THIRD SPACE LEARNING

GCSE Maths Scheme of Work Guide

A step-by-step approach including practical tips, templates, and examples

SLT Guides

THIRD SPACE LEARNING

Contents

Introduction

A GCSE maths scheme of work is the foundation of your school's success in teaching maths.

But creating a scheme of work from scratch is hard. So we have decided to make things a bit easier for you.

We've joined forces with experienced Head of Maths Christine Norledge to create a comprehensive step-by-step guide to creating your own maths scheme of work, including:

- Processes to follow
- Questions to ask
- Templates to use
- Detailed curriculum examples
- Essential resources

The focus in this resource is GCSE maths, but the principles discussed below apply equally to Key Stages 3 and 5, or to a five-year curriculum model.

Please note, wherever possible we provide concrete example topics and timings to illustrate the strategy or process that we refer to. These may not align with your setting or students and we encourage you to adapt them to suit your own particular needs.

How we created this resource

Every week, we help Year 10 and 11 students across the country feel more confident and familiar with GCSE maths questions through weekly online tuition delivered by Skye, the AI maths tutor.

We developed the scheme of work for our tutoring programmes to help guide students through their own personalised one to one learning journey, focusing on the topics that matter most for each individual student.

Head of Maths Christine went through a similar process for her school's scheme of work following changes to the GCSE exams.

Together, we hope our combined experience borne out over many years, and tested with thousands of students, will prove a useful starting point for you.

> My scheme of work was a labour of love and a steep learning curve, and I made plenty of mistakes which I hope I've now learnt from to support others today!
>
> 
> **Christine Norledge**
> Deputy Head of Maths

"As curriculum content developers, we are lucky enough to see our scheme of work enacted every week in the thousands of lessons we deliver. If something works or doesn't work, we can be quick to adapt accordingly."


Bethan Edwards,
Third Space Learning Curriculum Expert and Teacher

A note about Ofsted

It is not the purpose (or intent) of this guide to help you create a scheme of work 'for Ofsted'. That said, following the steps to consciously address what you want and need from your scheme of work is a major part of mapping out your own curriculum, and addressing the 3 I's regularly referenced by Ofsted - the intent, implementation and impact.

Planning your new scheme of work

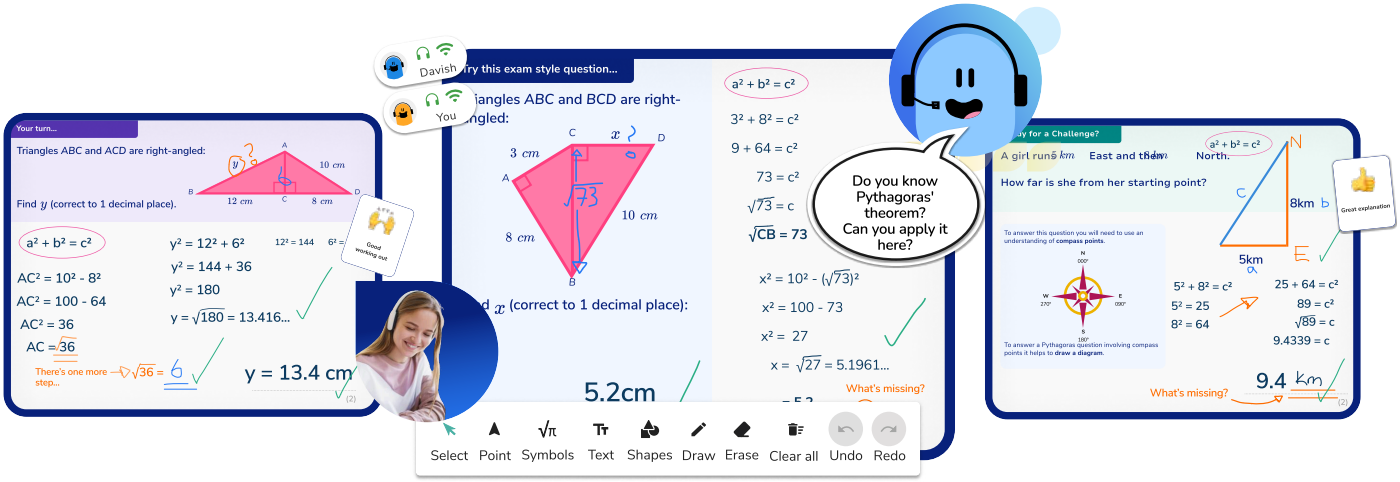
Establish key principles with stakeholders

It's likely to be a balance between the following with potential variations between settings, year groups and classes.

- Fluency;
- Mastery;
- Functional skills;
- Problem solving;
- Enrichment;
- Cross-curricular opportunities.

A good scheme of work should contain a healthy balance of all of the above. It is important that students are fluent with mathematical knowledge and skills, but also that they are given the opportunity to regularly apply those skills to unfamiliar and non-procedural problems.

A sprinkling of enrichment is also useful to keep students connected to the point of all their learning so don't forget the history of maths, interesting real world applications, puzzles and so on.



Examples of non-procedural problems from Third Space Learning lesson slides

"We've had to make some hard decisions when creating our GCSE maths tuition lessons and one of those was to focus it entirely on how to answer exam questions as that's what teachers tell us students need. This gives students plenty of opportunities to develop fluency, mastery, functional skills and problem solving at GCSE."

Candida Crawford,
Third Space Learning Head of Academic Standards and Teacher

It's worth reflecting on what you've already got in place and working out what works and what doesn't. If your students currently find problem solving really difficult, what adaptations can you make to the new scheme to help? If fluency is an issue, where will you embed more skills practice?

Key questions to consider:

1. Do you adapt what you have or start from scratch?
2. How will you manage resources?
3. Are there specific requirements due to department staffing?

Pre-existing schemes of work

There are many pre-existing schemes of work available, both free and purchased. When students arrive at secondary school, their starting points are even more diverse than when starting primary school, and a scheme of work purporting to be ready to use 'off the shelf' is unlikely to be right for your particular setting or cohort without some tweaking.

It might be appropriate to begin with a free scheme and adapt this for your setting. Alternatively, the three main exam boards now each provide an interactive scheme of work which allows you to sequence units flexibly; this may also be a suitable starting point:

- AQA
- Edexcel
- OCR

Counterintuitively it's often actually more time-efficient to start from scratch and design a scheme of work for your particular setting and cohorts.

If you do choose to spend money on your scheme, look for something adaptable that allows you to build a scheme that's tailored to your students, rather than buying in a finished scheme.

Key questions to consider:

1. Do any available free schemes or exam board resources provide a good enough starting point, or are you better off starting from scratch?
2. Is there money in the budget to consider buying in a scheme-building resource (as opposed to a finished scheme of work)?
3. How does this scheme of work fit with other interventions or maths support we've purchased as a school?

Decide the scope of your scheme of work

Work out who you're writing the scheme of work for - again, this depends on your department's needs. You might have:

- A one-year scheme for each year group;
- A two-year KS3 for Years 7 and 8, three-year KS4 for Years 9-11;
- A three-year KS3 for Years 7-9, two-year KS4 for Years 10-11;
- A five-year scheme running from Year 7 right through to Year 11.

Here we look at the traditional model of three-year KS3 and two-year KS4, focusing on planning the GCSE scheme of work for Years 10 and 11.

Be prepared that writing out a full five year scheme is a huge undertaking, considerably more challenging than planning a two or three year scheme!

Key questions to consider:

1. Does your setting require a separate scheme for KS3 and for KS4, or will you plan for the full five years?
2. Are there timetabling implications for other subjects?

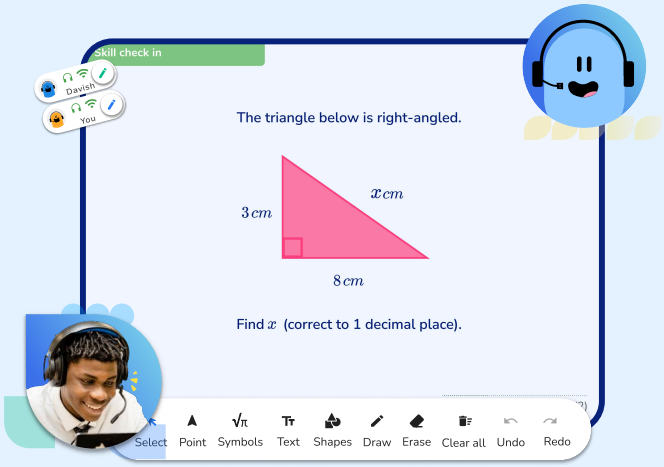
Third Space Learning's secondary maths scheme of work

Before every GCSE revision programme lesson, students complete an initial diagnostic Skills Check In assessment. This helps AI tutor Skye precisely identify any knowledge gaps in understanding, competency in answering the exam-style question, and determine the level of support each student requires.

