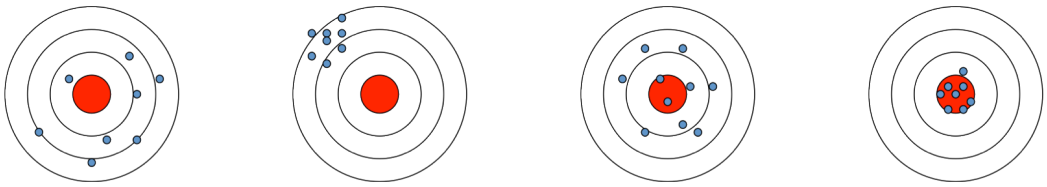
Goal: to minimize measurement error

Types of Error (Sec. 3-3)
Accuracy - how close measurement is to "true" value.
Precision - measure of the reproducibility of a measurement.



Accurate?

Precise?

Systematic (determinant) error
- error caused by procedural factors that make a measurement consistently too large or too small
- can be discovered and corrected

Random (indeterminant) error
- could be high or low for any individual measurement
- based on ultimate physical limits of measurements
- minimized by good technique
- reduced by averaging

Balances (Sec. 2-3 Harris, pg 19 lab manual)

Three types of balances:

1) Analytical (Mettler) balance

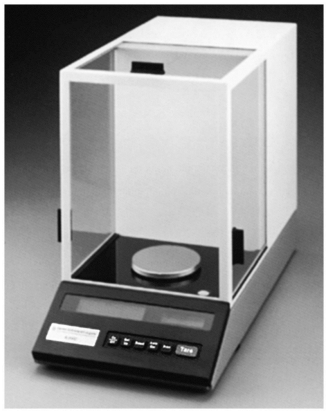
- for measuring small quantities (< 10 g) with high precision
  ± 0.1 mg 0.9982

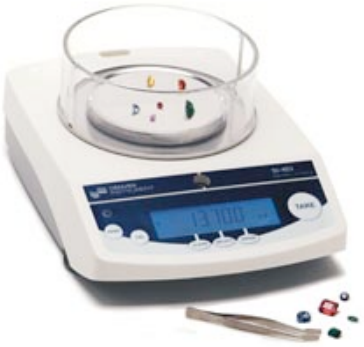
2) Denver balance

- for weighing larger quantities (> 10 g) with precision
  ± 1 mg 0.998

3) Top loading balance

- for quick dispensing of reagents
  (by reagent shelf)
  ± 10 mg 1.00 g





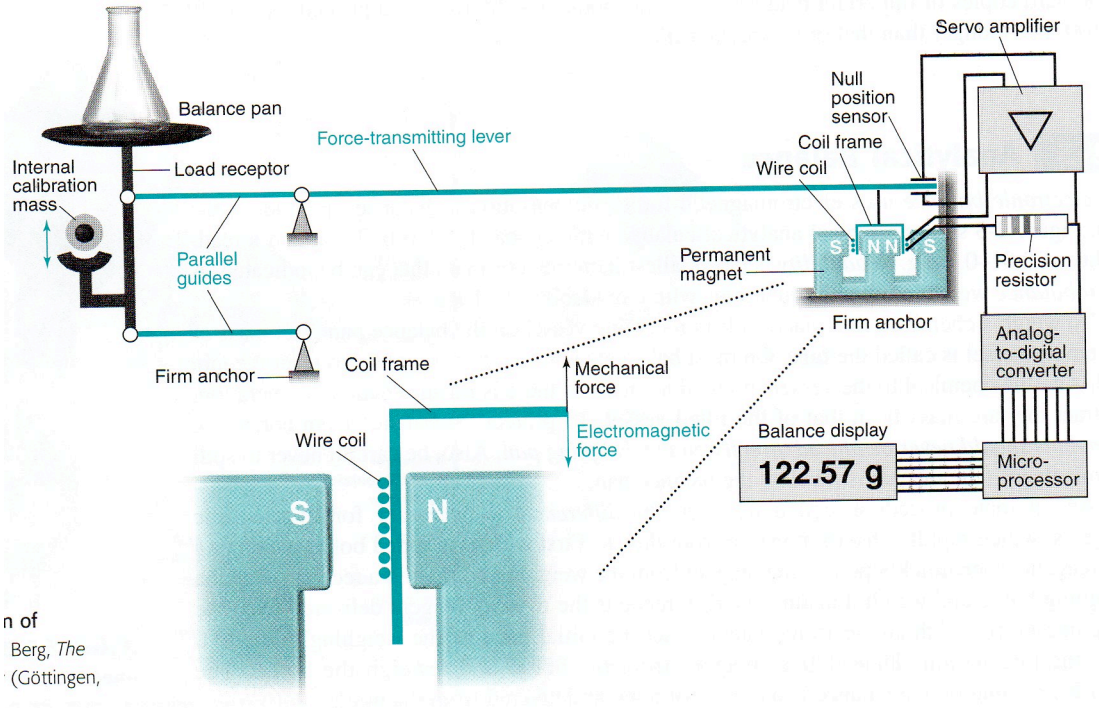
The Electronic Balance (Fig. 2-3)

