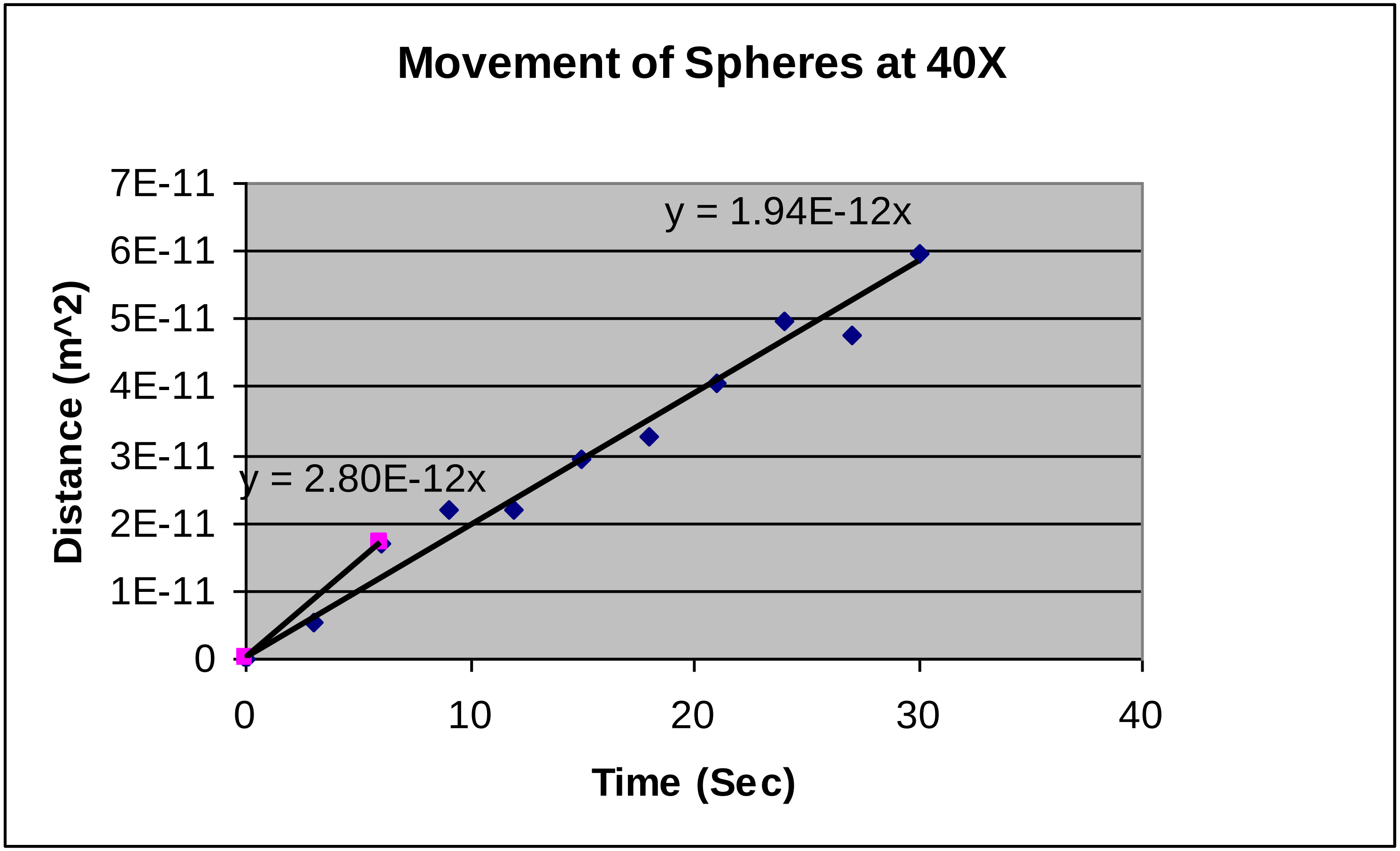
Calculating Avogadro's Number

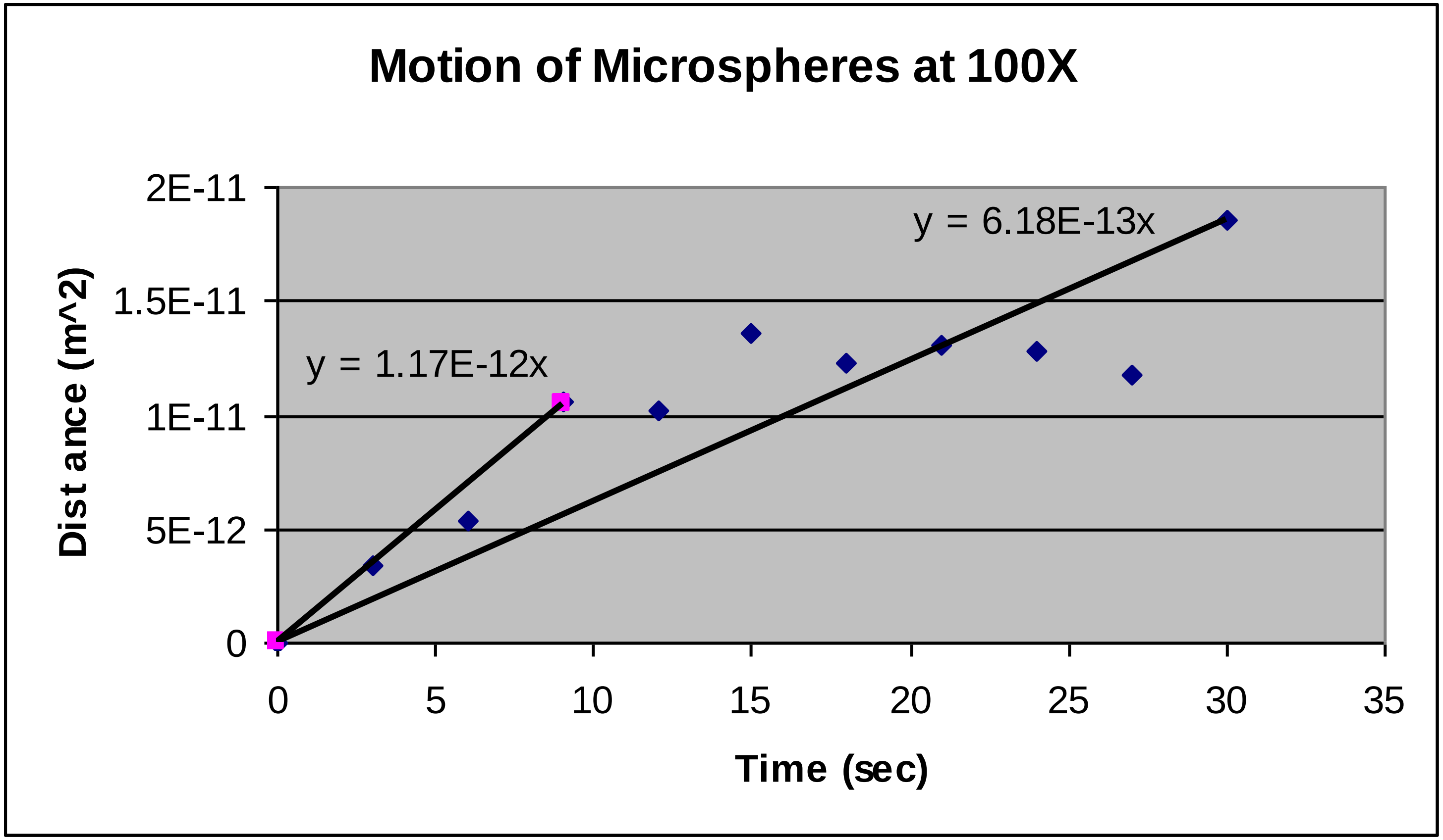
- *The Theoretical Equation is:*

$$\left\langle X^2 + Y^2 \right\rangle = \left(\frac{nRT}{3\pi\eta a N_A} \right) t$$

