

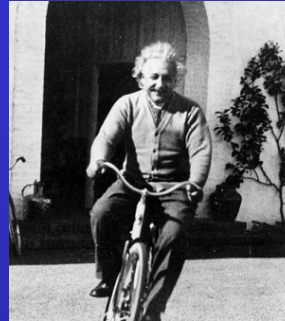
# Physics Skills

Tim Freegarde



# Physics skills

- BECOME A BETTER PHYSICIST...



- GRADUATE WITH A BETTER DEGREE CLASS...



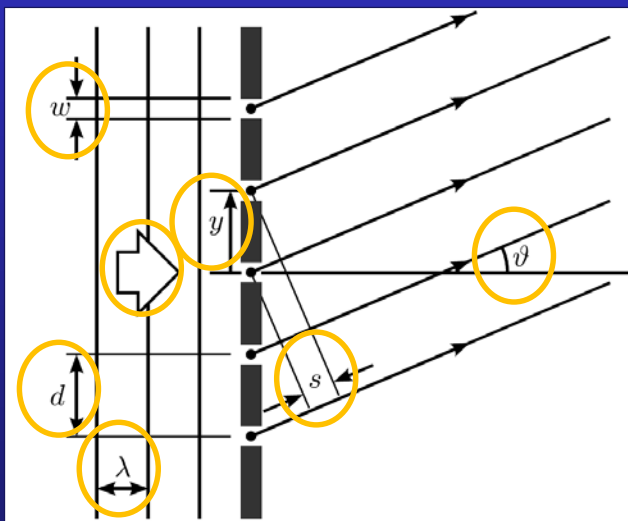
- GENERAL AIMS:

- identify physics in a physical situation
- apply physical laws, logical deduction and mathematics
- analyse qualitatively and quantitatively
- compare theory with experiment, or predict what happens next

# Physics skills

## I. IDENTIFY PHYSICS IN A PHYSICAL SITUATION...

- parse the question
- draw a diagram representing the information provided



- **QUESTION TERMINOLOGY**
  - State, What, Identify, Express, Find
    - *no derivation required*
  - Explain, Describe, How
    - *in words...*
  - Derive, Prove, Show that, Determine
    - *state assumptions, proceed logically*
  - Evaluate, Indicate, Calculate, Estimate
    - *numbers, with clear assumptions*
  - Sketch
    - *as it says...*

# Physics skills

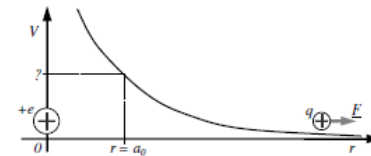
## 2. APPLY PHYSICAL LAWS, LOGICAL DEDUCTION & MATHEMATICS

### • STRUCTURE OF A DERIVATION

- diagram
  - *establishes problem, defines parameters, visualizes question*
- **fundamental principles**
  - *physical laws and general assumptions*
- **particular assumptions**
  - *approximations, values, regime limitations*
- **mathematics**
  - *tautologies which introduce no new physical information but*

### EXERCISE

Calculate the electric potential established by the nucleus of a hydrogen atom at the average distance ( $a_0 = 5.29 \times 10^{-11}$  m) of the atom's electron (taking  $V = 0$  at infinite distance).



The force  $F$  exerted upon a charge  $q$  by a charge  $+e$  at a distance  $r$  is given by Coulomb's law

$$F = \frac{qe}{4\pi\epsilon_0 r^2}$$

The potential energy of two charges is given by the work done to bring them together, where the work done against a force is equal to the force  $\times$  distance moved against the force

$$\Delta E = E_2 - E_1 = F(-\Delta r)$$

The potential energy of our two charges, when separated by  $a_0$ , is therefore given by

$$E_{a_0} - E_{\infty} = - \sum_{r=\infty}^{r=a_0} F \Delta r$$

where the force  $F$  depends upon the separation  $r$ . We must therefore cast this as an integral,