- The current in the electromagnet required to keep the balance pan at a constant location is directly related to the weight of the sample

Why balances drift?

http://www.merrowscientific.com/blog/bid/38379/Just-drifting-along-Removing-the-influence-of-balance-drift-on-your-measurement

General Procedures:
http://www.dartmouth.edu/~chemlab/techniques/a_balance.html

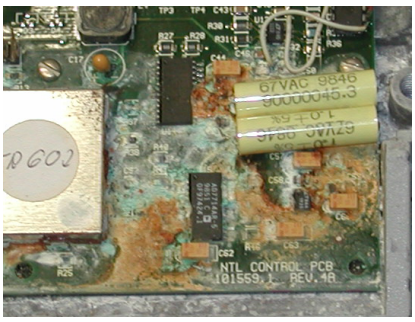


Tips

1) Never weigh directly on balance pan
   Use container or weigh paper
2) Avoid drafts
3) Do not use fingers
   Use finger cots or folded paper
4) Never return un-used reagents to reagent jar !!!

Common Weighing Problems:

wet beaker (weight will drift down)	~90%
hot beaker, water condenses on it (weight drifts up)	
drafts, (erratic)	~ 5%
static electricity (highly erratic) (not a problem until winter)	~ 5%



Balances (Sec. 2-3 Harris)

Rules for using balances:

- Never place chemicals directly on pan
- do NOT transfer chemicals inside balance compartment
- Keep balances clean

Weighing by Difference – necessary for hygroscopic cpds

General procedure:

1) Zero balance
2) Weigh sealed bottle of hygroscopic reagent
3) <u>Quantitatively</u> transfer reagent from bottle to beaker
4) Seal bottle
5) Zero analytical balance and re-weigh reagent bottle
6) $W_{dispensed} = W_{bottle,2} - W_{bottle,5}$

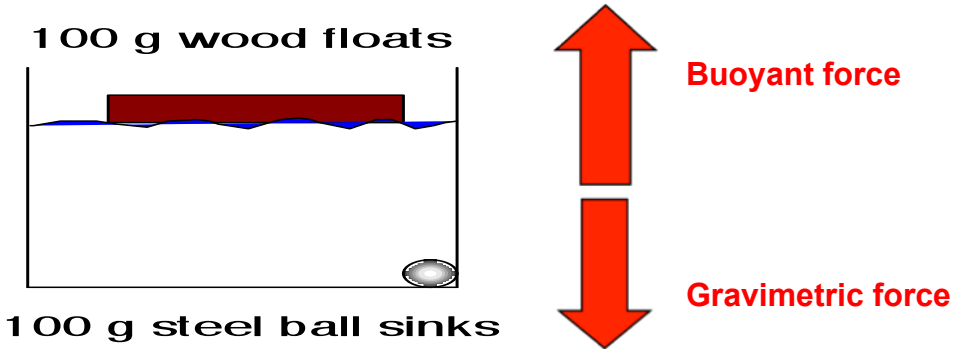
Quantitatively transfer

- All of material removed from reagent bottle must be in beaker
- Avoid spillage
- Use camel-hair brush to move all material from spatula to beaker

Weighing by Addition – normal procedure

1) Zero balance
2) Weigh clean dry small beaker on analytical balance
3) Record weight in lab book
4) Take beaker out
5) Using top loading balance weigh out the approximate weight (±10%) of analyte
6) Zero balance and reweigh beaker on analytical balance
7) Record weight in lab notebook
8) Difference between the two weighings is the weight of analyte

Buoyancy Effect (Sec. 2-3)



Both experience buoyant force from water displaced.
But one is denser than water and sinks, the other is less dense and floats

