MASS DETERMINATION
WITH LABORATORY BALANCES

One of the most common laboratory operations is the determination of mass using a laboratory balance. There are three types of balances used in the chemistry laboratory, the general purpose electronic top-loading balance, the triple beam balance, and the analytical balance. Within each of these types, balances vary with manufacturers' design and functions, but all accomplish the same task.

Before using any balance, there are two rules that must be observed:

> **NEVER PLACE CHEMICALS DIRECTLY ON THE BALANCE PAN!** Use a piece of weighting paper, weighing boats or trays, a watch glass, or a small beaker to hold chemicals.
>
> **KEEP THE BALANCE AND THE AREA AROUND THE BALANCE SPOTLESSLY CLEAN!** Clean up any spills immediately to avoid contact with laboratory chemicals, as well as to keep the balance in good working order.

In addition to the above two rules, **always use the same balance** to weigh samples during any experiment. Balances are precise measuring tools, but there are small variations between different balances.

Mass determination with an electronic top-loading balance

The electronic top-loading balance is the general purpose balance used in most chemistry laboratories. (See Figure B-1.) Depending on the model available, most provide digital readouts of mass to centigrams (0.01 g) or milligrams (0.001 g). Although the actual controls may differ, all the balances work in a similar fashion.

Figure B-1. An electronic top-loading balance

Before using the balance, you should make sure that the balance is level. This is important to get precise masses. Check the leveling bulb to see if the bubble is centered. Leveling is accomplished by turning the leveling feet on the balance. Before attempting to level the balance, ask your instructor for assistance.

1. If the balance display in not on, turn it on using the display on/off button. Allow the balance to go through its power up internal check procedure. Wait until the display stabilizes at or near a reading of zero grams.

2. Set the zero on the balance by pressing the zero/tare bar or button.

3. Place a piece of weighing paper, a weighing boat, or other container on the balance pan.

4. Press the zero/tare bar or button. This will electronically subtract the mass of the object on the weighing pan and reset the display to zero.

5. Add the material to be weighed to the container on the balance pan.

   If the bottle holding the material to be weighed is small, you can carefully pour from the container into the weighing container. You can also use a clean spatula to add the material to the weighing container.

   To add small increments of sample, hold the spatula over the weighing container and tap your hand with the fingers of the other hand. (See Figure B-2)

   Get as close as possible to the desired mass. It is not necessary to get the exact mass of the material. For example, if you need to measure 2.500 g of a substance, a mass between 2.490 g and 2.510 g is acceptable.

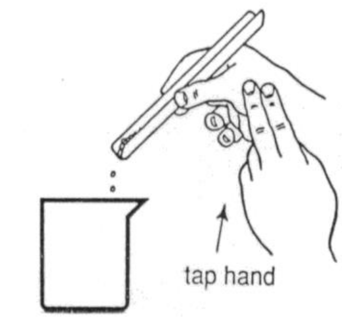


Figure B-2. Adding a small Increment of sample.

6. Record the mass of the material exactly as displayed on the balance. Include all tailing zeros. This represents an exact measurement, all the digits are significant.

7. Remove the weighing container and the material. Reset the zero. Clean up any spilled material.

Mass determination with a triple beam balance

The triple-beam balance is a general purpose balance in the laboratory used when the mass of a substance is greater than the capacity of the electronic top-loading balance. It consists of a pan, a fulcrum, three beams with mass riders, a pointer, a fixed scale, and a supporting base. At some point on, or below the beam is a zero adjustment screw. Some models of triple-beam balances have a magnetic dampening device. (See Figure B-3)

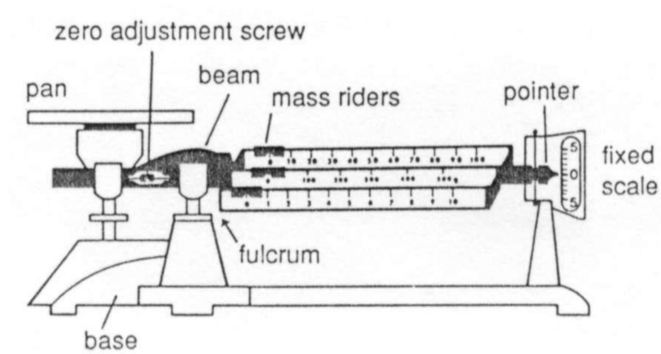
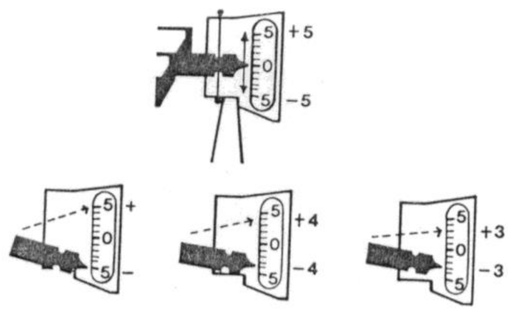


Figure B-3. A triple beam balance.

