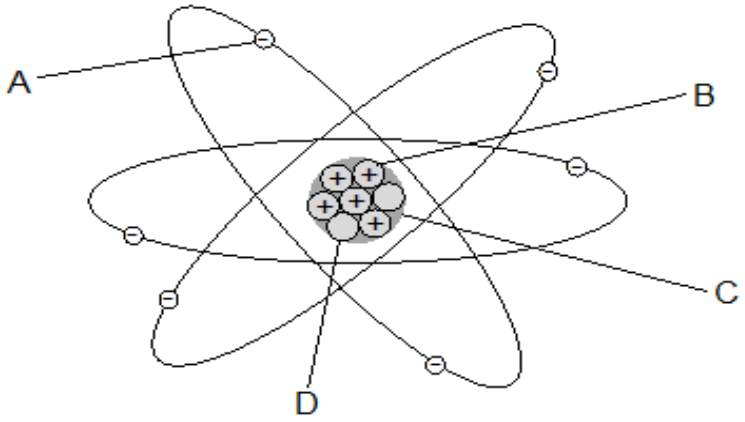
Higher Physics

Unit 2 : PARTICLES & WAVES

The Standard Model

Orders of Magnitude

1. The diagram shows a simple model of the atom.



Match each of the letters A, B, C and D with the correct word from the list below.

electron **neutron** **nucleus** **proton**

2. In the following table the numbers or words represented by the letters A, B, C, D, E, F and G are missing.

Order of magnitude/m	*Object*
10^{-15}	A
10^{-14}	B
10^{-10}	Diameter of hydrogen atom
10^{-4}	C
10^{0}	D
10^{3}	E
10^{7}	Diameter of Earth
10^{9}	F
10^{13}	Diameter of solar system
10^{21}	G

Match each letter with the correct words from the list below.

diameter of nucleus **diameter of proton** **diameter of Sun**

distance to nearest galaxy **height of Ben Nevis**

size of dust particle **your height**

Use these answers for questions 3 to 7

A. 10^{-3} m
B. 10^{-1} m
C. 10^{0} m
D. 10^{1} m
E. 10^{2} m

3. The approximate length of a high school science lab is…

4. The approximate width of the door to the lab is…

5. The approximate height of a first year pupil in the lab is…

6. The approximate thickness of a human hair is…

7. The approximate length of a football park…

8. Compare the distance from Paris to Berlin, which is approximately 1000 kilometres, with the length of a running track, which is 100 metres, in terms of orders of magnitude.

9. Compare the mass of a bison, which is 1000 kilograms, with the mass of a mouse, which is 10 grams, in terms of orders of magnitude.

10. Compare the mass of an African bush elephant, which is 7000 kilograms with the mass of Mr McFarlane, who is 85 kilograms, in terms of orders of magnitude.

11. Compare the height of Mount Everest, which is 8848 metres, with the height of a redwood tree, which is 76 metres, in terms of orders of magnitude.

12. Compare the mass of a star, which is 4.83×10^{30} kilograms, with the mass of an exoplanet, which is 5.69×10^{27} kilograms, in terms of order of magnitude.

13. Compare the mass of the Higgs boson, which is 2.2×10^{-25} kilograms, with the mass of an electron, which is 9.1×10^{-31} kilograms, in terms of order of magnitude.

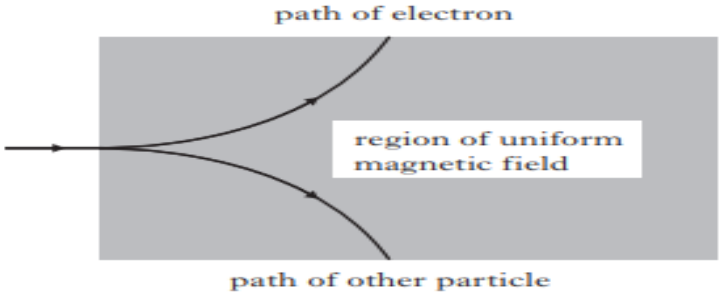
The Standard Model of Fundamental Particles and Interactions

1. Name the particles represented by the following symbols.

   (a) p (b) $\bar{p}$ (c) e

   (d) $\bar{e}$ (e) v (f) $\bar{v}$

2. An electron and another particle of identical mass pass through a uniform magnetic field. Their paths are shown in the diagram below.



   What does this observation provide evidence of?

3. (a) Explain what is meant by the term *fundamental particle*.

   (b) State the name given to the group of matter particles that contains quarks and leptons.

4. Construct a table with the headings quarks and leptons and place the particles in the list below in the correct column of the table.

bottom	**charm**	**down**	**electron neutrino**
muon	**strange**	**tau**	**muon neutrino**
tau neutrino	**top**	**electron**	**up**

5. (a) State the difference between a hadron and a lepton in terms of the type of force experienced by each particle.

