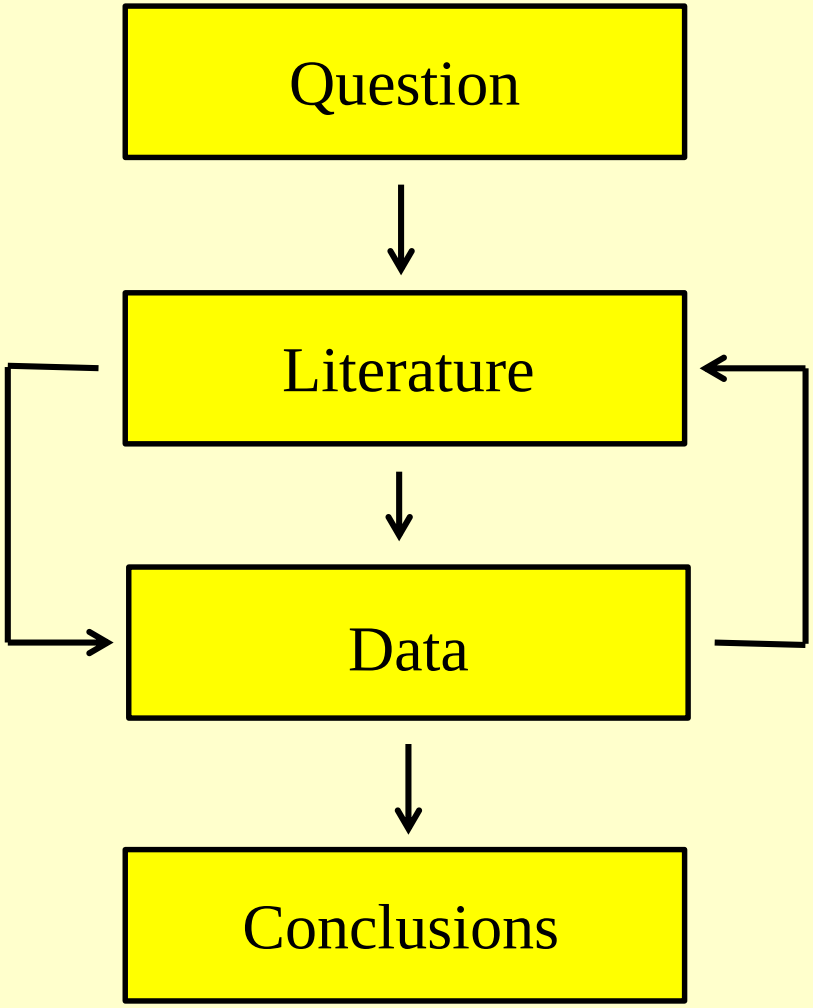
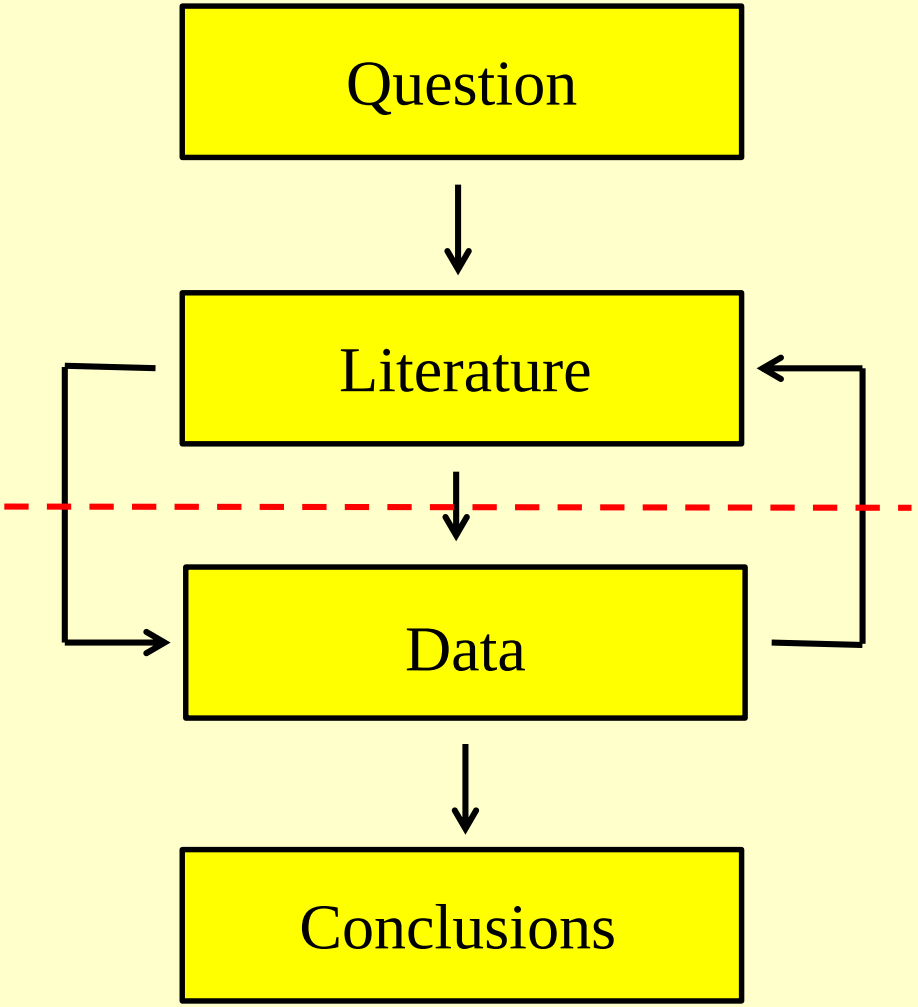
Research Methods - Quantitative

