# Teacher Delivery Guide Statistics: 2.05 Statistical Hypothesis Testing

| **OCR**  **Ref.** | **Subject Content** | **Stage 1 learners should…** | **Stage 2 learners additionally should…** | **DfE Ref.** |
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| **2.05** **Statistical Hypothesis Testing** | | | | |
| 2.05a | The language of hypothesis testing | a) Understand and be able to use the language of statistical hypothesis testing, developed through a binomial model: null hypothesis, alternative hypothesis, significance level, test statistic, 1-tail test, 2-tail test, critical value, critical region, acceptance region, *p*-value.  *Hypotheses should be stated in terms of parameter values (where relevant) and the meanings of symbols should be stated. For example,*  *“**,, whereis the population proportion in favour of the resolution”.*  *Conclusions should be stated in such a way as to reflect the fact that they are not certain. For example,*  *"There is evidence at the 5% level to reject . It is likely that the mean mass is less than 500 g."*  *"There is no evidence at the 2% level to reject . There is no reason to suppose that the mean journey time has changed."*  *Some examples of incorrect conclusion are as follows:*  *"is rejected. Waiting times have increased."*  *"Accept . Plants in this area have the same height as plants in other areas."* |  | MO1 |
| 2.05b  2.05c | Hypothesis test for the proportion in a binomial distribution | b) Be able to conduct a statistical hypothesis test for the proportion in the binomial distribution and interpret the results in context.  c) Understand that a sample is being used to make an inference about the population and appreciate that the significance level is the probability of incorrectly rejecting the null hypothesis.  *Learners should be able to use a calculator to find critical values.*  *Includes understanding that, where the significance level of a test is specified, the probability of the test statistic being in the rejection region will always be less than or equal to this level.*  [*The use of normal approximation is excluded*.] |  | MO2 |
| 2.05d  2.05e | Hypothesis test for the mean of a normal distribution |  | d) Recognise that a sample mean,, can be regarded as a random variable.  *Learners should know and be able to use the result that if  then .*  [*The proof is excluded.*]  e) Be able to conduct a statistical hypothesis test for the mean of a normal distribution with known, given or assumed variance and interpret the results in context.  *Learners should be able to use a calculator to find critical values, but standard tables of the percentage points will be provided in the assessment.*  [*Test for the mean of a non-normal distribution is excluded.*]  [*Estimation of population parameters from a sample is excluded*] | MO3 |
| 2.05f  2.05g | Hypothesis test using Pearson's correlation coefficient |  | f) Understand Pearson's product-moment correlation coefficient as a measure of how close data points lie to a straight line.  g) Use and be able to interpret Pearson's product-moment correlation coefficient in hypothesis tests, using either a given critical value or a *p-*value and a table of critical values.  *When using Pearson's coefficient in an hypothesis test, the data may be assumed to come from a bivariate normal distribution.*  *A table of critical values of Pearson's coefficient will be provided.*  [*Calculation of correlation coefficients is excluded.*] | MO1 |

# Thinking Conceptually

### General approaches

Prior to working with on statistical hypothesis testing, it would be beneficial if learners had a firm understanding of the different probability distributions. This should be a core component of the initial approach.

It is useful to make links with other subject areas; learners may have experience of using different tests to make inferences in these other subject areas.

It may also be useful to use graphs of the distributions as this may help learners understand some of the key concepts. Reference to interactive resources may help visualise the area of interest on the graph of the distribution.

It is important to emphasise that learners are using sample evidence to make a choice between a null and alternative hypothesis and it must be stressed that the null hypothesis stands unless the sample evidence clearly supports the alternative hypothesis. Leaners must have experience of lots of different examples to ensure that they understand the language needed to make the conclusions based on their calculations.

Learners must be encouraged to make a final and most important step to interpret, in the context of the problem, what the hypothesis test results suggest.

### Common misconceptions or difficulties learners may have

There are a number of misconceptions that learners may hold, or develop regarding statistical hypothesis testing and care should be taken to avoid these becoming ingrained in learners.

One source of confusion for learners may be in the language used to interpret and create the hypotheses. It is imperative that learners are clear in how these are constructed.

It would be useful to spend some time with examples of hypotheses and the final result for learners to then make their own interpretations. This would highlight misconceptions held and allow for discussion of the lack of absolute certainty with hypothesis testing.

It is important to highlight to learners the difference between significant and non-significant outcomes, it is important that they understand that a non-significant outcome means that the data does not conclusively show that the null hypothesis is false rather than being able to state definitely that the null hypothesis is true.

Learners should be encouraged to pay attention to the context of the data; learners often confuse their calculated answer with the final result, rather than referring back to the initial context given to give the result meaning. Teachers should encourage learners to check the reasonableness of their results within the context, and the context should remain at the centre of any learning.

It is often useful to present incorrect conclusions to the hypothesis to learners to encourage them to highlight and discuss the errors.

### Conceptual links to other areas of the specification

There is a lot of problem solving involved in statistical hypothesis testing, learners need to be able to extract the information they need from the questions and data given in order to solve these.

Learners must have a clear understanding of the basics of probability distributions and how they can be applied to perform statistical hypothesis testing.

Teachers should ensure that time is spent on longer questions so that learners have the opportunity to extract the data they need and ignore extraneous information.

The use of the formulae is expected and it aids understanding of the concepts.

It is strongly suggested that teachers provide as many real life uses of statistical hypothesis testing from other topic areas and different real world examples to emphasise the relevance of this area of mathematics to learners.

# Thinking Contextually

Learners need to see the relevance of their learning to real life events; they often struggle to understand the concepts in mathematics unless they can see the relevance.

The very nature of statistical hypothesis testing is contextual and many different areas can be used to enhance learners understanding, these can be as basic as a simple test to the need to collect data to test their own hypotheses. This can be a very useful way of checking their full understanding of the concepts covered in statistical hypothesis testing.

Learners will be more successful if they can see how the concepts can be used outside of the classroom. If scenarios are chosen that are meaningful to the learners will help to maintain their interest and motivation. This will also help learners to focus on the mathematics and lead to independent thinking and greater retention of the skills.

# Past paper examples

[2018 H230/01](https://www.ocr.org.uk/Images/535662-question-paper-pure-mathematics-and-statistics.pdf) Q 12: Routine 7 mark binomial hypothesis test.

[2018 H240/02](https://www.ocr.org.uk/Images/535611-question-paper-pure-mathematics-and-statistics.pdf) Q 10: This question starts with an assessment of sampling and the final part is a routine 7 mark Normal hypothesis test in the context of the sampling context.

