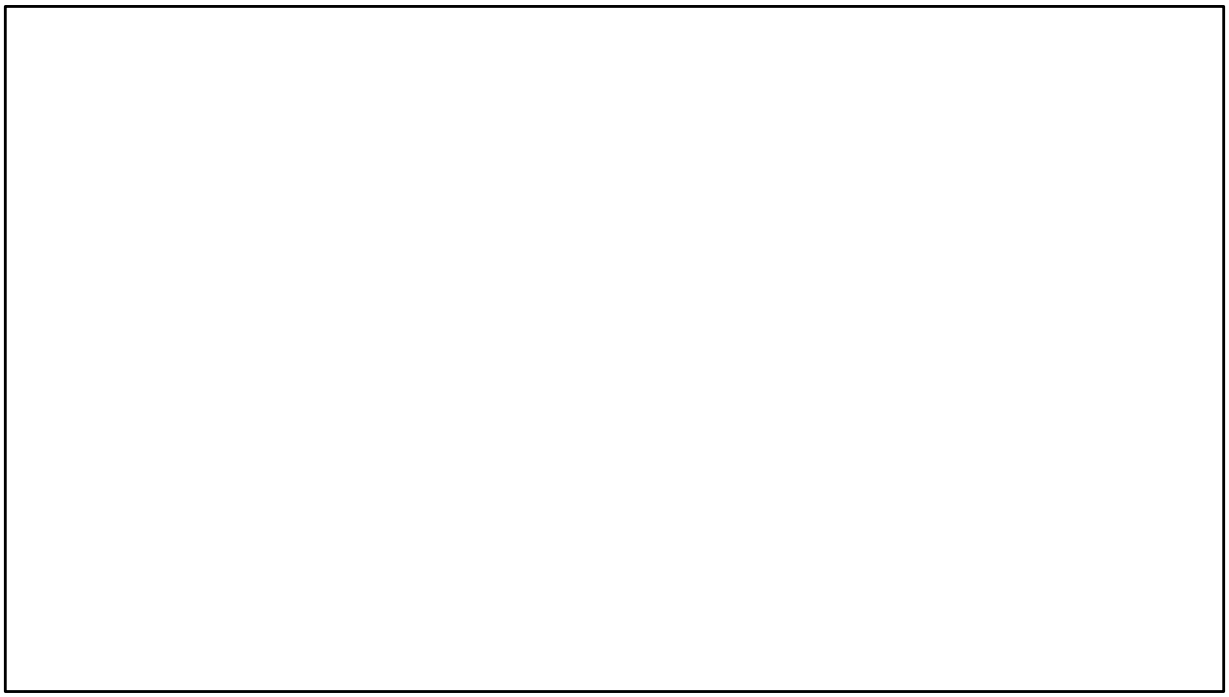
Introductions: today, we're going to make a machine which could run *forever*.

Comments:

- This image Wikimedia Commons.



2 minutes

A short introduction to the workshop leader including their work with gears.

Comments:
If possible, include a photograph of yourself in your workplace –a selfie with your product or project could work well. Do be aware of diversity issues.

4-5 minutes

Questions:
- Have you heard the word ‘gears’ before?
- Can you tell your partner what you know about gears?
- Can your table list as many places as they can that use gears?

Comments:
- You’ll likely be surprised by how much children already know, or think they know.
- This discussion also sets a precedent of pairs / table / group work, and allows you to practice how you’re going to regain attention from the class. This is a good time to tell them: “When I raise my hand, that means I’d like your eyes this way, please,” or similar.
- This is also good time to establish assistance from teachers and teaching assistants. They’ll very likely circulate tables and facilitate discussion, but do prompt them if necessary.

About 2 minutes for all these examples.

Bicycles

- We find gearing systems on bicycles.
- These are similar to the gears we'll explore today.
- They are also different, because they are linked by a chain.

Comments

- Be conversational through this – children will likely contribute their ideas and knowledge as you go along. If you can, incorporate their thoughts.
- Respond positively where you can. "I can see why you might think that" is better than "That's wrong"
- Don't be afraid of saying 'mechanical engineering.'

Comments:

- This image: Jonathan Sanderson, Northumbria University

Gears in cars

- You may also know about gears in cars.
- Do you recognise one of these?
- Does it look like the gears on a bicycle?

Comments:

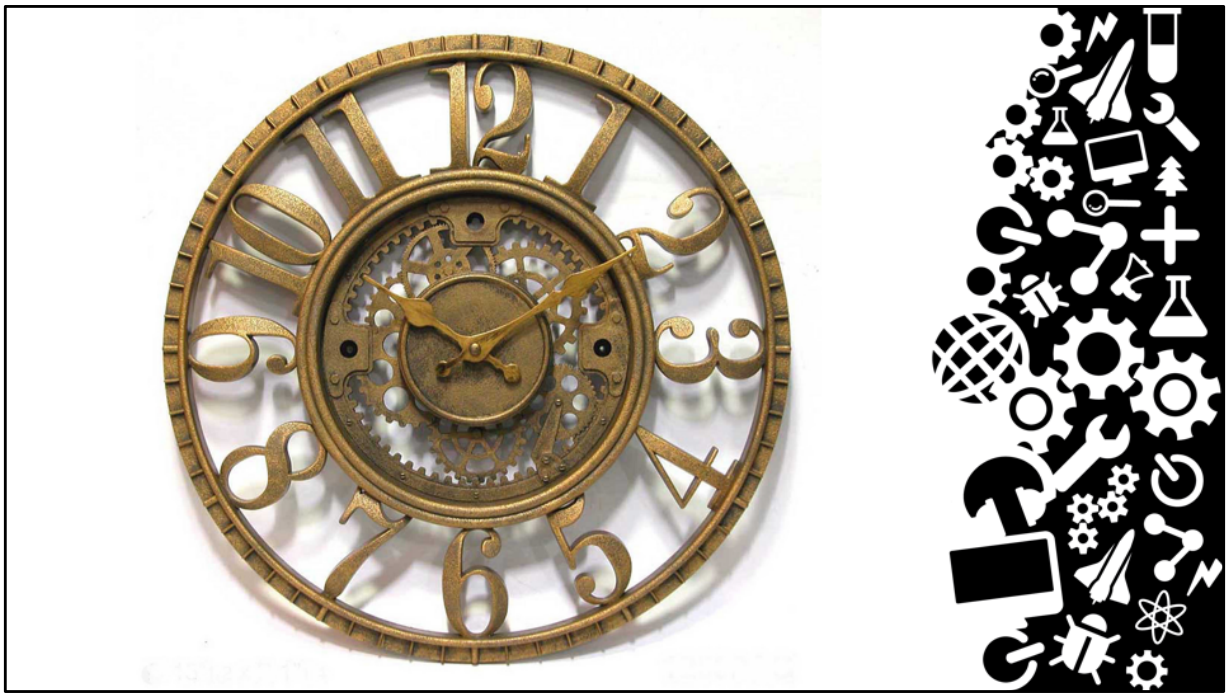
- This image: Jonathan Sanderson, Northumbria University

A gear box

- The gear lever in the previous slide actually controls a gear box
- A gear box allows the car's engine to drive the wheels at different speeds
- You might have noticed your parents/carers changing gear when they drive around town
- When a car gets faster, your parents/carers might change gear

Comments:

- This image Wikimedia Commons: https://commons.wikimedia.org/wiki/File:Cambio_H.jpg
- We'd love an alternative (better) photograph from a BGA member! Please contact nustem@northumbria.ac.uk

