

## Lego harmonics

### Generating harmonics of a fundamental frequency

#### You will need....

- ✓ A Lego set with a variety of gears, a motor and a battery or power supply.

#### Background:

If a piece of paper or card is held against the spokes of a rotating wheel or the teeth of gear wheels, notes of different frequency can be heard as the speed of rotation changes.

The ratios of the frequencies of the first six harmonics are:  
1 : 2 : 3 : 4 : 5 : 6.

These correspond to the notes  $d_1$ ,  $d$ ,  $s$ ,  $d^1$ ,  $m^1$ ,  $s^1$ .

#### Follow these steps:

1. In the assembly shown in the picture, one axle has wheels with 40, 24, 16 and 8 teeth respectively. The 8-tooth wheel is driven by a 24-tooth wheel which is attached to the motor.

#### So what happened?

Holding a piece of paper against these wheels generates notes whose frequencies are in the ratio:

1 : 2 : 3 : 5.

These correspond to the notes :  $d_1$ ,  $d$ ,  $s$ ,  $m^1$ .

#### What next?

1. Experiment with other sets of gears to generate the first six harmonics.
2. Add a worm gear to drive a pointer so that the rate of rotation can be easily measured. This can be used as a direct measurement of the frequencies.
3. For a more difficult challenge try to generate frequencies in the ratio:  
1: 9/8: 5/4: 4/3: 3/2.  
These correspond with the notes:  $d$ ,  $r$ ,  $m$ ,  $f$ ,  $s$ .

