	Mr
Units	K					Oe	Oe	emu
Comments								
F(x)=						(abs(B)+abs(C))/2	(B+C)/2	(D+E)/2
1	2	-2379	2382	-0.01709	0.01715	2380.5	1.5	3E-5
2	5	-2043	2020	-0.01605	0.01654	2031.5	-11.5	2.45E-4
3	10	-1766	1773	-0.01704	0.01706	1769.5	3.5	1E-5
4	20	-1325	1327	-0.01344	0.01346	1326	1	1E-5
5	25	-1164	1164	-0.0118	0.01181	1164	0	5E-6
6	30	-1027	1026	-0.01036	0.01038	1026.5	-0.5	1E-5
7	50	-962	960	-0.0025	0.00251	961	-1	5E-6
8	70	-864	862	-0.00168	0.00168	863	-1	0
9	100	-721	719	-9.45592E-4	9.51554E-4	720	-1	2.981E-6
10	130	-548	546	-5.04728E-4	5.0872E-4	547	-1	1.996E-6
11	150	-413	411	-3.01046E-4	3.03391E-4	412	-1	1.1725E-6
12	170	-262	264	-1.5808E-4	1.5946E-4	263	1	6.9E-7
13	200	-66	64	-3.09676E-5	3.19058E-5	65	-1	4.691E-7
14	250	-81	82	-1.47426E-6	1.56773E-6	81.5	0.5	4.6735E-8
15	300	-63	58	-7.18888E-7	7.65745E-7	60.5	-2.5	2.34285E-8

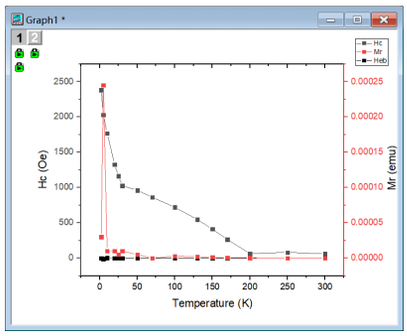




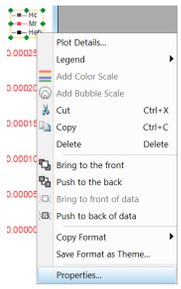
32. [Object Manager] $\rightarrow$ Right click H_c $\rightarrow$ [Plot Setup...] $\rightarrow$ Add the curve of H_{eb}

