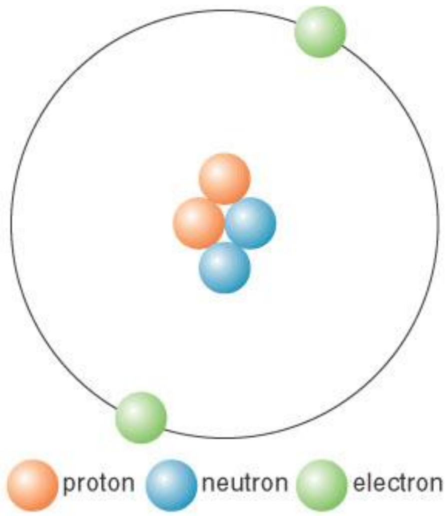
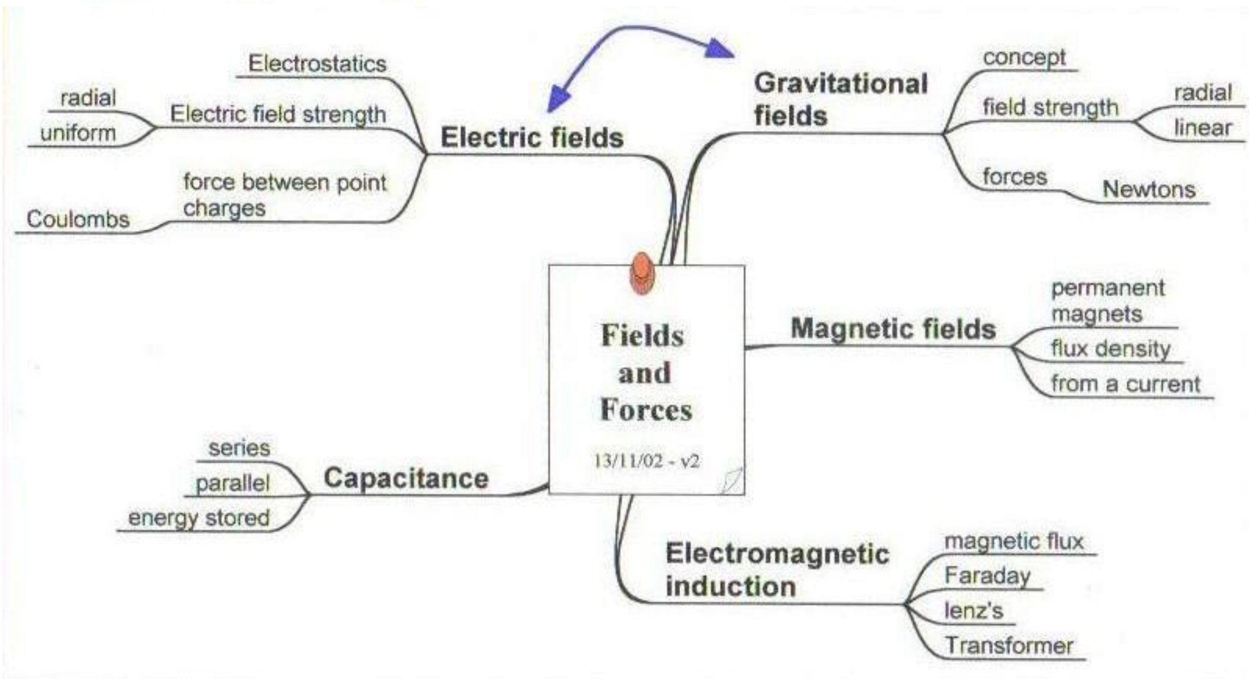

proton
neutron
electron


Fields and Forces
13/11/02 - v2
Electric fields
Electrostatics
Electric field strength
radial
uniform
force between point charges
Coulombs
Gravitational fields
concept
field strength
radial
linear
forces
Newtons
Magnetic fields
permanent magnets
flux density
from a current
Capacitance
series
parallel
energy stored
Electromagnetic induction
magnetic flux
Faraday
lenz's
Transformer

$\rho = \frac{m}{V}$ $\frac{1}{2}(u+v) = \frac{x}{t}$ $a = \frac{v-u}{t}$ $F = ma$