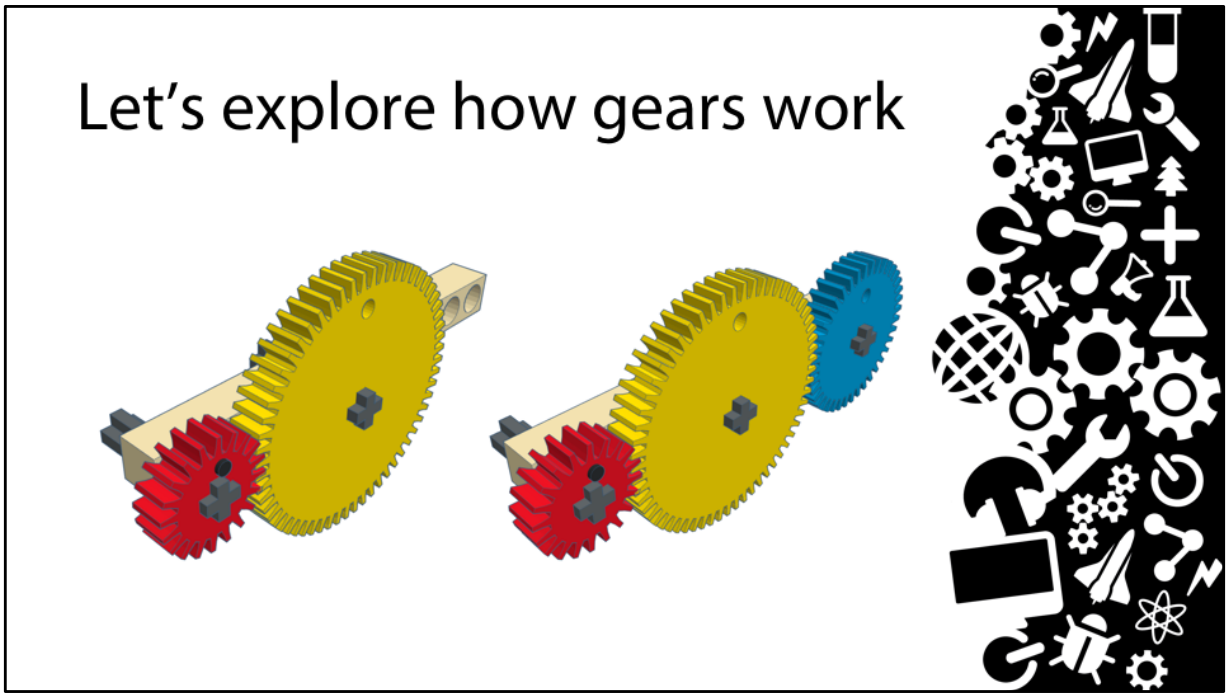


An analogue clock

- An analogue clock – one with hands – is driven by a motor
- Gears are used to turn (rotate) the hands at different speeds

Comments

- Mechanical clocks are a really useful example: it's clear to everyone that a clock with hands which all move at the same rate would be useless.
- Image: CC-BY from Flickr user Infinity Instruments, https://www.flickr.com/photos/75680924@N08/6976339493

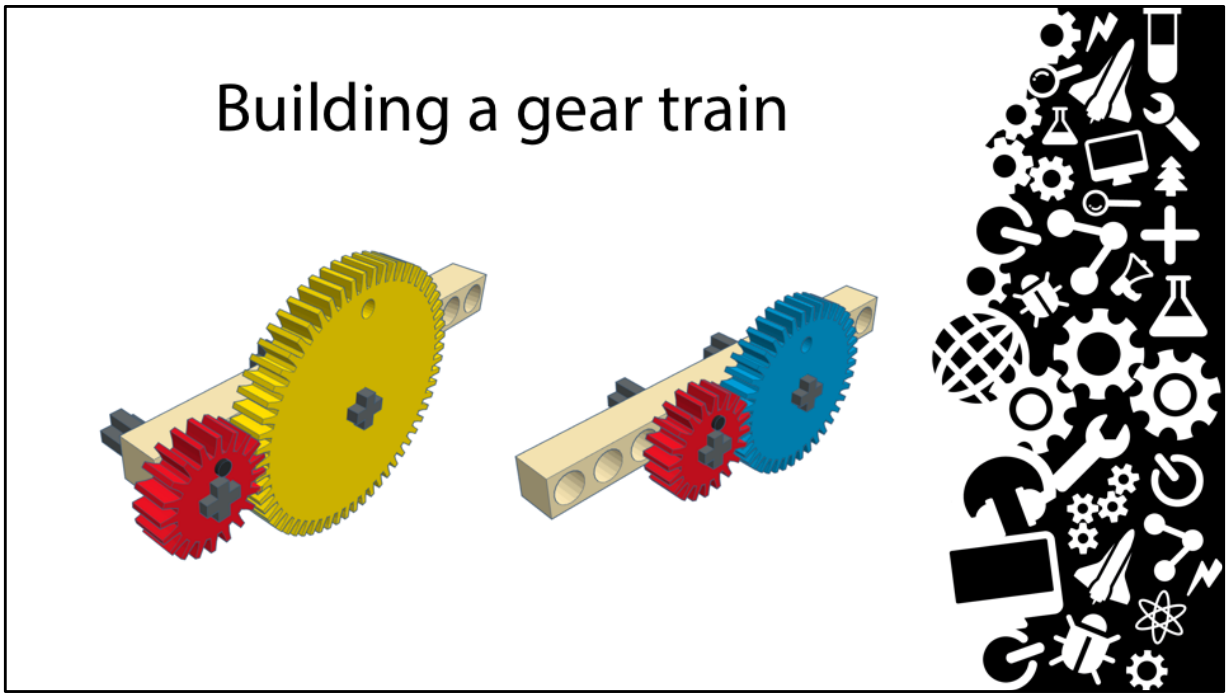


Hand out the gear kits, to pairs of students.

Exploring gears
Take the items out of the box/bag
- Can you work out how they fit together?
- Can you work out how they move?
- Put some together and see what you can find out about gears.

Feedback
Ask the class for feedback on what they have learned from their exploration
This may include, and should be drawn out during the discussion:
- Use of the word turn or rotation
- Discussion of rotational direction – clockwise and anticlockwise
- Description of the gears fitting (meshing) together
- Description of gears moving at different speeds when turned

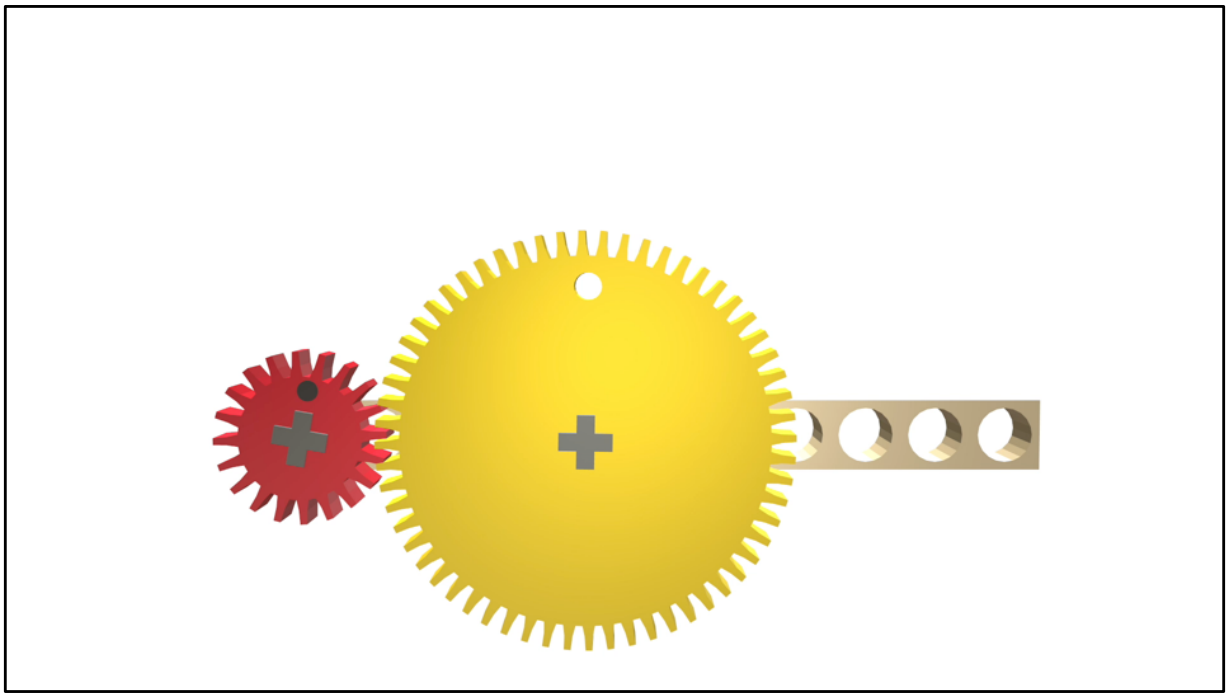
Comments
- We've included images here as a hint – without them, groups tend to make axles with wheels, or spinning tops, or… anything but gears meshing together.



