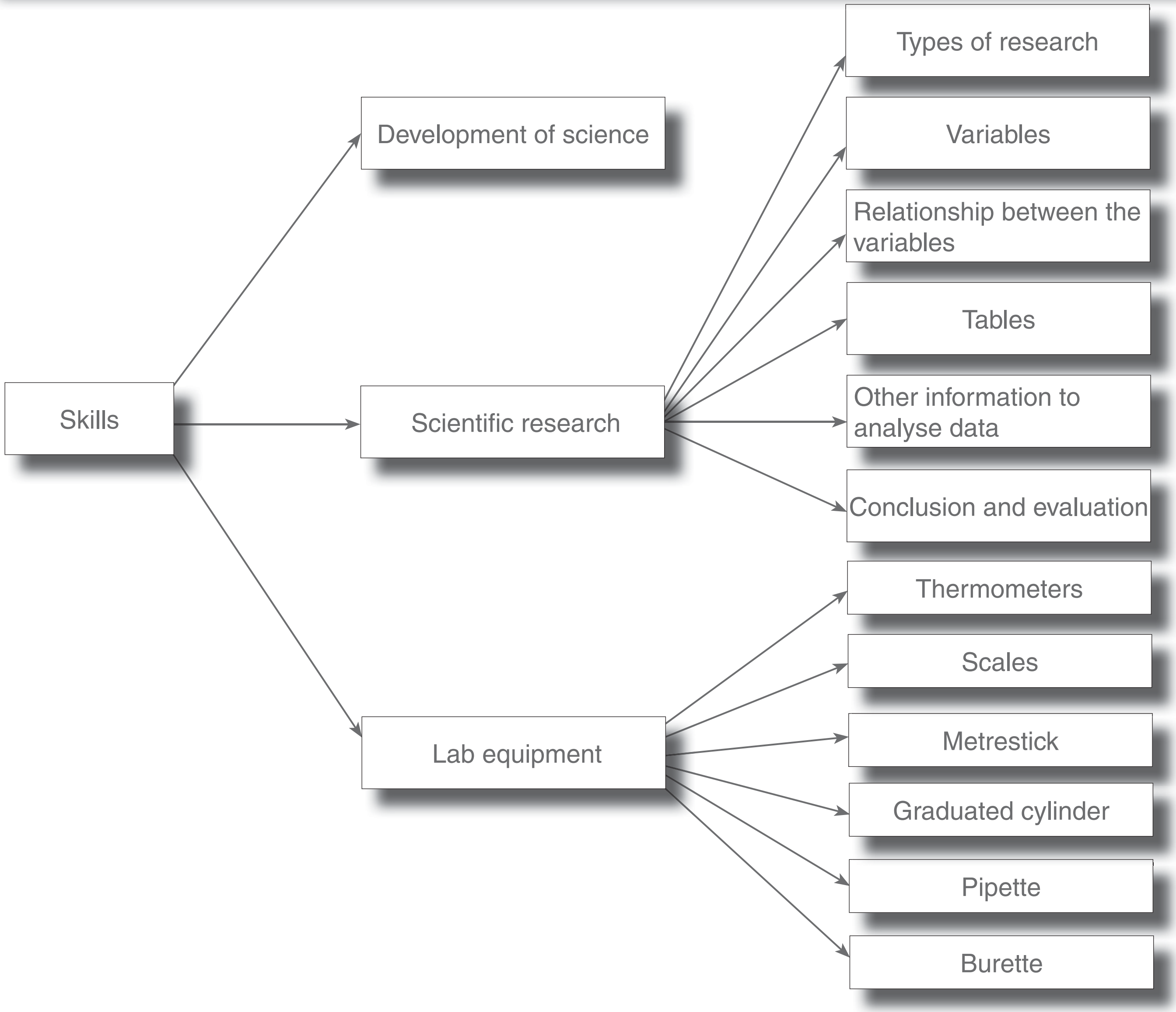
Masters for transparencies

5.1 Skills

SKILLS

SKILLS FOR PRACTICAL INVESTIGATIONS



1.1 Development of science

Early 1700's	Huygens
1839	Becquerel
1873	Smith
1900	Planck
1905	Einstein

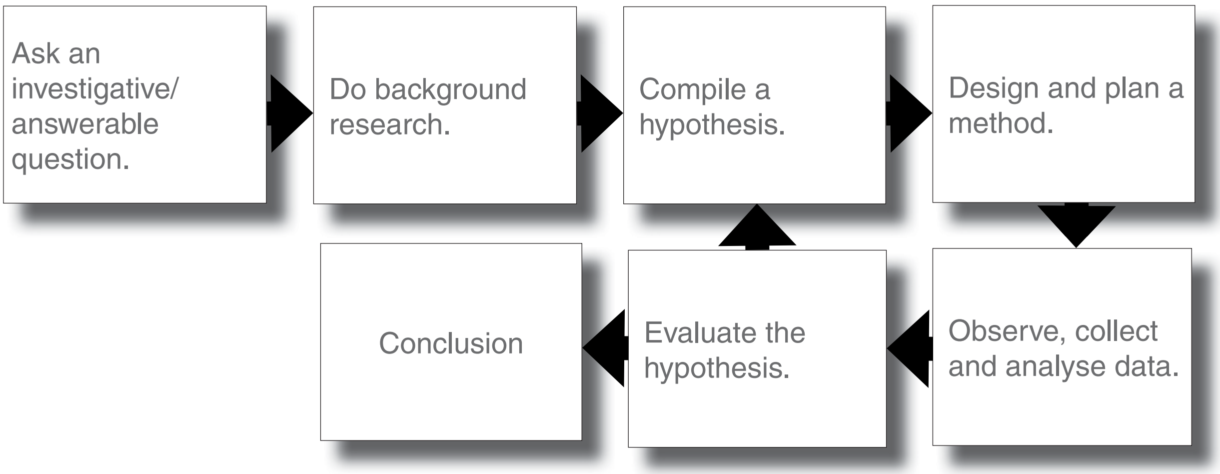
Research on particle properties → Era of solar power

http://www.2mcctv.com/blog/wp-content/uploads/2012/08/solar-panel.jpg

1.2 Scientific research

The step by step research of a specific topic to prove a hypothesis and/or to answer a specific scientific question.

Steps:



1.2.1 Types of research