A body will experience a loss in weight = weight of medium it displaces
- Archimedes principle

Objects in air displace air
- So they are buoyed by volume displaced

Dense steel weights are used to calibrate balances
- Other dense materials will be properly weighed
- Less dense materials will be “under-weighed”

Correction for Buoyancy

•We need to correct for buoyancy when weighing liquids
•There is no need to correct for most solids

Correction Formula:

$$m = \frac{m'\left(1 - \frac{d_a}{d_w}\right)}{\left(1 - \frac{d_a}{d_s}\right)}$$

m is true mass,
m' is apparent mass,
d is density, with subscript: a for air, w for steel weight, and s for sample

d_w = 8.0 g/ml
d_{water} = (see table)
d_a = 0.0012 g/ml

Table III-2. Density of Water at Various Temperatures

Temp, °C	Density, g/mL	Temp, °C	Density, g/mL
18	0.9986	24	0.9973
20	0.9982	25	0.9971
21	0.9980	26	0.9968
22	0.9978	27	0.9965
23	0.9975	30	0.9956

For 25°C water, and apparent weight of 9.970 g. The true weight is:

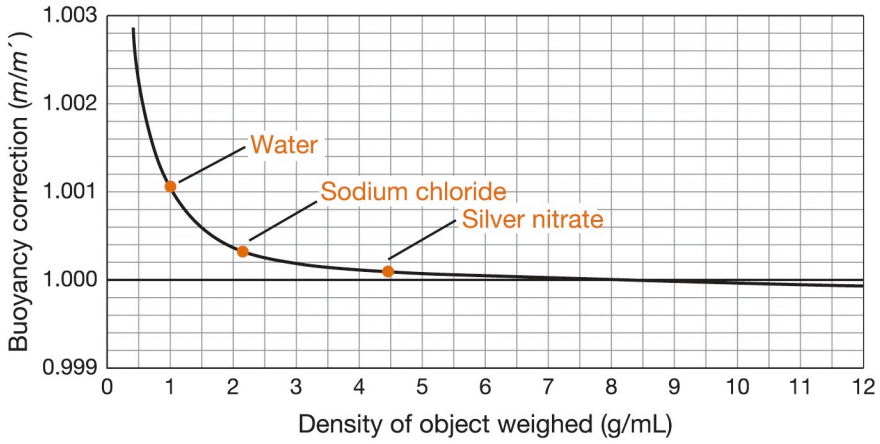
$$m = m'\left(\frac{1 - \frac{d_a}{d_w}}{1 - \frac{d_a}{d_s}}\right) = 9.970\left(\frac{1 - \frac{0.0012}{8.0}}{1 - \frac{0.0012}{0.9971}}\right) = 9.981 \text{ g}$$

Buret Calibration (in your lab manual):

Table III-3. Data and Calculations for Calibration of 50-mL Buret (At 25°C)

Approx. Interval	Buret Readings	Apparent Volume	Weight	Apparent Weight	True Weight	True Volume	Correction	Cumulative Correction
mL	mL	mL	g	g	g	mL	mL	mL
Initial	0.03B†		36.450E					
0-10	10.02	9.99	46.420	9.970	9.981	10.01	0.02	0.02
10-20	20.01	9.99	56.381	9.961	9.972	10.00	0.01	0.03
20-30	30.01	10.00	66.362	9.981	9.992	10.02	0.02	0.05
30-40	39.98	9.97	76.264	9.902	9.913	9.94	-0.03	0.02
40-50	49.99A	10.01	86.205D	9.941F	9.952	9.98G	-0.03	-0.01C

When should we apply buoyancy correction?



- when weighing out low density analytes; like water
- particularly for glassware calibration, which relies heavily on weight to determine volume

Additional Reading (optional):
Uncertainty Measurement of Weighing Results from an Electronic Analytical Balance
MEASUREMENT SCIENCE REVIEW, Volume 7, Section 3, No. 6. 2007

Review Questions:

1. Using a top loading balance to measure the weight of your sample will cause:
   a) no error.
   b) no significant error.
   c) increased random error.
   d) a systematic error.

2. Assuming your pipet delivers exactly 10.000 mL would cause:
   a) no error.
   b) no significant error.
   c) increased random error.
   d) a systematic error.

3. If the compound being weighed is hygroscopic (picks up water), this will cause
   a) no error.
   b) no significant error.
   c) increased random error.
   d) a systematic error.