Prof Alun Vaughan

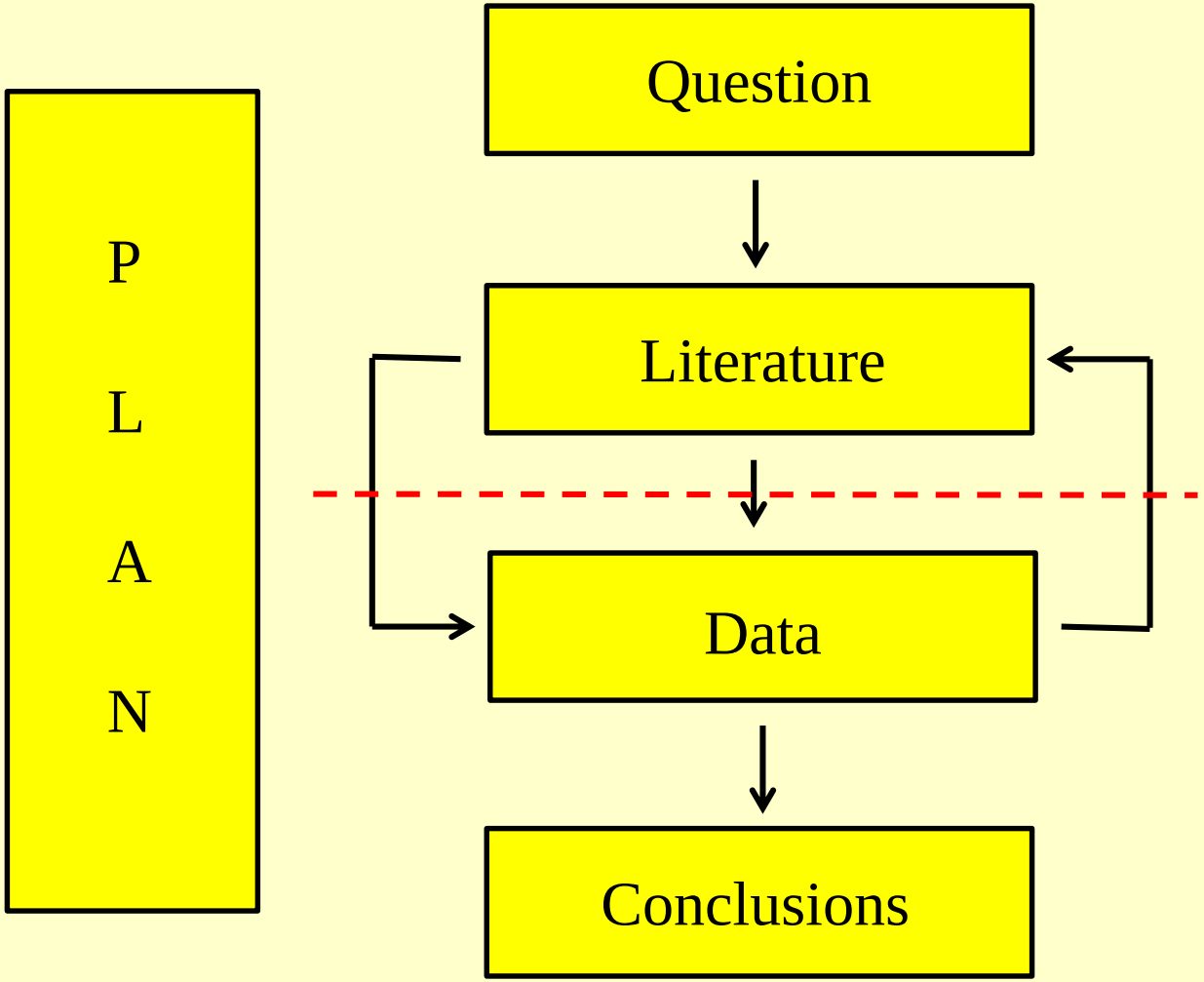
METHODS



METHODS



METHODS



The Question

The key to a successful project is having a clear view of the aims and objectives.

