ROYAL STATISTICAL SOCIETY

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Graduate (Level 6) standards in Statistics

The table below provides an indication of the knowledge and skills that would be expected of a student completing a Graduate programme accredited by the RSS. This is described in terms of a core body of knowledge and skills (in Column 3), supplemented by knowledge and skills in at least one area of statistical specialism which may be predominantly application oriented or predominantly technique oriented (in Column 4). In combination the core and the area(s) of specialism should provide a coherent set of knowledge and skills at Level 6. Column 2 provides the current QAA benchmark statement which is mapped to the skills and knowledge as defined by the RSS.

Programmes which are presented for accreditation at this level will be expected to demonstrate that they meet the learning objectives listed below. It is expected that all the core knowledge is covered. However some minor omissions, if substituted by alternative methods/techniques of similar complexity, may be considered acceptable, provided the coherence of the overall set of knowledge is maintained. It is also expected that the area(s) of specialism should add substantially to the Level 6 material covered. A programme that delivers only the core material would not satisfy the Level 6 standard and would not be worthy of accreditation.

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	QAA Benchmark Statement	RSS Core	Area of Specialism
1 2 3	a reasonable understanding of the basic body of knowledge for the programme of study, normally including calculus and linear algebra a reasonable level of skill in calculation and manipulation within this basic body of knowledge and some capability to solve problems formulated within it application of core concepts and principles in well defined contexts, showing judgement in the selection and application of tools and techniques	**A sound understanding, and skill in the appropriate use of, key mathematical operations in a given task** **A sound understanding, and skill in the use of, key statistical techniques in a given task** **Ability to solve practical problems, using appropriate statistical techniques e.g. modelling, experimentation and survey design.** **Core Knowledge and Skills:** ***<u>Mathematical techniques</u>*** **Students should be have knowledge of:** • Algebra: Permutations and combinations. Partial fractions, solution of linear and quadratic equations, simple inequalities, summation of series with notation, Limits of sequences and functions, geometric series, exponential and logarithmic functions • Calculus (differential and integral) underpinning the contents below.	**Knowledge and/or application of more advanced techniques or techniques used in a specific area of application.** **Examples of areas of specialism:** ***Application-oriented*** Actuarial Statistics Ecological Statistics Econometrics Environmental Statistics Financial Statistics Industrial Statistics Medical/Bio Statistics Official Statistics Statistical Genetics ***Technique-oriented***

		• Matrix algebra • Numerical methods: Iterative solution of equations **Skills: Students should be able to:** • Produce summary statistics for measures of location, variability and skewness and association between variables, e.g. correlation, odds ratio. • Produce tabular summaries of frequency distributions. Choose numerical and graphical summaries of data that are appropriate; designed to reveal patterns, in or errors in the data, and guide subsequent analysis • Produce numerical and graphical data, summaries ***Probability*** **Students should have knowledge of:** • Basic concepts of set theory and probability: relative frequency, degrees of belief. • Addition and multiplication rules. • Conditional probability and associated results: the law of total probability and Bayes theorem. • Dependence and independence.	Applied Probability Bayesian Statistics Data Mining Data Science/Big Data Experimental Design Mathematical Statistics Multivariate Analysis Modelling techniques Nonparametric Methods Spatial Processes Statistical Computation Stochastic Processes Survey Methodology Time Series This list is not intended to be exhaustive, but does include some of the more common specialities offered at Level 6. **Knowledge** The topics covered in each area of specialisation are not prescribed. The expectation is that a coherent and comprehensive set of topics are covered to deliver advanced

		• Random variables and probability distributions: univariate, multivariate, marginal, conditional. Summaries of random variables: moments, quantiles etc. • Important special distributions, e.g. binomial, geometric, Poisson, uniform, exponential, normal, multivariate normal, multinomial, t, chi-squared, F, beta, gamma.. • Expectation, variance and generating functions. • Sums of IID random variables, weak law of large numbers, central limit theorem. • Transformation of random variables, the delta method. **Skills: students should be able to:** • Carry out probabilistic calculations to answer specific questions, e.g. calculate/derive a specified quantity of interest, e.g. a probability, or a moment or a generating function of a random variable; determine whether specified events, or specified random variables, are dependent or independent. • Solve more open-ended problems where less direction is given, e.g. where it is necessary to decide which quantities are relevant ***<u>Statistical modelling and inference</u>*** **Students should be have knowledge of:**	and/or specialised techniques that build on the core knowledge. **Skills: Students should be able to:** • Understand the context in which the specialist statistical knowledge is applied. • Review and critique research papers in the area of specialism. • Solve open-ended or complex problems using the specialist techniques learnt.