If students lack the knowledge or skills required, Skye walks them through the lesson step by step. But, if they demonstrate a good understanding, Skye progresses them to more challenging practice questions.

This allows students to practice key skills in a variety of scenarios, at the right pace for them, while learning how to gain the maximum number of marks in their exams, all for one low, fixed annual cost.

The ultimate goal is to equip students with the support and maths knowledge they need to succeed in maths going forward.



Standardise methods and models

Writing a scheme of work can be a great opportunity to standardise things across the department. For example, if some members of staff are using bar modelling or ratio tables, does this need to be consistent across some or all teaching groups?

If using manipulatives and models is important for your department, these need to be embedded and used frequently to be really effective. Is it useful to choose a preferred algorithm for long multiplication? What format do you use for demonstrating methods when solving equations?

Prescription can be a good thing here. Students are very unlikely to have the same teacher all the way from Year 7 to Year 11, and the shift in methods, and particularly different notation, can be really confusing for students.

"Methods can vary from one student to another. In our tuition lessons we encourage the use of methods that allow the students to demonstrate a deep understanding of the concepts, however any valid method is acceptable and Skye knows how to adapt their teaching to support this. I've found that often the method a pupil uses can change as their understanding develops and they move towards efficiency over step by step procedure."

Paul Coffey,
Third Space Learning Maths Content Developer and Teacher

Why standardisation of notation is important

$$\begin{aligned} 2x + 7 &= 19 \\ -7 \quad &-7 \\ 2x &= 12 \\ \div 2 \quad &\div 2 \\ x &= 6 \end{aligned}$$

$$\begin{aligned} &\quad -7 \quad -7 \\ &\uparrow \quad \uparrow \\ 2x + 7 &= 19 \\ \div 2 \quad &\div 2 \\ 2x &= 12 \\ x &= 6 \end{aligned}$$

$$\begin{aligned} 2x + 7 &= 19 \quad \Big| \; -7 \\ 2x &= 12 \quad \Big| \; \div 2 \\ x &= 6 \end{aligned}$$

$$\begin{aligned} 2x + 7 &= 19 \quad \overset{-7}{\longrightarrow} \\ 2x &= 12 \quad \overset{\div 2}{\longrightarrow} \\ x &= 6 \end{aligned}$$

$$\begin{aligned} 2x + 7 &= 19 \\ 2x + 7 \; -7 &= 19 \; -7 \\ 2x &= 12 \\ 2x \div 2 &= 12 \div 2 \\ x &= 6 \end{aligned}$$

How to incorporate alternative methods

To be clear, we believe students should still be exposed to alternative methods, as this is really important for deepening understanding.

However, by keeping notation and a preferred method consistent across the department and all key stages, you greatly reduce the cognitive load for students.

Example: if you're recapping multiplication methods with Year 7, it might be quite nice to explore some different methods from other cultures and examine why they work to add enrichment.

However, when you then work on multiplying decimals further on in the scheme, you present your worked examples using the single consistent method for multiplication that the department has selected.

Look at any cross-curricular overlap

If you're thinking about a slightly larger curriculum overhaul, you may want to talk to your science department and work out what they do, as there's quite a bit of rearranging formulae that goes on there, particularly in physics. If they're using formula triangles, and you'd rather they didn't, perhaps you can joint-plan to recap rearranging formulae in maths around the time that the physics department is working on voltage, current and resistance. You may also want to look at how and when statistics is taught in geography.

Key questions to consider:

1. Do you want to incorporate any manipulatives or modelling, such as bar models, ratio tables or use of algebra tiles?
2. What's your standardised way of showing steps when working algebraically?
3. When modelling multiplication, do you use the standard algorithm or one of the gridded methods?
4. How do you approach expanding and factorising brackets - inspection or gridded method?
5. How will you approach rearrangement of formulae? Can you link up and ensure consistencya with your school's science department?
6. Are there any other topics or methods that need to be standardised?

Timetabling issues such as split classes

If you need to split classes due to timetabling, try to think about how this will affect the scheme of work. This will also depend on how your splits work.

Think about which topics split better and at which Key Stage you can focus these splits.

> I allocated all of our splits to KS3 as it was easier to split the particular topics taught in Years 7 and 8 between two members of staff than it was to split our chosen GCSE topics.
>
> 
> **Christine Norledge**
> Deputy Head of Maths

Most schools now allocate at least four hours per week of curriculum time in Years 10 and 11 to maths, although there is greater variability in Key Stage 3. For a split class in Key Stage 4, I offer the following suggestions:

Four hours per week, 3:1 split

- Allocate all of the Statistics and Probability content to the single lesson, as this has the fewest prerequisites;
- Use the single lesson for problem-solving and review - I discuss this in more detail below;
- In Year 11, use the single lesson for past paper revision, or general topic revision as directed by the main teacher.

Four hours per week, 2:2 split

- Allocate number, proportion, statistics and probability to one teacher, and algebra and geometry to the other teacher (preferably the more experienced member of staff);
- For a Foundation group, some of the number or proportion content may need to be handed over to the other teacher due to the higher proportion of number topics on the Foundation paper.

Similar time allocations, such as 7 hours over two weeks, can be adapted in a similar manner. It's more challenging to fit GCSE maths into three hours of curriculum time per week, but here are a couple of suggestions:

Three hours per week, 2:1 split

- For a Foundation group, allocate number, proportion and geometry to the main teacher, and allocate algebra and probability to the single-lesson teacher. Statistics can be mopped up by whoever finishes their main areas of content first.
- For a Higher group, allocate proportion, algebra and geometry to the main teacher, and allocate number and probability to the single-lesson teacher, with statistics dealt with as for Foundation.

Try not to split algebra

If possible, avoid splitting the algebra content between teachers. This is due to the hierarchical nature of algebraic work at GCSE. Keeping algebra and geometry together is advantageous because of links between formulae, particularly changing the subject, and the applications to geometry such as Pythagoras' theorum, trigonometry, area and volume, compound measures and so on.

These ideas aren't set in stone, as different classes will have different needs. Encourage members of staff to collaborate closely with split classes - departmental time could be allowed for this.

Key questions to consider:

1. If split classes are necessary, where is it best to allocate those splits - KS3 or KS4?
2. Are there certain classes that would cope better with splits than others?

Ask your department for common issues

Before embarking on a major project, discuss with the team to see if there are any common themes. It might be that your team needs more guidance and examples for 'teaching' problem solving, or perhaps there are pockets of excellent practice in the department that are not widely shared.

It may be that more experienced staff need assurances that a new scheme of work will not seriously impact their autonomy - there's further discussion below on finding the right level of prescription for a scheme of work. Involving the department all the way through will help you to keep a perspective on everyone's needs.

Key questions to consider (you might want to share this list with your team):

1. Is good practice shared widely?
2. Do any team members have untapped pockets of expertise?
3. Are resources shared well within the department?
4. What's the right level of detail for our scheme?
5. Do assessments need an overhaul?
6. Are there any major gaps or issues with fluency/applications/problem solving?

Don’t do it all on your own

Writing a scheme of work is an incredibly difficult job for one person to do. If possible, a small team of two or three people stops the job from being over-burdensome, and resourcing the scheme should be the responsibility of the entire department.

We recommend that whoever is leading the scheme of work project gets the framework and structure right to begin with, using the other members of the smaller team to bounce ideas off. It’s difficult to create a decent working document from scratch as a committee!

Once the bare bones are in place, the small team can begin to flesh out and resource the individual units of work. Alternatively, you could assign one team member to look solely at one of your key principles, such as problem solving or enrichment, and take responsibility for adding these in the relevant places.

Once the scheme is up and running, it’s important to involve the whole team in adding resources and ideas - see ‘designing and resourcing’ below.

“Although the first set of lessons we created for Third Space Learning were GCSE revision lessons, we were only able to do this by looking at each GCSE topic individually right from the start of KS3. For my own sanity, I started with algebra and mapped all of algebra first before moving on to number!”

