6 Graphs

This unit will help you to plot graphs and use them to describe relationships between different variables.

In the exam, you will be asked to tackle questions such as the one below.

**Exam-style question**

1. A student investigates how the current through a resistor changes as the potential difference across it is changed. The results are shown in the table below.

<table>
<thead>
<tr>
<th>potential difference (V)</th>
<th>current (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0.01</td>
</tr>
<tr>
<td>2</td>
<td>0.02</td>
</tr>
<tr>
<td>3</td>
<td>0.03</td>
</tr>
<tr>
<td>4</td>
<td>0.04</td>
</tr>
<tr>
<td>5</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Draw a graph of these results on the grid.

You will already have done some work on graphs. Before starting the **skills boosts**, rate your confidence in each area. Colour in the bars.

1. How do I plot a graph?
2. How do I draw lines of best fit?
3. How do I describe the relationship shown by a graph?
Graphs are used to represent data and show relationships between variables. You are expected to be able to draw graphs accurately and to make conclusions from them. This table shows the graph types used in physics.

<table>
<thead>
<tr>
<th>Bar chart</th>
<th>Pie chart</th>
<th>Line graph</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Bar chart" /></td>
<td><img src="image" alt="Pie chart" /></td>
<td><img src="image" alt="Line graph" /></td>
</tr>
</tbody>
</table>

The most commonly used graph in physics is the line graph. It shows the relationship between two continuous variables. A continuous variable is one that can have any value and can be measured, e.g. time.

1. List six other continuous variables used in physics.

The independent variable (the variable that has been controlled and changed in the experiment) goes on the horizontal axis (↔). The dependent variable (the variable that is then measured) goes on the vertical axis (↕).

2. Label the axes for the graphs below. The first one has been done for you.

   a. A graph showing how the speed (m/s) of a vehicle changes over time (s).
   b. A graph showing how the pressure (Pa) of a gas changes with temperature (K).
   c. A graph showing how the angle of refraction (°) changes as the angle of incidence(°) is increased.

   ![Graph example](image)

   Remember to add the units.

For questions where you are asked to draw a graph, you will usually get:
- 1 mark for plotting the points correctly
- 1 mark for labelling and using an accurate scale
- 1 mark for a straight or curved line of best fit.

If you are given a graph to interpret, you could get marks for:
- describing the relationship between the variables
- reading values from the graph
- identifying anomalous points that don’t fit the pattern.
How do I plot a graph?

To ‘plot’ a graph means to produce a graph by marking points accurately on a grid and then drawing a line of best fit through these points. You must include a suitable scale and appropriately labelled axes if these are not provided in the question.

Step 1: Choose a scale:
- Look at the range of values you need to plot, i.e. the lowest and highest values.
- Make sure your graph fills at least half the height and width of the grid given.
- It is easiest to go up in intervals of 1, 2, 5 or 10.

The diagram below shows the best way to fit a range up to 80 s on the grid. It is usual to make your scale slightly longer than needed so this scale goes up to 100 s.

1. a. You have a set of values from 0 s to 20 s. Add a suitable scale to the axis below.

2. b. You have a set of values from 0 s to 5 s. Add a suitable scale to the axis below.

Step 2: Plot the data points:
- Plot each point as a small neat cross, using a sharp pencil.
- Your points should be accurate to +/- half a small square.
- Find the value on the x-axis (the horizontal axis) first, and then go up to the value on the y-axis.

2. Look at the diagram on the right. This shows how to plot the point (2, 27).

3. a. What value does each small square have on the horizontal scale?

4. b. What value does each small square have on the vertical scale?

4. Now plot these points on the grid.
   - (1, 22)
   - (2.8, 6)
   - (3.5, 33)
How do I draw lines of best fit?

Lines of best fit can be straight or curved. Some will pass through all of the points, while others will have an even spread of points on either side. There is usually no right or wrong line, but the guidelines below will help you to draw the best one you can.

To draw a line of best fit:
• Draw a single line in pencil.
• For straight lines, use a transparent ruler so you can see all the points.
• Avoid ‘tram lines’ or double lines.
• Only use dot-to-dot lines for distance/time and velocity/time graphs.

1 Look at the examples below and draw a line or curve of best fit on each graph.

Can you draw a straight line that passes through all the points? If not, can you draw a curve that passes through all the points? Can you draw a line or curve that passes through most of the points?