		• Frequentist and Bayesian approaches: principle features of, and the differences between. • Sample and population, sampling variability. • The concept of a parametric statistical model. • Likelihood-based inference. • Other methods of estimation, e.g. moment-based methods, least squares. • Point estimation: maximum likelihood estimators in particular. • Estimation of uncertainty, e.g. interval estimates. • Observed and expected information, Cramer-Rao lower bound. • Significance testing and hypothesis testing, including likelihood ratio test. Types of error, power. • Bayesian methods (including prior and posterior distributions, Bayesian estimates and intervals for parameters and predictions, use of Monte Carlo simulation of the posterior distribution to draw inferences). • Introduction to designed experiments and surveys (including concepts such as replication, randomisation, blinding, blocking, stratification, clustering, precision,	

		sample sizing). • Understand the role of asymptotic results. • Model checking / criticism: informal and formal. • Prediction, predictive inference. • Exposure to simple non-parametric methods. Could be as simple as an empirical distribution function or simple sample summaries such as those in ` Summarising and interpreting data' above or some standard non-parametric tests. • Regression modelling. Knowledge of at least one form of regression modelling with one response and multiple explanatory variables, probably multiple linear regression with IID normal errors. • Awareness of data protection issues **Skills: students should be able to:** • Perform calculations to carry out specific inferences, e.g. write down the likelihood based on a random sample from a specific probability distribution and derive specified related quantities. • Use core inferential concepts to tackle more open-ended problems, e.g. requiring a choice of model, inference technique, generation of hypotheses to test, revision of a	

		model a result of a clear lack-of-fit.	
4	an understanding of logical arguments, identifying the assumptions made and the conclusions drawn	**Skills: students should be able to:** • Demonstrate understanding of the logical arguments underlying the theory of statistical inference, e.g. the testing of hypotheses, the interpretation of model structures and inference • Appreciate assumptions underlying statistical analyses. • Recognise the limitations of statistical analyses and the effects on the conclusions e.g. the ability to draw a conclusion about association but not necessarily about causation. • Be able to sense check conclusions.	
5	a familiarity with the notion of mathematical modelling and a reasonable level of skill in comprehending problems, formulating them mathematically and obtaining solutions by appropriate methods	**Students should be have knowledge of:** Mathematical modelling • The importance of stochastic models (as opposed to deterministic models) in describing many practical situations. **Skills: students should be able to:** • read descriptions of problems, datasets and background material and to understand how variables relate to the main questions of interest; • formulate questions to improve this understanding and/or to clarify issues; • identify the main variable(s) of interest, e.g. the response variable in a regression problem; • consider what kind of probability distribution/model is a sensible choice of working model for the	

		data; • understand how the parameters of the model relate to the questions of interest; • appreciate the main modelling assumptions. • fit a statistical model to a set of data, interpreting and reporting on the findings and any assumptions and limitations of the model.
6	an ability to communicate straightforward arguments and conclusions reasonably accurately and clearly	**Skills: students should be able to:** • present data in written and graphical form that conveys a reasoned analysis and conclusions • handle and interpret data sets, assess data relevance and integrity • answer subject-matter questions using non-technical language that addresses specific scientific questions of interest. • communicate arguments/issues to others clearly, in both appropriate written and verbal form • report on the findings of a statistical analysis through coursework, presentation etc.
7	competent use of appropriate computer technology in mathematics	**Skills: Students should be able to:** • use statistical software for design (e.g. sample sizing) • use statistical software for the management of data (e.g. checking for data errors, creating analysis data sets from raw data sets), • use statistical software to explore and analyse data. Examples of appropriate packages include: R, STATA, SPSS, SAS
8	the ability to manage their own learning and make use of	**Skills: Students should be able to:** • plan work effectively by setting appropriate targets and monitoring progress against them.

	appropriate resources.	• prioritise and organise their time using a range of techniques to deliver high quality work to challenging deadlines. • independently identify a range of sources which to improve own learning • reflect on own learning and put strategies in place to improve own learning • work effectively with others to agree realistic objectives, prioritise tasks and identify the resources and timescales needed to complete an activity or project Could be evidenced through individual or group project work