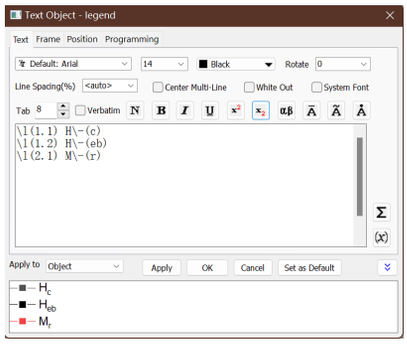




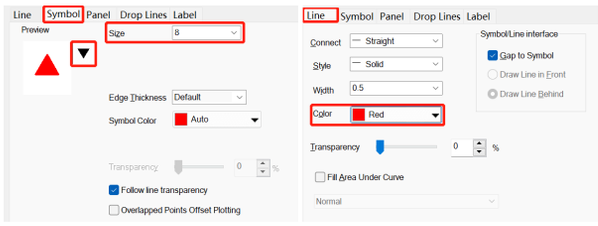


33. Right click *Legend* → [Properties...] → re-order and rename



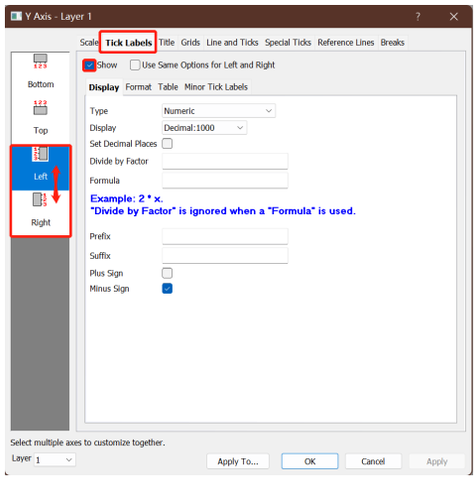


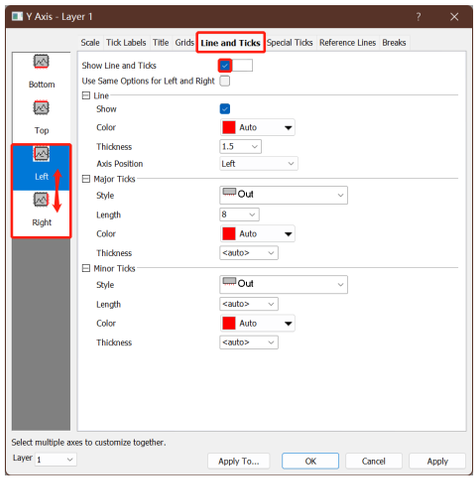
34. Double click the marker in the *Legend* to modify the markers



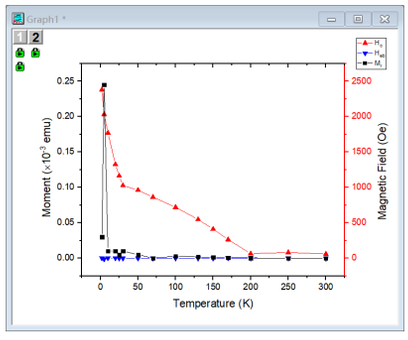
35. Please keep all the figures in a similar configuration. If you want to exchange the two Y axis, you can do the following
    - Double click the left Y axis. For both *Tick Labels* and *Line and Ticks*, disable *Show* on the *Left* and able it one the *Right*

- Do the same for the right Y axis



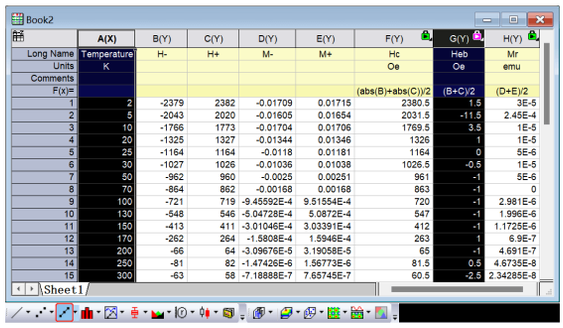


- Rename the title of the left and right Y axis

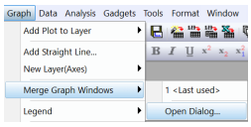


36. Since the Y range of H_{eb} is too small in this figure, we can add a subplot to show H_{eb} only

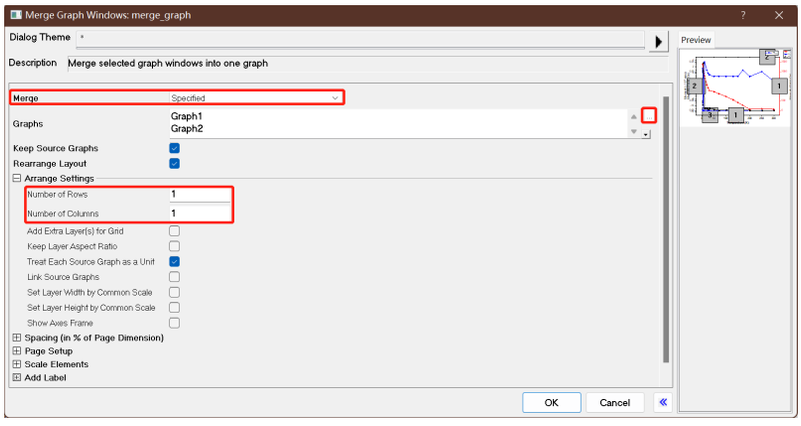
- Plot Temperature vs H_{eb}

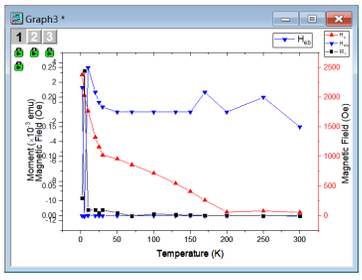


- [Graph] → [Merge Graph Windows] → [Open Dialog]

