AS/A level subject criteria for use of statistics: QCA consultation draft

For first teaching from September 2011

Contents

1   Introduction

1.1   These subject criteria set out the knowledge, understanding, skills and assessment objectives common to all advanced subsidiary (AS) and advanced (A) level specifications in use of statistics. They provide the framework within which the awarding body creates the detail of the specification.

Subject criteria are intended to:

• help ensure consistent and comparable standards in the same subject across the awarding bodies

• define the relationship between the AS and A level specifications, with the AS as a subset of the A level

• ensure that the rigour of A level is maintained

• help higher education institutions and employers know what has been studied and assessed.

Any specification that contains significant elements of the subject use of statistics must be consistent with the relevant parts of these subject criteria.

2   Aims and learning outcomes

Aims

2.1   AS and A level specifications in use of statistics should encourage students to:

• study a statistics curriculum that is integrated with other areas of their study, work or interest leading to the application of statistics in these areas

• develop statistical awareness for citizenship and recognise common abuses and misuses of statistics

• develop their understanding of statistics and statistical processes in a way that promotes confidence and fosters enjoyment

• develop an awareness of the relevance of statistics to other fields of study, to the world of work and to society in general

• take increasing responsibility for their own learning and the evaluation of their own development

- be well prepared for progression to further study and to employment.

Learning outcomes

2.2   AS and A level specifications in use of statistics should enable students to:

- use the statistical problem-solving process to argue a case, recognise incorrect reasoning and communicate the outcomes effectively

- extend their range of statistical skills and techniques, and judge when it is appropriate to use them

- investigate open-ended problems

- understand the relationship between 'real world' problems and statistical models, and recognise the potential limitations of models

- understand what is involved in statistical experiments and surveys through working with real primary and secondary data

- use technology as an exploratory tool for developing statistical understanding and when exploring hypotheses and solving problems

- read, comprehend and assess the validity of arguments, reports and articles concerning applications of statistics.

3   Subject content

3.1   Statistics is a coherent discipline in its own right with an increasingly vital role to play in many aspects of modern life, including science, social sciences, business, policy and decision making. This course emphasises the development of statistical understanding that can be applied in a wide variety of other disciplines from business to psychology. The criteria build on the knowledge, understanding and skills established in GCSE mathematics and/or GCSE statistics.

Knowledge, understanding and skills

3.2   Statistical process skills

AS and A level specifications in use of statistics should require:

- use of statistics to solve real problems, explore and interpret data, including large data sets, and model situations, through the statistical problem-solving process:

- o setting up the problem

- o planning

- o collecting

- o analysing

- o drawing conclusions

- o returning to the first step if necessary

- effective communication.

These requirements should pervade the core content material set out below.

3.3   Core content material for AS and A level examinations in use of statistics is listed below. Understanding should be developed through application.

3.3.1 Data collection

	AS core content	A2 core content
(a)	Choosing and evaluating sources of data	
(b)	Obtaining secondary data Obtaining primary data using designed surveys and experiments Sampling from a parent population using appropriate methods	
(c)		Experimental design: randomisation, replication, blocking, blinding

3.3.2 Techniques and procedures

	AS core content	A2 core content
(a)	Interpretation, explanation and evaluation of data using appropriate diagrams and summary statistics	

(b)	Bivariate data Correlation coefficients	Regression
(c)	Use of set notation in the context of probability Multiplication and addition laws for probabilities	
(d)	Probability models: the Binomial distribution	Probability models: the Poisson distribution
(e)	Probability models: the Normal distribution	Normal approximations
(f)	Inference: hypothesis test for a Binomial p (using cumulative Binomial tables). Selection and use of hypothesis tests (z, t and Wilcoxon) for a single parameter Hypothesis tests based on correlation coefficients	Inference: selection and use of hypothesis tests (z, t and Wilcoxon) for two parameters (paired and unpaired)
(g)		Confidence intervals
(h)	χ^2 test for a contingency table	χ^2 test for goodness of fit

3.3.4 Investigations

The controlled assessment units must each comprise two tasks. Each task must be coherent, with a consistent theme, and, where feasible, draw on work done in other subjects. Each of the two tasks in the AS controlled assessment must be largely based on the work of a different AS unit. Each of the two tasks in the A2 controlled assessment must be largely based on the work of a different A2 unit.