Your first gear train

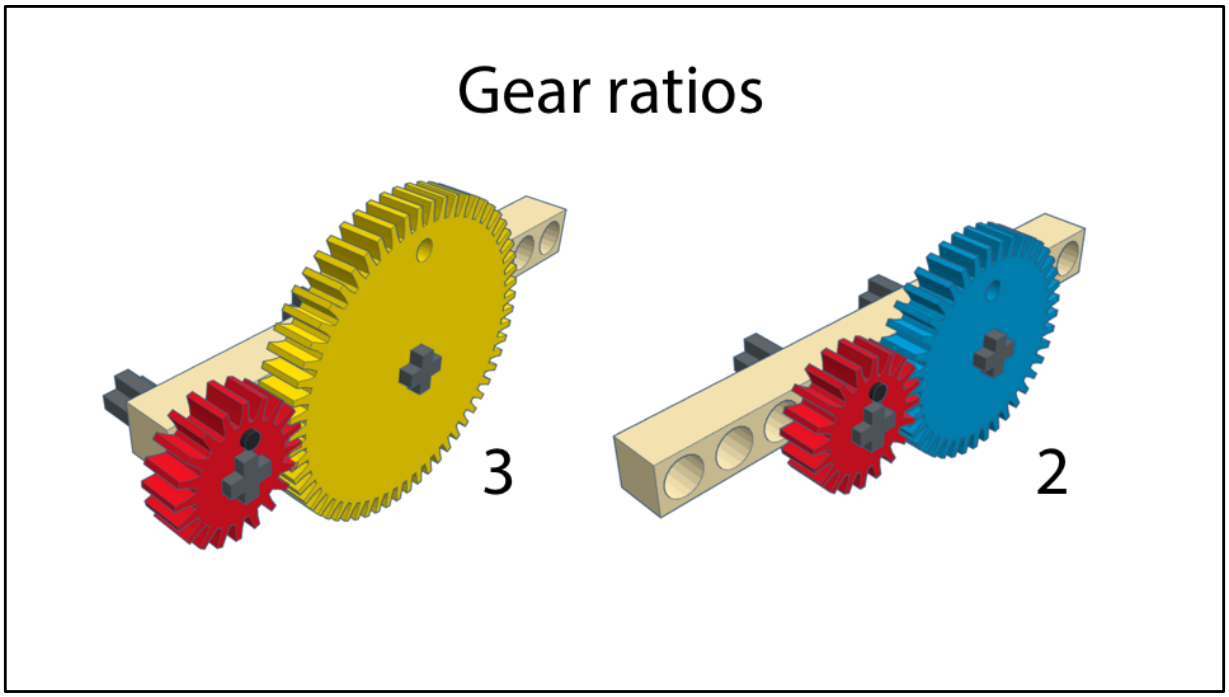
- Ask the children to build the two gear trains in the slide

Comments



Calculating gear ratios

- Explain that when we have two gears or different sizes, one rotates more quickly than the other.
- Show the video above, whilst demonstrating how to count the numbers of rotations.
- Get the children to count along with you.
- You probably won't want to play through the complete animation.



Calculating your own gear ratios

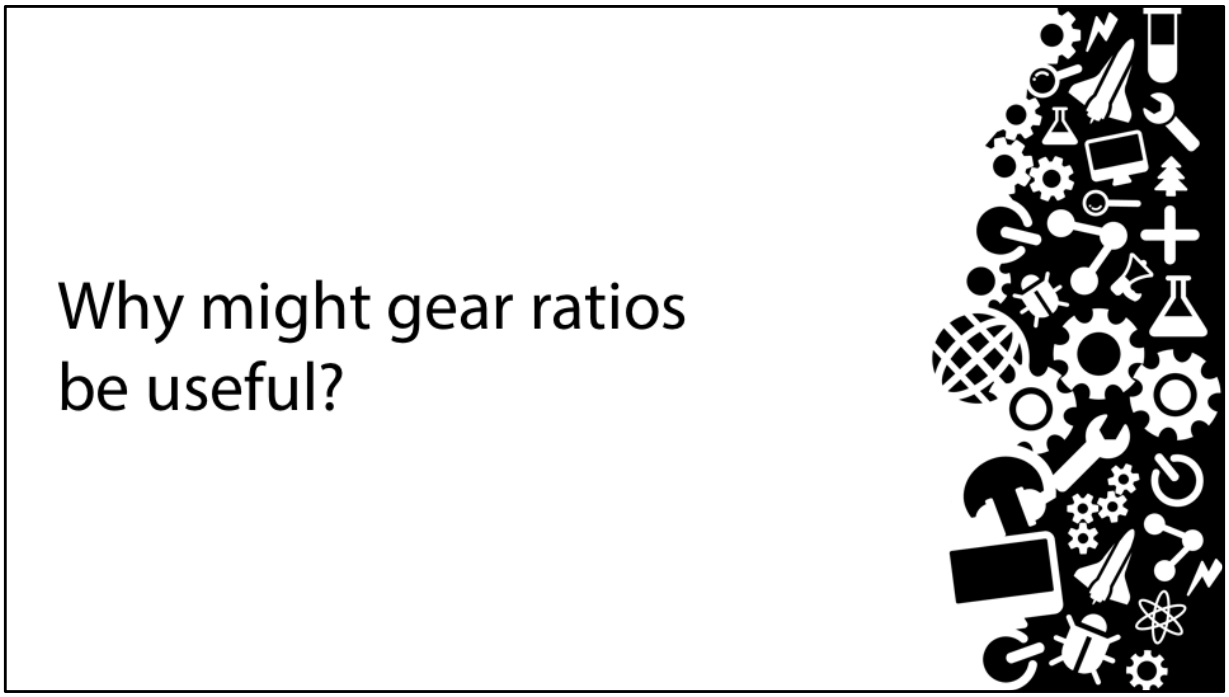
- The children should now use the worksheet to calculate the gear ratios of the first two examples (on the slide)
- The workshop leader should circulate around the room to support this activity

Feedback and discussion

- Once everyone has an answer, collect the answers fro the class
- Show the answers on the slide above.