- In general an aim is a high level aspiration – why are you doing this?
- Objectives should be specific

A convenient means of dealing with this is to think in terms of "deliverables". All deliverables should be SMART:

- Specific
- Measureable
- Attainable
- Relevant
- Time-dimensioned

The Literature

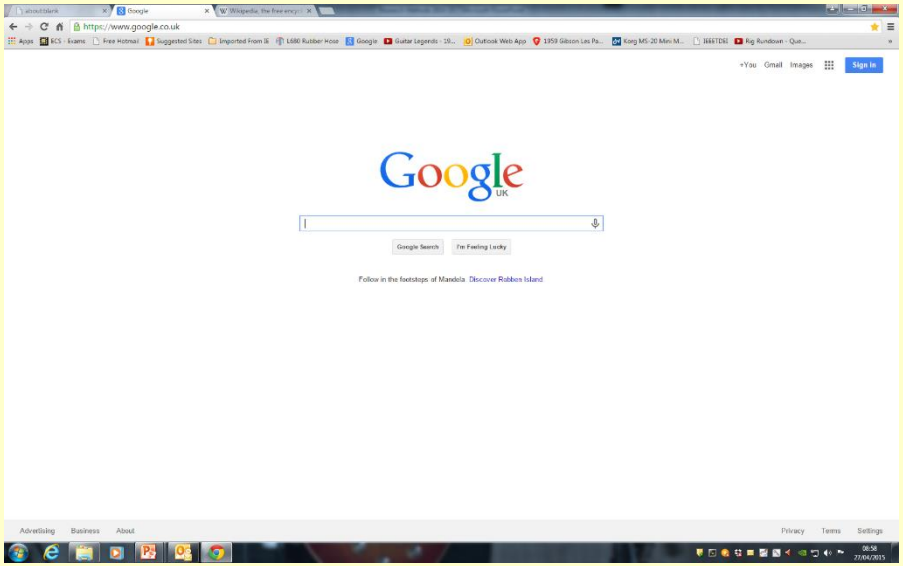
- You need to have a good knowledge and understanding of the published literature
- There are may ways to find out the current state of knowledge
- Books are good at providing general background; journal and conference papers represent the state of the art

NOT EVERYTHING THAT IS PUBLISHED IS CORRECT! BE CRITICAL!

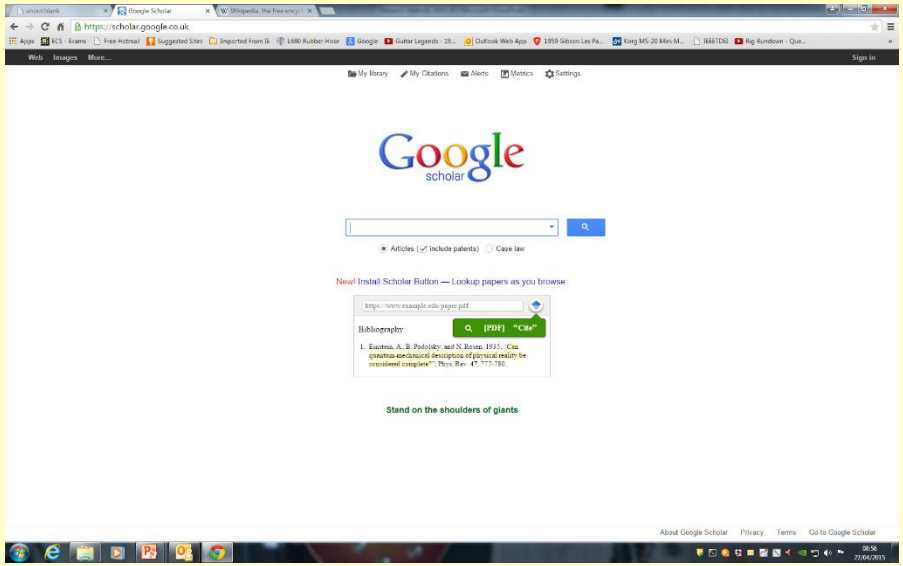
- So, you need to contrast various sources: REVIEW
- Referring to the literature helps you to refine your aims and objectives: PLAN
- Referring to the literature helps you to refine your methods: PLAN
- Referring to the literature helps you interpret your data and draw conclusions: PROJECT

ARE YOUR DATA CONSISTENT WITH PUBLISHED WORK?

