

## Electronic balance buying guide

### For use by students up to GCSE

Feature	Essential	Desirable	Points to consider
<b>Capacity and readability</b>	Capacity 1000 g reading to 0.1 g	Capacity 1500 g	Suitable for most physics, some biology and some technician applications.
	Capacity 200 g reading to 0.01 g		Suitable for most chemistry and many technician applications. A balance of 1000 g capacity reading to 0.01 g costs about twice as much as a balance reading to only 0.1 g.
<b>Repeatability and accuracy</b>	Repeatability more important than accuracy		The same load should always give the same reading This becomes more significant as readability increases. Differences in mass are usually more important than absolute measurements. Check repeatability especially of cheaper instruments before buying by asking a rep to bring in a balance.
<b>Display</b>		LED or LCD with backlight	The same balance may be located in different ambient light; pupils may be of different heights.
<b>Robustness and spill-resistance</b>	Yes		More expensive force-motor balances (see Technical notes below) will generally be more robust than cheaper balances. High capacity balances can withstand a high overload. Cheaper balances often have glued cases which cannot be opened for repair.
<b>Tare (zeroing)</b>	No		Not helpful for small changes in mass and may confuse some pupils.
<b>Levelling</b>		Yes	Benches may not be level.
<b>Modes and features</b>		As few as possible	Ease of use is important. Do controls have obvious meanings with no possibility of students changing settings, units, etc?
<b>Data-logging</b>		Yes	Schools seem to make less use of this than they anticipate.

### For use by students at A-level

Feature	Essential	Desirable	Points to consider
<b>Capacity and readability</b>	Capacity 1000 g reading to 0.1 g	Capacity 1500 g	Suitable for most physics, some biology and some technician applications.
	Capacity 100 g reading to 0.001 g	Capacity 200 g reading to 0.001 g	Required for some A-level chemistry specifications. Draft shield needed.
<b>Repeatability and accuracy</b>	Accuracy also important		Accuracy only important for precise quantities, such as volumetric analysis or when technicians are preparing reagents.
<b>Display</b>		LED or LCD with backlight	The same balance may be used in different ambient light.
<b>Robustness and spill-resistance</b>	Yes		More expensive force-motor balances (see Technical notes below) will generally be more robust than cheaper balances. High capacity balances can withstand a high overload. Cheaper balances often have glued cases which cannot be opened for repair.
<b>Tare (zeroing)</b>		Yes	
<b>Levelling</b>	Yes		Necessary for accurate work; two adjustable feet better than four.
<b>Modes and features</b>		As few as possible	Ease of use is important. Do controls have obvious meanings with no possibility of students changing settings, units, etc?
<b>Data-logging</b>		Yes	Schools seem to make less use of this than they anticipate