Comments

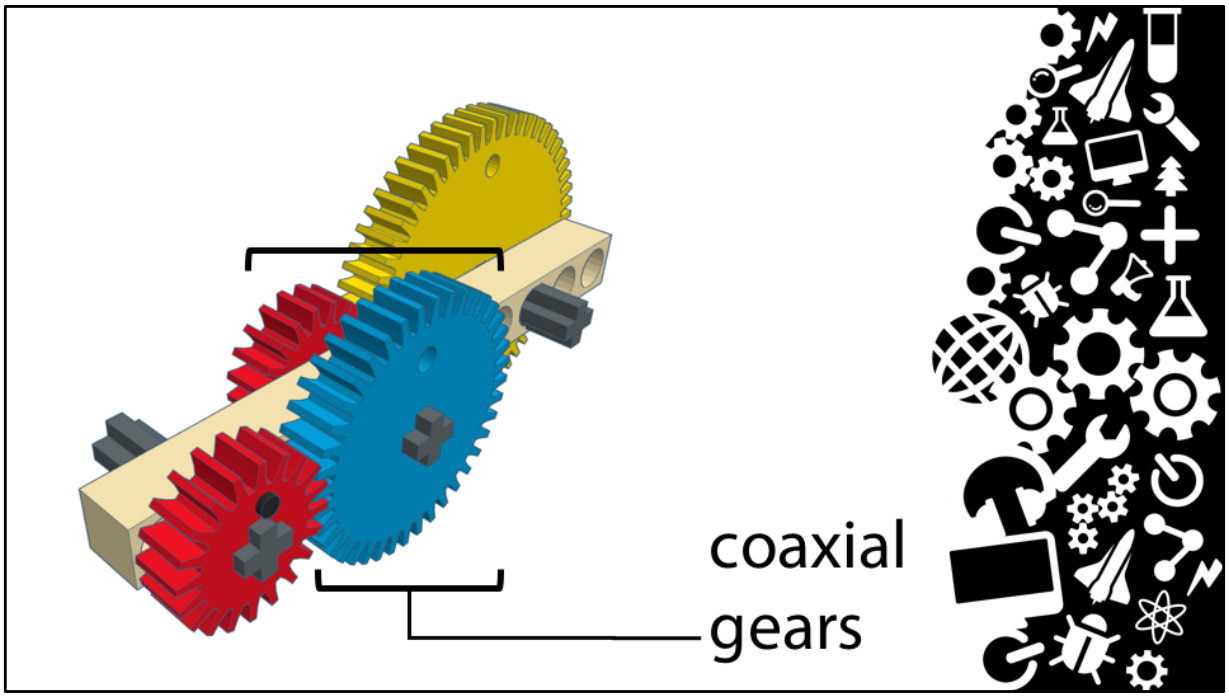
You'll notice that we aren't using formal ratio notation to describe the gear ratios. For this session its enough to say that the red gear turns 3 times to turn the yellow gear once. Hence an answer of 3 for the Red-Yellow train. We've made this choice so that the session is accessible to as many children as possible.



Why might gear ratios be useful?
Ask the question.
Allow time for discussion and feedback answers.

Answers might include:
- The can change the rotational (turning) speed of the gears
- They move the location of rotation.

Comments
A particularly good example of the important of gear ratio is an analogue clock. This section maybe more didactic, you may want to tell (or show) the group why gear ratios are useful.



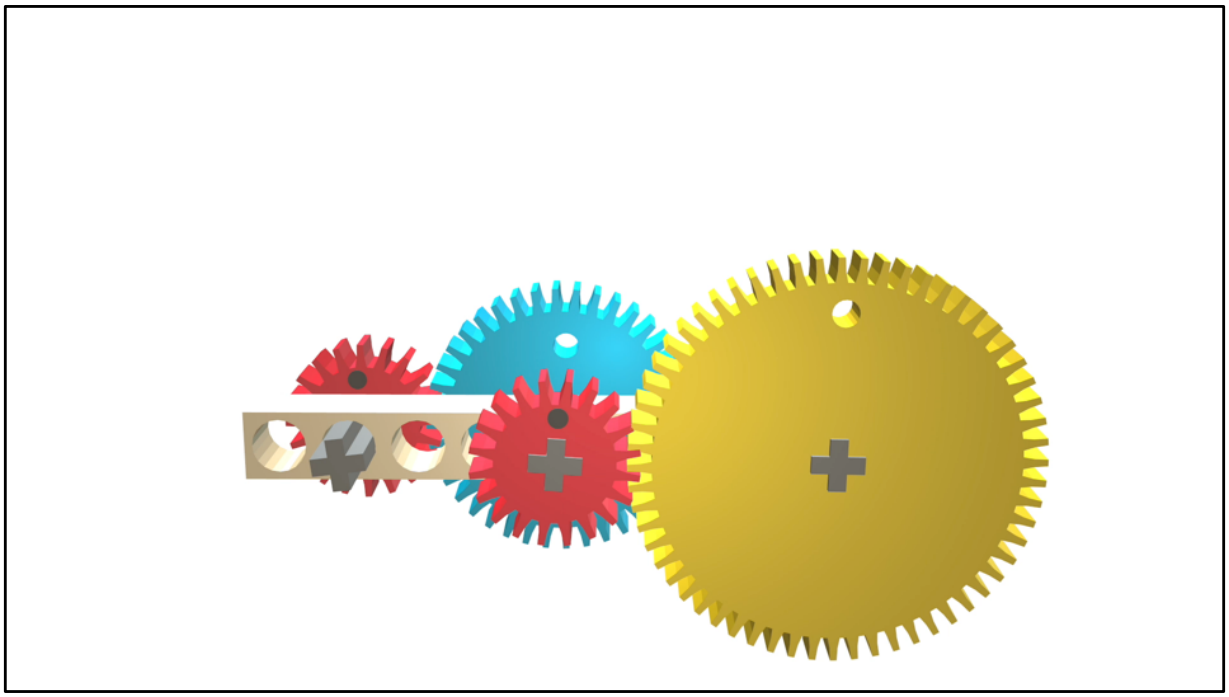
Coaxial Gear

Explain to the children that:

- In this gear train the blue and red gears are mounted (fixed) coaxially.
- That means they are on the same axle.

Comments

This is a new piece of technical vocabulary. Be sure to use it repeatedly throughout the session. Also try to provide opportunity for the class to use it.

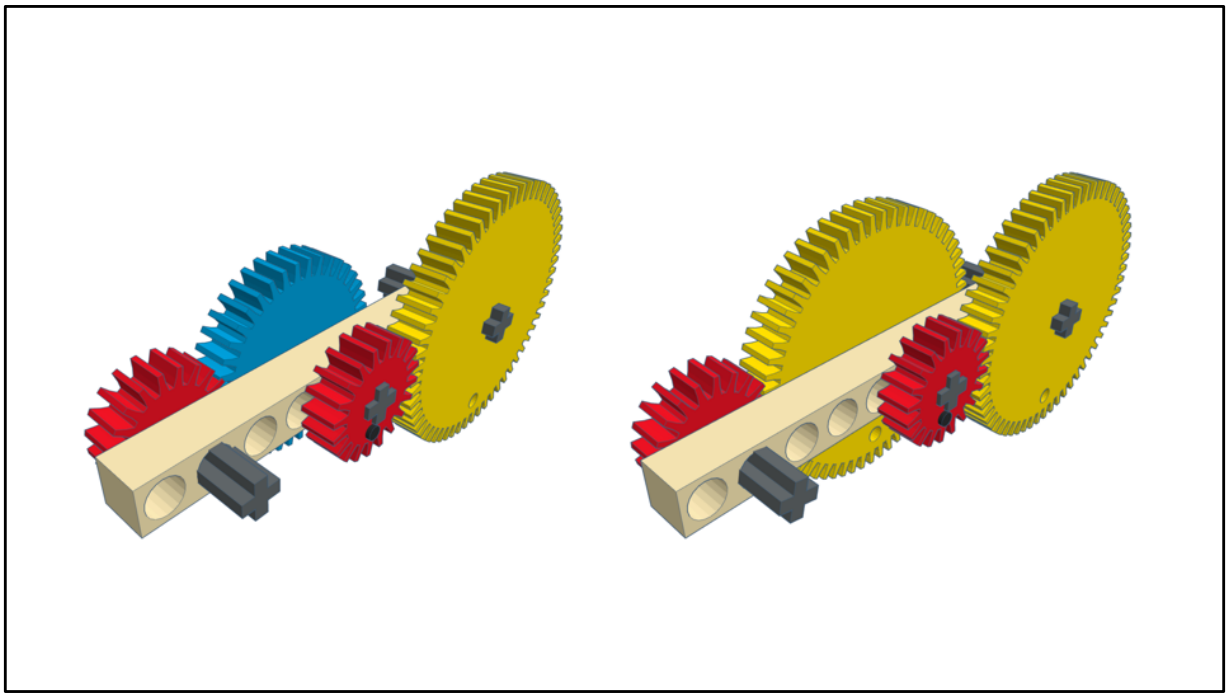


Calculating gear ratio from a compound train

- Demonstrate how to count the overall ratio of this gear train.
- Get the children to count along with you.