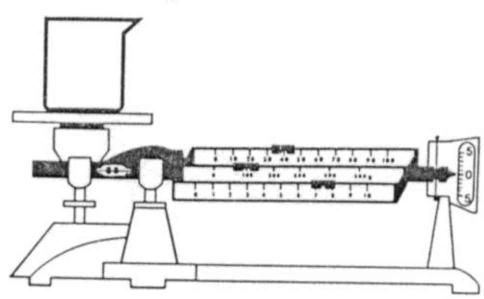
One beam, usually the middle one, has notched positions labeled in 100-g steps from 0 to 500 grams. The rider on this beam is referred to as the 100-g rider. The second beam, usually the rear one, has notched positions labeled in 10-g steps from 0 to 100 grams. The rider on this beam is referred to as the 10-g rider. The third beam, the one in front, is not notched, it has marks at 0.1-g steps and is labeled at the 1-g positions from 0 to 10 grams. The rider on this beam is referred to as the 1-g rider.

The mass of an object can be read to 0.1 g from the positions of the riders when the balance is at equilibrium. The position of the 1-g rider can be easily read to 0.05 g (half-way between two of the lines), but can only be estimated to 0.01 g with some difficulty. Depending on the requirements of a particular experiment, the mass of an object will normally be determined to the nearest 0.1, or 0.05 g. Only in a few situations will an experiment require reading the mass to 0.01 gram. Examine a triple-beam balance in the laboratory, identify its parts, and try pushing the 1-g rider to several arbitrary positions and read the indicated mass to 0.1 g, 0.05 g and 0.01 g.

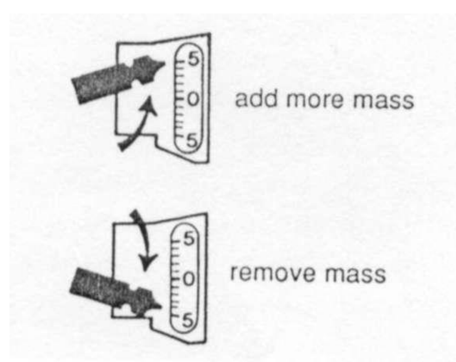
To use the balance to weigh 7.80 g of a common material such as salt (sodium chloride) using a 100-g beaker to hold the sample:



1. Set all three riders to the zero position. Make sure that the 100-g and the 10-g riders are set into their zero notches and that the 1-g rider is exactly on the zero position. Lightly push the balance beam to cause the pointer to swing between the +5 and -5 positions on the fixed scale. If the balance is properly zeroed, the pointer should swing between points such as +4, -4; +3, -3; +2, -2. If these or very similar readings are obtained, the balance is properly zeroed. If readings such as +5, -3; or +4, -2 are obtained, the balance is not properly zeroed. Reading a swinging pointer is the preferred method of determining mass with the balance, a static pointer on the zero mark does not guarantee a precise reading. Until you are familiar with the workings of the balance, ask your instructor to help you adjust the balance with the zero-adjustment screw.



2. Place a weighing container, such as a clean and dry 100-mL beaker, on the pan. The pointer will go to the top of the scale. This indicates that you should "add weight". Slide the 100-g rider into the 100-g notch. If the pointer moves down and remains down, the beaker is lighter than 100 g. Move the rider back to the zero notch. If the pointer moves up and remains up, the beaker is heavier than 100 g. In this case advance the rider to the 200-g notch. Note the position of the pointer. If necessary, continue moving the rider one notch at a time until the pointer moves down and stays down. *Then set the rider back one notch*. It is important that the rider be placed in a notch to get an accurate reading on the balance.

