Gears

On the left is a solar-powered K'Nex counting machine (the counter at the top was made by English Numbering Machines and is not a K'Nex component). The small black wheels at the top simply help to hold the counter in place. In bright sunshine, the counter is incremented by 1 about every 5 seconds.

This construction demonstrates the use of the K'Nex small and large gears: if two 8-way connectors are joined by a blue rod, then the small and large gears will mesh perfectly.

If small and medium gears are to mesh then the connectors must be joined with a green rod, and if two medium gears are to mesh then a white rod is needed.

A small gear has 14 teeth; a medium gear has 34, and a large one has 82 — but why?

Ted thinks he has worked out why these numbers of teeth have been used, and his reasoning appears below.

Two Medium Gears

If two medium gears are to mesh, two 8-way connectors must be joined by a green rod. The axles for the gears will then be formed from a rod in each of the centre holes of the connectors.

We know from the "1. Know Your Pieces – Rods (Non-flexible)" document that the distance between the centre of the holes is 53mm. The radius of a medium gear is therefore 26½mm.

Medium and Small Gears

Here, the connectors must be joined by a green rod, and the distance between the connectors' holes is 37½mm. The radius of the small gear is therefore 37½ - 26½ = 11mm.

Large and Small Gears

The connectors must be joined by a blue rod, producing a distance of 75mm. The radius of the large gear is therefore 75 - 11 = 64mm.

The Number of Teeth

If the number of teeth on the large gear is L, then the number of teeth on the medium gear needs to be 26½L/64, and the number of teeth on the small gear needs to be 11L/64.

If these are not very nearly whole numbers then the mesh won't be smooth. We therefore need values which deviate by only a small amount from a whole number.

Also, the teeth mustn't be so small or large that they look out of line with the scale of K'Nex pieces.

The number of teeth on the small gear needs to be at least 12, otherwise the gear would look clunky, but more than 16 and they would be too fine.

Let's look at the possibilities:

Number of Teeth on Gears		
Large Gear L	Medium Gear = 26½L / 64	Small Gear = 11L / 64
75	31.1	12.9
76	31.5	13.1
77	31.9	13.2
78	32.3	13.4
79	32.7	13.6
80	33.1	13.7
81	33.5	13.9
82	34.0	14.1
83	34.4	14.3
84	34.8	14.4
85	35.2	14.6
86	35.6	14.8
87	36.0	15.0
88	36.4	15.1

The possibilities which have the smallest deviations from whole numbers are in green in the above table. Having an odd number of teeth on a gear wheel is aesthetically unpleasing, and the only possibility left is the actual K'Nex number of teeth — 82, 34 and 14.

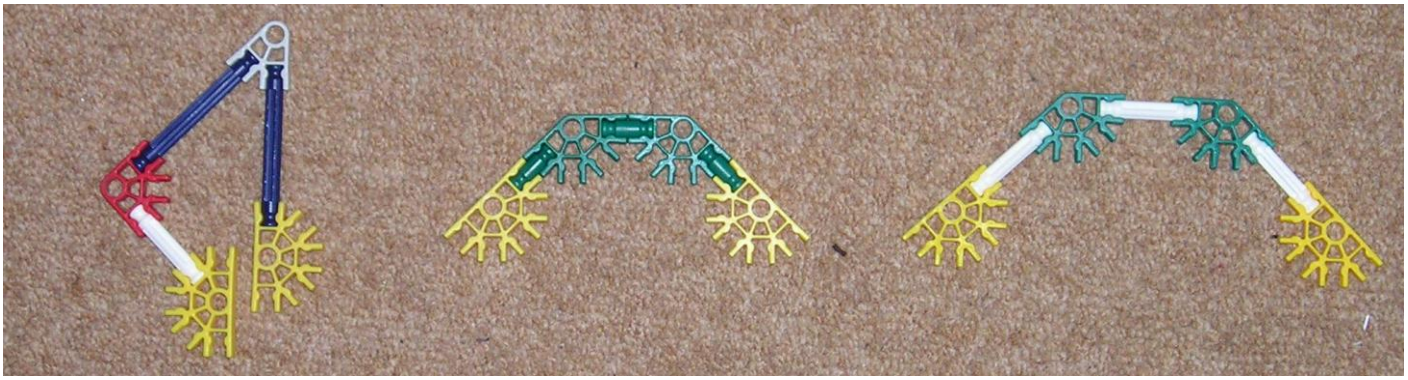
Other Combinations of Gears which can Mesh

We have seen how small/medium, medium/medium and small/large gears can mesh.

There are, though, three other ways: small/small, medium/large and large/large. Here's how to achieve those combinations (though in practice they'll be used less often than the other ones).

It might at first seem impossible to get two small gears to mesh; indeed, it has little practical use. However, it is possible, as explained below (it is left as an exercise for the reader to prove that it works, but Ted will be happy to explain it to anyone who asks).

Gears



FOR TWO SMALL GEARS FOR MEDIUM AND LARGE GEARS FOR TWO LARGE GEARS

In the first arrangement above, the holes in the yellow 5-way connectors are 22mm apart, and so two small gears would be in mesh.

In the second arrangement, a medium and large gear can mesh, and in the third, two large gears.

Gear Ratios

Because there are only three sizes of K'Nex gears, and because the number of teeth on them is a funny number, it is rarely possible to achieve a required ratio. For example, to build a clock which has a minute and an hour hand, a 12:1 ratio is required. It is not possible to achieve this with gears which have teeth in the proportion 7:17:41.