

Question 17

(8 marks)

The elementary particles of the Standard Model are shown below.

Mass →	$\approx 2.3 \text{ MeV}/c^2$	$\approx 1.275 \text{ GeV}/c^2$	$\approx 173.07 \text{ GeV}/c^2$	0	$\approx 126 \text{ GeV}/c^2$
Charge →	$2/3$	$2/3$	$2/3$	0	0
Spin →	$1/2$	$1/2$	$1/2$	1	0
	u up	c charm	t top	g gluon	H Higgs boson
Quarks	$\approx 4.8 \text{ MeV}/c^2$	$\approx 95 \text{ MeV}/c^2$	$\approx 4.18 \text{ GeV}/c^2$	0	
	$-1/3$	$-1/3$	$-1/3$	0	
	$1/2$	$1/2$	$1/2$	1	
	d down	s strange	b bottom	γ photon	
Leptons	$0.511 \text{ MeV}/c^2$	$105.7 \text{ MeV}/c^2$	$1.777 \text{ GeV}/c^2$	$91.2 \text{ GeV}/c^2$	
	-1	-1	-1	0	
	$1/2$	$1/2$	$1/2$	1	
	e electron	μ muon	τ tau	Z Z boson	
	$<2.2 \text{ eV}/c^2$	$<0.17 \text{ MeV}/c^2$	$<15.5 \text{ MeV}/c^2$	$80.4 \text{ GeV}/c^2$	
	0	0	0	± 1	
	$1/2$	$1/2$	$1/2$	1	
	ν_e electron neutrino	ν_μ muon neutrino	ν_τ tau neutrino	W W boson	
				Gauge bosons	

(a) If up (u) and down (d) quarks are the building blocks of nucleons, suggest a combination of three quarks that would produce a

(i) proton: _____ (1 mark)

(ii) neutron: _____ (1 mark)

(b) Identify **one** type of gauge boson and describe its role in the nucleus. (2 marks)

- (c) Muons and taus are created in a particle accelerator and accelerated to the same velocity. Sketch their paths if the two particles were directed into a magnetic field as shown in the diagram below. (4 marks)