Bethan Edwards,
Third Space Learning Curriculum Expert and Teacher

Key questions to consider:

1. Who will lead the development of the scheme? Head of Department, Key Stage coordinator, etc.?
2. Which other members of staff will be directly involved? Do you have team members with specific areas of expertise to draw on?
3. At what stage do you roll out to the whole department and how will their contributions be managed?

What to teach, when and for how long

Define learning content broadly

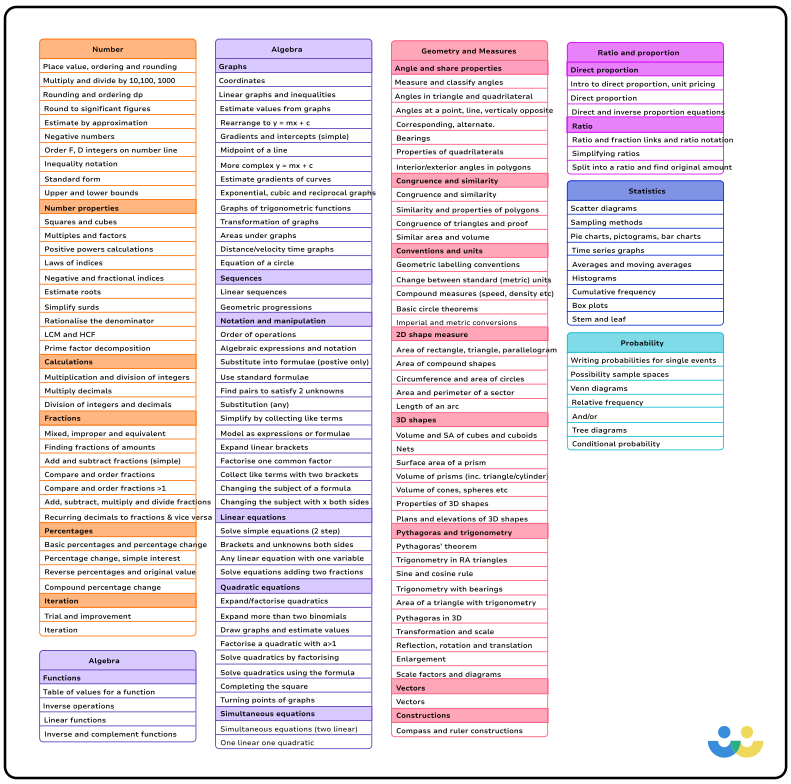
Work out roughly what you want your students to learn over the period of time you're planning for and bullet point these into broad categories. For a two-year GCSE scheme, you're looking at the specification content, bearing in mind what's already been covered at KS3.

Think carefully about the students' starting points - both assumed and actual!

Example: It's likely that work on tree diagrams in probability will require some recap on multiplication of fractions, despite students having 'already learned this' in primary school and at KS3. Allow time for these necessary recaps.

List all the content

If mapping out a five-year curriculum from Year 7 to 11, you'll need to list all the topics out. Here's how that could look for all the KS3 and KS4 objectives and requirements from the Programmes of Study classified by strand and rough topic:



See Appendix 1 for printable version

The next stage is to work through this and assign each subtopic area to a broad unit of work, and then start sequencing the topics within each unit.

If planning a GCSE scheme of work, you'll probably start with a similar list but make sure to remove all the topics that you're sure students have covered in depth and understood in Years 7-9.

Then, begin sequencing the remaining content, following the advice below.

"We've created our GCSE revision programme to ensure each student gets as much time as they need on each of the topics chosen to plug their gaps. Skye only moves on to the next topic when they're confident the student can successfully apply their knowledge to a range of GCSE-style questions."

Bethan Edwards,
Third Space Learning Curriculum Expert and Teacher

Teaching for mastery

A full analysis of mastery in maths and implementation of a mastery curriculum is beyond the scope of this guide. However, one important principle applies even if you're not interested in implementing a full-scale mastery scheme - **the amount of time spent on a topic should be variable and depend on students' needs, prior knowledge and understanding.**

When we started, we found ourselves rushing through topics in an attempt to 'finish' a curriculum each year, often at a pace completely inappropriate for students. In fact, our students tended to do better with more time to cover fewer topics.

Christine Norledge
Deputy Head of Maths

The key thing here is to carefully consider your students and to build in as much flexibility on timings into your scheme as you can.

When students meet a topic for the first time, they need sufficient time to develop understanding of the new concepts through in-depth teacher explanation and independent practice.

Where possible, new concepts should be broken down into small chunks and developed gradually over a series of lessons.

Example: when students first encounter trigonometry, they're better off spending two or three weeks working in depth and practising until they've gained a good understanding, than spending one week in Year 9, another week in Year 10, and another week in Year 11. A two or three week block is a more efficient use of time in the long run, and is more likely to result in longer-term retention.

Adapting the teaching method according to the outcome:

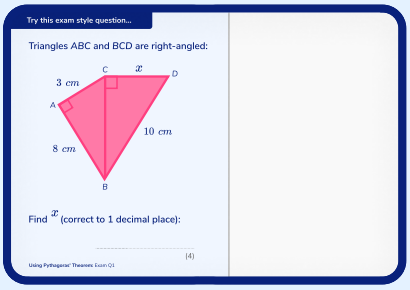
Skye, the AI maths tutor, uses different approaches in lessons depending on each student's understanding.

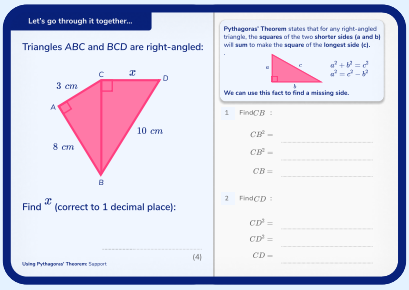
Every session starts with a Skill Check In exam-style question on a particular maths topic. How the student responds to this question determines Skye's teaching methods for the rest of the lesson.

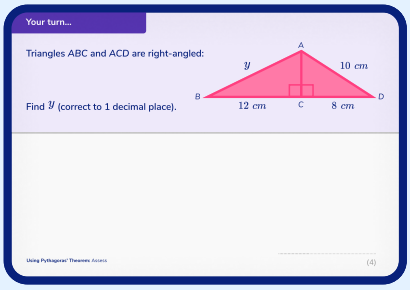
If the student is not able to fully or confidently answer the question, then Skye will provide scaffolded support to break down the question and teach the key concepts required. AI tutor Skye asks the student questions that, in turn, determine the level of support they receive. Once the student is feeling confident, they have the opportunity to do some independent practice.

However, if the student demonstrates a good level of understanding in the Skill Check In question, they will go straight to the independent practice, with Skye on hand to support as much as needed.

Finally, all students answer a 'check-out' question to demonstrate what they have learned.







Scaffolded slides help students explore the strategies they can use to answer exam style questions and practise applying that knowledge independently.

Allow flexibility and build in ‘mop up’ time

Students never progress in a linear manner, and an over-prescriptive scheme of work can hinder good understanding and progress. While it’s generally a good idea for set movements and collaboration to have the team teaching the same content at roughly the same time, you don’t want to be in the position where a class needs that ‘one more lesson’ just to cement their understanding, but their teacher feels they have to move on because they’re still on Week 4 and everyone else has moved on to Week 5.

In the long term, you’re far better off allowing a little teacher autonomy and providing a bit of slack time for that extra one-off lesson, if this is the difference between students surface-learning the new ideas or developing a deeper understanding that is more likely to persist.

“The aim of our tutoring programmes is to give those students who need it most additional opportunities to practise and help them catch up. Because schools tend to schedule the tutoring sessions outside of their maths lessons, it gives those students a chance to consolidate and apply their learning"

Bethan Edwards,
Third Space Learning Curriculum Expert and Teacher

Mastery and flexibility:

- Students learn best when the amount of time spent on a topic is suited to their needs, prior knowledge and understanding;
- Where possible, a scheme of work should allow some flexibility so that units can be compressed or expanded as per students’ needs;
- Curriculum constraints and the timings of external exams are a big driving factor of the pace of lessons, so it is a difficult balancing act!

