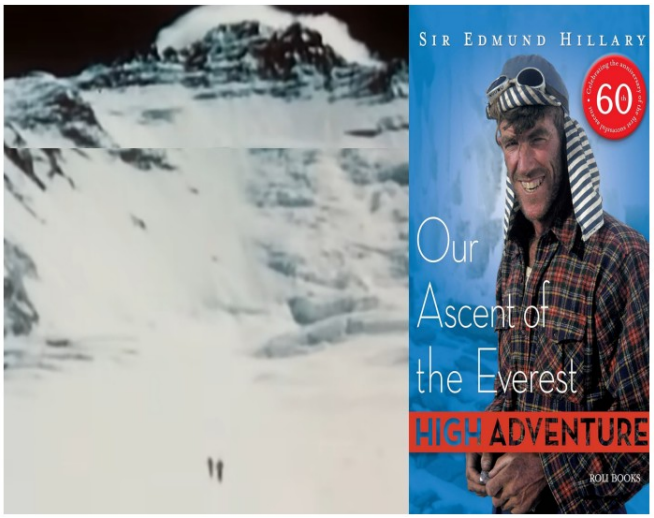
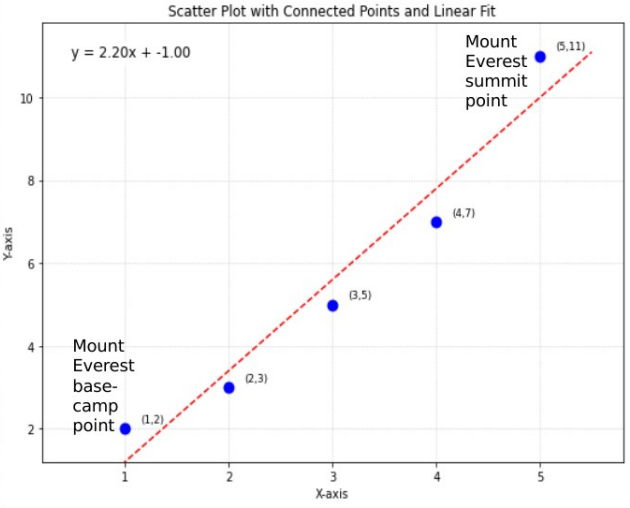
#Section 2.1: Understanding Mathematical Concepts in Physics And Reality

2.1.1 Role of mathematics in describing physical space

Mathematics is a powerful tool that helps us understand and describe the physical space around us. It provides methods to measure, analyze, and predict how things move and interact in our world. This can be seen through formulas like distance equals speed times time or area of a shape. These equations help visualize real-world situations such as an object's motion or the size of a surface. [1] [2]

Understanding Dimensions: Mathematics also helps us comprehend dimensions, including length, width, and height in spaces described by Cartesian coordinates. This can be thought of like a grid system where every point has x, y, and z coordinates, similar to how locations are marked on maps. Scientists use this method for accurate location measurements or calculating the distance light travels over time. **Abstract Mathematical Objects:** In space, mathematical objects such as points, lines, and planes represent abstract concepts that help model real-world situations. These concepts aren't just numbers—they help us model things like forces acting on objects, paths of moving cars, or even atomic structures. These abstract mathematical objects provide a framework for understanding complex ideas in our world. **Everyday Applications:** In everyday life, mathematics is omnipresent. From calculating the area needed to paint a room to determining travel time between cities using speed and distance, math plays an essential role in making sense of reality through patterns and relationships. By simplifying complex ideas into formulas and visualizing them spatially, we can better understand our surroundings with precision and clarity.

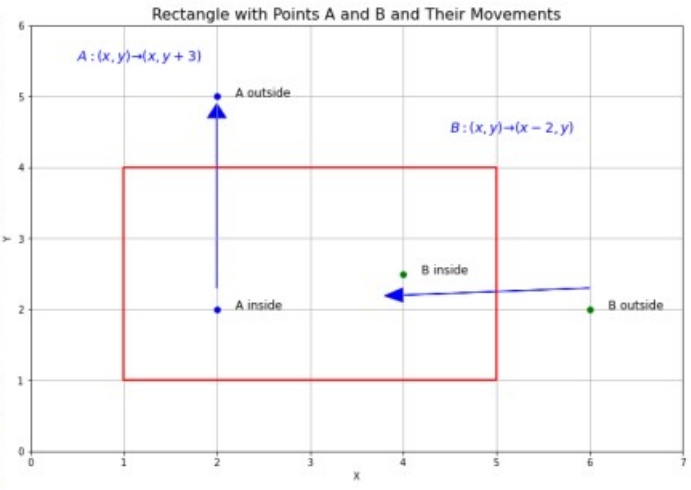




2.1.1 Role of mathematics in describing physical space – Figure 2.1.1 A, B: **A) Real World:** Sir Edmund Hillary and Tenzing Norgay's 'High Adventure' (title of book) going from base camp to higher locations, and finally reaching the summit of Mount Everest, the highest mountain on Earth. **B) Mathematics World:** Each location climbed from base camp to top of Mount Everest can be represented as a point and connecting the points with a line can be used to represent a path, which in turn can be modeled or described by