   (b) Give one example of a hadron and one example of a lepton.

6. A student makes the following statement.

All baryons are hadrons, but not all hadrons are baryons.

Explain why this statement is correct.

7. Information on the sign and charge relative to proton charge of six types of quarks (and their antiquarks) is shown in the table.

Quark name	*Charge relative to size of proton charge*	*Antiquark name*	*Charge relative to size of proton charge*
up	+2/3	antiup	–2/3
charm	+2/3	anticharm	–2/3
top	+2/3	antitop	–2/3
down	–1/3	antidown	+1/3
strange	–1/3	antistrange	+1/3
bottom	–1/3	antibottom	+1/3

Calculate the charge of the following combinations of quarks:

(a) two up quarks and one down quark
(b) one up quark and two down quarks
(c) two antiup quarks and one antidown quark
(d) one antiup quark and two antidown quarks.

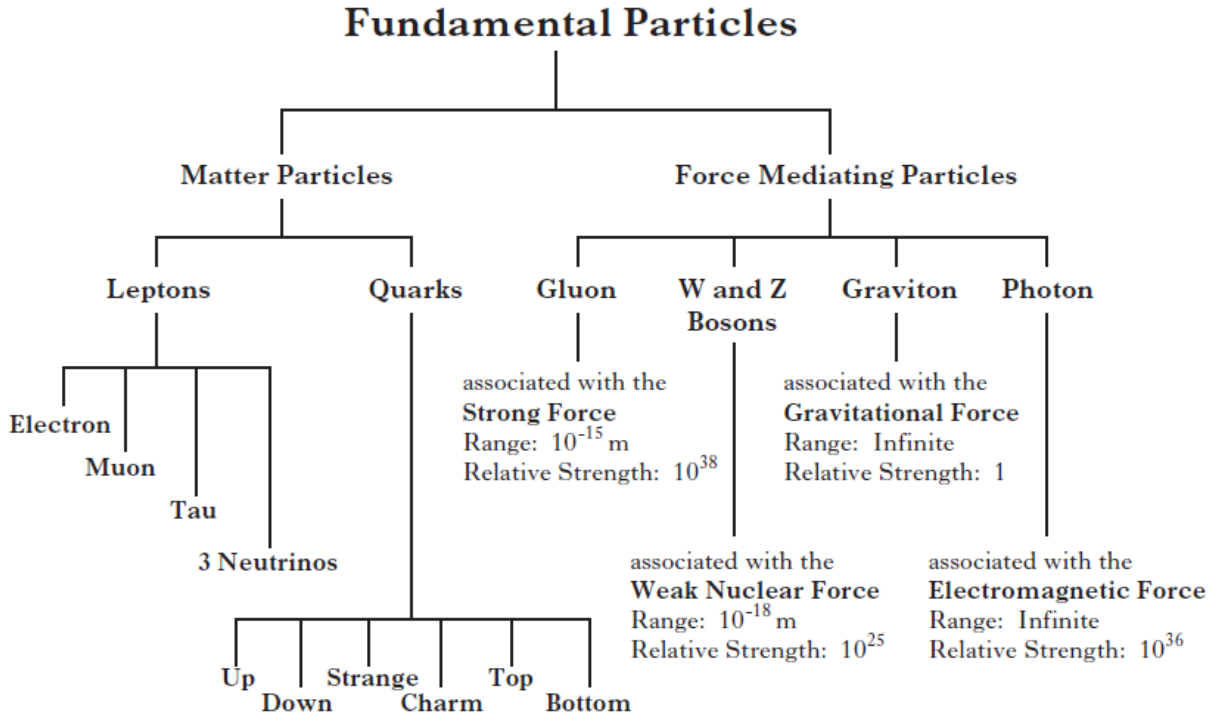
8. Neutrons and protons are considered to be composed of quarks.

(a) How many quarks are in each neutron and in each proton?
(b) Comment briefly on the different composition of the neutron and proton.

9. (a) Briefly state any differences between the 'strong' and 'weak' nuclear forces.
(b) Give an example of a particle decay associated with the weak nuclear force.
(c) Which of the two forces, strong and weak, acts over the greater distance?

10. Explain how the emission of beta particles in radioactive decay provides evidence for the existence of neutrinos.

11. The following diagram gives information on the Standard Model of Fundamental Particles and Interactions.



Use information from the diagram and your knowledge of physics to answer the following questions.

(a) Explain why particles such as leptons and quarks are known as *Fundamental Particles*.

(b) The Standard Model classifies *force mediating particles* as bosons.
Name the boson (i) associated with the electromagnetic force;
(ii) that is the mediating particle for the strong force.

(c) Explain why the gluon cannot be the force mediating particle for the gravitational force.

(d) A particle called the sigma plus has a charge of +1. It contains two different types of quark. It has two up quarks each having a charge of $+\frac{2}{3}$ and one strange quark. What is the charge on the strange quark?