Look at your minimally different concepts

Minimally different concepts are those that are closely related, and frequently taught at the same time, or back to back. They can even be taught sometimes in the same lesson, and this can be confusing for students. To compound this, students have already experienced teaching on some of these topics at primary level, so if they've not fully understood the distinct concepts the first time around, revisiting factors and multiples as a combined topic is likely to reinforce rather than dispel those misconceptions.

> As far as I know, the idea of 'minimally different concepts' originates from Bruno Reddy's work on curriculum design - if you're not familiar with it, this is definitely worth looking up.
>
> 
> **Christine Norledge**
> Deputy Head of Maths

Our advice when teaching a topic is to clearly separate the teaching of these concepts or you risk confusing students, particularly the ones who already find maths a challenge. Obviously when working through more complex exam style questions at GCSE, there may be multiple concepts (minimally different and very different) grouped together in one question.

List of minimally different concepts

This is not an exhaustive list, but here are the main ones to watch out for:

- Factors and multiples;
- Highest common factor and lowest common multiple;
- Perimeter, area and volume;
- Circumference and area of circles;
- Median, mode, mean;
- Transformations: rotation, reflection, translation and enlargement;
- Pythagoras and trigonometry;
- Sine and cosine rule;
- Expanding and factorising.

Example: Consider splitting first teaching of **circumference of a circle** and **area of a circle** into two separate topics as far apart on the scheme of work as possible. Once happy that students understand the distinct concepts, then look at combining the two and incorporating some problem-solving using circumference to find area or similar.

There's no hard and fast rule for spacing, but try to avoid teaching them back-to-back where possible, as this is likely to have a similar effect of students confusing separate concepts.

With topics that students have seen before, there needs to be a judgement call based on your assessment of your students' general prior knowledge, which may vary from set to set.

Free GCSE maths guides - all topics covered
Don't miss our free GCSE maths library[1] of over 400 GCSE maths revision guides, worksheets and practice papers.

> You can see on our Year 10 scheme (below) that we chose to recap expanding and factorising single brackets together, because students **had already encountered them in depth** in KS3 and we knew they were pretty good at both processes by the time they got to Year 10.
>
> However, we split expanding and factorising quadratics and taught these separately, as this was the **first time students had encountered them**.
>
> 
> **Christine Norledge**
> Deputy Head of Maths

Sequence learning and consider prerequisites

Using the ideas discussed above, sequence your broad topic areas, bearing any prerequisites in mind.

Year 10 example scheme term by term
It's worth taking the time to study this in-depth as you will be making similar decisions but for your own context. The context for this scheme is as follows:

- It is quite algebra heavy because most of the number, ratio and Foundation geometry content has been taught in Years 7-9
- Students in this year struggled with coordinate geometry, so plenty of time has been allocated to go through that more slowly in Year 10 once students have mastered prerequisite algebra skills
- Certain prerequisites are deliberately introduced early on in Year 10, such as changing the subject of a formula (needed for rearrangement with linear graphs, trigonometry, simultaneous equations and compound measures, among others)
- In Year 10 the students were 'finishing' their solving equations content which they'd already started in Year 9

	HT1	HT2	HT3	HT4	HT5	HT6
Week 1	Dividing decimals	Solving equations and inequalities with unknowns both sides and brackets	Law of indices Estimating powers and roots	Pythagoras' theorem	Circumference of circles	Simultaneous equations (two linear)
Week 2	Brief review of expanding and factorising Collecting like terms with two brackets				Trigonometry in RA triangles	
Week 3		Changing the subject of a formula	Linear graphs - Rearrangement Gradient and intercept interpretation, Midpoint	Linear graphs: Finding gradient Finding y-int Equation of line		Cubic and reciprocal graphs
Week 4	Linear sequences Recognising other sequences Linear graphs: plotting y = mx + c		Factorising quadratics (a=1 only)		Area of circles	Standard form
Week 5		Expand quadratics (a=1 only)		Interior and exterior angles in polygons	Area of compound shapes and problem solving	Compound measures
Week 6			Graphs of quadratocs	Angle facts problem solving		Slack
Week 7		Slack		Slack		
Week 8	Slack					

Building your scheme of work

Overviews and unit plans

When creating a new scheme, you have two options for document organisation:

- Create one master table which contains all the information for each unit of work;
- Create an overview like the one above, showing the broad outline for the year, then provide linked and resourced unit plans.

Your overview can cover the whole five years for your scheme, or it might be appropriate to have this split KS3/KS4 if your department uses that divide.

Below are some examples that we've seen used. They are not the only way of going about this but will hopefully provide some ideas for how you might want to structure

Example of a Year 10 and 11 overview document

Please note that this is not intended to be a complete GCSE Foundation scheme of work. There are some topics missing which will have been covered in depth at KS3 and only revisited during KS4.

	Year 10	Year 11
1	Dividing decimals	Geometric progressions Frequency trees
2	Brief review of expanding and factorising Collecting like terms with two brackets	HCT LCM PPF, Venn diagrams
3		Nets, plans and elevations and surface area (all shapes)
4	Linear sequences Recognising other sequences Linear graphs - Plotting, y - mx + c	
5		Compound interest and depreciation
6		Volume (all shapes)
7		Translations and vectors
8	Slack	Constructions
	Half term	
1	Solving equations and inequalities with unknown both sides and brackets	Direct and inverse proportion
2		Enlargement
3	Changing the subject of a formula	Solve quadratics a-1 by factorising
4		Mock exams
5	Expand quadratic (a=1 only)	Distance/velocity time graphs
6		Bounds
7	Slack	Slack
	Christmas	
1	Laws of indices Estimating with powers and roots	Arc length and sector area
2		Tree diagrams
3	Linear graphs - Rearrangement, gradient and intercept interpretation midpoint	Scatter graphs
4	Factorising quadratic (a-1 only)	Pie charts, frequency polygons
5		Average from grouped data
6	Graphs of quadratics	Mock exams
7		Slack
	Half term	
1	Pythagoras' theorem	Revision
2		
3	Linear graphs - Finding gradient and y-int, equation of line	
4		
5	Interior and exterior angles in polygons	
6	Angle facts and problem solving	
7	Slack	
	Easter	
1	Circumference of circles	Revision
2	Trigonometry in RA triangles	
3		
4	Area of circles	
5	Area of compound shapes and problem solving	
	Half term	
1	Simultaneous equations (two linear)	
2		
3	Cubic and reciprocal graphs	
4	Standard form	
5	Compound measures	
6	Slack	

See Appendix 3 for printable version and blank template

Example of an expanded unit plan: linear sequences and recognising other sequences

You can then expand on objectives for the unit, highlight expected prior knowledge and flag any prerequisites that would need to be recapped. Consider also including:

- Suggested resources
- Teaching techniques
- Problem solving opportunities
- Non-related previous learning that would need to be quickly revisited in starters

6.3 Linear sequences

Resources

6.4 Recognising other sequences

Resources

Topic for review: Dividing decimals, expanding single bracket, collecting like terms, solving simple linear equations

Prerequisites:
- Substitution 2.7 - substitution into expressions and formulae using positive numbers, including fractions

Pos objectives:
- Generate terms of a sequence from either a term-to-term or a position-to-term rule (KS3)
- Recognise arithmetic sequences and find the nth term (KS3)
- Recognise and use sequences of triangular, square and cube numbers, Fibonacci type sequences, quadratic sequences (KS4)

Interlinked prior learning:
- Recap of squares and cubes - index notation
- Sort of triangular, square and cube numbers on Venn diagrams
- Sequences with fractions and negative numbers
- Forming and solving linear equations (i.e given nth term rule and term, find the position)
- Forming and solving linear inequalities (i.e. find when a sequence first exceeds a certain value)

Notes:
- Link with 6.5 (Linear graphs), particularly similarities between linear graphs and arithmetic sequences (i.e. common difference/gradient and 0th term/y-intercept) - see multiple representations task and linear rules with contexts.
- MathsPad has some great resources for both linear and "other" sequences.
- For extension, see Extending Sequences from Increasingly Difficult Questions for sequences with algebraic terms.