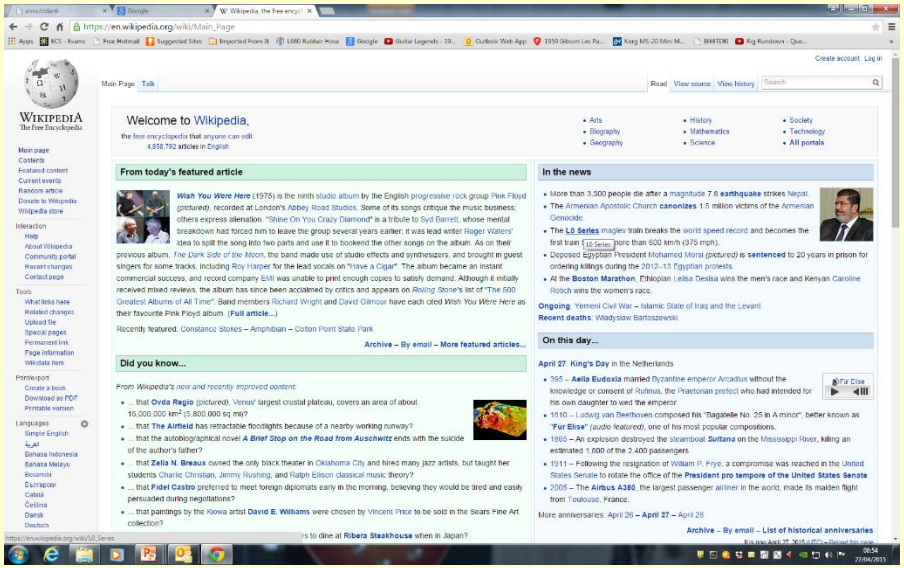
Google



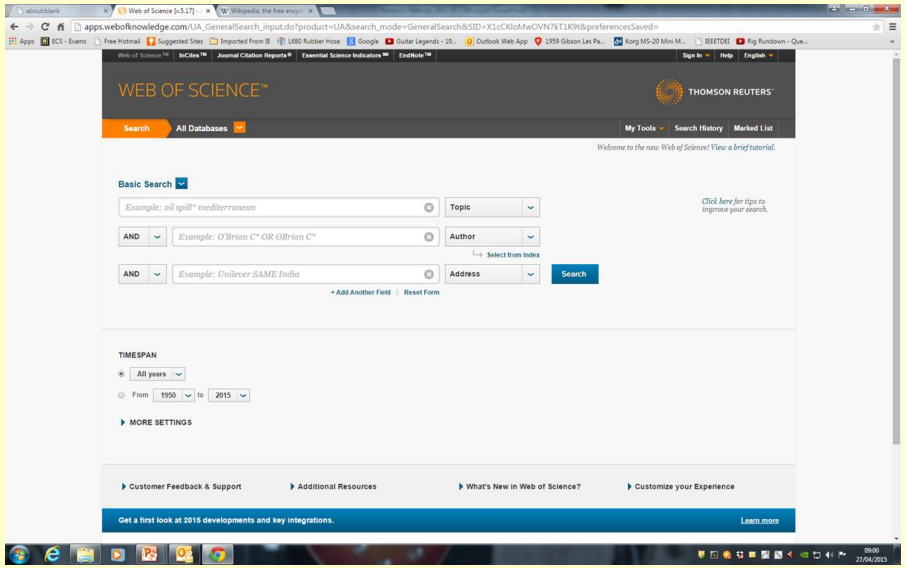
Google Scholar



Wikipedia?



Web of Science



What does the literature tell you?

- What people have done
- How they did it

- Underpinning theoretical or hypothetical aspects which inform your experimental design

The Data and Experimental Design

Professional engineers and scientists need to be able to make reliable measurements to make sense of the physical world.

This involves:

- The generation of physical data
- Its analysis

Experimental design is the process by which we ensure that the experiment is properly organized to ensure:

- The right data are obtained
- They are gathered as clearly and efficiently as possible

Example

- PROVE that acceleration due to gravity is a constant for all objects
- DETERMINE the value.

- Experiment?

Experiment: Pendulum

- PROVE that acceleration due to gravity is a constant for all objects
- DETERMINE the value.

- Experiment?

- Determine the acceleration due to gravity using a simple pendulum

Experiment: Pendulum

- PROVE that acceleration due to gravity is a constant for all objects
- DETERMINE the value.

- Literature says that the period of oscillation is independent of the mass of the pendulum:

$$\tau = 2\pi\sqrt{\frac{l}{g}} \qquad \tau^2 = 4\pi^2\frac{l}{g} \qquad g = 4\pi^2\frac{l}{\tau^2}$$

Experiment: Pendulum

- PROVE that acceleration due to gravity is a constant for all objects
- DETERMINE the value.

$$g = 4\pi^2 \frac{l}{\tau^2}$$

- This equation is the core of your design and construction of variable parameter space for your data.

- What are the parameters?

Experiment: Pendulum

- PROVE that acceleration due to gravity is a constant for all objects
- DETERMINE the value.

$$g = 4\pi^2 \frac{l}{\tau^2}$$

- Parameters of the apparatus:
  - The length of the pendulum l – *does this matter?*
  - The mass of the pendulum m – *does this matter?*
- Other parameters:
  - The period of oscillation τ

Experiment: Pendulum

- PROVE that acceleration due to gravity is a constant for all objects
- DETERMINE the value.

$$g = 4\pi^2 \frac{l}{\tau^2}$$

- Exploring parameter space is important in an experiment – WHY?

Experiment: Pendulum

- PROVE that acceleration due to gravity is a constant for all objects
- DETERMINE the value.

$$g = 4\pi^2 \frac{l}{\tau^2}$$

- Exploring parameter space is important in an experiment – WHY?

- This produces a range of data and is necessary for PROOF.
- You need the correct measurements and the correction understanding of error and uncertainty as well.

Experiment: Pendulum

- PROVE that acceleration due to gravity is a constant for all objects
- DETERMINE the value.

$$g = 4\pi^2 \frac{l}{\tau^2}$$

- Apparatus?