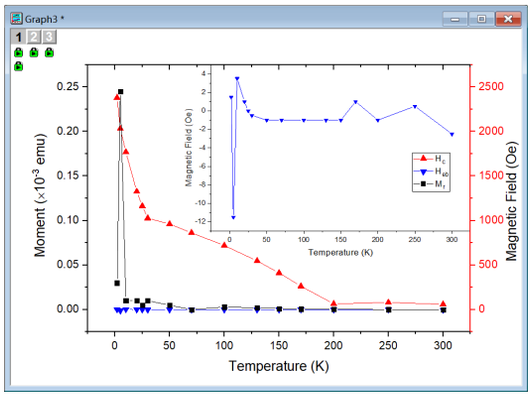


- Choose *Specified* type and choose the graphs that you want to merge. We want to create 1×1 figure here





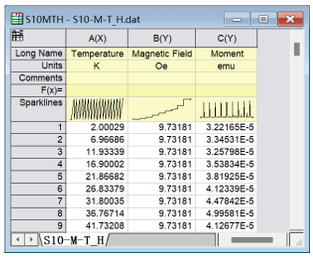
- Resize and reposition the "Temperature vs H_{eb}" figure, delete the useless elements on the figure



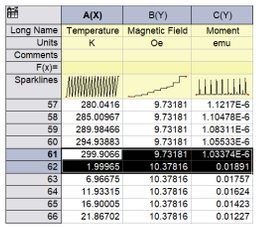
And this is the figure that we want. Please save the project and export the graphs.

Analyze M-T data

1. Now *Temperature* is X

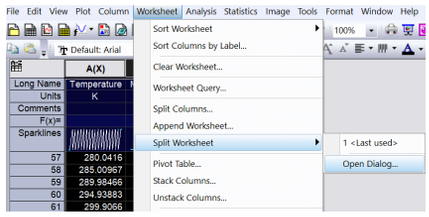


2. We need to analyze ZFC (Zero Fieldcool Curve) and FC (Fieldcool Curve) in our experiment. Their *Magnetic Field*s are similar (for example, in this case, the Magnetic field for ZFC is 9.73181 Oe, and for FC is 10.37816 Oe. And we consider them as the 10 Oe group)



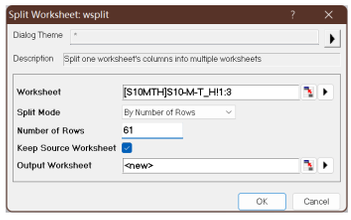
	A(X)	B(Y)	C(Y)
Long Name	Temperature	Magnetic Field	Moment
Units	K	Oe	emu
Comments			
F(x)=			
Sparklines			
57	280.0416	9.73181	1.1217E-6
58	285.00967	9.73181	1.10478E-6
59	289.98466	9.73181	1.08311E-6
60	294.93883	9.73181	1.05533E-6
61	299.9066	9.73181	1.03374E-6
62	1.99965	10.37816	0.01891
63	6.99675	10.37816	0.01757
64	11.93315	10.37816	0.01624
65	16.90005	10.37816	0.01423
66	21.86702	10.37816	0.01227

3. Select all columns → [Worksheet] → [Split Worksheet] → [Open Dialog]

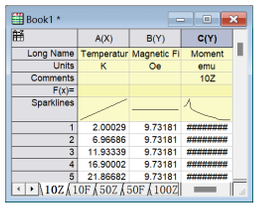


4. Set

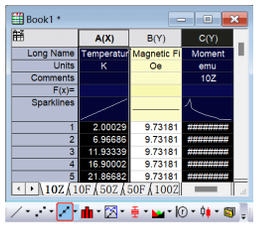
   - Split Mode: By Number of Rows
   - Number of Rows: (the number of each set, take ZFC and FC as 2 groups)