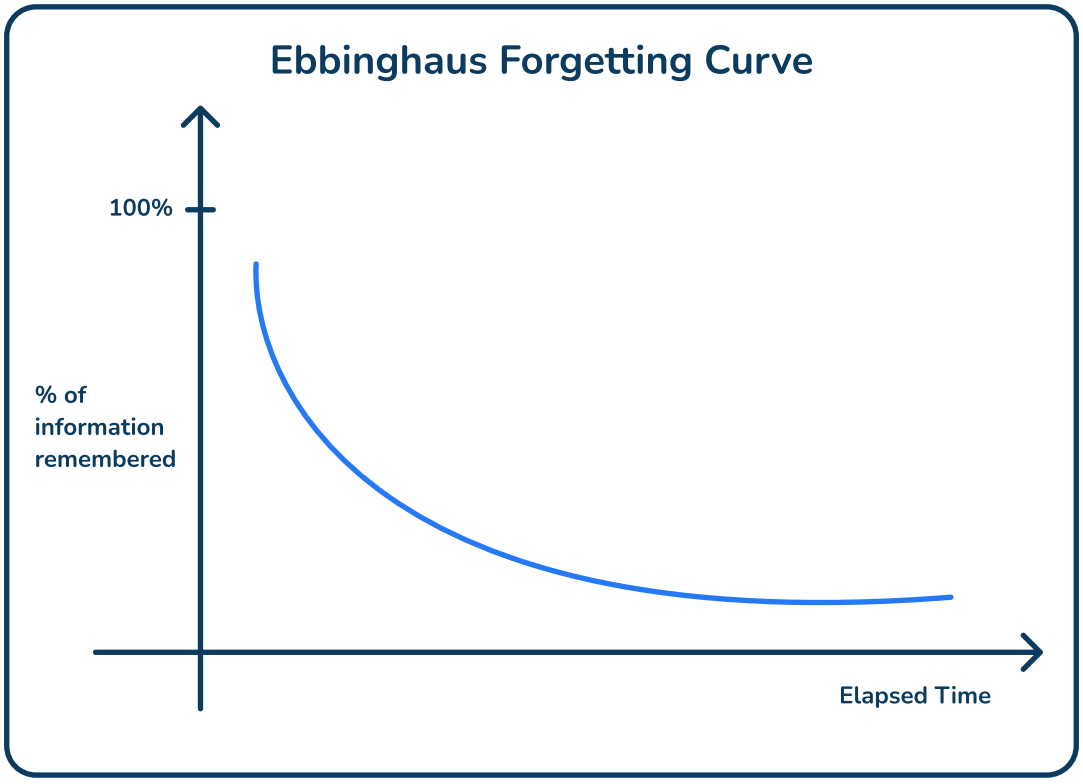
Problem solving:
- Picturing square numbers
- Picturing triangular numbers
- Odds, evens and more evens
- Square diamond
- Patterns for nth term rules

Opportunities to resist sequences:
- Linear equations with unknowns both sides (6.6) see Arithmetic sequences meets equations
- Simultaneous equations (9.1) - I.e. given two terms, form and solve two equations to find the nth term rule

> Rather than include all available resources on each unit plan, we cherry-picked a few of the top resources for each topic, then hyperlinked to individual folders on the shared drive for additional resources.
>
> 
> **Christine Norledge**
> Deputy Head of Maths

Memory and spaced repetition

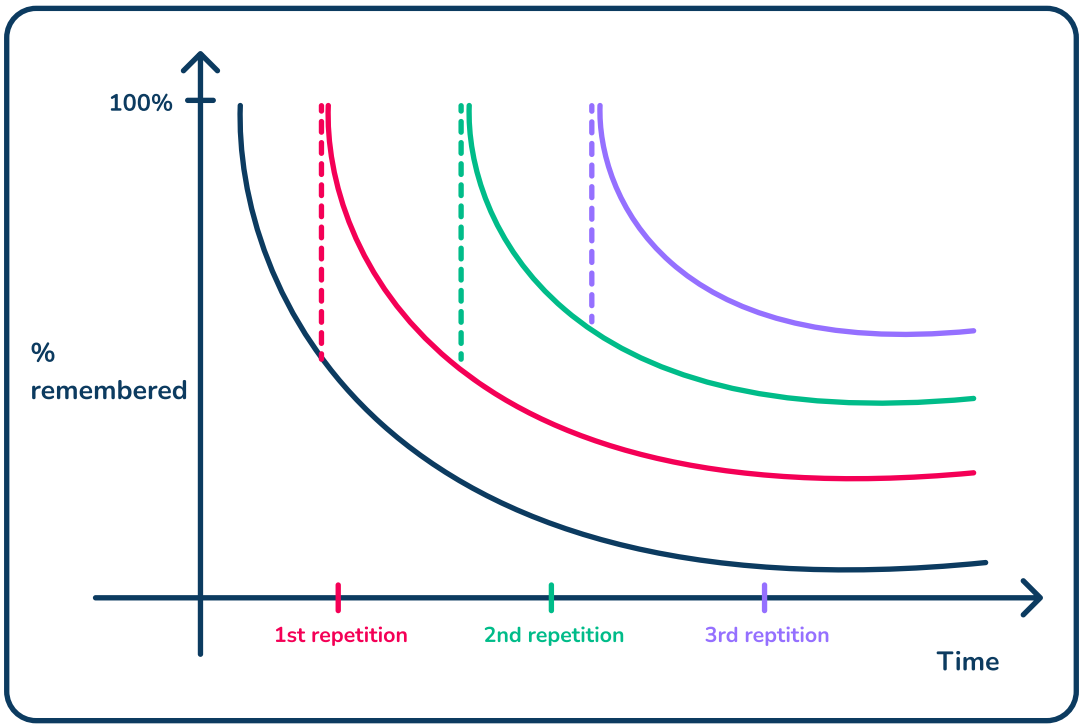
The process of retrieving facts and concepts from long-term memory is incredibly important for long-term persistence of those facts and concepts. This idea goes right back to Hermann Ebbinghaus's 1885 book *Über das Gedächtnis (Memory: A Contribution to Experimental Psychology)*, and his 'forgetting curve', showing that most of a newly learned concept or skill is forgotten in a matter of days or weeks if it is not rehearsed or reviewed.



This makes sense cognitively - it's difficult to see how our brains would function effectively if we tried to permanently store every single memory, idea and new concept. The brain decides what's most useful by how often it's accessed, and prunes away the rest.

The forgetting curve:

- Generally, newly learned concepts do not persist in long-term memory unless they are reactivated and accessed in a short period of time (a matter of days);
- New information is easier to recall when it's based on or connected to something already known;
- There is some suggestion that regular reviewing 'flattens' the curve - if concepts are regularly rehearsed, they are forgotten less quickly each time.



This isn't a new concept: the spiral curriculum model is based on the idea that students need to frequently revisit topics to ensure they aren't learned once and then forgotten. In fact, this seems almost at odds with themes of 'mastery' - rather than teaching trigonometry once, we should be teaching it in Years 9, 10 and 11 to ensure it isn't forgotten.

It is undeniably important that we frequently revisit previously learned skills and concepts throughout a scheme of work. However, this re-visitation does not need to be a complete re-teaching - we just need to embed prior learning as much as possible throughout the scheme, and also ensure we build in time for repeated practice of previously acquired skills.

"At the end of each Third Space Learning lesson we ask some low stakes quiz questions that give the student a chance to try to answer without any hints or scaffolding. Building on their responses, the following lesson we will recap the quiz questions done the previous week. On each iteration of our lesson slides, we try to better sequence our approach to retrieval practice."

Candida Crawford,
Third Space Learning Head of Academic Standards and Teacher

Practise recall with regular low stakes quizzes

We recommend a five or ten question recall quiz at the start of each lesson. This gives students a greater understanding of the interconnectedness of mathematics and helps them to seat the new piece of knowledge within a preexisting, well-defined web.

A good scheme of work helps prompt teachers to think about spaced repetition of prior skills and concepts as well as covering the new content. Otherwise, it's easy to forget to do the recall or check on prior knowledge.

Create an entry on your scheme of work for 'topics to review'. Prioritise either those that will not be recapped or those that will be required as a prerequisite in the next few weeks. These can be adapted to the needs of a class.

Example: In the Year 10 example above for the lessons on sequences (approx Weeks 4-5), the suggested review topics were:

- Dividing decimals;
- Expanding single brackets;
- Collecting like terms;
- Solving simple linear equations.

The first three topics had been covered in the first three previous weeks; expanding single brackets would also be needed for upcoming work on solving linear equations. Solving simple linear equations was covered in Year 8, so reviewing at this point is an opportunity to front-load prior knowledge and also diagnose existing misconceptions.

