In physics, as with all sciences, we are concerned with the relationship between observed measurements.

There are two types of correlations **direct** and **indirect**.

## Direct Correlations

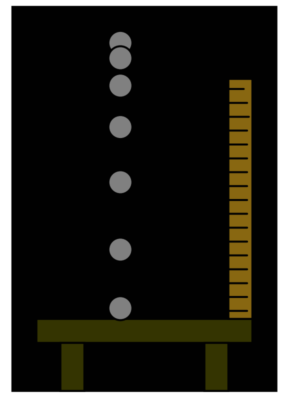
These are correlations where as one measured quantity increases, so does the other.

## Indirect Correlations

These are correlations where as one measured quantity increases the other decreases.

In science, when collecting data, there are usually two measured quantities. Generally, one measurement is controlled and the other observed. The controlled measurement is called the **independent variable**, the observed measurement is called the **dependent variable.**

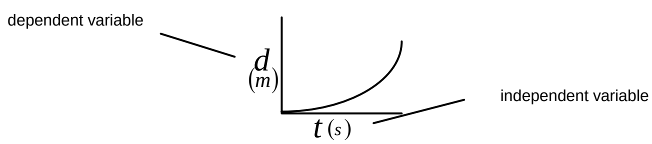
**Ex:** In an experiment to measure the acceleration due to gravity, you drop a ball and photograph it with a stroboscope camera set-up.



A stroboscope is a device that creates bright flashes as a constant rate. (a.k.a strobe light). The images produced are exposed to film. With this apparatus, the time between each flash is fixed; as a result, each exposure is separated by a precise amount of time.

In this case the time increments are fixed, therefore time is the **independent variable.** The observed distances between exposures would be the **dependent variable** in this case.

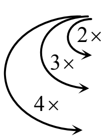
If you were to make a graph to represent the data, the x-axis **ALWAYS** represents the independent variable and the y-axis **ALWAYS** represents the dependent variable.



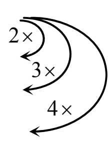

## Linear Relationships

Linear relationships are those where the dependent and the independent variables increase at the same rate.

**Ex**:




| d(m) | t(s) |
|---|---|
| 100 | 2 |
| 200 | 4 |
| 300 | 6 |
| 400 | 8 |

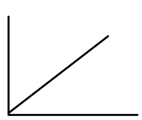



Linear relationships always take the form of a straight line when represents graphically.

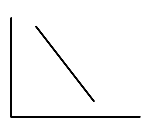
**Sample**

| A | B |
|---|---|
| 5 | 3 |
| 10 | 6 |
| 15 | 9 |
| 20 | 12 |
| 25 | ? |
| 30 | ? |

**Note:** Linear relationships can be both direct and indirect relationships.



**Direct**: slopes up and to the right



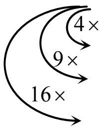
**Indirect**: slopes down and to the right

## Non-Linear Relationship

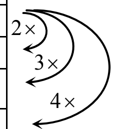
Non-linear relationships are those where the dependent and independent variables are related by an exponential relationship.

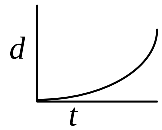
### Quadratic relationship (squared)

Where the **dependent variable** is directly related to the **square** of the **independent variable**.



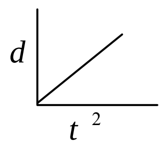

| d | t |
|---|---|
| 1 | 1 |
| 4 | 2 |
| 9 | 3 |
| 16 | 4 |




Now compare $d \; vs. t^2$

| d | t | $t^2$ |
|---|---|---|
| 1 | 1 | 1 |
| 4 | 2 | 4 |
| 9 | 3 | 9 |
| 16 | 4 | 16 |




$\therefore d \propto t^2$

**Example:** Find the relationship.

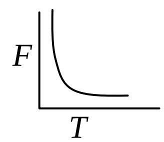
| A | B |
|---|---|
| 5 | 1 |
| 20 | 2 |
| 80 | 4 |
| 180 | 6 |
| 320 | 8 |

## The inverse relationship

Where the **dependent variable** is directly related to the **inverse** of the **independent variable**.

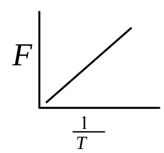
| F | T |
|---|---|
| 100 | 0.01 |
| 200 | 0.005 |
| 400 | 0.0025 |
| 500 | 0.002 |

F: $2\times$, $4\times$, $5\times$ T: $\frac{1}{2}\times$, $\frac{1}{4}\times$, $\frac{1}{5}\times$




Now compare $F\ vs.\ \frac{1}{T}$

| F | T | $\frac{1}{T}$ |
|---|---|---|
| 100 | 0.01 | 100 |
| 200 | 0.005 | 200 |
| 400 | 0.0025 | 400 |
| 500 | 0.002 | 500 |



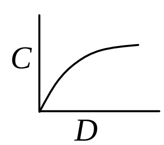

$$\therefore F \propto \frac{1}{T}$$

## The square root relationship

Where the **dependent variable** is directly related to the **square root** of the **independent variable**.

| C | D |
|---|---|
| 1 | 4 |
| 2 | 16 |
| 3 | 36 |
| 3.5 | 49 |

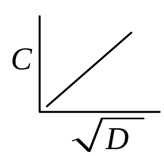
C: $2\times$, $3\times$, $3.5\times$ D: $4\times$, $9\times$, $12.25\times$




Now compare $C\ vs.\ \sqrt{D}$

| C | D | $\sqrt{D}$ |
|---|---|---|
| 1 | 4 | 2 |
| 2 | 16 | 4 |
| 3 | 36 | 6 |
| 3.5 | 49 | 7 |

C: $2\times$, $3\times$, $3.5\times$ $\sqrt{D}$: $2\times$, $3\times$, $3.5\times$

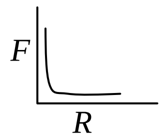



$$\therefore C \propto \sqrt{D}$$

## The inverse square relationship

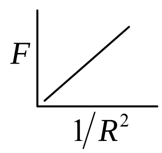
Where the **dependent variable** is directly related to the **inverse square** of the **independent variable**.

| F | R |
|---|---|
| 2 | 1 |
| 8 | $\frac{1}{2}$ |
| 32 | $\frac{1}{4}$ |
| 72 | $\frac{1}{6}$ |




Now compare $F\ vs. \frac{1}{R^2}$

| F | R | $\frac{1}{R^2}$ |
|---|---|---|
| 2 | 1 | 1 |
| 8 | $\frac{1}{2}$ | 4 |
| 32 | $\frac{1}{4}$ | 16 |
| 72 | $\frac{1}{6}$ | 36 |




$\therefore F \propto \frac{1}{R^2}$

**Exercise:** Determine the relationships between the dependent and independent varialbes. **Note:** Independent variables are always in the right column, dependent in the left.

| A | B |
|---|---|
| 2 | 100 |
| 8 | 200 |
| 50 | 500 |
| 200 | 1000 |

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| C | D |
|---|---|
| 3 | 120 |
| 6 | 60 |
| 9 | 40 |
| 12 | 30 |

______________

| E | F |
|---|---|
| 2 | 90 |
| 54 | 270 |
| 16 | 180 |
| 250 | 450 |

______________

| G | H |
|---|---|
| 6 | 5 |
| 12 | 20 |
| 18 | 45 |
| 42 | 245 |

______________

| K | L |
|---|---|
| 7 | 800 |
| 35 | 32 |
| 28 | 50 |
| 70 | 8 |

______________

| M | N |
|---|---|
| 2 | 3 |
| 4 | 24 |
| 6 | 81 |
| 8 | 192 |

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## Analysing Experimental Data Lab

**Purpose**: To practice analysing experimental data in order to determine the relationship between the dependent and independent variables.

**Apparatus**:

- 50cm of string
- 1 meter stick
- 1 retort stand
- 1 retort stand clamp
- 1 mass of any size (no larger than 200g)
- 1 stop watch

**Procedure:**

1. Tie a small loop at the end of the string
2. Hang the mass from the loop
3. Using the clamp to support the string, adjust the length of the string so that center of the mass is 10cm away from the point of rotation (fulcrum), located at the mouth of the clamp.
4. Pull the mass to an angle of approximately 30 degrees to the vertical.
5. Using the stop watch, determine the time it takes for the pendulum to complete 10 cycles. (one complete cycle is defined as the point where the mass returns to it's launch position. Of course as energy is lost it won't return to the same height as its initial launch but it will be close, and won't have an effect on the frequency of the pendulum.
6. Determine the frequency of the pendulum using the following formula $f = \frac{\#of\ cycles}{time}$ where $t$ is the time in seconds (s) and $f$ is the frequency in Hertz ($Hz$)
7. Repeat steps 1-6 for the following lengths; 15cm, 20cm, 25cm, 30cm, 35cm

Observations

| Length (cm) | Time for 50 cycles (s) | Frequency (Hz) |
|---|---|---|
| 10cm | | |
| 15cm | | |
| 20cm | | |
| 25cm | | |
| 30cm | | |
| 35cm | | |

**Questions and Analysis:**

1. In this lab we are comparing length to frequency. Which one is the dependent variable and which one is the independent variable?
2. Graph your results using a **line or curve** of best fit. Remember the **y-axis** represents the **dependent variable** and the **x-axis** represent the **independent variable**
3. Using the techniques described in the preceding pages, what is the nature of the relationship between the dependent and independent variables?
4. Collect the results from the other groups in the class and determine the standard deviation in frequency for **each** of the lengths. Use the chart below to record the data. For the write up, you need only show **one** full calculation for a **single** length (i.e. the 10cm), the remaining results can be displayed in table format.

| Group | 10cm | 15cm | 20cm | 25cm | 30cm | 35cm | | Group | 10cm | 15cm | 20cm | 25cm | 30cm | 35cm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | 13 | | | | | | |
| 2 | | | | | | | | 14 | | | | | | |
| 3 | | | | | | | | 15 | | | | | | |
| 4 | | | | | | | | 16 | | | | | | |
| 5 | | | | | | | | 17 | | | | | | |
| 6 | | | | | | | | 18 | | | | | | |
| 7 | | | | | | | | 19 | | | | | | |
| 8 | | | | | | | | 20 | | | | | | |
| 9 | | | | | | | | 21 | | | | | | |
| 10 | | | | | | | | 22 | | | | | | |
| 11 | | | | | | | | 23 | | | | | | |
| 12 | | | | | | | | 24 | | | | | | |

5. What trend, if any, do you notice with the standard deviation? If you notice a trend, give a possible explanation.