Big and Small Masterclass:

Session Script

This icon means there's a slide, or slides in the presentation to accompany this line of the script.

This icon indicates the students will have an activity to do, or something to write.

Introduction (10 minutes)

[Hand out Bigger and Smaller worksheet]. Welcome to today's Masterclass. To start with, there's an activity for you to work on - can you give some answers to each of the two questions on the worksheet? Give as many answers as you can, and if you want to also guess how many times bigger or smaller things are, or draw pictures, do that too.

[This next section can be skipped if this masterclass is not the first one in the series.]

These masterclasses are organised by the Royal Institution. Has anyone heard of the Royal Institution before? It was founded in 1799, and has always been about letting everyone have access to science - organising masterclasses and lectures, including the Christmas lectures.

Many famous discoveries have been made in the Faraday building where they are based, including 10 chemical elements. Michael Faraday, who the building is named after, did work there on electricity and optics, which we all use every day.

The Ri are perhaps most famous for Christmas Lectures for young people, which have taken place since 1825. They have been televised for several decades, and many past series are available on the Ri website. The Masterclass programme was born out of the Christmas lectures delivered by Christopher Zeeman in 1978, which were the very first ones on mathematics!

There are many opportunities for you to visit the Ri building in London, and see the historic rooms for yourself. There is a small museum too. There are lots of talks and holiday events for young people: all the details are on the Ri's website.

Bigger and Smaller (10 minutes)

In this Masterclass session, we'll be thinking about big things and small things. You've been writing down examples of things that are bigger than you, or smaller than you. How big do you think you are? 1.5m? 150cm?

- **Put your hands up and tell me the answers you've written - I'll write them in two separate lists on this whiteboard/flipchart. We need roughly the same number of ideas in each list.**

Now we need to split into two groups. This group will take all of these 'bigger' things and try to work out which out of them is biggest, put them in order, and work out how many times bigger each of them is than you. This group will do the same with the 'smaller' things. Write your answers down on a new piece of paper, and I'll read them out for each group.

Estimation and assumptions (5 minutes)

In the previous activity, we didn't come up with exact answers for all of these things - we just made an estimation. This is a very useful thing to be able to do, as it means you can have a rough answer to use even if you don't know the answer exactly.

Imagine you have 100 of something. If it helps you to picture what 100 of something looks like, think about how many fingers you have.

One pair of hands is 10 fingers.

That means if 10 people all held up all 10 of their fingers [if you like, count 10 students at the front of the class and ask them to do this] that would be a total of $10\times10=100$ fingers.

Or, we could represent 100 things in a square - what length would the sides of the square be? 10 by 10, because 10×10=100.

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If things are arranged in a grid, it can make it easier to estimate how many there are - how could we work out how many pictures of people are in this grid of faces? We can count the rows and columns - 20 columns, and 16 rows, so 16 × 20 = 16 × 2 × 10 = 320.

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What about this stadium? This is the National Stadium in Warsaw, which is in Poland.

- **Could we work out how many people can sit in this stadium just by looking at this photograph? What pieces of information would we need to get in order to make an estimate?**

We could estimate how many people sit in each section by counting how many chairs across and down they are, then counting how many sections there are in the ground. But this might not give us an exact answer - some of the areas have gaps in them, and some get wider as they go up so they're not a true rectangle.

This stadium holds around 60,000 people. So, if we wanted a million people to watch football at the same time, roughly how many stadiums would we need? How would you do that calculation? It's around 17.

Numbers and Zeroes (5 minutes)

We just mentioned a million, and we've talked about tens and hundreds - so let's investigate those numbers. [Hand out Numbers and Zeros worksheet]

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Here's a worksheet with gaps for you to fill in. Complete the 9 rows given, and if you have spare time come up with your own examples.

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The answers to this worksheet are here. Do you know what all of these numbers are called? Did you write any examples of your own?

Keeping track of numbers (10 minutes)

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Look at this newspaper headline - it says "one gram of water contains more than 30 000 000 000 000 000 000 000 water molecules". Is this number written in a useful way? Would anyone understand by looking how many this is?