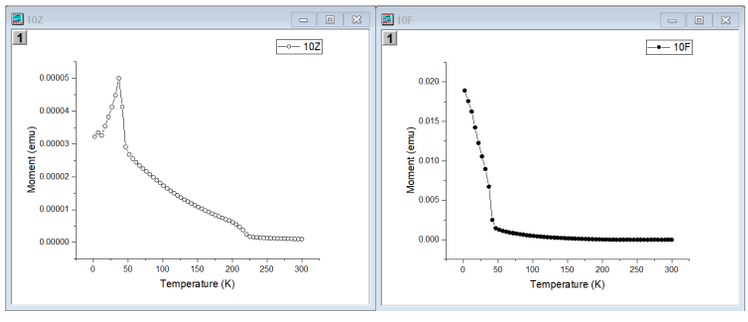
5. Rename the sheets. Also, add *Comments* in *Moment* column



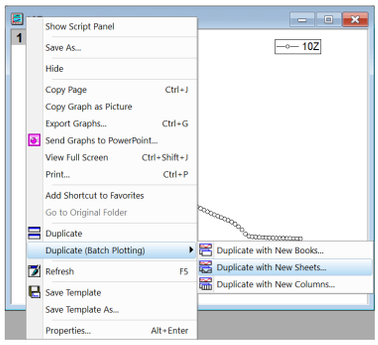
6. Plot "Temperature vs Moment"