Experiment: Pendulum

- PROVE that acceleration due to gravity is a constant for all objects
- DETERMINE the value.

$$g = 4\pi^2 \frac{l}{\tau^2}$$

- Apparatus?
    - String?
    - Mass?
    - Anything else?
    - A stopwatch
    - A means of producing a graph

Experiment: Pendulum

- PROVE that acceleration due to gravity is a constant for all objects
- DETERMINE the value.

$$g = 4\pi^2 \frac{l}{\tau^2}$$

- Apparatus?
    - String of varying lengths and types/weights
    - A ruler for determining length – error source – mitigation?
    - A selection of different masses/densities
    - A scale for determining mass – error source – mitigation?
    - A support
    - A stopwatch – error source – mitigation?
    - A means of recording data
    - A means of producing a graph

Experiment: Pendulum

- PROVE that acceleration due to gravity is a constant for all objects
- DETERMINE the value.

$$g = 4\pi^2 \frac{l}{\tau^2}$$

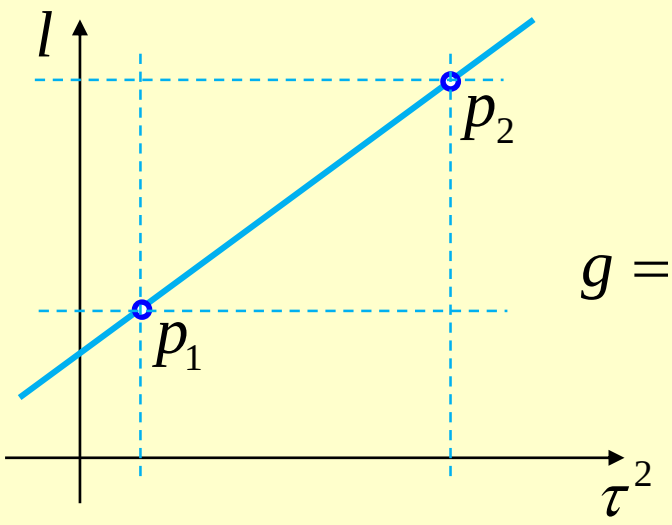
- Measurements:
  - Length of string
  - Mass
  - Period of oscillation
  - Draw a graph

Experiment: Pendulum

- PROVE that acceleration due to gravity is a constant for all objects
- DETERMINE the value.

$$g = 4\pi^2 \frac{l}{\tau^2}$$

- Analysis:



$$g = 4\pi^2 \frac{l(p_1) - l(p_2)}{\tau^2(p_1) - \tau^2(p_2)}$$

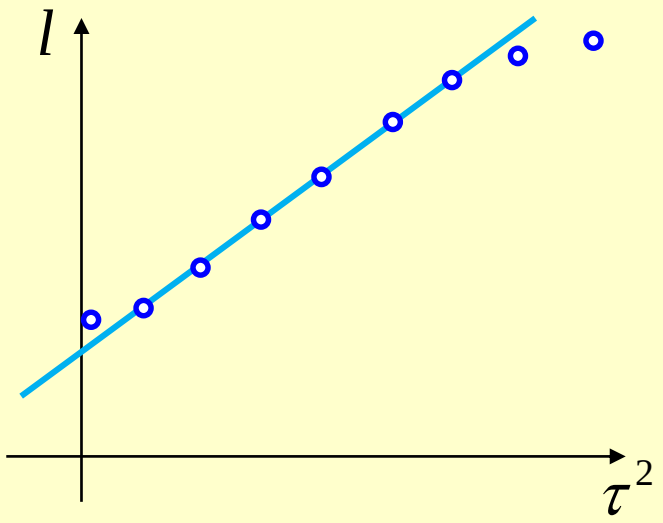
- Is this enough?

Experiment: Pendulum

- PROVE that acceleration due to gravity is a constant for all objects
- DETERMINE the value.

$$g = 4\pi^2 \frac{l}{\tau^2}$$

- No.
  - Repeat for different string weights
  - Repeat for different masses
  - Determine range of validity of method
  - Demonstrate linearity

