Particle Physics Masterclass Worksheet

Open a web browser and go to the Lancaster Particle Physics Package web site: http://lppp.lancs.ac.uk.

Click on "magnetic field" on the first screen of the Lancaster Particle Physics module.

Read through the "Introduction" page, then press "next".

Read through the revision material on the "Experiment" page. At the bottom of the page you will find the exercise. Press "Fire". You will see a simulation of what happens if an electron and a positron, from beams travelling in opposite directions with equal energies, collide and annihilate, producing two new particles which travel on circular tracks. Do this a few times to see the sort of things that happen. Do the two outgoing particles always move in opposite directions? Why?

Set the beam energy to 5 GeV. Vary the magnetic field strength using the slider. On the basis of what you see, how (roughly speaking) does the typical radius of curvature depend on the field strength? Why?

Vary the incident beam energy using the slider. On the basis of what you see, how (again roughly speaking) does the typical radius of curvature depend on the beam energy? Why?

Select 5 T and 2 GeV. Leave the field and beam energy at these values for the rest of the exercise. Press "Fire" to simulate an event and then "Measure Radius" to make a measurement of the radius of curvature. You do this by clicking with the mouse at 3 points along the track made by the 2 particles. (Why are the radii of the tracks caused by the two particles the same?) The best strategy is to measure a point at each end of the tracks and one in the middle. (Can you explain why this is the case?) The computer evaluates the radius of the circle passing through those 3 points. The result is displayed in the "Momentum Formula" box.

Click "Calculate" in the Momentum Formula box to determine the particle's momenta using the equation $\boldsymbol{p = 0.3Br}$.

According to the theory of relativity, the energy, momentum and rest-mass of a particle are related by $\boldsymbol{E^2 = p^2c^2 + m^2c^4}$. What does this reduce to if the particle's velocity is zero?

$\boldsymbol{E}$ = _____

If the units are chosen as GeV for energy, GeV/c for momentum and GeV/c^2 for mass, the equation above becomes $\boldsymbol{E^2 = p^2 + m^2}$. This formula can be rearranged to determine a particle's mass if its energy and momentum are known. Calculate the masses for the momentum values you found above by clicking "Calculate" in the Mass Formula box.

The masses of four types of particle that can be produced are:

Name	Symbol	Mass in GeV/c^2
Muon	μ	0.106
Pion	π	0.140
Kaon	K	0.494
Proton	p	0.938

Identify the four particles in your data. Is there any connection between the event colour and the particle type?

Colour μ_____Colour π_____Colour K_____Colour p_____

Once you have finished the magnetic field experiment, have a look at some of the other experiments on the LPPP web site; the "lifetime" exercise is another interesting one.

There is more material on Particle Physics on the web site http://www.particlephysics.ac.uk. For example, Brian Cox's television series can be found at http://www.particlephysics.ac.uk/teach/useful-links.html.