Year 13 Further Mathematics Applied	Working towards expected outcomes Your child is not yet making the expected progress within this course.	Working at expected outcomes Your child is achieving the expected progress for this point within the course.	Working beyond expected outcomes Your child is exceeding the expected progress.
Autumn Term	Students working **towards** expected outcomes in Y13 can: • Formulate simple linear programming problems with clear decision variables and constraints. • Represent feasible regions graphically for two-variable problems using shading. • Understand slack variables in Simplex for ≤ constraints. • Draw basic activity networks from precedence tables, including dummies. • Identify critical paths in activity networks and understand float. • Recognise Binomial, Poisson, Geometric and Negative	Students working **at** expected in Y13 can: • Formulate and solve linear programming problems using objective line and vertex methods. • Apply the Simplex algorithm (including two-stage Simplex and Big-M methods) to maximise or minimise objectives with ≤, ≥ and = constraints. • Use slack, surplus and artificial variables to rewrite constraints. • Interpret solutions in the context of real problems, including integer-valued solutions. • Model projects with activity networks from precedence tables and complete time analysis.	Students working **beyond** expected in Y13 can: **In addition to the skills listed under 'Working At' for this topic, students working beyond expected outcomes can:** • Justify the choice of linear programming solution methods for different problem types. • Tackle complex LP problems with mixed constraints and multiple units or conversions. • Analyse the efficiency and order of algorithms used in LP. • Critique limitations of graphical and algebraic LP approaches. • Optimise project schedules with resource constraints, explaining trade-offs between duration and resources. • Handle networks with multiple critical paths and justify choices in levelling resources.

	Binomial distributions and their uses in context. • State the necessary assumptions for using these distributions (independence, constant probability of success).	• Perform forward and backward passes to find earliest and latest event times. • Identify critical activities and calculate total float. • Construct and interpret Gantt charts and resource histograms, applying resource levelling. • Schedule activities to minimise the number of workers required. • Calculate mean and variance for Binomial, Poisson, Geometric and Negative Binomial distributions. • Apply these distributions appropriately to model real-world problems, stating assumptions clearly.	• Critically evaluate the suitability of Binomial, Poisson, Geometric and Negative Binomial models in context. • Solve linked problems combining different discrete distributions. • Derive or manipulate algebraic forms for mean or variance to find parameters. • Analyse real-world contexts to assess the validity of modelling assumptions.

Spring Term	Students working **towards** expected outcomes in Y13 can: • State null and alternative hypotheses with correct notation and context. • Understand significance levels, p-values and critical regions. • Recognise when to apply Poisson or Geometric distributions in hypothesis testing. • Quote the Central Limit Theorem and recognise when sample means are used. • Understand observed and expected frequencies in goodness of fit tests. • Define Type I and Type II errors clearly. • Recognise probability generating functions (PGFs) as	Students working **at** expected in Y12 can: • Conduct hypothesis tests for the Poisson and Geometric distributions, deciding on one-tailed or two-tailed alternatives. • Use the geometric distribution to calculate p-values in hypothesis tests. • State conclusions carefully in context. • Apply the Central Limit Theorem to approximate sampling distributions of means. • Recognise when the CLT is needed in applied problems. • Carry out goodness of fit tests for Binomial, Poisson and Geometric distributions, using χ^2 statistics and appropriate degrees of freedom.	Students working **beyond** expected in Y12 can: • Justify model choice and testing approach in real-world contexts. • Handle unusual significance levels and tailor tests to context. • Critique appropriateness of the CLT approximation, discussing effects of sample size. • Discuss the impact of grouping and parameter estimation on degrees of freedom in goodness of fit tests. • Interpret χ^2 test outcomes critically with clear contextual reasoning. • Derive or manipulate PGFs for given distributions to demonstrate understanding of properties. • Prove additive properties or transformations using PGFs for enrichment.

	representing discrete distributions.	• Analyse contingency tables to test for independence. • Find PGFs for given discrete distributions. • Use PGFs to find mean and variance of a distribution. • Apply PGFs to sums of independent random variables. • Calculate and interpret Type I and Type II errors for standard distributions. • Define and calculate the size and power of a test. • Use and interpret power functions for hypothesis tests.	• Analyse size and power of tests in detail, using conditional probability reasoning. • Interpret power functions graphically to assess effectiveness of tests. • Compare testing strategies to identify the most appropriate for given scenarios.

Summer Term	Students working **towards** expected outcomes in Y12 can:	Students working **at** expected in Y12 can:	Students working **beyond** expected in Y12 can:
