# Lesson Plan

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| **Title:** Hubble Flow | **Date:** |
| **Learning objective/s:**   * To develop an understanding of redshift and Universal expansion. * To investigate the correlation between redshift and recession velocity for a number of galaxies. * To familiarise the students with Excel and advance their skills. | **Curriculum links:** |
| **Learning outcomes**  **I want evidence students can:**   * Manipulate simple equations to discover unknown values. * Investigate scientific data in the form of graphs. * Draw appropriate conclusions from their results. * Discuss what implications their findings may have. | |
| **Notes on students who have exceeded the performance expected:** | **Action to be taken:** |
| **Notes on students who did not achieve the performance expected:** | **Action to be taken:** |
| **Essential vocabulary:**  Hubble flow, redshift, H-alpha, galaxy, recession velocity, Universal expansion, Hubble’s constant | **Possible misconceptions:** |
| **Cross curricular links:**  Physics, ICT, Mathematics. | |
| **Teacher resources including ICT:**   * Introductory Presentation * EXCEL Hubble flow spreadsheet | **Student’s resources including ICT:**   * Access to a computer * EXCEL Hubble flow spreadsheet * Equation sheet |

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| **Organisation and class management:** | **Teaching points:** | **Notes:** |
| **Introduction:**  Whole class discussion | * Introduce the task and the learning objectives. * Use the PowerPoint presentation to discuss the background behind the Hubble Flow. * Discuss the concept of redshift and what effects the Hubble Flow could have on it in the context of galaxy separation. * Discuss the method behind approximating Hubble’s constant; the rate of expansion of the Universe. |  |
| **Main phase:**  Independent work | * Students work independently or possibly in groups of 2 (the activity is good practice for using some of the main features of Excel so students are encouraged to work independently to practice these skills). They are also provided with the spreadsheets and PowerPoint equations. * Students should use the data and equations given to them to work out the unknown variables in the Excel spreadsheet. * Using the completed data table, and the graph that has been created (Key Stage 6 students must create this graph using Excel) students should plot a line of best fit to the data points (students must also check ‘display equation on chart’ in format options to see the trendline equation. * Students should be asked (with reference to the PowerPoint) what the gradient of the line of best fit resembles. Which is in this case Hubble’s constant. | The equations can be inserted into an Excel ‘cell’ and dragged down for each galaxy, there is no need to use a calculator and do individual calculations although students can do so if they wish. To do this, click on a cell and, starting with ‘=’, manually **type in the equation** using manually selected variables or by clicking on the corresponding cells. When you drag the cell down using the bottom-right corner square it will automatically assign the variable for the following cell. To stop this happening when using constants, insert a ‘$’ before both letter and number of the cell the constant is situated in. For example: =$D$25\*F5 |
| **Plenary/Conclusion:**  Whole class discussion | * Discuss the class results – everyone’s should be the same given that they have the same data. What was the closest result of Hubble’s constant to the accepted value? * How accurate do you think our value is? Why? * Are there any ways in which we could improve our measurements to gain a better result? What were the possible errors involved with the data? |  |