$$E_{a_0} - E_{\infty} = - \int_{\infty}^{a_0} F dr$$

which, inserting the particular form of the force from Coulomb's law, gives

$$\begin{aligned} E_{a_0} - E_{\infty} &= \int_{\infty}^{a_0} \frac{-qe}{4\pi\epsilon_0 r^2} dr \\ &= \frac{-qe}{4\pi\epsilon_0} \int_{\infty}^{a_0} r^{-2} dr \\ &= \frac{qe}{4\pi\epsilon_0} \left[ \frac{1}{r} \right]_{\infty}^{a_0} \\ &= \frac{qe}{4\pi\epsilon_0} \left( \frac{1}{a_0} - \frac{1}{\infty} \right) \\ &= \frac{qe}{4\pi\epsilon_0 a_0} \end{aligned}$$

# Physics skills

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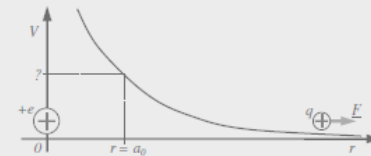
### • DERIVATIONS SHOULD BE

- logical
- rigorous



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The potential energy of two charges is given by the work done to bring them together, where the work done against a force is equal to the force  $\times$  distance moved against the force.

The electric potential  $V$  is defined as the electrostatic potential energy per unit charge, ie

$$V = \frac{E}{q}$$

$$= V_{a_0} - V_{\infty} = \frac{e}{4\pi\epsilon_0 a_0}$$

and we may assume that  $V = 0$  at  $r = \infty$ , so

$$V_{\infty} = 0$$

hence

$$V_{a_0} = \frac{e}{4\pi\epsilon_0 a_0}$$

Given the specific values  $e = 1.60 \times 10^{-19}$  C  
 $\epsilon_0 = 8.85 \times 10^{-12}$  F.m<sup>-1</sup>  
 $a_0 = 5.29 \times 10^{-11}$  m,

we obtain

$$V_{a_0} = \frac{1.6 \times 10^{-19} \text{ C}}{4\pi \times 8.85 \times 10^{-12} \times 5.29 \times 10^{-11} \text{ F.m}^{-1} \cdot \text{m}} = 27.2 \text{ C.F}^{-1}$$

i.e.

$$\underline{\underline{V_{a_0} = 27.2 \text{ V}}}$$

# Physics skills

## 3. ANALYSE QUALITATIVELY AND QUANTITATIVELY

- **APPLY and USE CONSISTENTLY:**
  - vectors
  - symbols/variables
  - definite integrals (especially  $>1D$ )
  - differentiation (especially products, powers, functions of functions)
- **SKETCH or PLOT GRAPHS**
  - label axes
  - show asymptotes/trends
  - plot specific values
  - label important features

# Physics skills

## 4. COMPARE THEORY WITH EXPERIMENT or PREDICT WHAT HAPPENS NEXT

- NUMERICAL VALUES AND INTERPRETATION

- units
- precision, uncertainty

- COMMENTARY

- required to explain logic, assumptions, interpretation, conclusions
- clarity and accuracy of language essential

<http://phyweb.phys.soton.ac.uk/quantum/writing.php>

# Physics skills

- COURSEWORK RECORD CARD**

- feedback and progress
- attach to every set of coursework

- RESOURCES**

- advice in lab manuals
- examples in every textbook

[www.southampton.ac.uk/~evans/PHYS-Skills/](http://www.southampton.ac.uk/~evans/PHYS-Skills/)

PHYS2023 Wave Physics  
2017-18

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exercise sheet	structure / layout / diagrams	assumptions	rigour / logic	commentary / discussion	care / legibility	precision / uncertainty	general comments	initials
1	✓	✗	✓	✓			Make sure to include and label all information from question.	JW
2	✓	✓	✓	✓	✓	✗	Consider errors and give values to appropriate precision	TS
3	✓	+	✓	✓		✓	Diagram excellent!	BB
4								
5								
6								
7								
8								
9								
10								
11								

+ excellent    ✓ satisfactory    ✗ requires improvement    (blank if not applicable)