Feature	Explanatory notes
<p>For further guidance and information about training refer to the CLEAPSS website: <a href="http://www.cleapss.org.uk">www.cleapss.org.uk</a></p>	
<b>Capacity and readability</b>	<p><b>Physics and some biology</b> need balances to weigh up to 1kg or 1.5kg, reading to 1 decimal place (dp).  <b>Chemistry and technicians</b> need balances to weigh up to 200 g or less, reading to 2 dp.  <b>A-level chemistry and some technicians' work</b> may need balances reading to 3 dp, with a draft shield to ensure stable readings.  <b>Dual range balances</b> can switch between two levels of accuracy eg 2 dp up to 400 g and to 1 dp up to 4000 g.  Other balances allow one or more digits to be suppressed in the display, converting a 2 or 3 dp balance to a 1 dp balance. This facility should be activated by staff (and difficult for students to access). It gives more accurate readings than a dual range balance.</p>
<b>Repeatability and accuracy</b>	<p><b>Good repeatability:</b> needed if a number of objects are being compared, or if the same object is being tested over a period of time. Repeatability can be tested by taking and comparing 6-10 separate readings of the same mass. Try masses near the limits of the range. A balance with poor repeatability cannot be considered reliable or accurate.  <b>Accuracy:</b> when measuring smaller masses, the percentage error increases.</p>
<b>Display</b>	<p><b>LCDs</b> are most common but are less visible in poor light than LEDs. Some LCDs have a backlight to compensate.</p>
<b>Robustness and spill-resistance</b>	<p><b>Over-load protection</b> is found in most balances. Most will not survive abrupt overloads, eg being thumped or having a school bag placed on them.  <b>Avoiding physical damage:</b> some balances have a locking mechanism for easy movement between rooms, and some have a plastic cover allowing several balances to be stacked without damage.  <b>Force-motor balances</b> (see Technical notes below) tend to be more robust than load-cell balances, because they have both mechanical and electrical protection.  Cheaper balances may have poor connections between electronic components, reducing their robustness.  Spills may damage a balance. Check that the design allows easy external cleaning and that spills are unlikely to seep inside the balance. A raised lip round the opening under the pan should restrict entry of most spills. Some balances have covers for keypad protection.</p>
<b>Tare (zeroing)</b>	<p>This is when the balance is set to read zero with a container on the pan. It will then register the net mass of whatever is added. This avoids the need for subtraction, but it is not so helpful if small changes in mass are expected (see 'Zero tracking' below). Some children may find it confusing.</p>
<b>Levelling</b>	<p>Levelling the balance is important if accurate readings are needed, or if a series of readings will be taken with the balance being moved between readings. Benches may not be level and can be inconsistently out-of-level.  Some balances have a spirit level and adjustable feet. The spirit level should be mounted for easy viewing. Levelling feet should be secure enough to retain their position after adjustment. It is usually easier to level a balance with two adjustable feet, rather than four.  Levelling does not affect most work up to GCSE, and many suitable models for lower-school use lack levelling facilities.</p>
<b>Modes and features</b>	<p>Features most likely to be used by schools include auto-off setting, calibration, filtering, and computer connection.  Many balances have unnecessary features and settings, eg a choice of weighing units. Avoid these or ensure they are disabled or difficult to access.</p>
<b>Data-logging</b>	<p>This enables data from the balance to be recorded and synthesised by a computer, but schools seldom use it.  Connection is via an RS232 port or jack plug and/or USB. Check before purchase that the balance and its software and leads are compatible with your computer and equipment. Consider whether the time needed to set up and use a balance with software is justified by the educational gains.</p>

## Other considerations

<b>Maintenance (including calibration) and repair</b>	<p>Keep the balance clean and periodically check / adjust the calibration. This is needed to ensure the balance is accurate. Follow manufacturer's instructions. For most school applications repeatability is more important than accuracy. Hence it is usually sufficient to calibrate only periodically and in one location unless a problem is suspected.</p> <p>Also check and change batteries if used.</p> <p><b>Electronic balances do not need specialist servicing.</b> If an electronic balance component fails, repair may not be possible or economic (except for the more expensive ones).</p>
<b>Power supply</b>	<p>Balances may be powered via a <b>mains adaptor</b>, by a <b>battery</b> or both.</p> <p>Batteries make a balance heavier.</p> <p>A built-in rechargeable battery can be useful for field work.</p> <p>Removable batteries can easily be stolen, so check if they can be secured.</p> <p>Technicians need to allocate time for checking batteries before issuing to a class.</p>
<b>Auto-off</b>	<p>Auto-off <b>switches off the display</b> when the load is unchanged for a given length of time. Useful to preserve battery life, but it may need disabling if repeated readings are taken.</p>
<b>Zero-tracking</b>	<p>Zero-tracking, <b>automatically resets the zero</b> when there is (almost) nothing on the pan. Limits can be set.</p> <p>Useful to prevent small residues affecting the zero reading between samples, or if temperature variations or draughts are affecting the balance.</p> <p>In some balances, <b>zero tracking can be disabled</b>. Useful for measurement of small masses or mass changes near zero.</p> <p>For small mass changes investigations, eg the 'marble chip investigation', the balance should not be tared. Mass should be calculated by subtraction of subsequent readings from an initial value.</p>
<b>Speed and stability of readings</b>	<p>The balance usually has a stability indicator. On some more expensive balances the user can vary time-checking readings, or limits within which stability is registered.</p> <p>This 'filtering level' may be pre-set or the user can adjust it.</p> <p>A low filtering level means more sensitivity to draughts and vibrations, but less time to display a stable reading.</p> <p>With high filtering the balance will never reach stability when the reading is changing gradually, eg change in mass of a marble chip in acid.</p>
<b>Security</b>	<p>Easy portability by technicians means easy portability by thieves. Some balances take a computer security cable. Others have a lug for a chain and padlock but this is sometimes inconveniently located.</p> <p>Some balances require a password – display this fact.</p>
<b>Under-bench weighing</b>	<p>Some balances have a ring to attach a hook and weigh items from below, for measurement of density and specific gravity. Not much used.</p>
<b>Students with special needs</b>	<p>Check suitability for special needs use:</p> <ul style="list-style-type: none"> <li>• clarity of display;</li> <li>• ease of use of keys (location by touch, and ease of activation);</li> <li>• audible beeps when a key is pressed.</li> </ul>

See Technical Notes on following page.