$v = \frac{d}{t}$

$p = mv$ $\Delta W = F \Delta x$ $P = \frac{W}{t}$

work done = energy transfered

weight = mg $KE = \frac{1}{2}mv^2$ $\Delta PE = mg\Delta h$

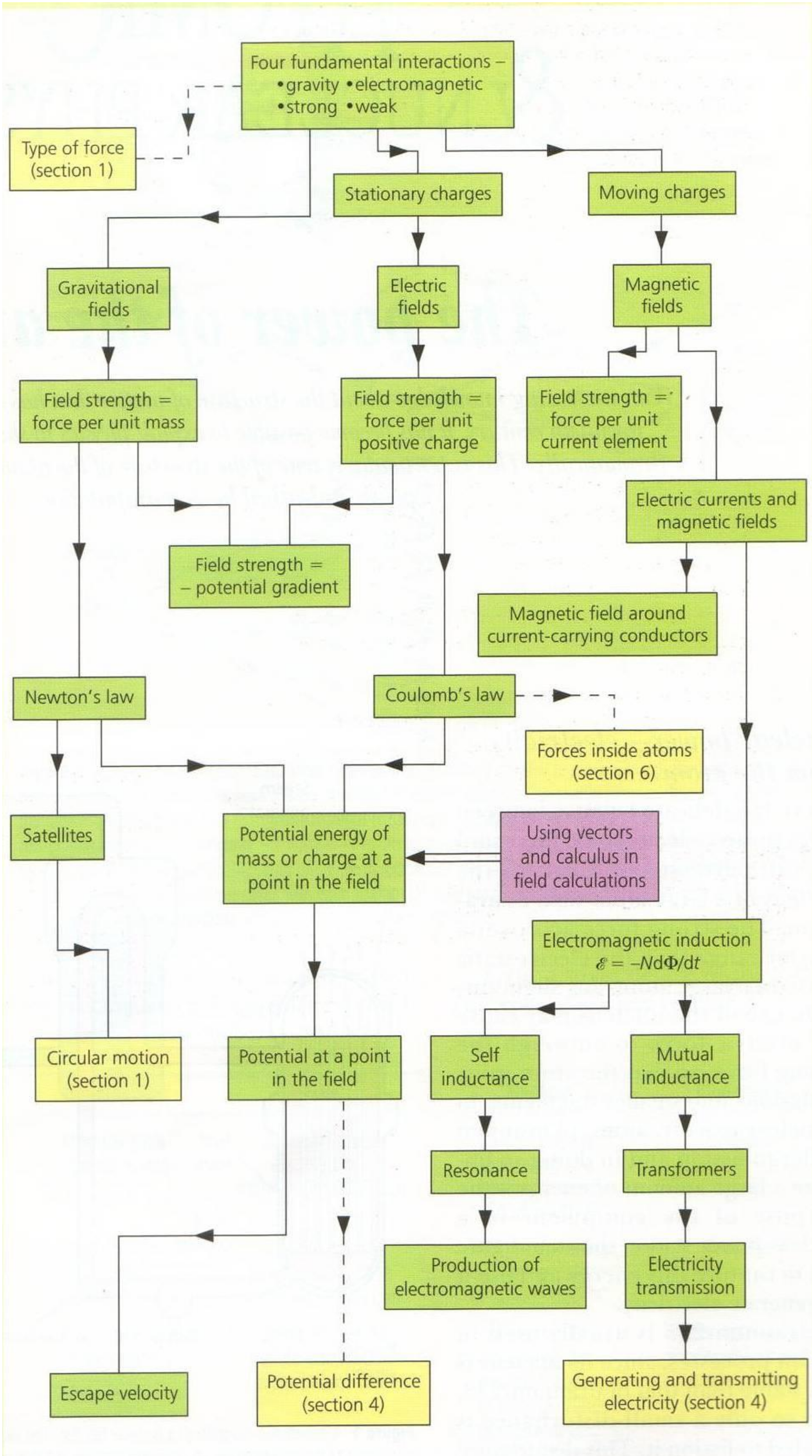
Potential difference

$Q = It$ $V = \frac{W}{Q}$ $V = IR$ $V = f\lambda$

$P = VI$ $W = VIt$ $R = \frac{\rho l}{A}$ $F = \frac{mv^2}{r}$

$F = \frac{G m_1 m_2}{r^2}$ $F = \frac{k q_1 q_2}{r^2}$ $C = \frac{Q}{V}$ $\frac{V_1}{V_2} = \frac{N_1}{N_2}$