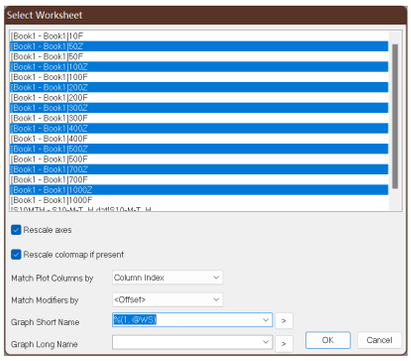


7. Set the markers as hollow circle in ZFC case, and solid circle in FC case. Rename the title of the figure windows

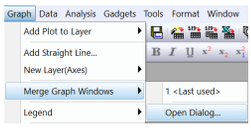


8. Duplicate the figures, please remember to separate the case of ZFC and FC

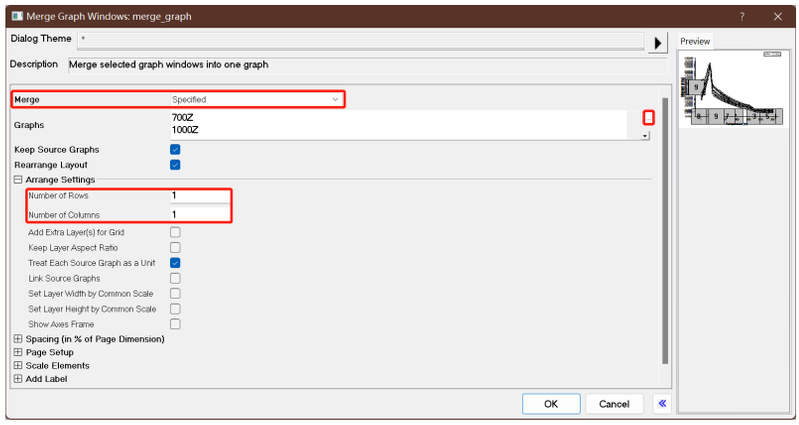


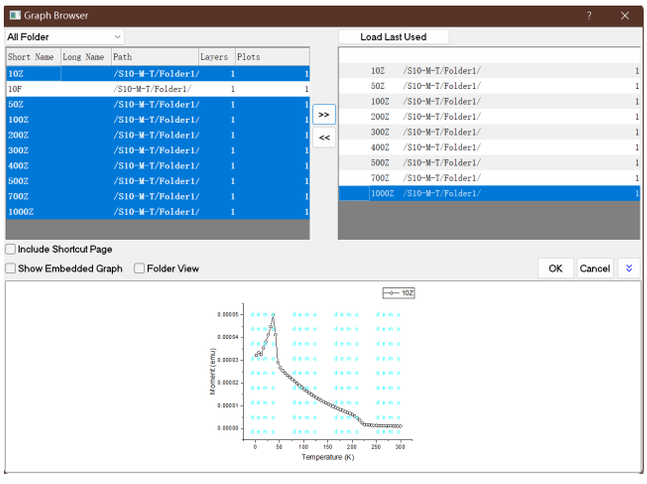


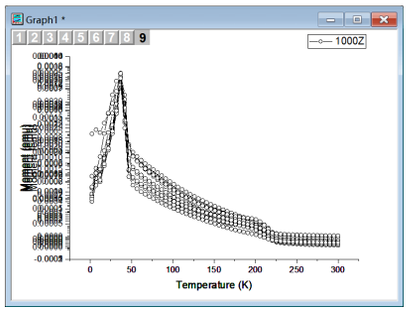
9. [Graph] → [Merge Graph Windows] → [Open Dialog]



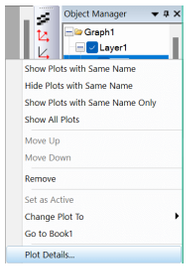
10. Select the images that you want to merge, and output it as 1×1 figure



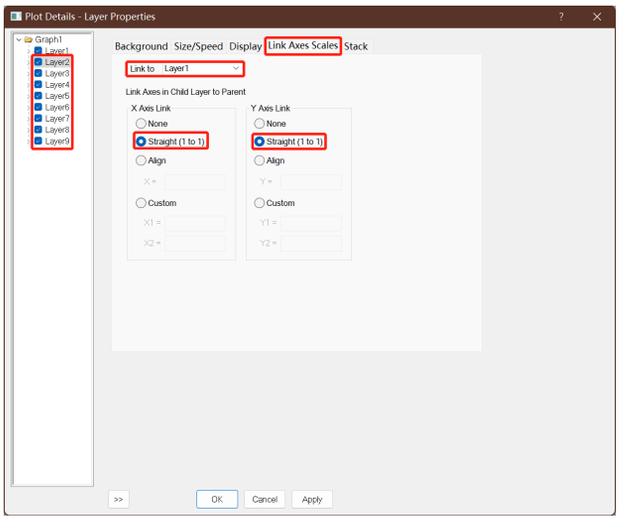


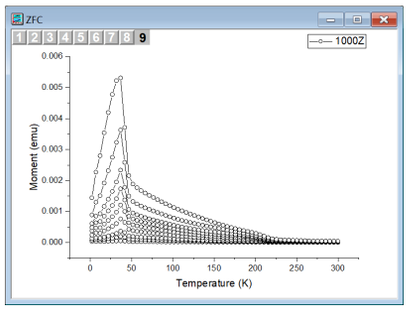


11. Right click on the curve in the Object Manager → [Plot Details...]

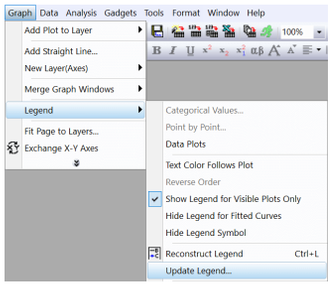


12. Except Layer 1, all other layers link to Layer 1 in the *Link Axes Scales* interface. Select Straight (1 to 1) for both X and Y Axis Link



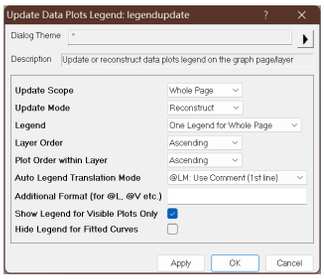


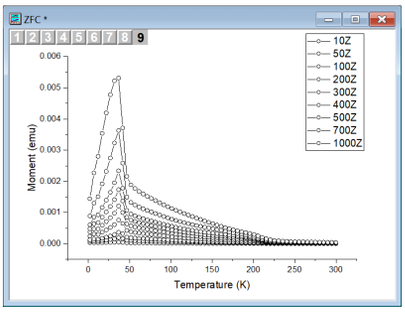
13. [Graph] → [Legend] → [Update Legend...]