- Quantitative research
- Qualitative research

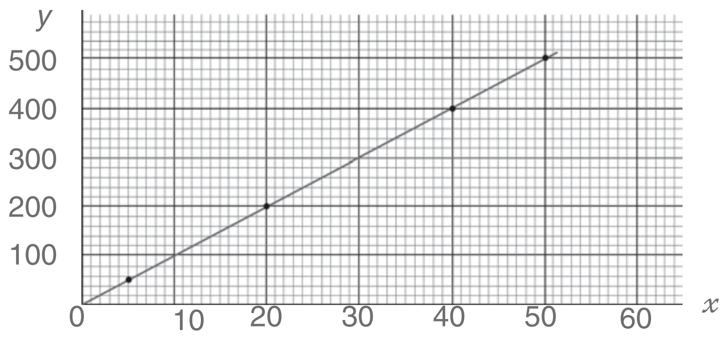
1.2.2 Variables

- Independent variable(s)
- Dependent variable(s)
- Controlled variable(s)
- Constant(s)

1.2.3 Relationship between variables

- **Directly proportional**
  This relationship exists between the variables when both sets of readings increase or decrease together in the same proportion.
  Mathematically: $x \propto y$ or $^y/_x$ = k (constant) or $y = kx$.
  Example:

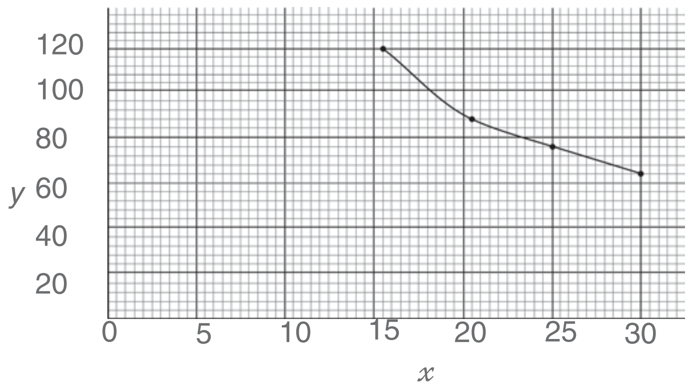
x	y	$^y/_x$
50	500	0,1
40	400	0,1
20	200	0,1
5	50	0,1