	Core content for both AS and A2	
(a)	Plan	Design an investigation related to a real context that includes: • identify sources of information and check for validity • select appropriate statistical techniques • identify constraints and other relevant factors.
(b)	Carry out the Investigation	Implement and review the planning. Collect reliable quantitative and/or qualitative data. Record data, if numerical, to an appropriate degree of precision. Select methods of checking the reliability of the data.
(c)	Process and present data	Use of appropriate methods to process the data. Treatment of any anomalous data collected. Present results in a suitable format.
(d)	Evaluate the investigation	Interpret results and draw conclusions in the context of the original investigation. Evaluate methods used and, if appropriate, suggest improvements. Discuss the importance of conclusions. Produce a report suitable for the identified audience.

4   Key skills

4.1   AS and A level specifications in use of statistics should provide opportunities for developing and generating evidence for assessing relevant key skills from the list below. Where appropriate, these opportunities should be directly cross-referenced, at specified

level(s), to the key skills standards, which may be found on the QCA website (www.qca.org.uk).

- Application of number

- Communication

- Improving own learning and performance

- Information and communication technology

- Problem-solving

- Working with others

5 Assessment objectives

5.1 All candidates must be required to meet the following assessment objectives. The assessment objectives are to be weighted in all specifications as indicated in the following table.

Assessment objectives		Weighting	
		AS level	**A2 level**
AO1	Use appropriate statistical methods to process, analyse and present data, including the use of ICT.	35–45	30–40
AO2	Design an appropriate strategy to investigate a problem, and select and use appropriate methods to collect data.	30–40	30–40
AO3	Use statistical evidence to make inferences and draw conclusions. Assess the validity of statistical arguments.	20–30	25–35

6 Scheme of assessment

6.1 AS level use of statistics will comprise the two core AS statistics-based FSMQ units and the AS controlled assessment unit.

A level use of statistics will comprise six units, including the two core AS statistics-based FSMQ units, the AS controlled assessment unit, the A2 controlled assessment unit and two further A2 FSMQ statistics units.

Synoptic assessment

6.2   Synoptic assessment in use of statistics should take place across the controlled assessments and A2 units and should allow candidates to:

- demonstrate understanding of the statistical problem-solving cycle

- solve problems that require candidates to bring different aspects of statistics together

- complete statistical project(s) that exemplify the statistical problem-solving cycle and draw on their other areas of study or interests.

6.3   All AS and A level specifications in use of statistics must explicitly refer to the importance of candidates using clear, precise and appropriate language.

6.4   AS and A level specifications in use of statistics must:

- explicitly include all the material in the relevant 'Knowledge, understanding and skills' section of the criteria in compulsory core units at each of AS and A2

- set out clear rules of dependency for the available units that indicate appropriate pathways and prohibit incoherent combinations of optional units

- permit the use of technology in all units

- encourage the use of real data from both secondary and primary sources

- indicate the statistical notation that will be used – this is listed in the Appendix.

Quality of written communication

6.5   AS and A level specifications will be required to assess the candidates' quality of written communication in accordance with the guidance document produced by QCA.

7   Performance descriptions

To be added

Appendix

1 Set Notation

$\in$	is an element of
$\notin$	is not an element of
$\{x_1, x_2, \ldots\}$	the set with elements $x_1, x_2, \ldots$
$\{x: \ldots\}$	the set of all x such that …
$n(A)$	the number of elements in set A
$\varnothing$	the empty set
$\mathcal{E}$	the universal set
A'	the complement of the set A
$\mathbb{N}$	the set of natural numbers, $\{1, 2, 3, \ldots\}$
$\mathbb{Z}$	the set of integers, $\{0, \pm 1, \pm 2, \pm 3, \ldots\}$
$\mathbb{Z}^+$	the set of positive integers, $\{1, 2, 3, \ldots\}$
$\mathbb{Z}_n$	the set of integers modulo n, $\{0, 1, 2, \ldots, n-1\}$
$\mathbb{Q}$	the set of rational numbers, $\left\{\dfrac{p}{q} : p \in Z, q \in Z^+\right\}$
$\mathbb{Q}^+$	the set of positive rational numbers, $\{x \in Q : x > 0\}$
$\mathbb{Q}_0^+$	set of positive rational numbers and zero, $\{x \in Q : x \geq 0\}$
$\mathbb{R}$	the set of real numbers
$\mathbb{R}^+$	the set of positive real numbers, $\{x \in R : x > 0\}$
$\mathbb{R}_0^+$	the set of positive real numbers and zero, $\{x \in R : x \geq 0\}$
$\mathbb{C}$	the set of complex numbers
(x, y)	the ordered pair x, y
$A \times B$	the Cartesian product of sets A and B, i.e. $A \times B = \{(a, b) : a \in A, b \in B\}$
$\subseteq$	is a subset of
$\subset$	is a proper subset of
$\cup$	union
$\cap$	intersection
$[a, b]$	the closed interval $\{x \in R : a \leq x \leq b\}$

