Physics Skills
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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
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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…*
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 \( r_0 = 5.29 \times 10^{-11} \) 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

\[
F = \frac{q \cdot e}{4\pi \varepsilon_0 r^2}
\]

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 \( \cdot \) distance moved against the force

\[
\Delta E = E_i - E_f = F \cdot \Delta r
\]

The potential energy of our two charges, when separated by \( r_0 \), is therefore given by

\[
E_{\text{pot}} = E_f - E_i = \sum F \cdot \Delta r
\]

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

\[
E_{\text{pot}} = \frac{q \cdot e}{4\pi \varepsilon_0} \int_0^{r_0} F \, dr
\]

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

- **DERIVATIONS SHOULD BE**
  - logical
  - rigorous

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**EXERCISE**

Calculate the electric potential established by the nucleus of a hydrogen atom at the average distance $(a_0 = 5.29 \times 10^{-11} \text{ m})$ 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:

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

The potential energy of two charges is given by the work done to bring them together, where the work done between a thens to each of the forces $F$ distance should be zero.

The electric potential $V$ is defined as the electrostatic potential energy per unit charge, i.e.

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

Thus,

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

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

$$V_n = 0$$

hence

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

Given the specific values:

- $e = 1.60 \times 10^{-19} \text{ C}$
- $E = 8.85 \times 10^{-12} \text{ F.m}^{-1}$
- $a_0 = 5.29 \times 10^{-11} \text{ m}$

we obtain

$$V_n = \frac{1.6 \times 10^{-19}}{4\pi \times 8.85 \times 10^{-12} \times 5.29 \times 10^{-11}} \text{ C.m}$$

I.e.

$$V_n = 27.2 \text{ V}$$
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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
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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/