$k = \frac{1}{4\pi\varepsilon_0}$



Four fundamental interactions – •gravity •electromagnetic •strong •weak
Type of force (section 1)
Stationary charges
Moving charges
Gravitational fields
Electric fields
Magnetic fields
Field strength = force per unit mass
Field strength = force per unit positive charge
Field strength = force per unit current element
Electric currents and magnetic fields
Field strength = – potential gradient
Magnetic field around current-carrying conductors
Newton's law
Coulomb's law
Forces inside atoms (section 6)
Satellites
Potential energy of mass or charge at a point in the field
Using vectors and calculus in field calculations
Electromagnetic induction
$\mathcal{E} = -Nd\Phi/dt$
Circular motion (section 1)
Potential at a point in the field
Self inductance
Mutual inductance
Resonance
Transformers
Production of electromagnetic waves
Electricity transmission
Escape velocity
Potential difference (section 4)
Generating and transmitting electricity (section 4)

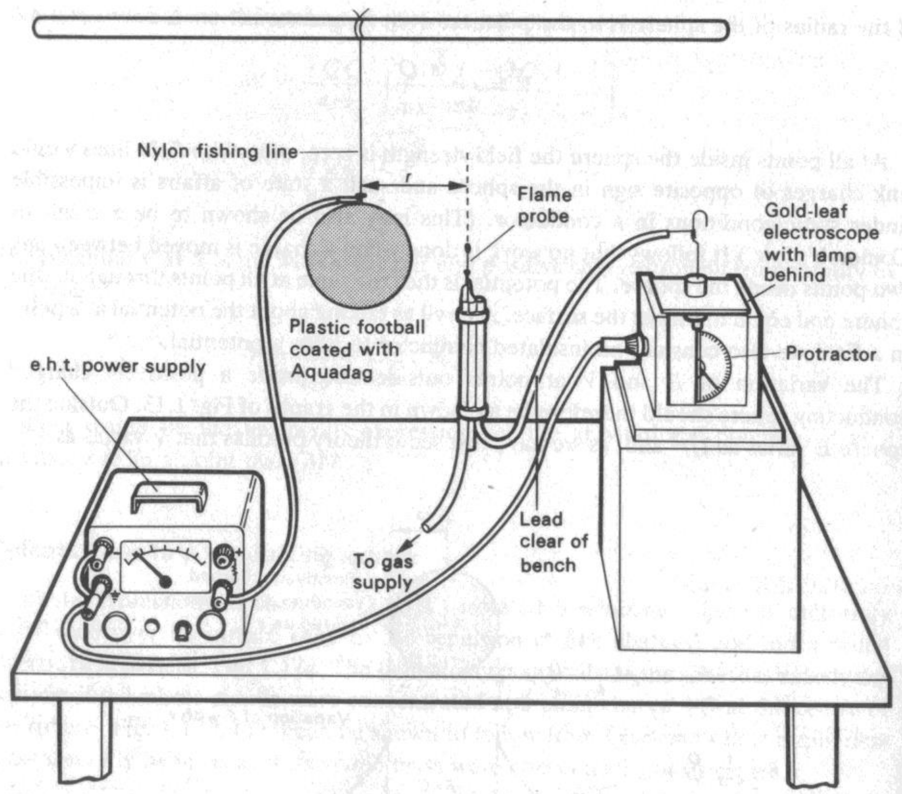

Nylon fishing line
r
Flame probe
Gold-leaf electroscope with lamp behind
Plastic football coated with Aquadag
e.h.t. power supply
Protractor
Lead clear of bench
To gas supply

Fig. 1.14

- $v = \frac{d}{t}$ — velocity; distance; time
- $\rho = \frac{M}{V}$ — density; mass; Volume
- $\frac{1}{2}(v+v) = \frac{x}{t}$ — starting velocity; velocity; distance; time
- $a = \frac{v-u}{t}$ — acceleration; velocity; initial velocity; time
- $F = ma$ — Force; mass; acceleration
- $p = mv$ — momentum; mass; velocity
- $\Delta W = F\Delta x$ — Force; distance
  - work done = energy transferred
- $P = \frac{W}{t}$ — Power; Energy; time
- $\text{weight} = mg$ — mass; acceleration due to gravity
- $KE = \frac{1}{2}mv^2$ — Kinetic Energy; mass; velocity
- $\Delta PE = mg\Delta h$ — Potential Energy; mass; change in height; acceleration due to gravity
- $Q = It$ — Charge; time; current
- $V = \frac{W}{Q}$ — Potential difference; work done; charge
- $V = IR$ — voltage; Resistance; current
- $V = f\lambda$ — wavelength; frequency; velocity
- $P = VI$ — Power; Voltage
- $W = VIt$ — work done; Voltage; current; time
- $R = \frac{\rho l}{A}$ — Resistance; resistivity; length; area
- $F = \frac{mv^2}{r}$ — Force; mass; velocity; radius
- $F = \frac{G m_1 m_2}{r^2}$ — Force; Gravitational constant; mass; distance
- $F = \frac{k q_1 q_2}{r^2}$ — charge; $k = \frac{1}{4\pi\epsilon_0}$
- $C = \frac{Q}{V}$ — Capacitance; Charge; voltage
- $\frac{V_1}{V_2} = \frac{N_1}{N_2}$ — Voltage; Number of coils