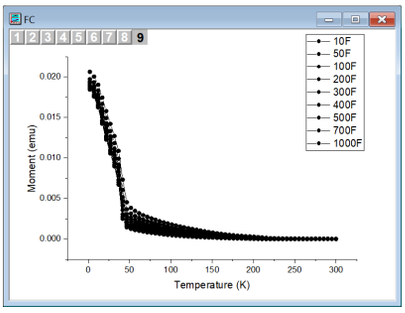
14. Set as

    - Update Mode: Reconstruct
    - Legend: One Legend for Whole Page

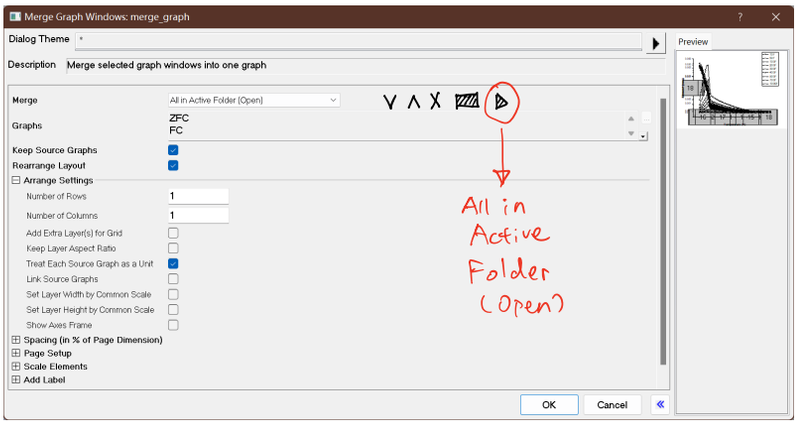


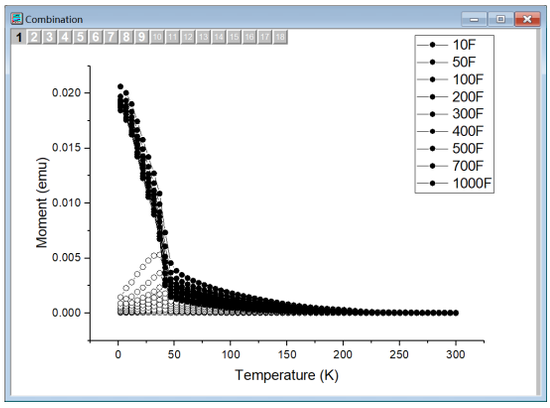


15. Repeat step 8~14 for FC

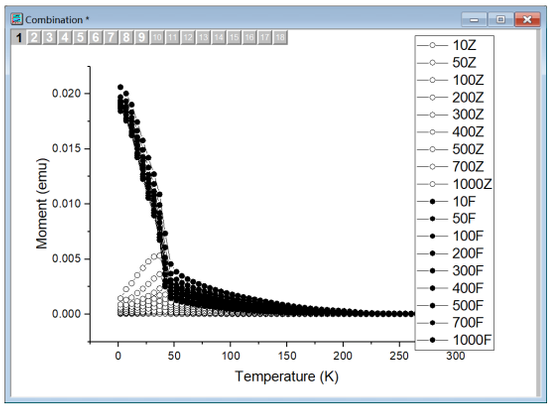


16. Now we need to merge ZFC and FC into one figure. Please also link the curves together

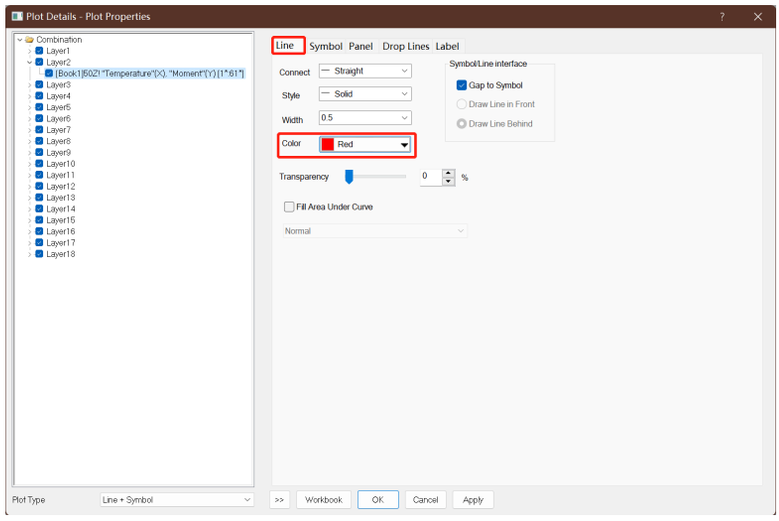


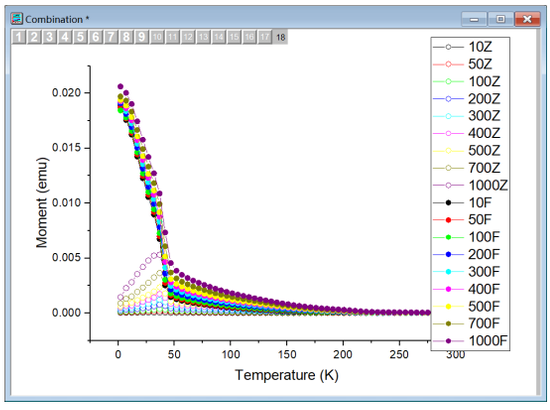


17. Again, merge the *Legend*