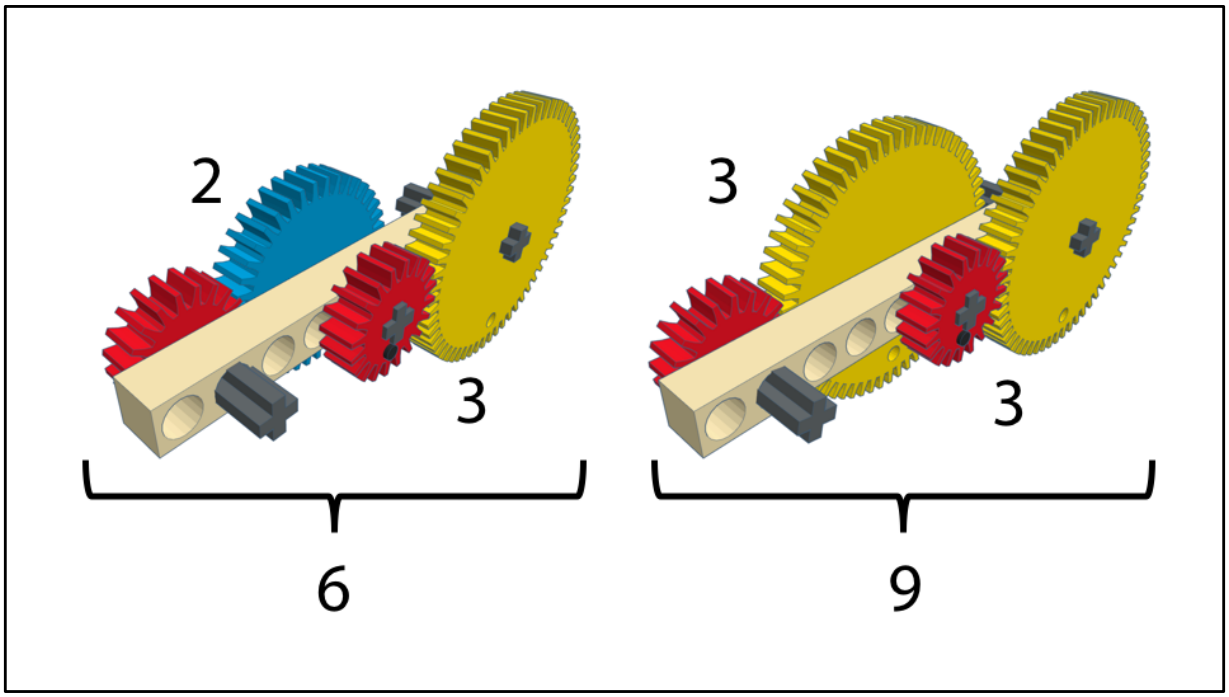
Comments

One common mistake made by children here is that they count the rotations of the coaxially mounted gears. For this exercise, all that matters is the rotations of the the first and last gears in the gear train.



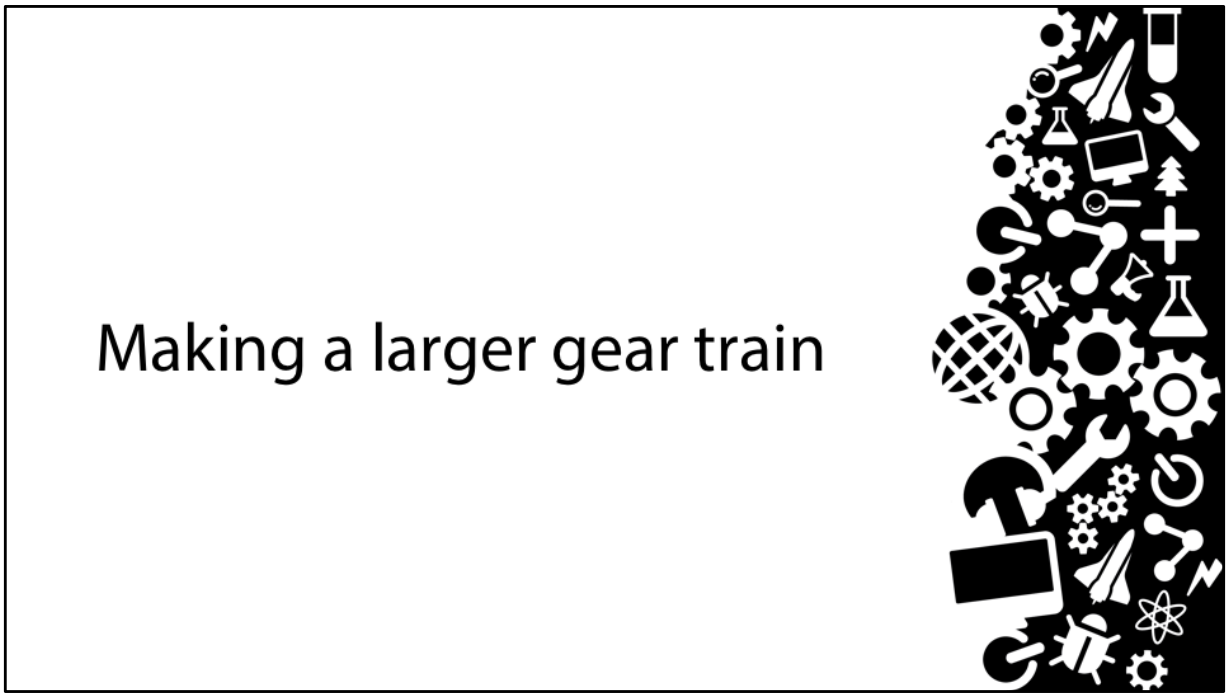
Calculating gear ratio from a compound train

The children now build and calculate the overall gear ratios of these compound gear trains and mark the answers on their worksheets.



Calculating gear ratio from a compound train
Show the children how to calculate compound gear ratios by multiplying the ratios of the paired gears.

Comments
You could make another gear train and ask them to calculate the ratio using the method above.

