Name of the Student:_____
Max. Marks : 17 Marks **Time : 17 Minutes**

Mark Schemes

Q1.

Question Number	Acceptable Answers		Additional guidance	Mark
a	• fundamental – quarks and leptons	(1)	MP2 and 3 could be given for a named particle and its quark composition	5
	• Baryons made of 3 q	(1)		
	• Mesons made of quark and antiquark	(1)	Can be inferred if either set named	
	• 6 quark **Or** 6 leptons	(1)		
	• Each particle has an antiparticle	(1)		

Question Number	Acceptable Answers		Additional guidance	Mark
b	• Use of $\Delta E = \Delta mc^2$	(1)	Example of calculation: $E = 2.2\times10^{-25}\text{kg}\times(3.0\times10^{8})^{2}(\text{ms}^{-1})^{2}$ $E = 1.98\times10^{-8}\text{J}$ $E = 1.98\times10^{-8}\text{J}\div1.6\times10^{-19}\text{JeV}^{-1}$ $E = 124\times10^{9}\text{eV}$	3
	• Conversion of J to eV	(1)		
	• mass = 120 GeV/c^2	(1)		

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Question Number	Acceptable Answers	Additional guidance	Mark
c(i)	• Energy (of protons) converted to mass (of Higgs) **Or** Energy is required to overcome electrostatic repulsion between protons (1) • Reference to $E = mc^2$ (can be written in any form) (1) • Because c^2 is very large (E must be large) **Or** Higgs particle is massive so needs a lot of energy to create it (1)	Alternative based on numerical values: Observation that Higgs mass is 120 GeV/c^2 This requires an energy of at least 120 GeV Each beam of protons would need an energy of at least 60 GeV	3
c(ii)	• Use of circumference = $2\pi r$ (1) • Use of $p = Bqr$ (1) • $p = 5.7 \times 10^{-15}$ Ns (1)	Example of calculation: $r = 27000 \div 2\pi$ $r = 4300$ m $p = 8.3\text{T} \times 1.6 \times 10^{-19}\text{C} \times 4300\text{m}$ $p = 5.7 \times 10^{-15}$ Ns	3
ciii	0 (1)	zero	1

Question Number	Acceptable Answers	Additional guidance	Mark
d	• High speeds **Or** relativistic (1) • Mass (of proton) increases (1) • **Or** this equation is only valid at non-relativistic speeds	Alt: speeds close to speed of light	2

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