Practical 1 – Option H

This also could cover Option J if students have some knowledge of relativity.

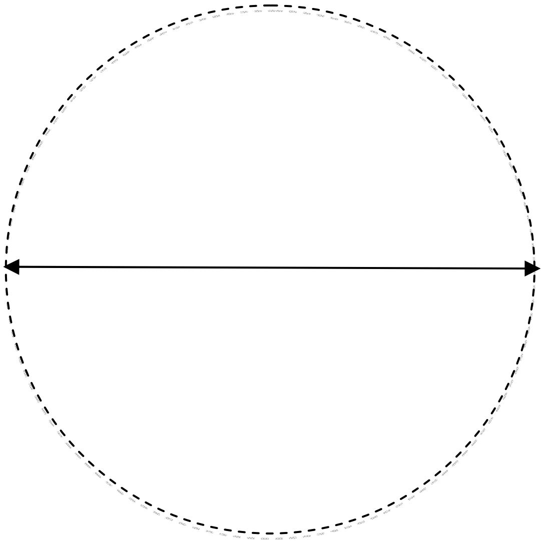
This practical exercise is adapted from the excellent *Onscreen Science*, Particle Physics. For more information, see http://www.onscreen-sci.com/

Relativistic decay of a charged pion

A charged pion of mass 140 MeV c^{-2} and momentum 13.0 MeV c^{-1} enters a region of magnetic field 0.0800 T at right angles to the magnetic field.

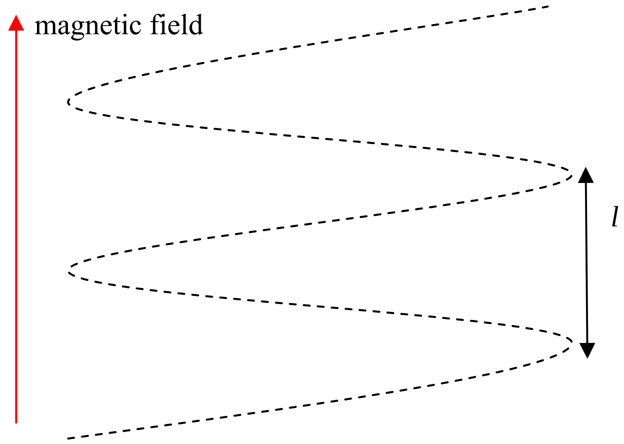
The pion decays into one charged particle and one neutral particle. The path of the charged particle is shown in the two diagrams below.

The first diagram shows the path on the *x*-*y* plane (the plane normal to a magnetic field). It is a circular path with diameter *D* measured to be 232.5 cm.



- Calculate the component P_T of momentum of the charged particle on the *x*-*y* plane using the circular path. The momentum, in MeV c^{-1}, is given by $p = 3BR$, where *B* is in Tesla and *R* in cm. The charge of the particle is assumed to be 1 electronic charge. (You need to verify this statement.)

The path projected in a direction along the magnetic field is shown below. The distance l travelled along the magnetic field during one period is 47.5 cm.



- Explain why $P_z = P_T \dfrac{l}{\pi D}$.
- Calculate the momentum along the magnetic field.
- Hence calculate that the total momentum of the charged particle is 28.0 MeV c^{-1}.

Momentum conservation demands that $\vec{P}_\pi = \vec{P}_q + \vec{P}_0$ where $\vec{P}_q$ is the momentum of the charged particle and $\vec{P}_0$ is the momentum of the neutral particle.

- Show that the momentum of the neutral particle has a magnitude equal to 30.8 MeV c^{-1}.
- Explain why $140.6 = \sqrt{28.0^2 + (m_q c^2)^2} + \sqrt{30.8^2 + (m_0 c^2)^2}$ (energies in MeV) where m_q and m_0 are the masses of the charged and the neutral particle respectively.
- Deduce that $m_q c^2 = \sqrt{\left(140.6 - \sqrt{30.8^2 + (m_0 c^2)^2}\right)^2 - 28.0^2}$.
- Plot m_q versus m_0. (Let $c = 1$ to make your life easier.)

Look up a table of particle masses and estimate the values of m_q and m_0, explaining how you reached your answer.