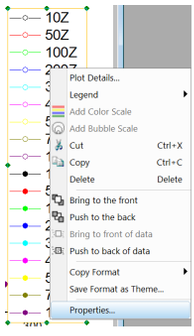


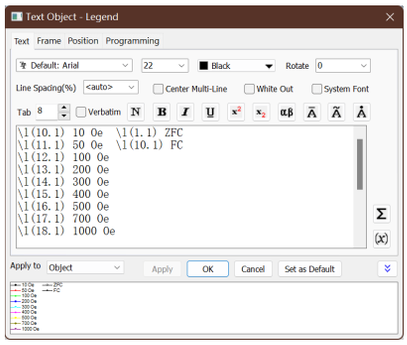
18. Double click on the markers in the *Legend* to change their color. Please remember to select the same color for the similar *Magnetic Field* group (for example, 10Z's and 10F's markers should be in the same color)

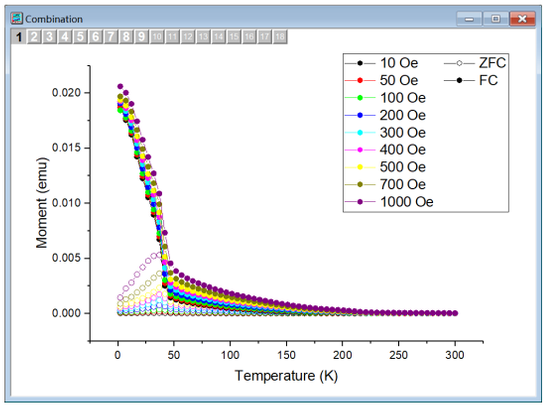




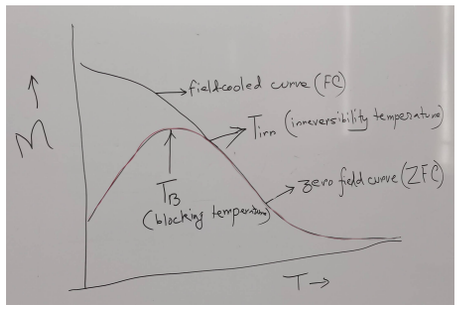
19. Right click on the Legend to reorder it. List the *Magnetic Field* Groups on the first column and the type on the second column