Straight line

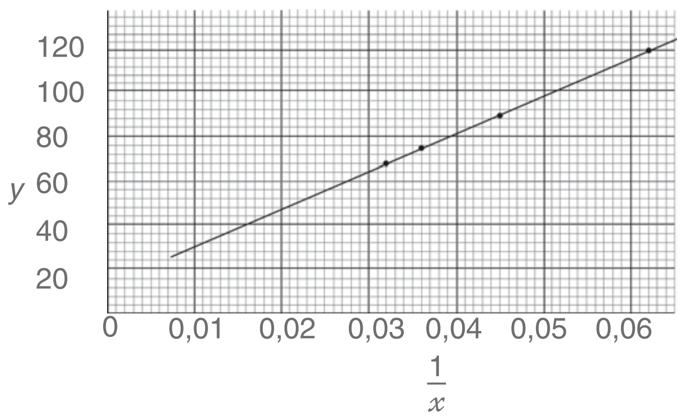
- **Inversely proportional**
  Mathematically: xy = k (constant) or $y \propto {}^1/_x$.
  Example:

x	y	xy	$^1/_x$
30	65	1 950	0,033
26	75	1 950	0,0385
21,7	90	1 953	0,046
16,25	120	1 950	0,062



Hyperbola

But when y is plotted against $^1/_x$ on a graph, a straight line is obtained $y = k(^1/_x)$.



1.2.4 Table

- Relevant, underlined heading
- No units must be written next to the values.
- Written in scientific notation ($\times 10^x$)
- Values of the table are not necessarily in SI units.
- One complete calculation must be written out underneath.

1.2.5 Other information to analyse the data

Other information obtained from the experimental readings and or graph to analyse the data:

- Mathematical average

Examples

During a titration, the following readings are obtained: 24,09; 24,15; 24,03; 24,25 cm^3.

Average $= \frac{24{,}09 + 24{,}15 + 24{,}03 + 24{,}25}{4}$

Average $= 24{,}13\ cm^3$

- Median

Examples

Once sorted into increasing order, the values are: 24,03; 24,09; 24,15; 24,25

The median $= \frac{24{,}09 + 24{,}15}{2}$

The median $= 24{,}12\ cm^3$

- **Gradient** $= \frac{\Delta y}{\Delta x}$

  Examples: If the position (x) is drawn on the y-axis and time (t) on the x-axis, then the gradient of the graph will indicate the velocity of the object.

  gradient $= \frac{\Delta y}{\Delta x} = \frac{\Delta x}{\Delta t}$ = average velocity

- **Area**

  Examples: An acceleration-time graph's area shows the change in velocity of the object.

  Area $= b \times \ell = a \times \Delta t = \Delta v$

  Area of a triangle $= \frac{1}{2} b \times \perp h$, and the area of a rectangle $= \ell \times b$.

- **Accuracy**

Examples

The experimental mass is measured if the actual value must be 285g.
The deviation is therefore 285 – 283 = 2 g.

The percentage error is then $\frac{2}{285} \times 100 = 0{,}7\%$

However when the experimental value is measured as 30 g the actual value is 32 g,

the actual value is $\frac{2}{32} \times 100 = 6{,}25\%$ for the same deviation of 2 g.

Even though the deviation is the same, the first experiment is the most accurate.

1.2.6 Conclusion and evaluation

- Evaluate hypothesis.
- Verdict on hypothesis
- Use words that suggest a ratio/relationship. That means words like larger, more, higher, smaller, faster, etc.
- In evaluation: independent, dependent and controlled variable(s).
- Discuss accuracy.
- Motivate/explain deviations.
- Data that do not match, may not be rejected.
- All information must be discussed.

Example

Let us use Newton's second law, $F_{net} = m \times a$, since we did it in Grade 11 to explain the process of scientific research. The investigation involves determining the acceleration of an object of constant mass if a net force is applied to it.

Quick facts

The net/resultant force is the vector sum of all the forces acting on the object.

We use this investigation as an example to illustrate the scientific process.

I. Answerable/investigative question

How will the acceleration of the trolley change if the net force exerted on it is increased?

II. Hypothesis

The acceleration of the trolley will increase if the force exerted on it is increased.

III. Independent variable

The force applied on the trolley (this is represented by the mass that is hanging over the pulley).

IV. Dependent variable

The magnitude of the acceleration of the object (this can be determined by a ticker timer).

V. Controlled variable(s)

1. Mass of the system; that is the mass of the trolley as well as the hanging mass.
2. The gradient of the track
3 The frequency of the ticker timer that is used.
4. The friction in the system

VI. Table

Results obtained during the investigation of the relationship between the applied force and the acceleration, in the friction-compensated system using a mass of 2 kg.