## Technical notes

### Types of balance

There are two main types of electronic balance.

Force motor	Load-cell
<p>The weight of the object (load) on the pan is balanced by a force generated electromagnetically by the force motor.</p> <p>The pan is supported on the beam of a frame which flexes very slightly when a load is placed on it.</p> <p>Displacement of the frame causes movement of the coil mounted above a fixed magnet. This is detected by a light sensor, and the current through the electromagnet is adjusted to restore the frame to its original position. The size of the current required to do this is measured and converted to a reading of mass, assuming a value of 'g', which may need adjustment ('calibration').</p>	<p>The pan rests on a shaped piece of metal fixed to the case of the balance. The shape is designed so that strain gauges mounted on the load-cell can detect distortion when the pan is loaded.</p> <p>The resulting changes in the resistance of the gauges are sensed by a bridge circuit, and changes in the out-of-balance current are converted to a reading in grams or other units.</p> <p>Some balances utilise a variable-capacitance sensor.</p>
<p>Sensitive balances with a typical capacity and readability of: 2000 g to 0.1 g or 200 g to 0.01 g</p> <p>Sensitive to strong magnetic, electrostatic or electromagnetic fields, and to electromagnetic radiation (eg radio waves). The force motor is mounted inside a metal box to protect it from interference from such sources. Take care to avoid unnecessary exposure to potential interference. Keep away from sources of strong fields.</p> <p>If the strengths of magnetic or electrostatic forces are to be measured on a balance, mount the sample securely on a box or support placed on the pan before taking readings. This increases the distance between the field produced by the sample and the force motor, reducing the effect exerted on it by the external field.</p> <p>Force-motor balances are protected from overload and mechanical shock by a mechanical 'fuse'. This flexure or flexus is a strip of metal with weak points which break if overloaded, protecting other parts of the balance. The thickness and positioning of these weak points is critical to ensure that they will break under the appropriate load for the capacity of the balance. Broken flexures can be replaced, though at a cost.</p> <p>Monoblocks may now either replace a multi-component design or be used for part of the mechanism. These may be referred to as 'hybrid force motors'. They work on the same principle as traditional force motors, though have different physical properties which affect their specifications.</p> <p>Monoblock balances do not usually have flexures; they are designed to withstand a certain amount of overloading.</p>	<p>Less sensitive than the force-motor type, with a typical capacity and readability of: 2000 g to 2 g or 200 g to 0.1 g</p> <p>For a readability of 0.01 g, a load-cell balance would have a capacity not much more than 600 g. A load-cell balance reading to 0.001 g (3 dp) would have a capacity not much more than 60 g. High-capacity balances are expensive because only force motors have high readability at high capacities.</p> <p>Load-cell balances are less susceptible to interference from magnetic and electrostatic fields, and electromagnetic radiation. But electrostatic interference may be a problem.</p> <p>Load-cell balances are generally protected from overload and mechanical shock by a simple mechanical stop, such as a screw or bolt to prevent the pan from being pushed down too far.</p> <p>Domestic load-cell balances may be adequate for rough measurements in labs, but cheaper ones cannot be recalibrated and may be inaccurate. Cheap load-cell balances tend to be uneconomical to repair beyond the guarantee period.</p> <p>There are more sophisticated models with more features, including calibration and computer linkage. These are more expensive than domestic load-cell balances, but cheaper than force-motor types.</p> <p>Load-cell balances are usually small and light so easy to pilfer. The simplest ones are battery-operated, though most have an AC adaptor (possibly as an optional extra). Some have only AC connectors; they are cheaper to run, but are not suitable for fieldwork use. Batteries are also easy to pilfer and technicians need to check and replace them from time to time.</p>



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