Create a bank of recall quizzes

Once a scheme is fairly well-embedded and you're happy with the content order, you can start to collate a central bank of recall quizzes particular to each stage in the scheme - if everyone in the department contributes, this cuts workload considerably.

Example:
Week 5 recall quiz.

1. $3.2 \div 8$
2. $0.4 \div 0.5$
3. $12 \div 0.3$
4. Expand $3(2x + 4)$
5. Expand $-2(6 + 3y)$
6. Simplify $3x + 4x - 2x$
7. Simplify $4a - 2b + 2a - 3b$
8. Solve $3x + 4 = 16$
9. Solve $12 - 3y = 3$
10. Solve $-2 = 4 + 2x$

How to space practice:

- Revisit newly learned concepts frequently - include a recap in the next couple of lessons, then within a week, then within a fortnight;
- Revisit older concepts less frequently, but ensure they're mixed in with other newer concepts;
- Explicitly link to prior knowledge and concepts wherever possible and include practice on these concepts (e.g. include fractional coefficients when solving equations);
- Encourage student buy-in - share the ideas behind the Forgetting Curve with them and promote attempting homework tasks as soon as they get them.

Problem solving

Our brains really aren't very good at solving unfamiliar problems - for a discussion of this, see Willingham's 2009 article, Why Students Don't Like School[2]. Interestingly, Willingham posits that, despite being pretty bad at thinking in an unfamiliar situation, we actually quite enjoy the experience, particularly if we are rewarded with finding a solution - otherwise, the cryptic crossword would be nowhere near as popular as it is!

If our students' brains are having to work really hard to solve problems and to find strategies that might apply universally - when we're 'teaching problem solving skills' - it makes sense to reduce some of the cognitive load by asking them to solve problems using concepts they're comfortable with, rather than a new concept they've just encountered.

> Working on problems that are at the right level of difficulty is rewarding, but working on problems that are too easy or too difficult is unpleasant.
>
> 
> **Daniel Willingham,**
> Why Students Don't Like School

"To get the Zone of Proximal Development right - ie the problems at the right level of difficulty - we rely on diagnostic assessment followed up by the personal attention of a one to one AI tutor to make sure we spend our time only on things that the student needs help with. We're able to test both the concept and the pre-requisites too which means we are able to create a personalised journey for each student which is as close as possible to their ZPD, and with clear paths to success."


Candida Crawford,
Third Space Learning Head of Academic Standards and Teacher

Problem solving provides opportunities for:

- Discussion of how new knowledge relates to prior knowledge;
- Identification of which methods are appropriate and when;
- Memory retrieval practice on concepts taught previously;
- Practising use of problem solving skills with familiar concepts;
- Experience of independent success.
- Space repetition

Example: You've just finished teaching right angled trigonometry, developed understanding and allowed plenty of time for practice on fairly procedural problems. Towards the end of the lesson sequence, you've probably thrown in some context-based trigonometry problems.

When considering the problem-solving element, rather than look at unfamiliar problems requiring students to apply the new trigonometry concepts they've just encountered, why not pick a couple of challenging Pythagoras questions to have a go at instead.

This results in:

- An opportunity to discuss how our new knowledge of trigonometry relates to our prior knowledge of Pythagoras, and consider similarities and differences - we can start to identify which method is appropriate when;
- Some memory retrieval practice on Pythagoras' theorem, which might have been taught several weeks previously;
- Time for students to practise using problem solving skills with a concept they're more familiar with, resulting in them being more likely to experience success.

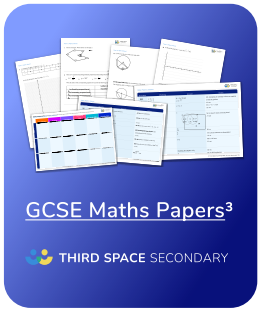
This might seem a little at odds with the discussion above about minimally different concepts, but the idea of minimally different concepts relates to **first teaching.**

Teaching Pythagoras and trigonometry together for the first time causes confusion, but when both concepts are well-learned, it's important that we do bring themes together so that students can appreciate the interconnectedness of the structure of mathematics.

Assessment

A full discussion of assessment and its purposes will be covered in a separate resource. However, writing a new scheme of work affords an opportunity to also overhaul assessments and bring them in line with the new content order.

Consider how often you will assess and the purposes of these assessments. Most schools have an end-of-year exam, but you may also want to include key checkpoints at Christmas and Easter. It is likely that these will be formal assessments - and, depending on the age and stage of the students, a past GCSE paper or a selection of past GCSE questions may be appropriate.



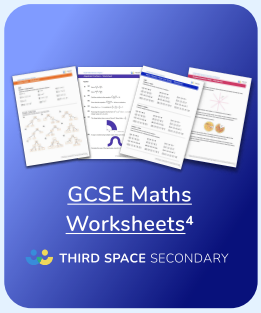
Frequent low stakes assessments are very useful to inform planning and future teaching approaches; they're also crucial for identifying personal areas of development for students.

If you're interested in going down the mastery route, assessments are useful at the end of each unit to gauge understanding and to work out whether to move on or to re-teach.

Build up a central bank of assessments for each unit of work - these can be created throughout the year and saved to a shared area. If you're using principles of mastery in your curriculum planning, you may need a couple of versions of each assessment to allow for re-testing.

"One thing I always wanted more of as a teacher was practice questions to support low stakes assessment in class and as homework outside of class. So I've made an entire resource bank of GCSE maths worksheets for any other teacher like me. And it's free!"

Paul Coffey,
Third Space Learning Maths Content Developer and Teacher



Resourcing the scheme

Wider team involvement

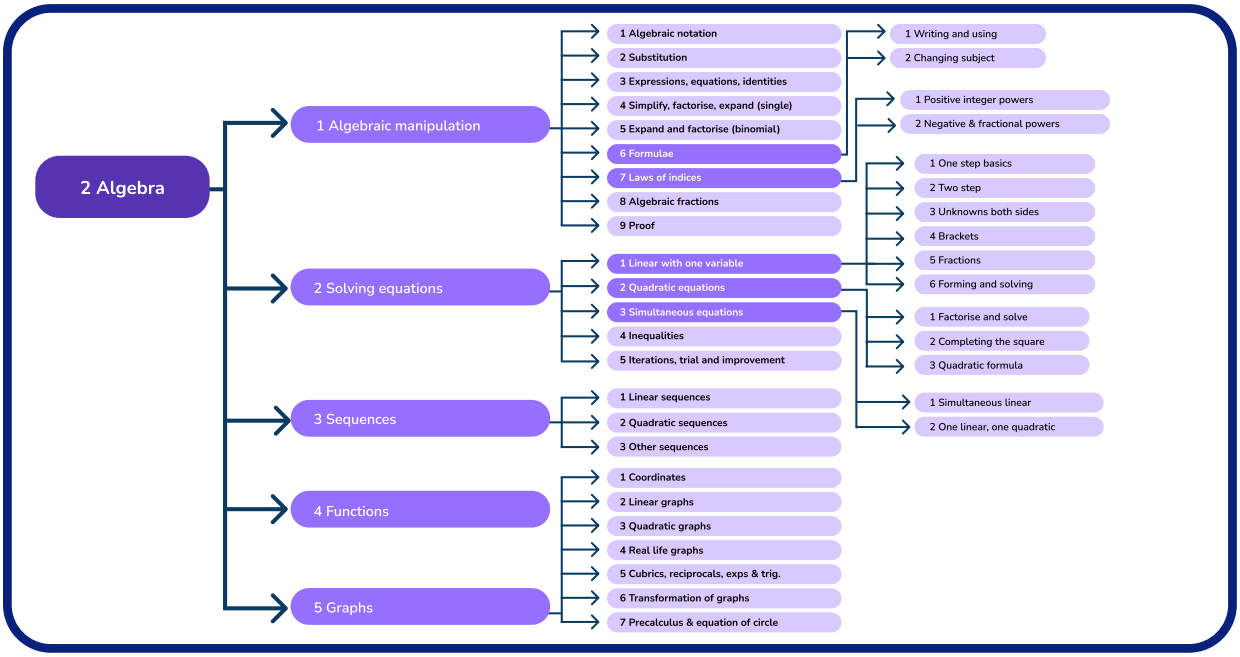
Once the document templates, structure and basic ideas are sketched out, this is a good opportunity to involve the rest of the team in adding teaching resources or ideas to the scheme of work. Allocate specific time for this - either departmental meeting time, or gained time during the summer term.