Reading number	Hanging mass (g)	Applied force (N) $F = F_g$ $F = m \times g$	Initial velocity ($m \cdot s^{-1}$) v_i = ave v $v_i = \frac{\Delta D}{\Delta t}$	Final velocity ($m \cdot s^{-1}$) v_f = ave v $v_f = \frac{\Delta D}{\Delta t}$	Acceleration ($m \cdot s^{-2}$) $a = \frac{v_f - v_i}{\Delta t}$
1	100	0,98	0,33	0,43	0,5
2	200	1,96	0,41	0,61	1,0
3	300	2,94	0,52	0,82	1,5
4	400	3,92	0,58	0,98	2,0

Period of the ticker timer:

$$T = \frac{1}{f} = \frac{1}{50} = 0{,}02 \text{ s}$$

Initial velocity:

$$v_i = \frac{\Delta D}{\Delta t} = \frac{0{,}02}{0{,}06} = 0{,}33 \text{ m}\cdot\text{s}^{-1}$$

[Three spaces per interval]

Final velocity:

$$v_f = \frac{\Delta D}{\Delta t} = \frac{0{,}026}{0{,}06} = 0{,}43 \text{ m}\cdot\text{s}^{-1}$$

[Three spaces per interval]

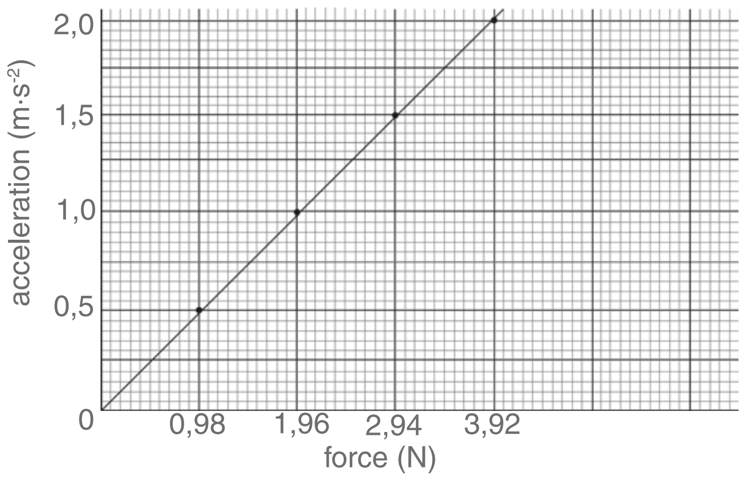
Acceleration:

$$a = \frac{v_f - v_i}{\Delta t} = \frac{0{,}43 - 0{,}33}{0{,}2} = 0{,}5 \text{ m}\cdot\text{s}^{-2}$$

[Ten spaces from v_i to v_f]

VII. Graph

The relationship between the applied force and the acceleration of the object



VIII. Gradient

The gradient of the graph = $\frac{\Delta y}{\Delta x} = \frac{\Delta a}{\Delta F} = \frac{(2 - 0)m\cdot s^{-2}}{(3,92 - 0)kg\cdot m\cdot s^{-2}} = 0,51kg^{-1}$

$\therefore$ gradient = $\frac{1}{m}$ $\therefore$ m = $\frac{1}{0,51}$ = 1,96kg

$\therefore$ % accuracy = $\frac{0,04}{2} \times 100$ = 2%. The investigation is therefore fairly accurate.

IX. Surface

In the case of the acceleration-force graph, the surface is negligible and therefore not applicable.

X. Conclusion and evaluation

The acceleration of the trolley increases if the force applied on the trolley increases, provided the gradient of the track and the frequency of the ticker timer remain constant.

Exercise A: Page 20

1. Explain what a hypothesis is.

The theoretical answer or an educated guess as to what the answer will be to the scientific question. OR
What the researcher thinks will happen. It should be formulated in the same way as the question.

2 Sandile notices that his cup of coffee becomes fuller when he adds sugar. He plans an investigation to determine how much fuller the cup becomes. Write the following for Sandile's investigation:

2.1 An investigative question that is verifiable.

How will the volume of the coffee change when more sugar is added?

2.2 The independent variable **The amount of sugar added.**

2.3 The dependent variable **The volume of the coffee**

2.4 Controlled variable(s) **The volume of the cup**
The temperature of the coffee

2.5 Constant(s) **Specific heat capacity of water**

3 Bongiwe carries out a ballistic experiment in an open field alongside an old mine dump (for safety reasons).

(*Gauteng, June exam Q1 2012*)

Bongiwe investigates the impact that the distance travelled by the pellet has on the speed of the pellet. He fires an air rifle at a polystyrene ball, which is suspended from a light string. The pellet gets stuck in the polystyrene ball. He replaces the polystyrene ball after every shot. The polystyrene ball and the pellet swing away to the right, as shown in the diagram, to a height h. The mass of the pellet is 10 g and the mass of the polystyrene ball is 50 g. The experiment is repeated by increasing the range by 5 m each time, until the range is 20 m.