$[a, b)$	the interval $\{x \in \mathrm{R} : a \leq x < b\}$
$(a, b]$	the interval $\{x \in \mathrm{R} : a < x \leq b\}$
(a, b)	the open interval $\{x \in \mathrm{R} : a < x < b\}$
$y \, R \, x$	y is related to x by the relation R
$y \sim x$	y is equivalent to x, in the context of some equivalence relation

2 Miscellaneous Symbols

$=$	is equal to
$\neq$	is not equal to
$\equiv$	is identical to or is congruent to
$\approx$	is approximately equal to
$\cong$	is isomorphic to
$\propto$	is proportional to
$<$	is less than
$\leq, \not>$	is less than or equal to, is not greater than
$>$	is greater than
$\geq, \not<$	is greater than or equal to, is not less than
∞	infinity
$p \wedge q$	p and q
$p \vee q$	p or q (or both)
$\sim p$	not p
$p \Rightarrow q$	p implies q (if p then q)
$p \Leftarrow q$	p is implied by q (if q then p)
$p \Leftrightarrow q$	p implies and is implied by q (p is equivalent to q)
$\exists$	there exists
$\forall$	for all

3 Operations

$a + b$	a plus b
$a - b$	a minus b

$a \times b, \quad ab, \quad a.b$	a multiplied by b
$a \div b, \quad \dfrac{a}{b}$	a divided by b
$\displaystyle\sum_{i=1}^{n} a_i$	$a_1 + a_2 + \ldots + a_n$
$\displaystyle\prod_{i=1}^{n} a_i$	$a_1 \times a_2 \times \ldots \times a_n$
$\sqrt{a}$	the positive square root of a
$\lvert a \rvert$	the modulus of a
$n!$	n factorial

$$\binom{n}{r}$$

the binomial coefficient $\dfrac{n!}{r!(n-r)!}$ for $n \in \mathrm{Z}^{+}$

or $\dfrac{n(n-1)...(n-r+1)}{r!}$ for $n \in \mathrm{Q}$

or $_n\mathrm{C}_r$

4 Functions

$\mathrm{f}(x)$	the value of the function f at x
$\mathrm{f}: A \to B$	f is a function under which each element of set A has an image in set B
$\mathrm{f}: x \to y$	the function f maps the element x to the element y
f^{-1}	the inverse function of the function f
gf	the composite function of f and g which is defined by $\mathrm{gf}(x) = \mathrm{g}(\mathrm{f}(x))$ or $\mathrm{g} \circ \mathrm{f}$
$\displaystyle\lim_{x \to a} \mathrm{f}(x)$	the limit of $\mathrm{f}(x)$ as x tends to a
$\Delta x, \quad \delta x$	an increment of x
$\dfrac{\mathrm{d}y}{\mathrm{d}x}$	the derivative of y with respect to x
$\dfrac{\mathrm{d}^n y}{\mathrm{d}x^n}$	the nth derivative of y with respect to x
$\mathrm{f}'(x), \ \mathrm{f}''(x), \ \ldots, \ \mathrm{f}^{(n)}(x)$	the first, second, ..., nth derivatives of $\mathrm{f}(x)$ with respect to x

$\int y \, dx$ the indefinite integral of y with respect to x

$\int_a^b y \, dx$ the definite integral of y with respect to x between the limits $x = a$ and $x = b$

$\dfrac{\partial V}{\partial x}$ the partial derivative of V with respect to x

$\dot{x}, \ddot{x}, \ldots$ the first, second, ... derivatives of x with respect to t