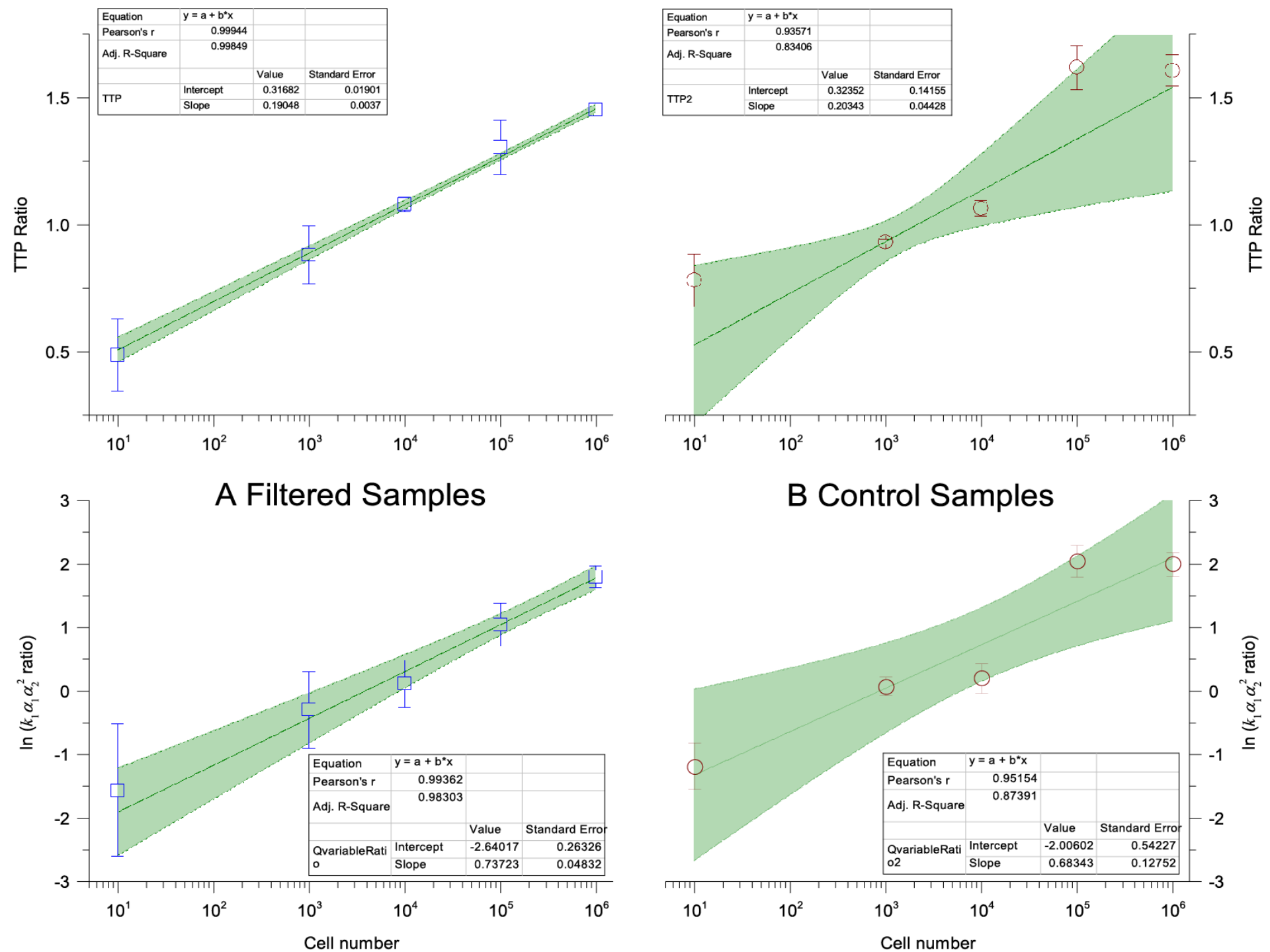


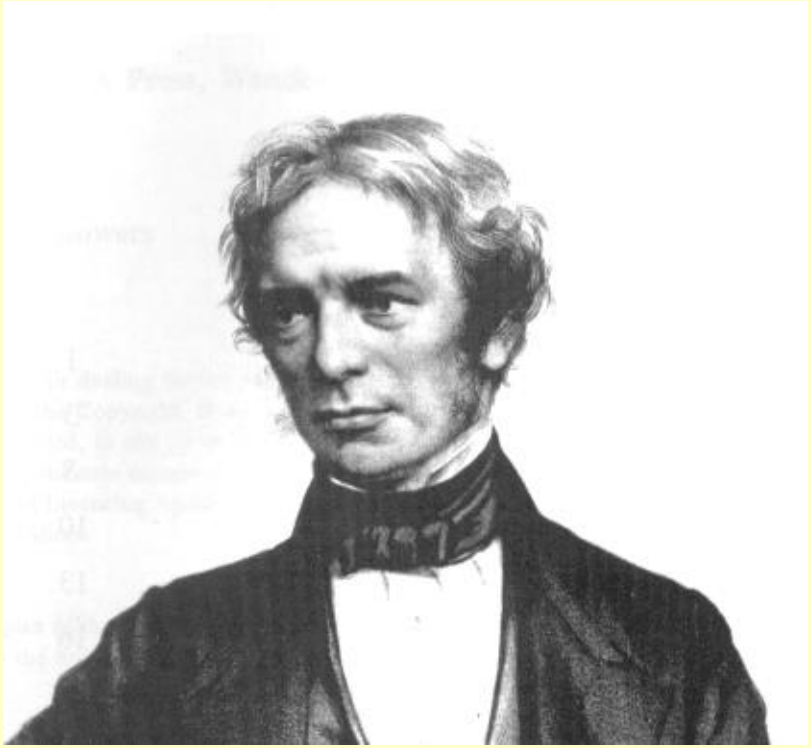
Experiment: Pendulum

- PROVE that acceleration due to gravity is a constant for all objects
- DETERMINE the value.