Depending on your team's structure, you could assign tasks to people according to their expertise - for example, allocating problem solving to someone with a good bank of appropriate tasks.

Digital and physical resources

If your department has shared physical resources, now is a good time to organise them and make sure they're available for everyone to use, and flagged at the appropriate points on the scheme. If possible, a shared resource cupboard is preferable to storing resources in individual classrooms.

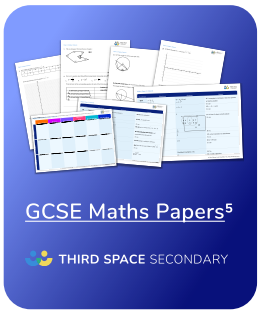
The organisation of digital resources is likely to be a considerably larger undertaking, particularly if they're stored everywhere. We recommend you start afresh with a clear folder and subfolder structure to locate and store digital resources in future.

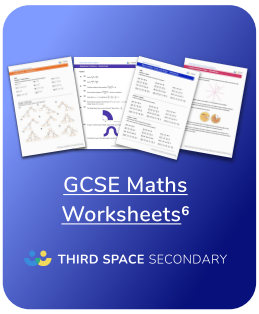


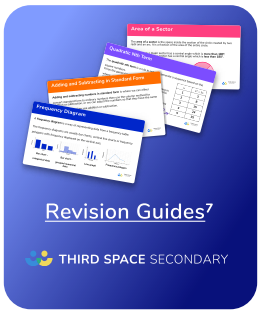
Example folder structure to organise files and resources by GCSE maths topic

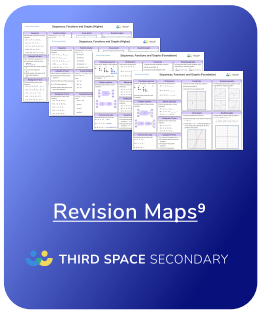
Do encourage people to be selective and only share resources or lesson ideas that have worked really well. A small selection of carefully curated resources is always preferable.

There's a lot of free but poor quality material available. The Third Space Learning resources go through several stages of authoring and reviewing by teachers before they're ready to share in our own resource library. Follow the links on the next page to see what's available.









Click on the links above to download these free GCSE maths resources

> One strategy I've used with my personal collection of resources in the last few years is to have a single PowerPoint for each topic, with my teaching slides alongside screenshots which are linked to the relevant worksheets/ online resources. This has made it much easier to quickly scan through to plan and personalise a lesson for a particular class by simply deleting all the irrelevant slides. This could also work with department-wide PowerPoints.
>
> 
> **Christine Norledge**
> Deputy Head of Maths

Homework

When developing a new curriculum, it's also a good opportunity to look critically at homework and how it's used in the department.

Rather than setting 'filler' tasks, it's a good idea to use homework as another slot for retrieval practice to try and combat the forgetting effect.

Create a bank of homework exercises

As for recall quizzes, it's worth planning now to create a bank of homework exercises tied into various points of the scheme that cycle through prior learning with a mixture of older concepts revisited every few weeks and a more rapid cycle of newer concepts.

Another great use of homework time is front-loading topics that are about to be taught - so if students are about to begin a unit on solving equations with unknowns both sides, their homework a couple of weeks previously could be to watch a revision video and attempt questions on standard two-step linear equations.

This can be reviewed in class and misconceptions cleared up before the new topic is taught or the teacher can re-plan their starting point for the new unit if there appear to be a lot of issues.

"The joy of the one to one tutoring session each week is that it can be used for each child differently. Occasionally, for example, we find a teacher using a student's weekly session to recap previously learnt content in advance of a more challenging concept they are about to teach. For example, it you are about to teach adding fractions with a class (unlike denominators) and you know that a particular student is going to struggle, you can set student x a lesson on adding fractions with unlike denominators prior to your in class lesson so they have already had some practice on the prerequisite for the topic."

Bethan Edwards,
Third Space Learning Curriculum Expert and Teacher

Reduce homework marking

Consider ways to reduce marking load from homework. Students could peer-mark retrieval practice questions or a marking proforma could be included for tasks intended to be marked by staff - see the example below.

Homework sheets can be printed with these on the bottom - when providing feedback, you can quickly RAG-rate each skill and standard.

Then, direct students towards additional help on individual topics if necessary or set extensions and challenge questions.

	Skills	Standards
A	Use a table of values to draw the graph of a linear equation	Presentation
B	Understand and use y = mx + c to find the gradient and y-intercept	Workings shown
C	Find the equation of a line from a graph	Punctuality

	Skills
1	Find the equation of the line parallel to y = 3x + 6 passing through the point (4, 10).
2	Have a look ahead at the online clips on perpendicular lines.

Ensure that you are confident with all the previous skills before moving on to these.

Tips for homework:

- Opportunity for retrieval practice of previously learned knowledge and skills;
- Can be used to front-load upcoming topics;
- Design tasks that can be peer-marked;
- Include a marking proforma for teacher-marked tasks.

"All our free GCSE maths resources contain a mix of self marking practice questions and exam questions, as well as flash cards for revision. And don't worry - answers come as standard to make marking easy."

Paul Coffey,
Third Space Learning Maths Content Developer and Teacher

Final step: reviewing your scheme

We've looked in this resource at the principal elements of creating a maths scheme of work. It's inevitable that you won't get everything right first time!

It's likely that the first time you run through it, you'll find elements that need changing, tweaking, or in some situations, removing completely. A scheme of work should be viewed as an organic document that will need to be adapted or altered regularly.

The end of the year is a good time to conduct a thorough review, but it's worth checking in with the department every so often and noting down issues as they crop up as fuel for that review and rewrite. If possible, encourage staff to note on the scheme how each unit or module has gone, including positives and negatives.

At the end of this resource, you'll find the appendices and a list of further reading and references.

We hope you've found this guide helpful in developing a GCSE maths scheme of work that works for you and your students. We know it's not the easiest of tasks, so don't hesitate to reach out to us if you have any questions or need additional guidance.

If you're looking for a way to ensure every student who needs it receives the right GCSE maths support, at the right time, delivered at the right pace - we'd love to speak to you about how we can help. Just visit our website or contact us on the details on the back page.

THIRD SPACE LEARNING

Appendices

Appendix 1: Example classification of all KS3 and KS4 topics

Number
Place value, ordering and rounding
Multiply and divide by 10,100, 1000
Rounding and ordering dp
Round to significant figures
Estimate by approximation
Negative numbers
Order F, D integers on number line
Inequality notation
Standard form
Upper and lower bounds
Number properties
Squares and cubes
Multiples and factors
Positive powers calculations
Laws of indices
Negative and fractional indices
Estimate roots
Simplify surds
Rationalise the denominator
LCM and HCF
Prime factor decomposition
Calculations
Multiplication and division of integers
Multiply decimals
Division of integers and decimals
Fractions
Mixed, improper and equivalent
Finding fractions of amounts
Add and subtract fractions (simple)
Compare and order fractions
Compare and order fractions >1
Add, subtract, multiply and divide fractions
Recurring decimals to fractions & vice versa
Percentages
Basic percentages and percentage change
Percentage change, simple interest
Reverse percentages and original value
Compound percentage change
Iteration
Trial and improvement
Iteration

Algebra
Functions
Table of values for a function
Inverse operations
Linear functions
Inverse and complement functions

Algebra
Graphs
Coordinates
Linear graphs and inequalities
Estimate values from graphs
Rearrange to y = mx + c
Gradients and intercepts (simple)
Midpoint of a line
More complex y = mx + c
Estimate gradients of curves
Exponential, cubic and reciprocal graphs
Graphs of trigonometric functions
Transformation of graphs
Areas under graphs
Distance/velocity time graphs
Equation of a circle
Sequences
Linear sequences
Geometric progressions
Notation and manipulation
Order of operations
Algebraic expressions and notation
Substitute into formulae (postive only)
Use standard formulae
Find pairs to satisfy 2 unknowns
Substitution (any)
Simplify by collecting like terms
Model as expressions or formulae
Expand linear brackets
Factorise one common factor
Collect like terms with two brackets
Changing the subject of a formula
Changing the subject with x both sides
Linear equations
Solve simple equations (2 step)
Brackets and unknowns both sides
Any linear equation with one variable
Solve equations adding two fractions
Quadratic equations
Expand/factorise quadratics
Expand more than two binomials
Draw graphs and estimate values
Factorise a quadratic with a>1
Solve quadratics by factorising
Solve quadratics using the formula
Completing the square
Turning points of graphs
Simultaneous equations
Simultaneous equations (two linear)
One linear one quadratic