- *You need values of:*
  - *Number of degrees of freedom n*
  - *Temperature T*
  - *Viscosity "eta"*
  - *Radius a*
  - *Gas constant R*



Movement of Spheres at 40X
y = 1.94E-12x
y = 2.80E-12x
7E-11
6E-11
5E-11
4E-11
3E-11
2E-11
1E-11
0
Distance (m^2)
0
10
20
30
40
Time (Sec)


Motion of Microspheres at 100X
y = 6.18E-13x
y = 1.17E-12x
Dist ance (m^2)
2E-11
1.5E-11
1E-11
5E-12
0
0
5
10
15
20
25
30
35
Time (sec)

Error Analysis

- Use Best Slope (from automatic **trend-line**) to find your "best" N_0 (Avogardro's Number)
  - Make sure you set Intercept =0 in the trend-line options
  - Make sure you formatted the "data label" on the trend-line equation to "scientific" and at least 2 digits (i.e. 3 significant digits)

Reminder: slope

$$Slope = \frac{nRT}{3\pi\eta a N_A}$$

Statistical Error

- To find the "statistical" error, find a second slope that barely touches your data distribution (this measures the amount of "statistical" fluctuations inherent in your data:
- Use this alternate slope to calculate N_1, the 1st alternate Avogadro's number
- Statistical error = $|N_1 - N_0|$

Systematic Error

- To find the “system,atic” error, assume the temperature is changed by 10K (to either 313K or 293K, you don’t need both)
- Use this alternate T AND the new value of viscosity (it changes a lot) to calculate N_2, the 2nd alternate Avogadro’s number
- Systematic error = $|N_2 - N_0|$

Adding errors

- Overall error = square root of (stat err ^2 + syst err ^2)
- At the end you should calculate how far your answer is from the nominal value of N_{STD}=6.02E23
  - D=(N0-N_{STD})/(Overall error)

Hand in

- Each group should submit TWO spreadsheets, and one WORD (or equivalent) file by either by e-mail tofizprof@gmail.com, or by upload to the http://access2010.wikidot.com
  - (1) for 40X results
  - (2) for 100X results
  - (3) calculation of Avogadro's Number along with estimation of statistical and systematic errors.
- SHOW all raw data and calculations

ERROR Analysis

- **Statistical Error:**
- NA’ = (8.314)(294)/3π(1.17E-12)(9.79E-4)(0.5E-6) = **9.05E22**
- |9.05E22 – 1.72E24| = 1.62E24
- **Systematic Error:**
- 3% of the radius of the microsphere: 0.5E-6 (.03) = **1.5E-8**
- 0.5E-6 + 1.5E-8 = **5.15E-7**
- NA = (8.314)(294)/3π(6.18E-13)(9.79E-4)(**5.15E-7**) = 8.32E23
- 0.5E-6 - 1.5E-8 = **4.85E-7**
- NA = (8.314)(294)/3π(6.18E-13)(9.79E-4)(**4.85E-7**) = 8.84E23
- Temperature Difference of 10 K
- 294 – 10 = **284** K
- the viscosity for water at 284 K is **1.27 E-3** kg/ms
- NA = (8.314)(**284**)/3π(6.18E-13)(**1.27 E-3**)(0.5E-6) = 6.38E23
- 294 + 10 = **304** K
- the viscosity for water at 284 K is **7.81E-4** kg/ms
- NA = (8.314)(**304**)/3π(6.18E-13)(**7.81E-4**)(0.5E-6) = 1.11E24
- ∴[∑(ΔNA)i2] ½ = [(8.32E232) + (8.84E232) + (6.38E232) + (1.11E242)] ½ = **1.76E24**