5 Exponential and Logarithmic Functions

e   base of natural logarithms

e^x, $\exp x$ exponential function of x

$\log_a x$ logarithm to the base a of x

$\ln x$, $\log_e x$ natural logarithm of x

$\lg x$, $\log_{10} x$ logarithm of x to base 10

6 Trigonometric and Hyperbolic Functions

sin, cos, tan
cosec, sec, cot   }   the trigonometric functions

$\sin^{-1}$, $\cos^{-1}$, $\tan^{-1}$
cosec^{-1}, $\sec^{-1}$, $\cot^{-1}$,
arcsin, acrcos,
arctan, arccosec,
arcsec, arccot   }   the inverse trigonometric functions

sinh, cosh, tanh
cosech, sech, coth   }   the hyperbolic functions

$\sinh^{-1}$, $\cosh^{-1}$, $\tanh^{-1}$
cosech^{-1}, sech^{-1},
$\coth^{-1}$ }   the inverse hyperbolic functions

7 Complex Numbers

i   square root of -1

z a complex number, $z = x + i\,y = r(\cos\theta + i\sin\theta)$

$\operatorname{Re} z$ the real part of z, $\operatorname{Re} z = x$

$\operatorname{Im} z$ the imaginary part of z, $\operatorname{Im} z = y$

$|z|$ the modulus of z, $|z| = \sqrt{x^2 + y^2}$

$\arg z$	the argument of z, $\arg z = \theta$, $-\pi < \theta \le \pi$
$z*$	the complex conjugate of z, $x - \mathrm{i}\,y$

8 Matrices

$\mathbf{M}$	a matrix $\mathbf{M}$
$\mathbf{M}^{-1}$	the inverse of the matrix $\mathbf{M}$
$\mathbf{M}^{\mathrm{T}}$	the transpose of the matrix $\mathbf{M}$
$\det \mathbf{M}$ or $|\mathbf{M}|$	the determinant of the square matrix $\mathbf{M}$

9 Vectors

$\mathbf{a}$	the vector $\mathbf{a}$
$\overrightarrow{AB}$	the vector represented in magnitude and direction by the directed line segment AB
$\hat{\mathbf{a}}$	a unit vector in the direction of $\mathbf{a}$
$\mathbf{i}$, $\mathbf{j}$, $\mathbf{k}$	unit vectors in the directions of the Cartesian coordinate axes
$\lvert \mathbf{a} \rvert$, a	the magnitude of $\mathbf{a}$
$\lvert \overrightarrow{AB} \rvert$, AB	the magnitude of $\overrightarrow{AB}$
$\mathbf{a}.\mathbf{b}$	the scalar product of $\mathbf{a}$ and $\mathbf{b}$
$\mathbf{a} \times \mathbf{b}$	the vector product of $\mathbf{a}$ and $\mathbf{b}$

10 Probability and Statistics

A, B, C, etc.	events
$A \cup B$	union of the events A and B
$A \cap B$	intersection of the events A and B
$\mathrm{P}(A)$	probability of the event A
A'	complement of the event A
$\mathrm{P}(A \mid B)$	probability of the event A conditional on the event B
X, Y, R, etc.	random variables
x, y, r, etc.	values of the random variables X, Y, R etc
x_1, x_2, $\ldots$	observations

$f_1, f_2, \ldots$	frequencies with which the observations $x_1, x_2, \ldots$ occur
p(x)	probability function $P(X = x)$ of the discrete random variable X
$p_1, p_2, \ldots$	probabilities of the values $x_1, x_2, \ldots$ of the discrete random variable X
f(x), g(x), $\ldots$	the value of the probability density function of a continuous random variable X
F(x), G(x), $\ldots$	the value of the (cumulative) distribution function $P(X \leqslant x)$ of a continuous random variable X
E(X)	expectation of the random variable X
E(g(X))	expectation of g(X)
Var(X)	variance of the random variable X
G(t)	probability generating function for a random variable which takes the values 0, 1, 2, $\ldots$
B(n, p)	binomial distribution with parameters n and p
N(μ, σ^2)	normal distribution with mean μ and variance σ^2
μ	population mean
σ^2	population variance
σ	population standard deviation
$\bar{x}$, m	sample mean
s^2, $\hat{\sigma}^2$	unbiased estimate of population variance from a sample, $s^2 = \dfrac{1}{n-1}\sum(x_i - \bar{x})^2$
ϕ	probability density function of the standardised normal variable with distribution N$(0, 1)$
Φ	corresponding cumulative distribution function
ρ	product moment correlation coefficient for a population
r	product moment correlation coefficient for a sample
Cov(X, Y)	covariance of X and Y

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