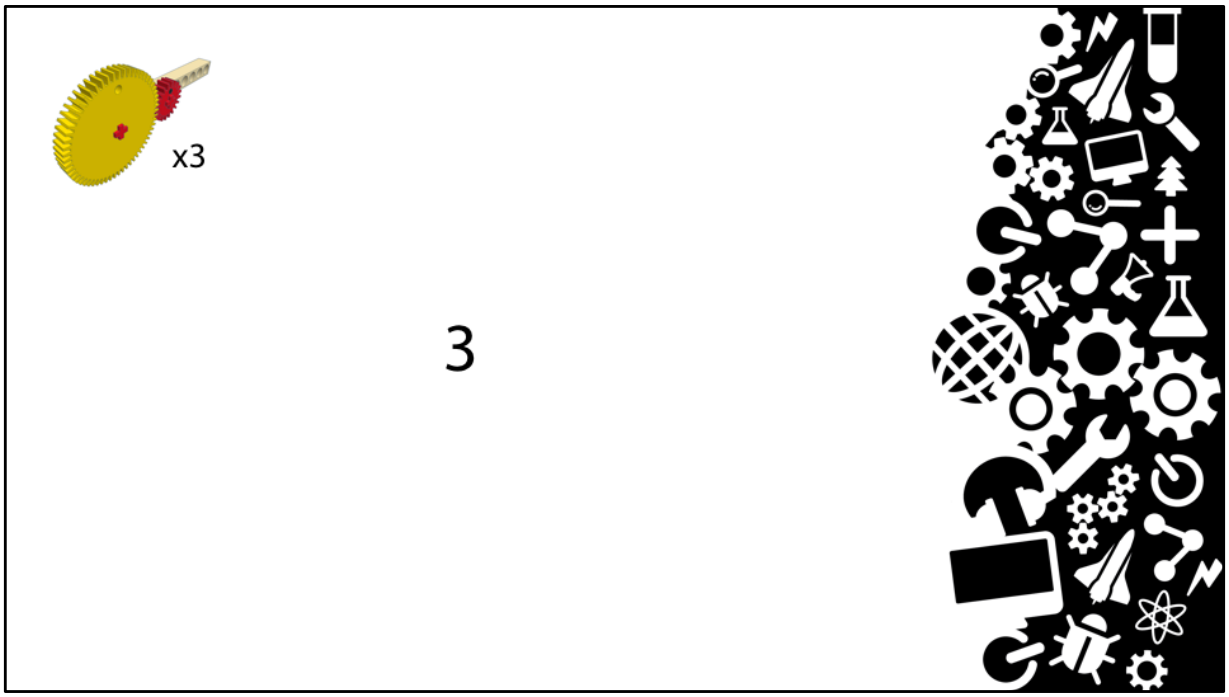


Making a larger gear train

- The children are given a diagram from which to build a set of compound gears.
- In pairs they build their gear train and then pair it with the other on their table.
- Once all the systems are built, the workshop leader combines them all to create a large gear train of multiple compound gears.

Comments

There are two diagrams A and B, make sure these are evenly distributed throughout the class. Otherwise you'll have trouble building the find machine.

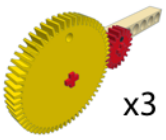


A huge gear ratio

- Use the next slides to calculate the final gear ratio of the machine the class have built.
- The children may be able to suggest the next answer by multiplying the current slide by three.

Comments

We have assumed that you have built a machine using 4 A Diagrams and 4 B Diagrams.



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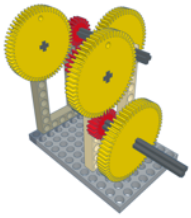

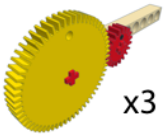

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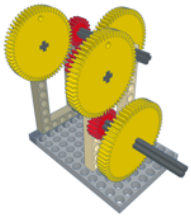

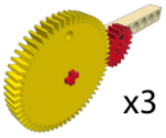

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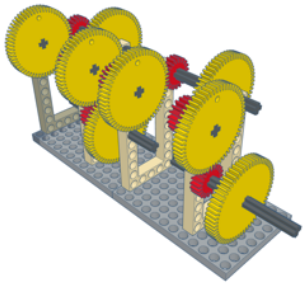

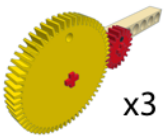

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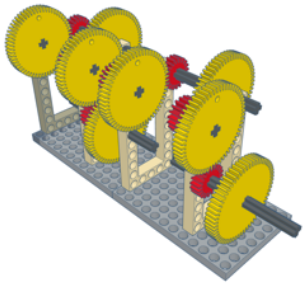

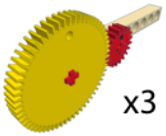

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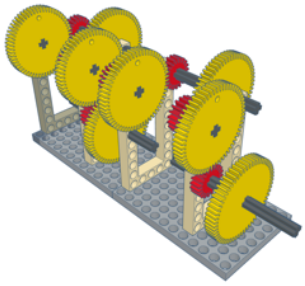

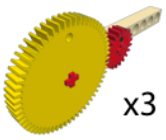

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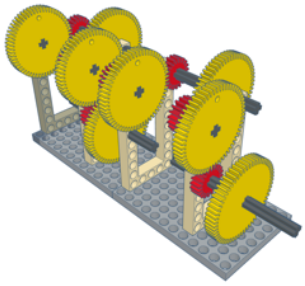

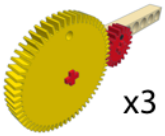

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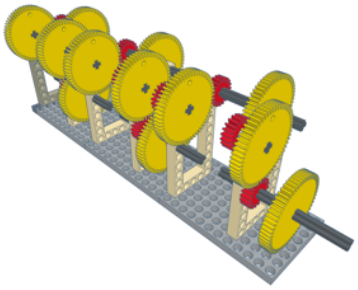

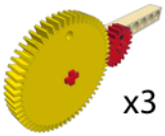

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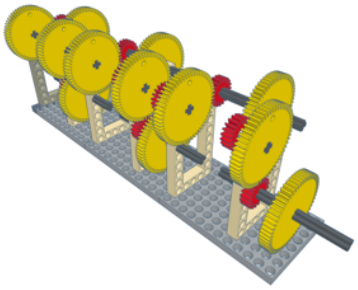

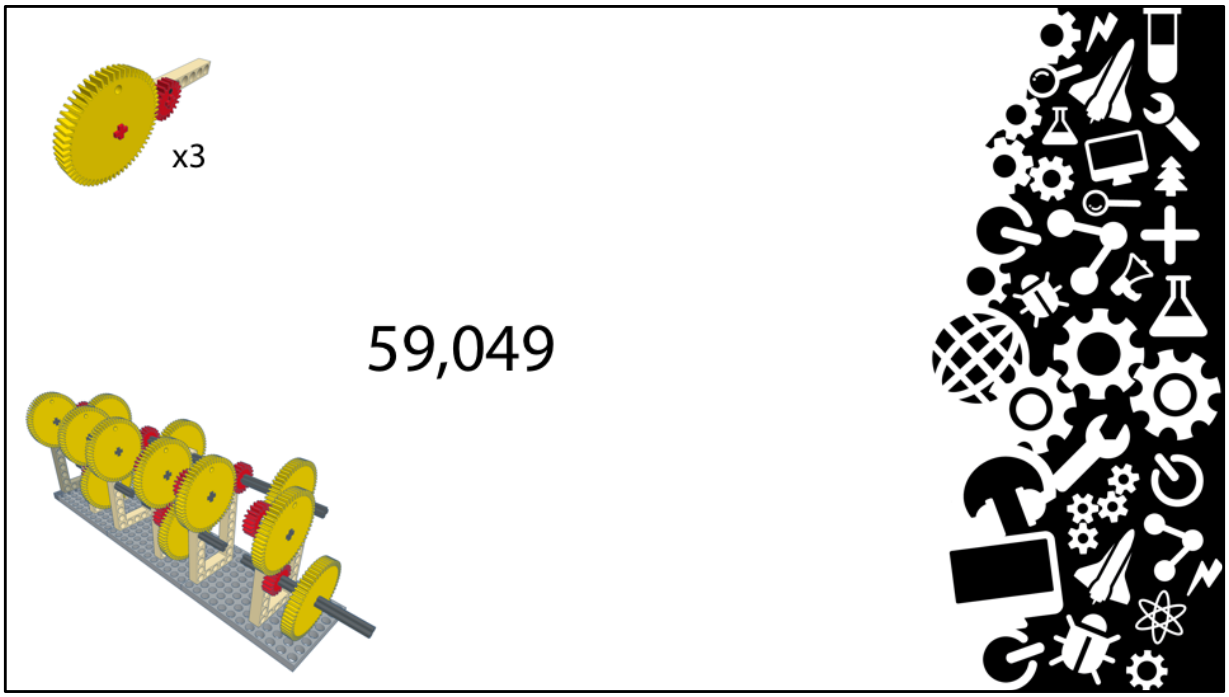
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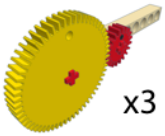
59,049