When writing big numbers like this, we sometimes put a comma after every third zero from the right to keep track of how many zeroes there are. In this article they've left a space after each group of three zeroes, so you can see how many there are more easily. How many zeroes are here? This number is 30 thousand billion billion - but it might take you a while to work out how much that is!

17 – 19

We have a useful way of writing big numbers like this, with lots of zeroes. Does anyone know what I mean by 10^2? Ten with a little two up there? This means 10 × 10, which is 100.

20 – 23

So what might I mean by 10^3? Ten with a little three up there? This is called ten cubed, and it's 10 × 10 × 10, which is 1000. And what about 10^4? That's 10 × 10 × 10 × 10, which is 10,000. Does anyone notice anything about the way we've written these numbers, and the number of zeroes on that number? They're called **powers of 10**, and the power tells you how many zeroes to put after the 1.

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Go back to your worksheet, and down the right-hand side, write the number as a power of 10 - write the number 10, then a little number at the top to indicate how many zeroes it has.

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If any of your own examples are also a power of ten, you can do the same for them too. Here are the answers.

26 – 28

This is much easier than writing out all the zeroes, but it's also good because it lets us make calculations more easily. For example, what's 1000 × 10? It's 10,000, which has one more zero than 1000 did. So multiplying by 10 will increase the number of zeroes by 1 - this goes from 3 zeroes to 4 zeroes.

29 – 31

So what if we did 1000 × 100? That's 100,000, which has 5 zeroes. Multiplying together two numbers which are both powers of 10 is easy, because you can just count how many zeroes there are altogether, or add the two powers together.

32 – 35

- **Let's try these examples together.**

Estimation - using an educated guess (5 mins)

Another thing you were doing when we talked about big and small things earlier was **estimation** - this means somehow coming up with an answer that you think is close to the real answer, even if you don't know exactly what the answer is. So we're going to have a go at some ways of estimating things even when we don't know the actual answer. Let's discuss one together.

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How many eggs will a chicken lay in a year?

Do you think you could guess an answer to this question now?

- **Hands up who thinks the answer is close to 100? 1000? 10,000?**

My friend has a pet chicken, and I asked them how many eggs their chicken lays. They said that it lays one or two eggs a day, depending on how happy it is - if it's sad, it might not lay any eggs at all. What kind of things might make a chicken happy or sad? Bad or cold weather? Poor food, poor housing? Having other chickens around? Between one and two eggs is a good estimate per day.

- **Does anyone know how many days are in a year?**
  365 - so a chicken might lay 300 to 400 eggs in a year.

If my family has four people in it, how many chickens would we need if we wanted all our eggs to come from our chickens? What information do you need to answer this question?

Discuss between yourselves - how many eggs do you eat per day, or per week, and how many do you eat in your family? Then we can work out how many chickens we would need.

Estimating - ping pong balls in a bucket (15 mins)

Now we're going to try estimating something more practical. Here's a bucket, and I'm going to fill it with these ping-pong balls.

- **First I want you to discuss with the person next to you how you might estimate how many balls I'll need to fill the bucket.**

Hands up if you'd like to share the method you've come up with…
You might count the bottom layer of balls, and then count how many layers of balls we can fit in the bucket. Would someone like to come up and count how many balls are in the bottom layer? Now you can count how many balls fit along the side of the bucket, and multiply these two numbers together to work out how many balls there are.

If you have a different method of estimating the number of balls, that's also good - you can share it now.

I can reveal that the number of balls that fits in this bucket is actually _____, which is higher/lower [most likely it will be higher!] than the estimate we just made.

- **Can anyone suggest why this might have been inaccurate?**

We have made some assumptions in our estimate - we've assumed that all the balls are the same size. In this case, this assumption is good as it's true - they all came from the same packet, although there may be small variations between them.

We've also assumed that the bucket is a cylinder with straight sides, bit it isn't quite - the layers get wider as we approach the top of the bucket, so there would be more balls in the higher layers.

Also, the balls won't necessarily sit in neat, flat layers - some of the balls on the bottom layer have gaps between, and the balls on top might sit lower in the gaps, so we can fit slightly more in the space.