Device:	Radiation:	Details of use:		
Endoscope	Visible light	Viewing inside stomach, intestines etc	TIR down optical fibres	Safety Ease of use Frequency / wave length Intensity Penetration Ionising / non-ionising
CAT scanner	X-Rays	See 3D images of bones or soft tissues.	A computer builds up 3D images	
Fluoroscope	X-Rays	Positioning catheters or stents in body	Video camera produces real time images	
Thermal imager/IR Thermometer	IR	Detects infections, muscle injuries	More IR produced from warmer parts of body. IR camera produces a map.	
Pulse Oximeter	Red/IR	Measure oxygen levels in the blood.	Light passed through finger and absorbed by blood	
PET Scanner	Gamma	Detecting Cancers	Electron/positron annihilation	
X-Ray machine	X-Rays	Broken bones	X-Rays absorbed more by hard tissues, pass through soft ones.	
Gamma Camera	Gamma	Viewing soft, internal organs	A radioactive source is injected. Gamma rays given off are detected by special film.	

Angle /°	Numbers proportional to number of particles scattered at more than ϕ
120	154
105	266
90	448
75	767
60	1 384
45	2 811
30	7 725
15	458 000

Testing the analogue by graph

The hill is shaped so that the height is proportional to $1/r$ (see figure 3) and will provide an exact gravitational analogue of the repulsive electric field around a nucleus. If results show that a moving ball is deflected by this hill in the way that α-particles are deflected by gold nuclei, we can obtain clear support for the idea that α-scattering is produced by an electrically charged nucleus.

If the hill is a good model, the relation between p^2 and the angle ϕ for the hill should be the same as the relation between the *number of α-particles* scattered through more than ϕ and the angle ϕ. The data calculated from Geiger and Marsden's results is given in the table left.

Plot a graph of number of α-particles scattered at more than an angle ϕ (y-axis) against the angle ϕ (x-axis).

A graph of p^2 against ϕ for measurements made with the hill should have just the same shape as the graph from Geiger and Marsden's data for α-scattering.

However, the two sets of data have to be brought onto a common scale. To do this, we will make the two sets of results fit at one point and then see if the rest fall into line.

From your results select p_1, one value of p which produces a scattering angle of between 25° and 40°. We will call this angle ϕ_1. (Select a value of scattering angle ϕ_1 in the middle of the curve.) From your graph record N_1, the number of particles which are scattered through an angle of more than ϕ_1 (see figure 4). To make the vertical scale the same for both sets of results, the values of p^2 must be multiplied by a factor k.

$$k = \frac{N_1}{p_1^2}$$

Calculate k. Record the corrected values of p^2 where corrected value of $p^2 = k \times$ actual value of p^2.

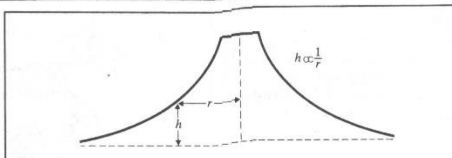


Figure 3

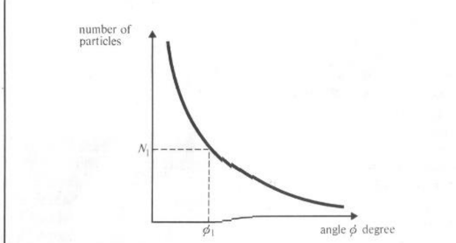


Figure 4

Plot a graph of the 'corrected values of p^2' against ϕ on the graph of number of α-particles scattered at more than any angle ϕ against ϕ (using the same axes).

Conclusions

Compare the graph you have obtained from the analogue experiment with the graph you have plotted from Geiger and Marsden's results. Say whether *your* results support the speculation that an α-particle is scattered near a nucleus by an electrical force which varies as $1/r^2$.