The Standard Model 3: Particle calculations

Components

	NAME	DESCRIPTION	AUDIENCE
	Particle calculations teacher guide	This guide suggests questions that may be used by students to develop their understanding of particle physics.	teachers
	Working with particles worksheet	This student worksheet contains questions about particles and their properties.	students

Purpose

Students reinforce their explanations of particle physics through calculations in the context of the Large Hadron Collider.

Outcomes

Students:

- use experimental data to calculate particle properties;
- calculate particle motion in a magnetic field;
- interpret tracks in a bubble chamber.

Activity summary

ACTIVITY	POSSIBLE STRATEGY
Students complete worksheet, *Working with particles*.	individual
Class discussion of points arising from worksheet.	whole class

Teacher notes

Question 1 in the worksheet uses the context of mesons created by proton-proton collision in the Large Hadron Collider to explore time dilation. Mesons are short-lived particles, with a mean lifetime of 1.5×10^{-12} s. However their tracks in the LHC are around 1 cm long. Even at the speed of light we might expect mesons to decay before they have travelled 0.05 cm.

The anomaly is explained because time is dilated for a fast-moving meson, from the point of view of the stationary observer who measures the 1 cm track. The Lorentz equation for time dilation can be used to determine what factor of v/c gives rise to the observed dilation. See worksheet answers for details of the calculation.

Question 2 also uses the LHC as a context, comparing the total beam energy to the kinetic energy of a Transperth train. Students have to convert between energy units of electron-volts and joules.

Questions 3 and **4** explore motion of charged particles in a magnetic field. The first of these questions introduces derivation of the formula to calculate radius of curvature by equating the force on a charged particle moving perpendicular to a magnetic field:

$F = q\,v\,B$

and the centripetal force of an object undergoing circular motion:

$F = m\,v^2 / r$

Rearranging, this gives:

$r = m\,v / q\,B$

Question 4 is a qualitative analysis of particle tracks in a bubble chamber. Direction of curvature of tracks is used to infer charge on particles and demonstrate charge conservation.

Technical requirements

The teacher guide and worksheet require Adobe Reader (version 5 or later), which is a free download from www.adobe.com. The worksheet is also available in Microsoft Word format.

Acknowledgements

Designed and developed by the Centre for Learning Technology, The University of Western Australia. Production team: Jenny Gull and Michael Wheatley.

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Associated SPICE resources

The Standard Model 3: Particle calculations may be used in conjunction with related SPICE resources to teach the topic of the Standard Model.

DESCRIPTION	LEARNING PURPOSE
The Standard Model (overview) This learning pathway shows how a number of SPICE resources can be used in teaching students about the Standard Model.	
The Standard Model 1: Big physics Students watch a TED talk on the Large Hadron Collider. What do scientists hope to discover with this machine?	**Engage**
The Standard Model 2: Structure of matter A series of presentations guide discussion of the fundamental building blocks of the Universe.	**Explore**
The Standard Model 3: Particle calculations Students perform calculations using properties of fundamental particles.	**Explain**
The Standard Model 4: Quantum approach A presentation introduces a quantum view of particle interactions.	**Elaborate**