$$g = 4\pi^2 \frac{l}{\tau^2}$$

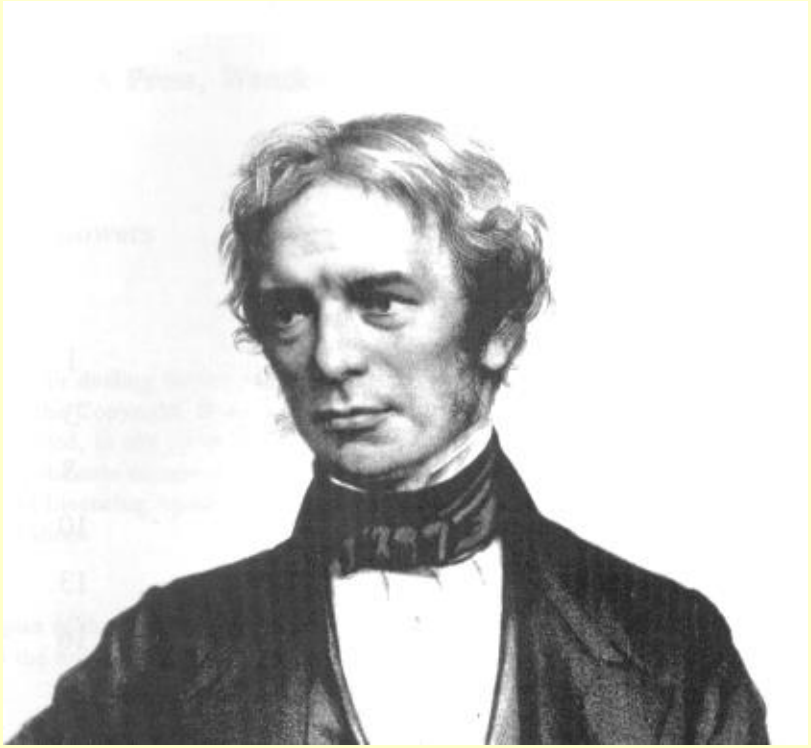
- Analyse errors and accuracy of results:


Equation y = a + b*x
Pearson's r 0.99944
Adj. R-Square 0.99849
Value Standard Error
TTP Intercept 0.31682 0.01901
Slope 0.19048 0.0037
TTP Ratio
Equation y = a + b*x
Pearson's r 0.93571
Adj. R-Square 0.83406
Value Standard Error
TTP2 Intercept 0.32352 0.14155
Slope 0.20343 0.04428
TTP Ratio
A Filtered Samples
B Control Samples
ln ($k_1 \alpha_2^2$ ratio)
Equation y = a + b*x
Pearson's r 0.99362
Adj. R-Square 0.98303
Value Standard Error
QvariableRatio Intercept -2.64017 0.26326
Slope 0.73723 0.04832
Cell number
Equation y = a + b*x
Pearson's r 0.95154
Adj. R-Square 0.87391
Value Standard Error
QvariableRatio2 Intercept -2.00602 0.54227
Slope 0.68343 0.12752
Cell number



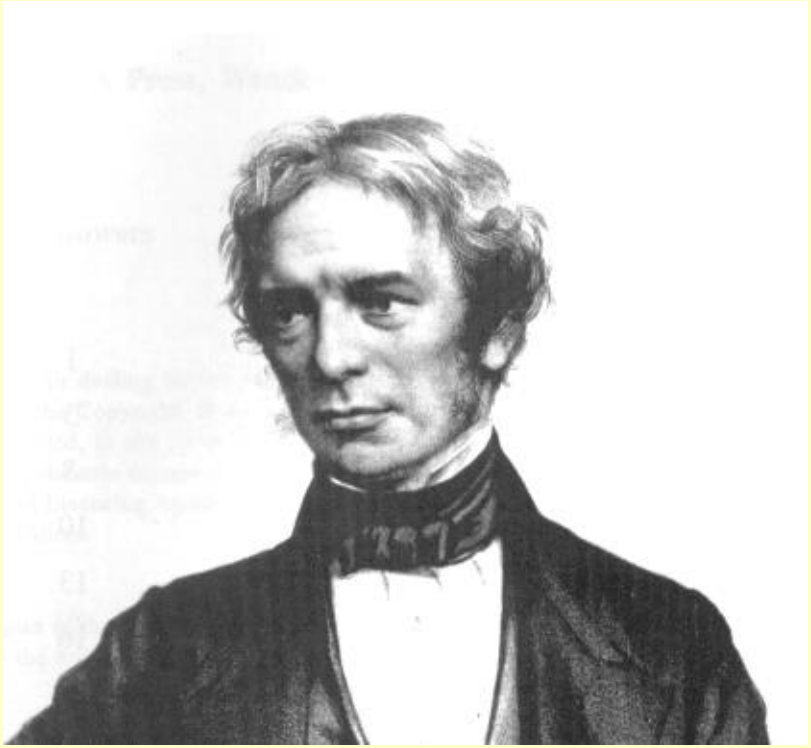
Who is this?

