EXERCISE: Graph the following data (on graph paper!)

<table>
<thead>
<tr>
<th>t/s</th>
<th>s/m</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td>3</td>
<td>45</td>
</tr>
<tr>
<td>4</td>
<td>80</td>
</tr>
<tr>
<td>5</td>
<td>125</td>
</tr>
<tr>
<td>6</td>
<td>180</td>
</tr>
<tr>
<td>7</td>
<td>245</td>
</tr>
<tr>
<td>8</td>
<td>320</td>
</tr>
<tr>
<td>9</td>
<td>405</td>
</tr>
<tr>
<td>10</td>
<td>500</td>
</tr>
</tbody>
</table>

When making graphs (whether by hand or by computer):

1. The independent variable is on the x-axis and the dependent variable is on the y-axis.
2. Every graph should have a title that this concise but descriptive, in the form ‘Graph of (dependent variable) vs. (independent variable)’.
3. The scales of the axes should suit the data ranges.
4. The axes should be labeled with the variable, units, and uncertainties.
5. Ample paper area should be used.
6. The data points should be clear.
7. Error bars should be shown correctly (using a straight-edge).
8. Data points should never be connected dot-to-dot fashion. A line of best fit should be drawn instead.
9. Each point that does not fit with the best fit line should be identified.
10. Think about whether the origin should be included in your graph (what is the physical significance of that point?)

The extrapolation of the graph continues the trend line.

The line is interpolated between the points.
EXERCISE: Determine the equations of the lines in the following graphs:

EXERCISE: Interpret the following graphs and describe what is happening physically:
EXAMPLE: the equation of motion $v = u + at$

![Velocity versus time graph](image)

$\text{Gradient} = \frac{20}{5} = 4 \text{ m/s}^2$

$\text{Intercept} = 0$

![Graph of the parabola $y = ax^2 + b$.](image)

![Graph of the hyperbola $xy = c$.](image)

EXAMPLES:

$y = ax^2 + b$ rewrite as $y = aw + b$ where $w = x^2$. Then graph $y$ vs. $w$.

$x y = c \rightarrow y = \left(\frac{1}{x}\right)c$ rewrite as $y = cw$. Then graph $y$ vs. $w$. 

![Graph of the parabola $y = ax^2 + b$.](image)

Figure 3.4 Graph of the parabola $y = ax^2 + b$.

Figure 3.5 By graphing against the variable $x^2$ we get a straight line.

Figure 3.6 Graph of the hyperbola $xy = c$.

Figure 3.7 We get a straight line by plotting against the variable $\frac{1}{x}$. 

3
EXAMPLES:
Draw the best-fit lines in these graphs, and determine the slopes of the lines in the proper units:
The 3 most useful things we use graphs for are:

1. **y-intercept**
   - A linear graph can only cross the y axis once.
   - In experimental data, this value has physical significance.
   - If a line goes through the origin, then the two quantities are proportional to one another.

2. **gradient (slope)**
   - The slope is the ‘rise over run’ or change in y over change in x or \( \Delta y/\Delta x \).
   - A linear graph has a constant slope.
   - Slope has units. They are the y-units / x-units.
   - When calculating the slope, always use the biggest triangle you can manage from your graph.
   - Only if the x-axis is time does the slope give the rate of change (‘rate’ always refers to the change in something per unit time and is often misused.)
   - The slope of a curve at a particular point is the slope of the tangent line at that point.

   \[
   \text{gradient of straight line} = \frac{\Delta y}{\Delta x}
   \]
   \[
   \text{at point } P \text{ on the curve, gradient} = \frac{\Delta y}{\Delta x}
   \]

3. **area between the line and the x-axis**
   - The area under a line often represents a physical quantity.
   - The area can be found by finding the area of a trapezoid (for linear data, easy).
   - The area has units. They are (y-units) x (x-units).
   - The area under a curve can be found by counting all the small squares under it and adding them all up (provided you know the area of one square – difficult!)

   \[
   \text{area under graph}
   \]
   \[
   \text{area under graph}
   \]