Geometry and Measures
Angle and share properties
Measure and classify angles
Angles in triangle and quadrilateral
Angles at a point, line, verticaly opposite
Corresponding, alternate.
Bearings
Properties of quadrilaterals
Interior/exterior angles in polygons
Congruence and similarity
Congruence and similarity
Similarity and properties of polygons
Congruence of triangles and proof
Similar area and volume
Conventions and units
Geometric labelling conventions
Change between standard (metric) units
Compound measures (speed, density etc)
Basic circle theorems
Imperial and metric conversions
2D shape measure
Area of rectangle, triangle, parallelogram
Area of compound shapes
Circumference and area of circles
Area and perimeter of a sector
Length of an arc
3D shapes
Volume and SA of cubes and cuboids
Nets
Surface area of a prism
Volume of prisms (inc. triangle/cylinder)
Volume of cones, spheres etc
Properties of 3D shapes
Plans and elevations of 3D shapes
Pythagoras and trigonometry
Pythagoras' theorem
Trigonometry in RA triangles
Sine and cosine rule
Trigonometry with bearings
Area of a triangle with trigonometry
Pythagoras in 3D
Transformation and scale
Reflection, rotation and translation
Enlargement
Scale factors and diagrams
Vectors
Vectors
Constructions
Compass and ruler constructions

Ratio and proportion
Direct proportion
Intro to direct proportion, unit pricing
Direct proportion
Direct and inverse proportion equations
Ratio
Ratio and fraction links and ratio notation
Simplifying ratios
Split into a ratio and find original amount

Statistics
Scatter diagrams
Sampling methods
Pie charts, pictograms, bar charts
Time series graphs
Averages and moving averages
Histograms
Cumulative frequency
Box plots
Stem and leaf

Probability
Writing probabilities for single events
Possibility sample spaces
Venn diagrams
Relative frequency
And/or
Tree diagrams
Conditional probability

Appendix 2a: Example Year 10 term by term sequencing of topics

Year 10	HT1	HT2	HT3	HT4	HT5	HT6
Week 1	Dividing decimals	Solving equations and inequalities with unknowns both sides and brackets	Law of indices Estimating powers and roots	Pythagoras' theorem	Circumference of circles	Simultaneous equations (two linear)
Week 2	Brief review of expanding and factorising Collecting like terms with two brackets				Trigonometry in RA triangles	
Week 3		Changing the subject of a formula	Linear graphs - Rearrangement Gradient and intercept interpretation, Midpoint	Linear graphs: Finding gradient Finding y-int Equation of line		Cubic and reciprocal graphs
Week 4	Linear sequences Recognising other sequences Linear graphs: plotting $y = mx + c$		Factorising quadratics (a=1 only)		Area of circles	Standard form
Week 5		Expand quadratics (a=1 only)		Interior and exterior angles in polygons	Area of compound shapes and problem solving	Compound measures
Week 6			Graphs of quadratocs	Angle facts problem solving		Slack
Week 7		Slack		Slack		
Week 8	Slack					

Appendix 2b: Blank sequencing schedule term by term

	HT1	HT2	HT3	HT4	HT5	HT6
Week 1						
Week 2						
Week 3						
Week 4						
Week 5						
Week 6						
Week 7						
Week 8						

Appendix 3a: Example Year 10 and Year 11 overview document

	Year 10	Year 11
1	Dividing decimals	Geometric progressions Frequency trees
2	Brief review of expanding and factorising Collecting like terms with two brackets	HCT LCM PPF, Venn diagrams
3		Nets, plans and elevations and surface area (all shapes)
4	Linear sequences Recognising other sequences Linear graphs - Plotting, y - mx + c	
5		Compound interest and depreciation
6		Volume (all shapes)
7		Translations and vectors
8	Slack	Constructions
	Half term	
1	Solving equations and inequalities with unknown both sides and brackets	Direct and inverse proportion
2		Enlargement
3	Changing the subject of a formula	Solve quadratics a-1 by factorising
4		Mock exams
5	Expand quadratic (a=1 only)	Distance/velocity time graphs
6		Bounds
7	Slack	Slack
	Christmas	
1	Laws of indices Estimating with powers and roots	Arc length and sector area
2		Tree diagrams
3	Linear graphs - Rearrangement, gradient and intercept interpretation midpoint	Scatter graphs
4	Factorising quadratic (a-1 only)	Pie charts, frequency polygons
5		Average from grouped data
6	Graphs of quadratics	Mock exams
7		Slack
	Half term	
1	Pythagoras' theorem	Revision
2		
3	Linear graphs - Finding gradient and y-int, equation of line	
4		
5	Interior and exterior angles in polygons	
6	Angle facts and problem solving	
7	Slack	
	Easter	
1	Circumference of circles	Revision
2	Trigonometry in RA triangles	
3		
4	Area of circles	
5	Area of compound shapes and problem solving	
	Half term	
1	Simultaneous equations (two linear)	
2		
3	Cubic and reciprocal graphs	
4	Standard form	
5	Compound measures	
6	Slack	

Appendix 3b: Blank overview document template

	Year 10	Year 11
1		
2		
3		
4		
5		
6		
7		
8		
Half term		
1		
2		
3		
4		
5		
6		
7		
Christmas		
1		
2		
3		
4		
5		
6		
7		
Half term		
1		
2		
3		
4		
5		
6		
7		
Easter		
1		
2		
3		
4		
5		
Half term		
1		
2		
3		
4		
5		
6		

Appendix 4a: Example of an expanded unit plan: linear sequences and recognising other sequences

6.3 Linear sequences

Resources

6.4 Recognising other sequences

Resources

Topic for review: Dividing decimals, expanding single bracket, collecting like terms, solving simple linear equations

Prerequisites:
- Substitution 2.7 - substitution into expressions and formulae using positive numbers, including fractions

POS objectives:
- Generate terms of a sequence from either a term-to-term or a position-to-term rule (KS3)
- Recognise arithmetic sequences and find the nth term (KS3)
- Recognise and use sequences of triangular, square and cube numbers, Fibonacci type sequences, quadratic sequences (KS4)

Interlinked prior learning:
- Recap of squares and cubes - index notation
- Sort of triangular, square and cube numbers on Venn diagrams
- Sequences with fractions and negative numbers
- Forming and solving linear equations (i.e given nth term rule and term, find the position)
- Forming and solving linear inequalities (i.e. find when a sequence first exceeds a certain value)

Notes:
- Link with 6.5 (Linear graphs), particularly similarities between linear graphs and arithmetic sequences (i.e. common difference/gradient and 0th term/y-intercept) - see multiple representations task and linear rules with contexts.
- MathsPad has some great resources for both linear and "other" sequences.
- For extension, see Extending Sequences from Increasingly Difficult Questions for sequences with algebraic terms.

Problem solving:
- Picturing square numbers
- Picturing triangular numbers
- Odds, evens and more evens
- Square diamond
- Patterns for nth term rules

Opportunities to revisit sequences:
- Linear equations with unknowns both sides (6.6) see Arithmetic sequences meets equations
- Simultaneous equations (9.1) - I.e. given two terms, form and solve two equations to find the nth term rule

Appendix 4b: Blank expanded unit plan template

Topic for review:

Prerequisites:

POS objectives:

Interlinked prior learning:

Notes:

Problem solving:

Opportunities to revisit sequences:

Further reading

Lessons learned - writing a scheme of work
A brief overview of Christine Norledge's experiences of writing our scheme of work

Writing a new Maths Scheme of Work collection
19-part blog series covering how Craig Barton and his team developed their scheme of work

Design your own mastery curriculum in maths
Useful reading from Bruno Reddy, particularly around minimally different concepts

Scheme of work development
Jo Morgan's thoughts on developing a KS4 scheme of work

Why students don't like school
Daniel Willingham's influential article on cognition and problem solving

References

[1] https://thirdspacelearning.com/gcse-maths/

[2] https://www.aft.org/sites/default/files/WILLINGHAM%282%29.pdf - 'Why Students Don't Like School by Daniel T. Willingham

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