Y9 Lesson 2

Overview:
This lesson introduces the idea of how we can model the atmosphere by first examining 3 dimensional co-ordinate systems, then investigating how temperature can vary with time by a cooling model.

Lesson Plan:
* = individual whiteboard activity,
** = recommended for advanced sets, alternatively just state $\mathbf{d^2=x^2+y^2+z^2}$

1. Start the lesson by displaying the first minute of a video such as https://www.youtube.com/watch?v=DFcuZka0LLA which displays the global circulation pattern of clouds for 2011. Instruct students that they will be learning some of the key examples climate scientists use in order to model the atmosphere and predict the weather.
   1.1. Start by discussing the observations and forecasts for the past few days, have they been accurate? Is a particular type of weather dominating? Is the temperature above or below average?
   1.2. The www.mathmetics.org/cForecast%20Verification/ section of the website has an overview of the weather observations over the UK for the past week.

2. Using a whiteboard sketch a horizontal x axis and vertical y axis.
   2.1. Ensure students know how to plot a point (x,y) on this graph:
   2.2. *Ask students to sketch these axis and plot the points A at (1,1), B at (5,1) and C at (5,4) and connect these to form a triangle ABC.
   2.3. Ask students if they can find the distance, between points A and B & B and C. Solution: 4 & 3.
   2.4. Now ask students if they recognise what type of triangle ABC is (right-angled) and ask them what property (Pythagoras' theorem) can be used to calculate the distance between A and C.
   2.5. If necessary repeat this activity using another Pythagorean triple such at 6, 8, 10 or 5, 12, 13.

3. **Worksheet:** Ask students to complete questions 1 and 2 on the worksheet, these will require the use of basic trigonometry (SOHCAHTOA) which can be omitted if necessary.

4. **Now, ask students to suggest how we could find the distance between two points if there is a North-South, East-West and elevation difference.
   4.1. Sketch a cuboid on the board representing this situation, labelling each vertex with a letter.
   4.2. Firstly consider the diagonal distance between two points on the base of the cuboid, show how this can then be considered as one side of a triangle which can be used to calculate the diagonal distance between two opposite points on the cuboid.
   4.3. This involves demonstrating that $\mathbf{d^2=x^2+y^2+z^2}$ where **d** is the distance between two points which have a change in the x-axis of **x**, a change in the y-axis of **y** and a change in the z-axis of **z**.

5. Explain to students that weather forecasts are dependent on solving equations at different locations on a 3 dimensional grid which covers the Earth's surface.
   5.1. As demonstrated in question 1, understanding the motion of clouds and across the UK is crucial to predicting rainfall.
   5.2. Now, students will learn how we can predict how temperature changes with time.

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6. Introduce the idea of the sun warming the air in the atmosphere during daylight hours, which then cools during the night as there is no source of warming. Suggest how we could think of a simpler example such as the water in a bath tub cooling after it has stopped filling.
   6.1. *Ask students to sketch a graph of how they think water cools over time in a bathtub. (Temperature on vertical axis against time on horizontal axis)
      6.1.1. Solution: should look something like an inverse decay **y = A + B/(x+C)**
   6.2. **Worksheet:** Let students work through questions 3 on the worksheet.
   6.3. Use www.mathmetics.org/cForecast%20Verification/ section of the website to demonstrate how we can vary these parameter to suitably fit the model given observations.

7. Explain to students how weather forecasters solve equations such as these in order to predict the air temperature for the next morning.
   7.1. Similarly forecasters can use a warming model by using negative values of **B**, demonstrate the effects of this using the www.mathmetics.org/cForecast%20Verification/ section of the website.
   7.2. Explain how producing an accurate forecast for the UK requires 1000s of observations to determine the constants in these equations at each point on a latitude-longitude grid covering the country.

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