1 Mike X. Cohen, *Linear Algebra: Theory, Intuition, Code* (sincXpress, 2021), p. 14.
2 Gareth Williams, *Linear Algebra with Applications*, The Jones & Bartlett Learning Series in Mathematics, 8. ed (Jones & Bartlett Learning, 2014), p. 363.

an equation. **The graph consists of a grid with two arrows:** the x-axis going to the right and the y-axis going up. Blue dots represent individual data points, each located at specific positions on the grid (e.g., (3,5)). The red dashed line is a line of best fit that passes close to all blue dots, showing their general trend. A small equation in the top-left corner describes the slope and position of this line, allowing predictions for new points based on existing data. Light dotted lines help read exact positions on the graph. Here's a more detailed explanation, imagine you have a sheet of graph paper with two arrows: one going to the right (the bottom edge) and one going up (the left edge). The bottom arrow is called the x-axis and the left arrow is called the y-axis. **The Points (The Dots):** The blue dots represent individual pieces of information or actual data points. Each dot sits at a specific location on the graph. For example, one dot might be at the spot that is '3 steps to the right' and '5 steps up.' The small text labels near each dot tell you its exact address on the graph, like (3,5). This address means '3 steps right, 5 steps up.' **The Line (The Prediction):** The red dashed line is a line of best fit or a smart guess at the general rule that those points follow. It is drawn so that it passes as close as possible to all the blue dots. Instead of connecting the dots in a zigzag, the line shows you the general direction or trend of the points. If the dots were all higher on the right side, the line would tilt upwards. **The Equation (The Rule):** The equation shown on the plot (usually in the top-left corner) is a mathematical rule that describes the exact slope and position of that red line. For a simple straight line, it looks something like y = 2.1x + 0.3. This formula allows you to predict where a new, unseen point would probably be, based on the trend shown by the existing points. **The Grid:** The light dotted lines across the entire plot area help you read the exact position of any dot or line by simply counting the squares. The grid and labels are tools to help you read the graph precisely. **Citation:** 1)'The Race To Everest' by BBC | Documentary on Sir Edmund Hillary and Tenzing Norgay's historic ascent of Everest in 1953. https://www.bbc.co.uk/programmes/b008wfgr 2) Sir Edmund Hillary's book 'High Adventure' https://www.britannica.com/biography/Edmund-Hillary#ref111313 3) "Everest" – 12 November 2012 by Public Service Broadcasting is a British rock band https://soundcloud.com/psbhq/everest 4) Figures drawn using Matplotlib [3] on Python.



3 'Matplotlib — Visualization with Python', n.d. <https://matplotlib.org/> [accessed 25 April 2026].

2.1.1 Role of mathematics in describing physical space – Figure 2.1.1 C, D: Diagram illustrating key mathematical concepts related to space and movement. This diagram is a simplified example of how mathematics describes physical space—using numbers (coordinates) and shapes (lines, rectangles). The coordinates and formulas help us understand movement (distance), size (area), and position (coordinates). It's a practical tool for visualizing abstract mathematical ideas. **C) Real World:** Teams (Coaches, Players and Staff) go in and out of the field in a line to shake hands. **D) Mathematics World:** Cricket field can be represented with a rectangle shape. Teams (say 50 individuals in each team) can be represented as points 'A' and 'B' moving inside and outside of the field (instead of representing each individual, just representing the teams reduces number of variables from say 50 to 2, this is called dimensionality reduction). This movement can be modeled with linear equations. Arrows in blue illustrate the movement of the points: One arrow shows Point A moving from its inside position to outside the rectangle. The other arrow shows Point B moving from outside the rectangle to inside. Briefly, the plot depicts a rectangle with four vertices, forming a closed shape on a coordinate plane. Inside and outside points labeled as A and B are marked with blue and green dots, respectively. **Point A has two positions:** Inside the rectangle at coordinates (2, 2) and Outside the rectangle at (2, 5). An arrow originating slightly inside point A's initial position points upward toward the outside position, illustrating the movement of A from inside to outside the rectangle. **Point B has two positions**: Outside the rectangle at (6, 2) and Inside the rectangle at (4, 2.5). An arrow originating from outside point B points inward toward its inside position, showing B moving from outside to inside the rectangle. **On the plot, the rectangle is outlined in red.** Labels identify the points and their positions relative to the rectangle. The arrows clearly indicate the direction of movement for each point. **Additionally, equations describing the movement are placed on the sides of the plot for clarity, specifying how A and B move**: A moves vertically upward by 3 units and B moves horizontally left by 2 units. The plot provides a visual understanding of how the points move relative to the rectangle, highlighting their initial and final positions and the nature of their movement. **Citation:** 1) Cricket screenshot from Hampshire Men v Somerset | Rothesay County Championship Day Four, English County Cricket, English Cricket Board (ECB), 20th April 2026 https://somersetcountycc.co.uk and https://en.wikipedia.org/wiki/Hampshire_County_Cricket_Club 2) Figures drawn using Matplotlib [4] on Python.

4 'Matplotlib — Visualization with Python', n.d. <https://matplotlib.org/> [accessed 25 April 2026].