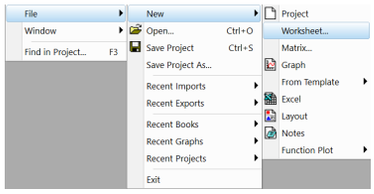


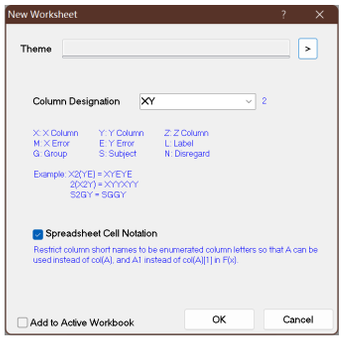


20. We want to find whether the material has T_F (or called T_B) or T_{irr}. T_F is the peak of ZFC, while T_{irr} is where ZFC and FC start to overlap (the first intersection point). Not all materials have these two properties

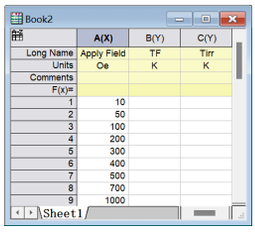


21. [File] → [New] → [Worksheet] → [OK]

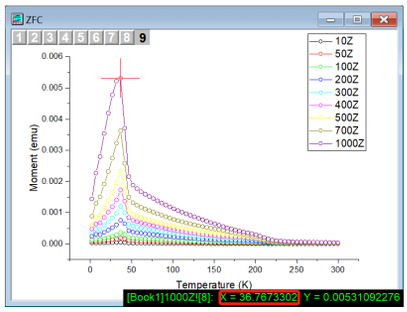


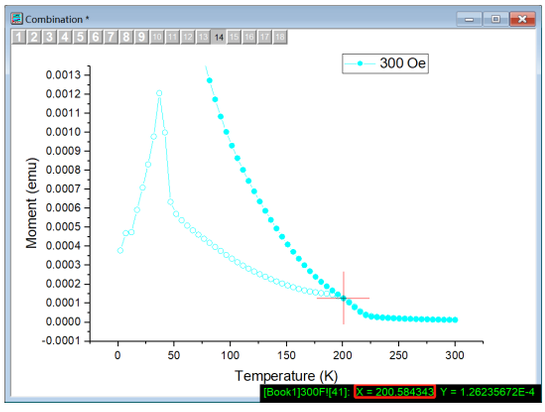


22. Please input the title, unit, (and the temperatures) as following

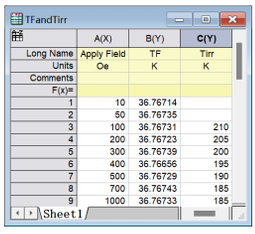


23. Use *Data Reader* ( ) to find T_F in the ZFC figure, and T_{irr} in the ZFC & FC figure

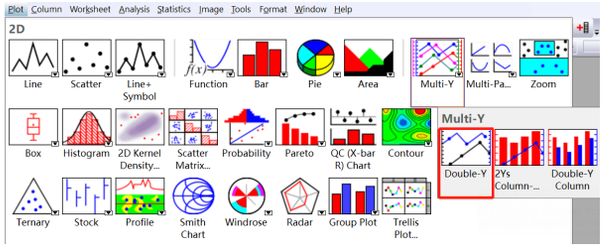


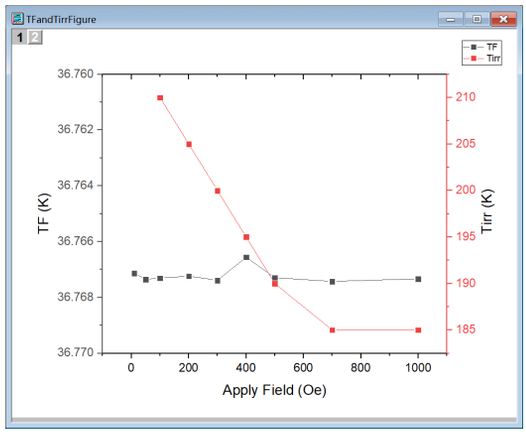


24. Record these data into the worksheet



25. Select all data → [Plot] → [Multi-Y] → [Double-Y]





And these are the figures that we want. Please save the project and export the graphs.