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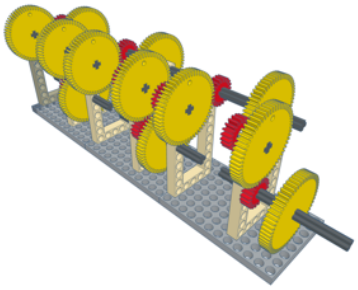

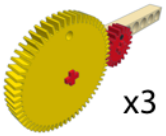

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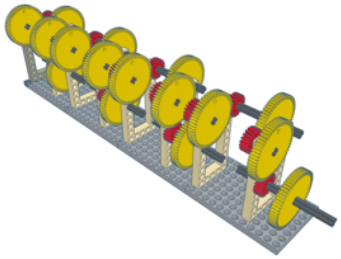

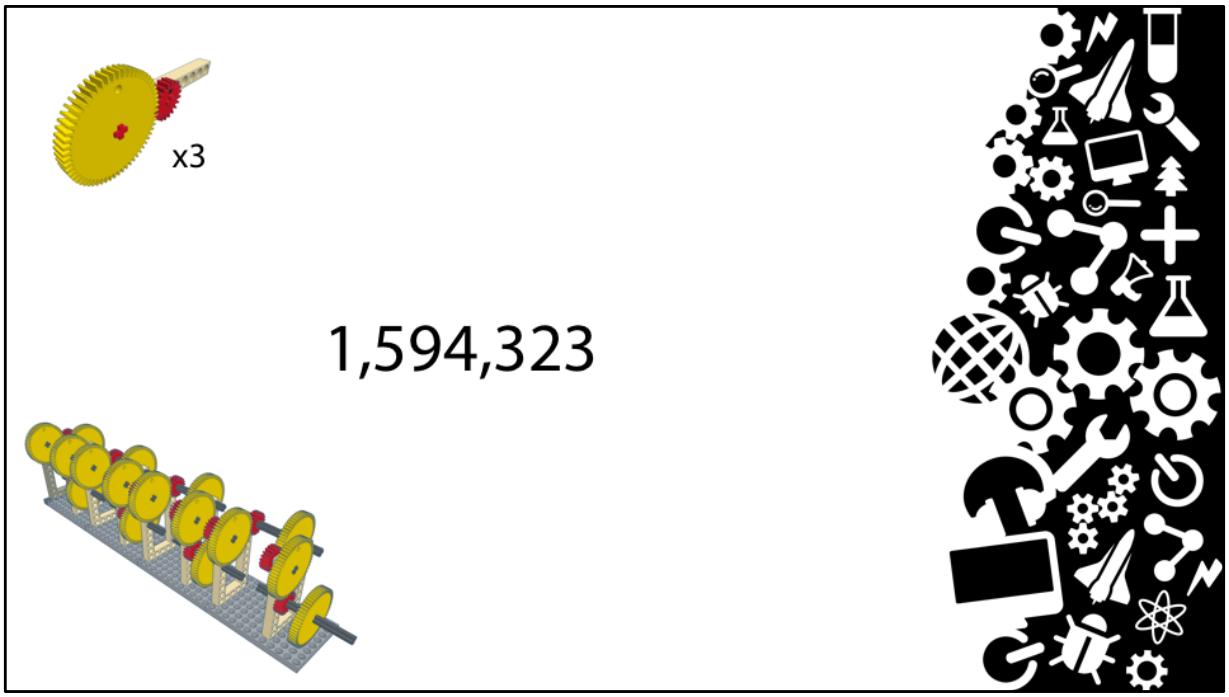
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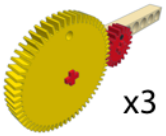

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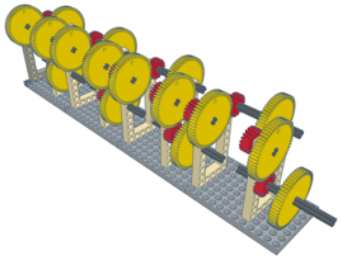
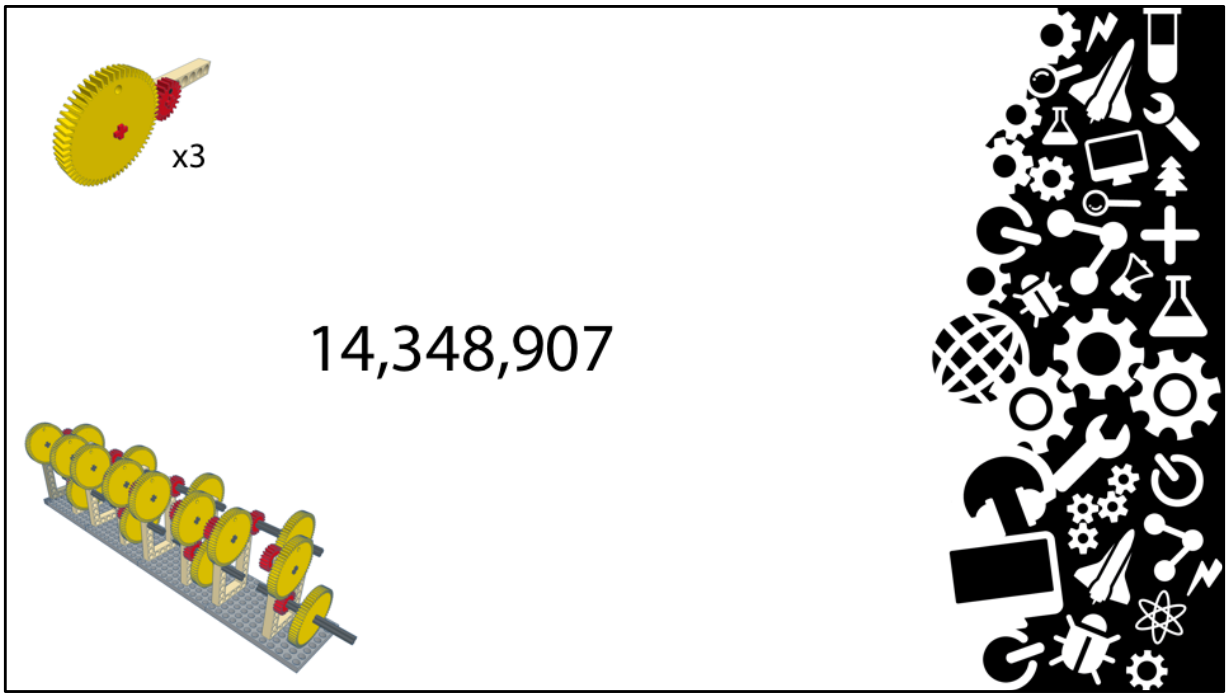


