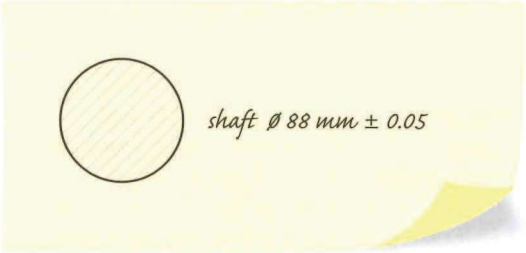
7 Dimensional accuracy

A Precision and tolerance

It is impossible to produce components with dimensions that are absolutely **precise**, with sizes exactly the same as those specified in a design. This is because all production processes are **imprecise** to a certain extent. Therefore, the sizes of several components produced from the same design will **vary** (differ). Although the **variation** may only be a few hundredths of a millimetre, sizes will not be 100% **accurate** (exact) compared with the design.

Because engineers know that **accuracy** cannot be perfect, in designs they often specify **tolerances** – that is, acceptable variations in **precision**. Instead of giving one precise size, a tolerance specifies a **range** of acceptable sizes – an allowed amount of variation. This is often given as a **deviation** (difference) from a precise size.

The drawing below shows a shaft with a specified diameter of 88 mm, **plus or minus** (±) 0.05 mm. This means the diameter may **deviate** 0.05 mm either side of this size. Therefore, diameters of 87.95 mm and 88.05 mm, which are slightly **inaccurate**, are still **permissible** (allowed), as they are **within tolerance**. However, diameters of 87.94 mm or 88.06 mm are not permissible – they are **outside tolerance**.



When the permissible deviation in size is very small, we say it is a **tight tolerance** (or a **close tolerance**). A large permissible deviation is a **loose tolerance**. For example:

- Machining a metal component to a tolerance of ±0.1 mm is relatively easy to do, so this tolerance is loose. But a tolerance of just ±0.01 mm is a tight tolerance in metalworking.
- In a concrete structure, ±10 mm is a loose tolerance. But ±1 mm is tight, because it is difficult to place wet concrete accurately.

B Fit

When one component goes through another, such as a shaft or a bolt going through a hole, the two must **fit together** – their sizes and shapes must match. The key question is, how tightly (or loosely) should they fit together? There are two main types of **fit**:

- A **clearance fit** allows a component to slide or turn freely, by leaving **clearance** (a gap) between itself and the sides of the hole. This distance must be quite precise. If there is **insufficient clearance** – if the gap is too small – the component will fit too tightly. As a result, the component will **bind** – it will not be able to slide or turn freely. In other words, there will not be enough **play**. However, if there is too much clearance, there will be **too much play** and the component will be able to move too much.
- An **interference fit** is a very tight fit which does not allow a component to move freely inside a hole. This type of fit can be achieved by forcing the component into the hole. Alternatively, the metal around the hole can be heated so that it **expands** (increases in size due to heat). After sufficient **expansion**, the component is placed in the hole. The metal then cools and **contracts** (decreases in size due to cooling). The **contraction** results in a tight fit. An example of an interference fit is a train wheel fitted on an axle.

7.1 Find words and expressions in A opposite with similar meanings to the words and expressions below (1–10). Sometimes there is more than one possible answer. The first one has been done for you.

1 allowed *permissible*
2 exact
3 differ
4 exactness
5 not exact
6 deviation between maximum and minimum
7 an acceptable deviation
8 an unacceptable deviation
9 little deviation allowed
10 large deviation allowed

7.2 Match the related sentences. Look at B opposite to help you.

1 It'll bind.
2 It'll contract.
3 It'll expand.
4 There'll be too much play.
5 It needs a clearance fit.
6 It needs an interference fit.

a The bolt will have to turn in the hole.
b The bolt won't be able to turn freely enough in the hole.
c The bolt won't fit tightly enough in the hole.
d The wheel will have to fit very tightly on the axle.
e The hole will widen with the high temperature.
f The shaft will shorten and narrow slightly as it cools.

7.3 Complete the article about engine blueprinting using the words in the box. Look at A and B opposite to help you.

clearances	minus	plus	range	variation
fit	permissible	precise	tolerances	within

Blueprinting for performance

The advantage of racing in a kart class with a standard engine spec seems obvious – everyone has the same power, so it's driving talent that makes the difference. But things aren't quite that simple. No two standard engines are identical. There will always be a slight (1) ..... in the size of engine parts, since they are manufactured, not to perfectly (2) ..... dimensions, but to specified (3) ..... . Although these differences may only be (4) ..... or (5) ..... a few hundredths of a millimetre, they will nevertheless result in a slight performance gap between any two engines.

One way round this problem (if you have the cash) is to have your engine blueprinted. The process is perfectly legal, as the sizes of all parts remain (6) ..... the tolerances that are (7) ..... for the standard engine specification. However, by carefully matching pairs or groups of parts that are all in either the lower or upper half of the tolerance (8) ..... , a blueprinted engine is built to (9) ..... together very precisely, thanks to almost perfect (10) ..... between moving parts.

Over to you

Think of a type of product or structure you're familiar with. Imagine you're designing it, and are discussing the tolerances required for different components. Say what tolerances are permissible, both for production (not too tight due to cost), and for quality (not too loose). Say which parts require the tightest tolerances, and explain why.