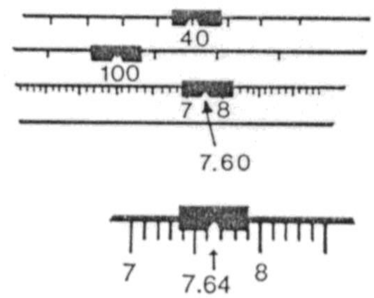


3. Repeat this procedure with the 10-g rider, advancing it one notch at a time until the pointer goes down. *Then set the rider back one notch.*

4. Advance the 1-g rider slowly by 1-g increments until the pointer goes down. Watch the pointer as the beam swings up and down. When readings are in equilibrium (very close to +4, -4; +3, -3; or +2, -2) stop the beam. Them push the beam lightly to start it swinging between the +5 and -5 scale positions. If the readings are not in equilibrium, move the 1-g rider in very small increments until the proper swings are obtained.

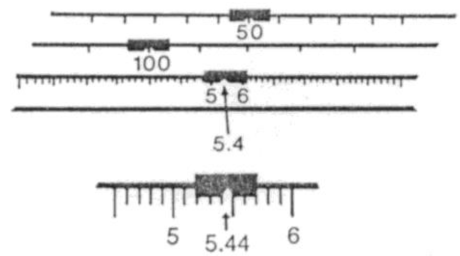
5. Read the rider positions and add them together to obtain the mass of the beaker. Read the 1-g rider position first to 0.05 g, then try to read it to 0.01 g. The positions of the riders in the illustration give the mass of the beaker as

approximately 147.6 g. The position of the 1-g rider in the enlarged illustration shows the mass to be 147.65 or with estimation to 0.01 g - 147.64 g.



6. Now you are ready to add your sample. Change the rider positions to make them correspond to the mass of beaker plus the mass of the sample (Using the mass of the beaker in the discussion above, this is: 147.64 g + 7.80 g = 155.44 g).

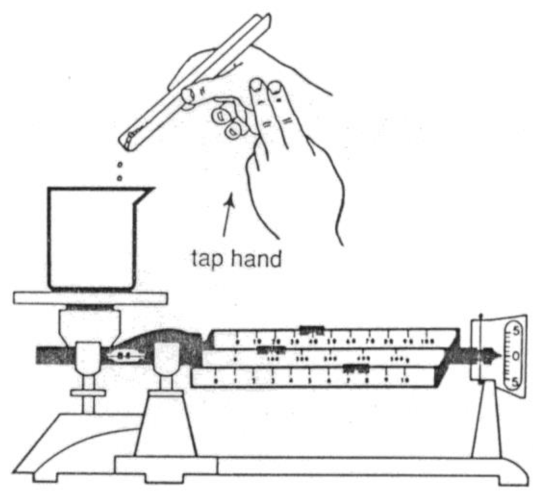
   The 100-g rider should be in the 100-g notch. Set the 10-g rider into the 50-g notch and slide the 1-g rider to the 5.44-g position.



7. With your clean and dry spatula take some sample from the stock bottle and add it to the beaker in small increments. Take care to not spill any sample during this operation. From time to time push down gently on the balance pan. If the beam is reluctant to swing, you are not yet close to the desired mass of the sample. If the beam starts to swing easily, add the sample in very small increments by gently tapping the hand holding the spatula over the beaker with a finger from your other hand. When the beam begins to swing freely, observe the swing points of the pointer on the fixed scale. Add tiny increments of the sample until the pointer is in equilibrium.

   If you added too much of the sample, you may remove some of it from the beaker and repeat the incremental addition with care. Removal of sample from the beaker is a more difficult operation than careful incremental addition.

   When you judge the balance to be at or very close to equilibrium, stop the beam. Then push the beam gently and observe whether or not the balance is at equilibrium. If necessary, adjust the 1-g rider to bring the balance to equilibrium. You should not have to move the rider more than two lines in either direction. You can also bring the balance to equilibrium by adjusting the amount of sample in the beaker. Repeat the check procedure.



8. Read the rider settings and record the mass of beaker plus sample to 0.05 g and also to 0.01 g. Remove the beaker gently from the pan. Return all riders to the zero-position. Before leaving the balance, check the balance and the surrounding area. If they are not completely clean, clean up!

9. Take your weighed sample to your work area to use for your experiment. Discard any excess chemical in the proper waste container as indicated by your instructor. Calculate the mass of the sample to the nearest 0.05 g or to the nearest 0.01 g as required by the experimental procedure.

NOTE: In most experiments, the quantity of sample needed will usually be within a mass range such as between 7.70 and 7.90 g, rather than trying to obtain exactly 7.80 g of sample.