# Resources

| **Title** | **Organisation** | **Description** | **Ref** |
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| [A ducks story- introducing the idea of testing (statistical) hypotheses](http://serc.carleton.edu/sp/cause/conjecture/examples/18163.html) | CAUSE | A simple story and a worksheet with questions to guide the students. The teaching material is intended to be flexible depending on the time available. Instructors can choose to do just the interactive lecture type, interactive lecture + activity, or even add the optional material. | 2.05a, 2.05b and 2.05c |
| [Introducing Hypothesis testing](http://www.wiley.com/college/sc/lock/resources/Lock-Instructors_Manual_sample.pdf) | Wiley | A full set of class teacher’s notes and lesson plans on hypothesis testing that can be adapted.  All solutions to the examples are given. This goes on to confidence levels. | 2.05a, 2.05b, 2.05c, 2.05d and 2.05e |
| [Test for a Binomial Proportion](https://www.examsolutions.net/tutorials/test-binomial-proportion/?board=OCR&module=s2&topic=1876) | Exam Solutions | In this video, hypothesis testing for the binomial distribution is introduced along with notation used, one tail tests and significance levels. The conditions that are needed to consider in order to accept or reject the null hypothesis are also covered. | 2.05b |
| [S2 - Hypothesis Testing - The Population Proportion p, using a Binomial Distribution - Example 3](https://www.youtube.com/watch?v=cTHO4bxOPAQ) | MathsAcademyUK3 | Video demonstration of Hypothesis Testing - The Population Proportion p, using a Binomial Distribution - 2 tailed test. Goes into splitting the Significance Level. And using the Critical Values Method. | 2.05b |
| [Hypothesis testing using the binomial distribution](https://www.geogebra.org/m/rTGEWmn7) | Geogebra | Interactive resource representing Hypothesis test using the binomial distribution. | 2.05b and 2.05c |
| [Testing Hypotheses (Means, Proportions, and Standard Deviations)](https://education.ti.com/en/activity/detail?id=0ADE3A000C4447C9A4E6DD38FA01E3A3) | Texas Instruments | A full lesson dedicated to testing hypothesis using GDC, this includes all the resources needed and teacher notes. Although this resource focuses upon TI graphical calculator, activity could be adapted to alternate GDC or using a combination of graphing software and scientific calculators. | 2.05d and 2.05e |
| [Intro to Hypothesis Testing in Statistics - Hypothesis Testing Statistics Problems & Examples](https://www.youtube.com/watch?v=VK-rnA3-41c) | mathtutordvd | Video presentation of using normal distribution model. Part 1. Time spent define Null and Alternate Hypothesis (note this is an American source so Ho and Ha notation used). | 2.05a and 2.05e |
| [Null and Alternate Hypothesis - Statistical Hypothesis Testing - Statistics Course](https://www.youtube.com/watch?v=_Qlxt0HmuOo) | mathtutordvd | Video presentation of using normal distribution model. Part 2. Focuses on definition of Null and Alternate Hypothesis in greater detail(note this is an American source so Ho and Ha notation used). | 2.05a and 2.05e |
| [S2 - Hypothesis Testing - The Mean, µ using a Normal Distribution - Example 1](https://www.youtube.com/watch?v=9PkYISeHHI4&index=1&list=PL6KJ8qhTyY-GBB1BMc0ZmLkwqGduiCbTp) | MathsAcademyUK3 | Video demonstration of testing the population mean, µ of a continuous variable using the Normal Distribution. | 2.05e |
| [S2 - Hypothesis Testing - The Mean, µ using a Normal Distribution - Example 2](https://www.youtube.com/watch?v=f8J5nIZgrYY&index=2&list=PL6KJ8qhTyY-GBB1BMc0ZmLkwqGduiCbTp) | MathsAcademyUK3 | Video demonstration of testing the population mean, µ of a continuous variable using the Normal Distribution. | 2.05e |
| [Hypothesis Testing - Statistics](https://www.youtube.com/watch?v=0XXT3bIY_pw) | Math Meeting | Video example of a 2 tail hypothesis test undertaken on a data set modelled as a normal distribution. | 2.05e |
| [Hypothesis Testing Example 1 with CASIO fx 991 ES](https://www.youtube.com/watch?v=_xhJl6vgWj8) | Wei Ching Quek | Examples of statistical hypothesis tests for data modelled as a normal distribution using Casio fx 991 ES. Can be adapted slightly for alternate calculator models. | 2.05e |
| [Hypothesis Tests of Mean with Changing Sample Mean](https://www.geogebra.org/m/ZCxjHMj6#material/H7kgsXR7) | Geogebra | Interactive demonstration. | 2.05e |
| [Why Correlations?](http://www.cpalms.org/Public/PreviewResourceLesson/Preview/53889) | CPALMS | A full lesson plan on using the correlation coefficient. Worked examples and assessments are included. | 2.05f |
| [Hypothesis testing with Pearson’s](https://www.youtube.com/watch?v=dkrtZ4pbygg) | ProfNoria | A video using an example to show how to use Pearson’s for hypothesis testing. | 2.05f and 2.05g |
| [Hypothesis testing with Pearson’s](https://www.youtube.com/watch?v=rR-jptLvhFw) r | statslectures | A video with a situation and full worked example including calculations for Pearson’s. | 2.05f and 2.05g |

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