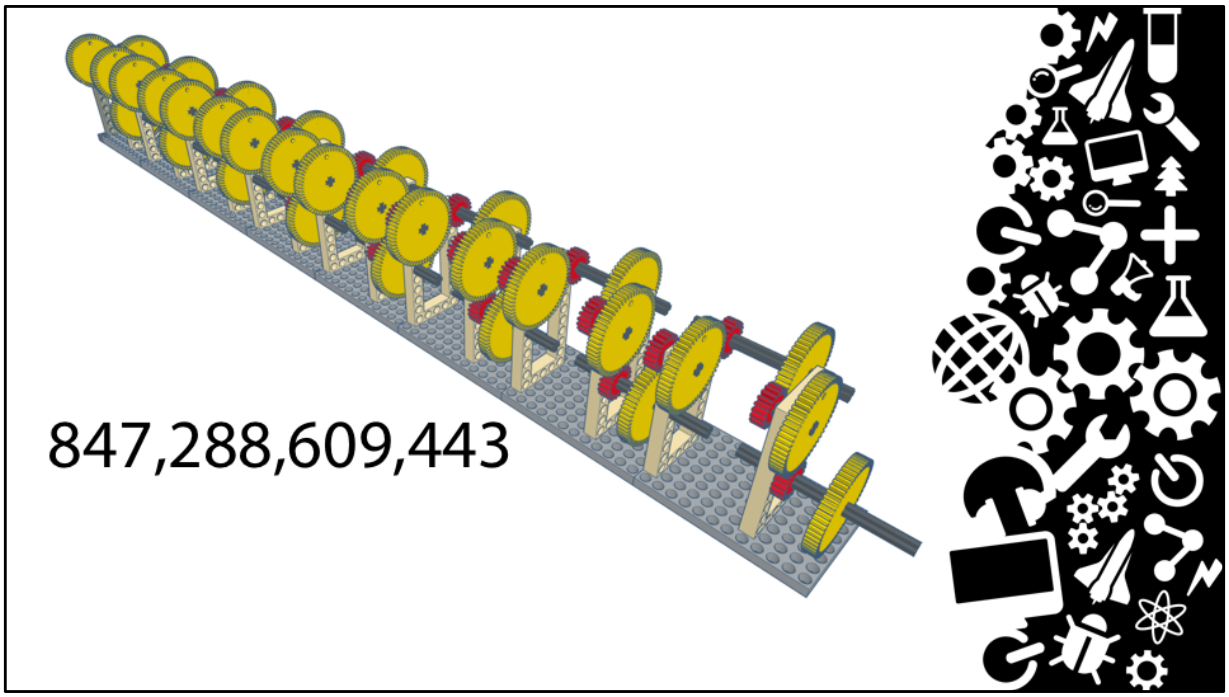


Our final ratio

- Turning once per second, the end gear would turn once in 166 days.

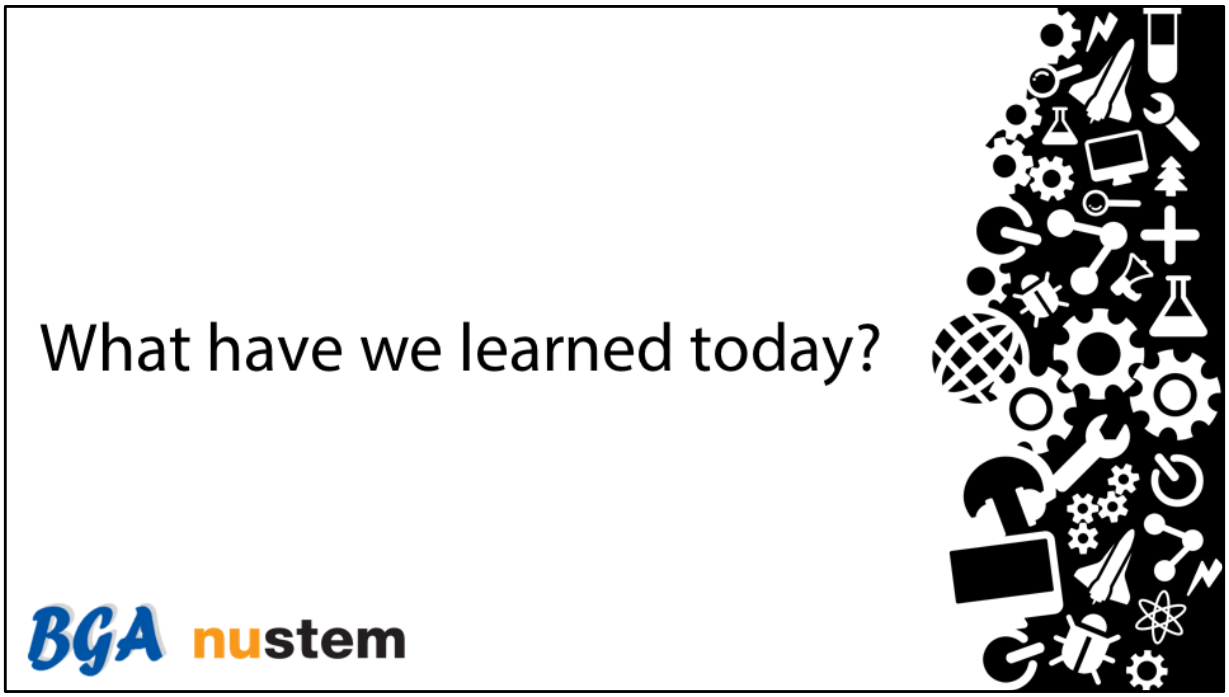
Comments

This is as far as we recommend you go with assembling the gears (if you even get here). Since you can't really see the gears moving at this stage, it's best to shift attention to the gear ratio.

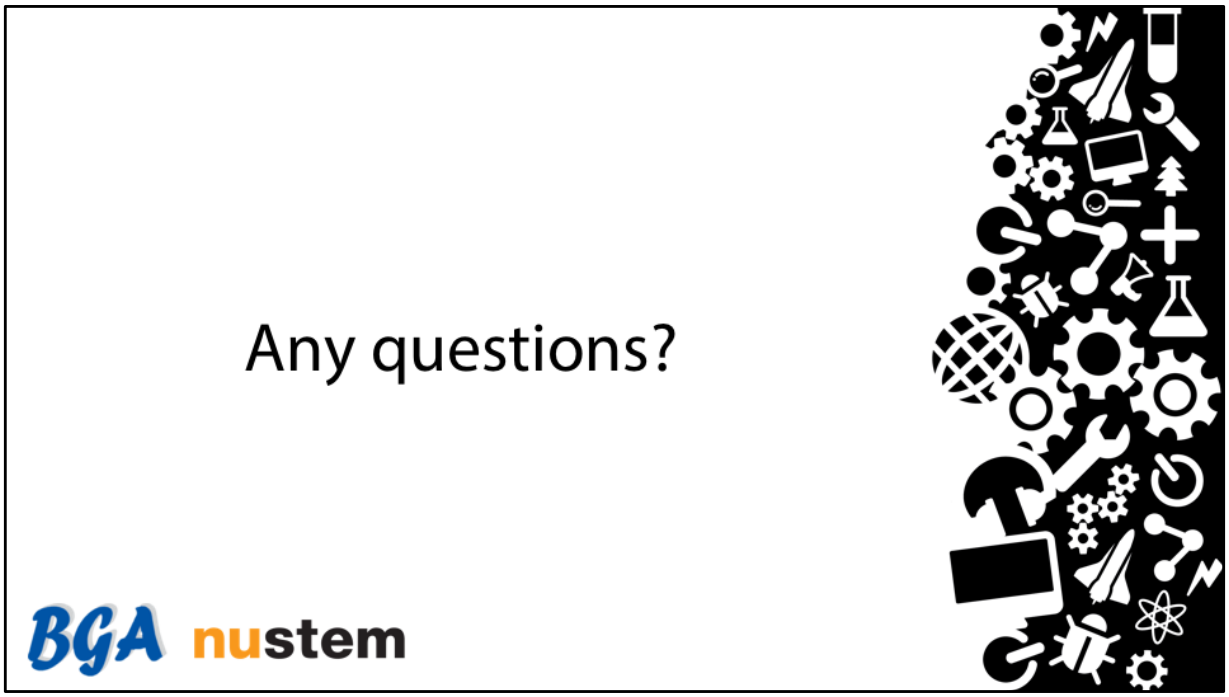


What if…

- Put together all the gears across the class, and you'd get this monster.
- Turning the input once per second again, this is one turn of the end gear in about 27 thousand years.
- Join with the class next door, and you'd have a ratio of 3^((3*16)+1) ≃ 2.4 x 10^23: one turn of the end gear would take much longer than the age of the universe.



In summary
Ask this question of the class and allow them time to discuss and then feedback answers.



And finally…
If time permits, ask the children is they have any questions about gears or your job.

Comments
You might want to display another image from your workplace on this slide to stimulate questions from the group.
If you were able to bring an example of gears from your workplace, this would help the group understand areal-world use of gears.