Michael Faraday



Michael Faraday and the Modern World, Brian Bowers

Michael Faraday



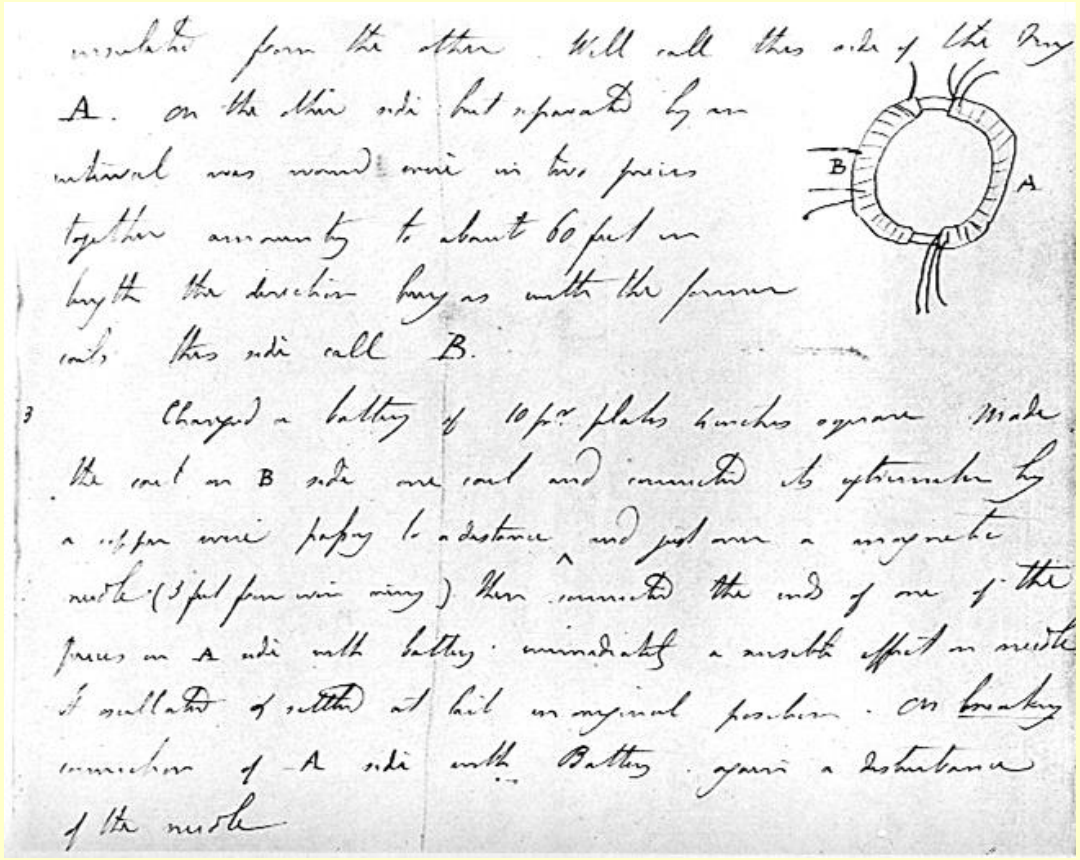
Michael Faraday and the Modern World, Brian Bowers

“The man who made engineering possible”

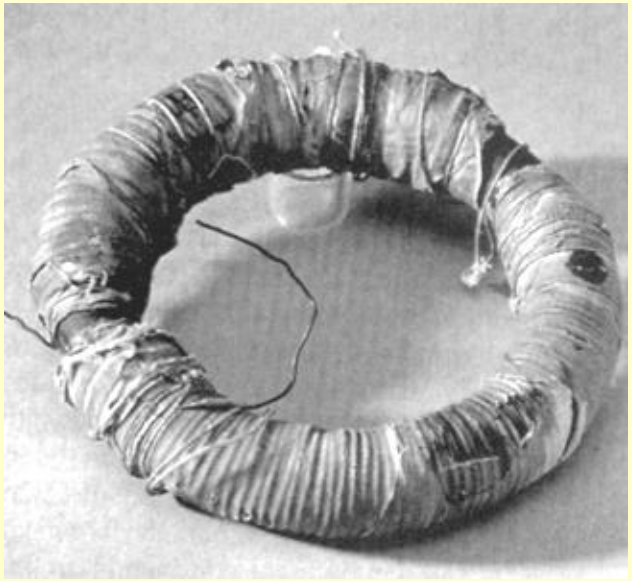
Sir William Bragg

His log books - 1820-62

The record ….. August 29th, 1831



Faraday's Diary, Michael Faraday



Michael Faraday and the Modern World, Brian Bowers

The thought process ..... April 13th, 1833

409. Why did Davy require water in decomposing potassa?

410. If decomposition by voltaic battery depended upon the *attraction* of the poles being stronger than that of the particles separated, it would follow that the *weakest electrical* attraction was stronger than the strongest or very strong *chemical* attraction ….

412. New view gives good reason why a body should sometimes go to one pole and sometimes to another, according to the element it is in relation or association with.

415. A single element is never attracted by a pole, ie without attraction of other elements at other pole. Hence doubt Mr Brande's Expts. on attraction of gasses and vapours.

Your Log Book

- It should be a complete record of what you have done and why you have done it in that way

Scope

- It may include the preparations you made for an activity
- It will contain a list of your actions – including times, dates, etc

It should also contain your thoughts and ideas