This doesn't mean that our estimate was wrong - it wasn't accurate, but it's still a useful figure to know, because if I wanted to go out and buy enough balls to fit in this bucket, it's good to know if the number I need is close to 10, or 100, or 100, or 10,000!

Estimating - sprinkles (15 mins)

Next you're going to do some estimation yourselves - we've been talking about hundreds and thousands, and now we've got some actual hundreds and thousands - these are sprinkles you can put on your dessert. But in a tub like this, how many individual sprinkles are there? Is 'hundreds and thousands' an accurate name?

So, how might we estimate this? Weigh the sprinkles? Count the individual sprinkles? That would take far too long. So we can split the task up between us. First, I'm going to mark the level of the sprinkles on the tub, so we can remember where it's full to.

I'll bring each of you a spoonful of sprinkles, on a piece of paper. Split this pile up into two equal smaller piles, then split each of those, and repeat this until you have all equal sized piles that are small enough that you can count how many sprinkles are in one pile. Then multiply by the number of piles, to get an estimate of the number of sprinkles!

Once everyone's done this, we can add all your estimated totals together, and see how many sprinkles are out on the tables. But there's still some left in the tub! Looking at this tub, we've counted ____ [half, three quarters?] of the sprinkles, so we can work out the total there originally were in the tub. [Depending on tub size and sprinkle size, it should be somewhere between 5 and 15 thousand sprinkles]

This is just an estimate, as we haven't counted every single one - but it should be a good estimate. So a better name might be thousands and thousands!

Estimating - words in a book (15 mins)

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We have one more estimation task to try - this time we're going to work out how many words are in a book.

- **How might we estimate this?**

In a similar way to how we've just estimated the number of sprinkles, counting how many words fit on a page, or a smaller piece of a page, and then multiplying by the number of pages, might give us a good estimate.

I'm going to hand everyone a piece of newspaper covered in words, **and a ruler**. Work out how many times your piece of paper will fit on a page, and count the number of words to get an estimate for words per page. If you count, say, 98 words, you can round this up to 100 to make the calculations easier.

The book I have here has ___ pages, which we can round to about _00 pages, and the rectangle of text on each page measures ___cm by ___cm. I'm going to write this information on the whiteboard/flipchart, so you can all work out your own estimate for how many words there are on a page.

Remember that if you're multiplying large numbers that start with a 1, you can just add the powers together.

You should all have your own estimate - someone share theirs - now hands up if your estimate is bigger, or smaller than this - who has the largest, and the smallest? It will depend on your piece of newspaper.

Now we have an estimate for how many words are in a book, how many books do you think fit on a shelf, and how many bookshelves are there in a library? So, how many words are in a library?

Smaller numbers (15 minutes)

40 – 42

Earlier we saw that multiplying by 10 increases the index by 1. What happens if we divide by 10? 1000/10 = 100. This subtracts one from the index.

43 – 46

So what if we now do 100/10? That gives 100/10=10, but if we subtract one from the index again, that means $10 = 10^1$. This is correct - we use 10^1 to mean 10, and it has one zero on the end.

47 – 49

But we can keep going! If we divide 10 by 10, what do we get? 1. So if we subtract one from the index again, that means 1 =

10^0. This makes sense too, as it has zero noughts on the end.

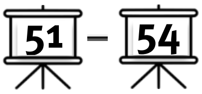
What happens if we go beyond this? If we divide 1 by 10, what do we get? And how might we write this as a power of 10? We can write $10^{-1} = 1/10$.

Use any empty space at the bottom of your 'numbers and zeroes' worksheet to write some other examples.

Video - The Power of Ten (5 minutes)

We're going to sit quietly now and watch this video - it shows some of the relative sizes of things in the universe, using powers of ten.

End of session - recap



In this session we've looked at how we can make an estimate for a quantity, even if we don't know exactly what it is; we've discovered you can use powers of 10 to write down big numbers, and if you're only estimating the nearest power of 10 is a useful place to start. We've seen some different methods of coming up with estimates for things in the real world, and we've thought about the sizes of very big and small things.

Next time you need to know roughly how many of something you see in the world, you could use these ideas to get an estimate - how many people are in a big room, or how many things can you fit in a shopping trolley?