If your line of best fit has a straight section and a curved section, use a ruler to draw the straight section.
To describe the relationship shown by a graph, state how the dependent variable (vertical scale) changes as the independent variable (horizontal scale) changes. This could include stating how the steepness of the line or curve changes and what this means.

This table shows the different types of graph.

<table>
<thead>
<tr>
<th>Graph Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Straight line graphs</strong></td>
<td>show a linear relationship. If a graph has a straight line through the origin, this shows that the two quantities plotted are directly proportional. In this graph, current increases as potential difference increases. The graph has a positive gradient. The gradient is constant (a straight line). This shows that the current increases at a constant rate.</td>
</tr>
<tr>
<td><strong>Curved graph lines</strong></td>
<td>Some graph lines are curved. In this graph, potential difference increases as current increases (as before). However, the gradient is not constant: the line gradually becomes less steep and starts to level off. This shows that the current is increasing at a slower rate.</td>
</tr>
<tr>
<td><strong>Inverse relationship graph</strong></td>
<td>This graph shows an inverse relationship. As the temperature increases, the resistance decreases. The line is steeper at lower temperatures. This shows that the resistance decreases quickly at first. At higher temperatures, the graph line is less steep. This shows that the resistance decreases more slowly as the temperature continues to increase.</td>
</tr>
</tbody>
</table>

Lines of best fit can be used to:
- show anomalies: any points that are a long way from the line may be due to experimental error
- make predictions: you can predict an unmeasured value by reading it off the line.

1. Describe the relationship shown by each of these graphs.
   a. A graph to show how the velocity of a moving object changes with time.

   If possible, give values where the graph changes.
   
   b. A graph to show how current changes as potential difference changes for a diode.

   If possible, give values where the graph changes.
Sample response

Use these example student responses to improve the way you draw graphs. Look at the variables, scales and units. Check if points are correctly plotted and whether any lines drawn should be straight or curved.

1. Look at each graph and identify the errors the student has made. 🍒

Highlight the errors on each graph to help you remember how to draw graphs correctly.

This graph is based on the data in the table below.

Identify the errors in the graph.

<table>
<thead>
<tr>
<th>Angle of incidence (°)</th>
<th>0</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angle of reflection (°)</td>
<td>0</td>
<td>10</td>
<td>20</td>
<td>30</td>
<td>40</td>
<td>50</td>
</tr>
</tbody>
</table>

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158  Physics Unit 6 Graphs
A student investigates how the current through a resistor changes as the potential difference across it is changed. The results are shown in the table below.

<table>
<thead>
<tr>
<th>potential difference (V)</th>
<th>current (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
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</tbody>
</table>

1. **Draw a graph of these results on the grid.** (3 marks)

1a. Which variable goes on the horizontal axis?

1b. Which variable goes on the vertical axis?

1c. Now draw the graph.

• Look at the maximum and minimum readings for potential difference and current.
• Choose suitable scales for the axes and label the axes, including the units.
• Use a pencil and ruler to draw the axes.
• Plot the points and draw a line of best fit. Do you need a ruler to do this?

In an exam, you will not be asked to describe the relationship shown by a graph you have plotted. However, you will have to do this for practical work.

2. **Describe the relationship shown by the graph you have drawn.**

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In the exam, questions about graphs could occur as:

- simple standalone questions
- part of a question on any topic
- part of a question about a practical test.

Make sure you plot all graphs accurately to gain maximum marks during investigations and exams.

Practise looking at the relationships shown by graphs where the variables are not directly proportional to each other.

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**Exam-style question**

1. A student investigates how the extension of a spring changes as the force on it is changed. The results are shown in the table.

<table>
<thead>
<tr>
<th>force (N)</th>
<th>0</th>
<th>0.4</th>
<th>0.8</th>
<th>1.2</th>
<th>1.6</th>
<th>2.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>extension (cm)</td>
<td>0</td>
<td>2.0</td>
<td>4.0</td>
<td>6.0</td>
<td>8.0</td>
<td>8.5</td>
</tr>
</tbody>
</table>

(a) Draw a graph on the grid to show how the extension changes as the force is increased.

(b) Describe the relationship shown by the graph.

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**Boost your grade**

Make sure you plot all graphs accurately to gain maximum marks during investigations and exams. Practise looking at the relationships shown by graphs where the variables are not directly proportional to each other.

How confident do you feel about each of these skills? Colour in the bars.