# Introduction

This booklet is a companion to the A-level computer software - 'Lancaster Particle Physics'. The software itself contains enough information to 'stand alone', but this booklet covers in greater depth the information and help pages contained within the program and it is recommended that, where possible, both are used in conjunction.

The software package is designed for use by students studying A-level modules in particle physics. Its main aim is to allow students to conduct particle physics experiments, in the classroom, via computer simulation (PC based). This booklet shows how to install and run the program and takes the user through each exercise in detail. The students should already be aware of most of the terminology and formulas, contained in the software, before starting the various exercises. Where needed, additional information and discussion is given and the derivation of some formulas shown, making the booklet of use to both students and teachers. However, if the user wishes to disregard this preamble then all the important formulas (those required for each exercise) are shown boxed for easy reference. In places the software introduces physics which goes beyond the A-level syllabus, this is intended to extend the students' knowledge and stimulate discussions.

The five sections of this booklet correspond to the five 'Options' in the software, of which the first four include exercises. It is estimated that each exercise will take a student between one and three hours to complete, but this is only a guide. The actual time will probably be influenced more by the teachers discretion and the availability of PC's than student ability.

Section 1 covers the exercise **'Billiards'** which re-familiarises the student with the conservation of energy and momentum in a <u>non</u>-relativistic system, i.e. when playing billiards or pool. Section 2, **'Particle Annihilation and Creation'**, compares i) stationary target experiments with ii) colliding beam experiments and serves as an introduction to the following options, which are all concerned with particle physics. Section 3, **'Charged Particle Motion in a Magnetic Field'**, allows the student i) to make measurements of charged particle tracks, ii) to use their knowledge of the <u>relativistic</u> equations of the conservation of energy and momentum to calculate the particle masses, iii) to identify the particles. Section 4, **'Lifetime'**, simulates the decay of the neutral particle, the kaon ( $K^0$ ), into two pions ( $p^+$ ,  $p^-$ ). The student can make measurements and use their data to determine i) the  $K^0$  mass and ii) mean lifetime. Finally Section 5, **'ALEPH'**, shows the students some real data from an ongoing experiment.

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ALEPH is one of four detectors at CERN detecting the debris from high energy electronpositron annihilations.

### **Computer Requirements:**

'Lancaster Particle Physics' is intended to be PC based. The minimum computer requirements are:

Computer:	IBM PC compatible 386, 486 or higher; with mouse.	
	Minimum 16 MHz CPU (33 MHz or higher recommended)	
Memory:	4MB (8MB recommended)	
Video:	VGA 16 colours, $640 \times 480$ resolution (or higher)	
Operating System:	DOS 5.0 or higher and Windows 3.1, 3.11 and Windows 95.	
Sound:	no sound card needed.	

### How to Install:

To install your copy of 'Lancaster Particle Physics'

1. Insert the distribution disk into your A: or B: drive.

2. Start Windows.

3. *Either*: from the Microsoft Windows Program Manager, select Run from the File menu and type:

#### a:setup

<u>*Or*</u>: run File Manager and open a window for the distribution disk in your A: or B: drive. Click on the file:

#### setup.exe

'Lancaster Particle Physics' will now be installed. Follow the dialogue boxes which ask you in which directory you want the software installed. If you have no preference then the installation program will create its own directory on your computer hard disk drive called 'collisn'. Once installation is complete a dialogue box will inform you; click the OK button.

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A window and program icon for 'Lancaster Particle Physics' will then appear. You can now remove the distribution disk.

(<u>Warning</u>: During installation you may get a message box which says that file A:\DDEML.DL\_ is already in use. Don't worry! If this happens click the OK button and the installation will continue as normal)

To Start 'Lancaster Particle Physics' double-click on the program icon with the mouse pointer.

### Navigating your way around 'Lancaster Particle Physics'

Upon starting 'Lancaster Particle Physics' you are presented with the Lancaster University logo page. Click the <u>OK</u> button and the logo page disappears to be replaced by the window shown in Figure I. As you can see this window contains a smaller window with text and four command buttons. This is the start-up page for the exercise 'Billiards'; the text describes how to run the exercise and what to calculate. (Each new option/exercise starts off with a text page and it is recommended that the student reads this before continuing)

- Lancaster Particle Physics			
<u>O</u> ptions <u>H</u> elp			
Billiards			
<ul> <li>► ELASTIC collision between a moving ball (white) with mass, m₁ and a stationary ball (red) with mass, m₂ = 3 kg. Click the <b>Graphics</b> button and then the <b>Eire</b> button to see this.</li> <li>&gt; The data boxes show the angles that the white and red balls make with the initial direction, after t' collision; θ, φ respective and the f' velocity of the white *</li> <li>&gt; Us your know Text Window of con Text Window of the white *</li> <li>&gt; Eire your Canculated value for m₁ in the data box and press return to display the Answer.</li> <li>&gt; You can change the relative masses of m₁ and m₂ by clicking on the <b>Option</b> buttons. You can change the incident velocity u₁ of the white ball by using the scroll bar. Experiment with different settings; calculating mass m₁ each time.</li> <li>&gt; To proceed onto the next graphics click the Mext button. (See the Help menu)</li> </ul>			
Exit (Back Next) Graphics			

<u>Exit</u>

Figure I 'Text window'

<u>G</u>raphics

Next >

< <u>B</u>ack

The four command buttons are:

• When you click the <u>G</u>raphics button a new window is displayed as shown in Figure II. This is the graphics window associated with the 'Billiards' option. (Each new option/exercise has a graphics window which can be opened by clicking the <u>G</u>raphics button in the text window. It is in these graphics windows that the simulations of particle interactions take place)

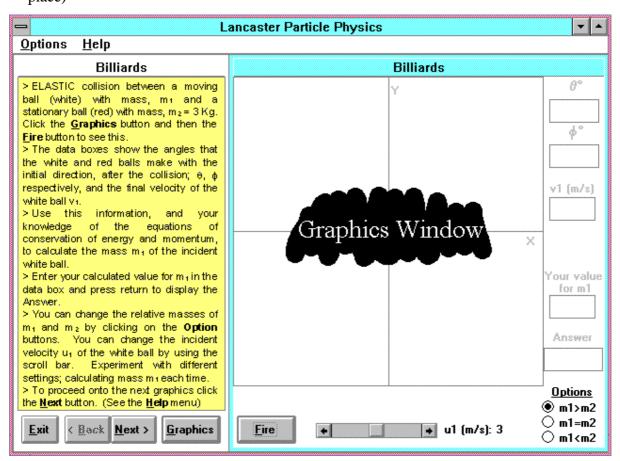


Figure II 'Graphics window'

- When you click the <u>N</u>ext button you move on to the next option/exercise and a new text box appears. (All previous windows for the last option are automatically closed. In essence each option or exercise is a mini self-contained program)
- When you click the <u>Back</u> button you move back to the previous option/exercise. In 'Billiards' the <u>Back</u> button is disabled and inoperative (appearing dimmed) because there are no previous exercises. (Once you click the <u>Next</u> button the next option/exercise is loaded and the <u>Back</u> button is now enabled. Hence by clicking the <u>Next</u> and <u>Back</u> buttons

one can move sequentially, forwards or backwards, through the various sections of 'Lancaster Particle Physics')

• To terminate the program click the  $\underline{E}xit$  button.

<u>Note</u>: the underline on the prefix character of the command buttons allows the user to either click the button, using the mouse and mouse pointer, or press Alt-*key* (where *key* is the underlined character).

Alternatively by pressing the Tab key the user can move the keyboard focus from control to control. You can easily recognise when a control has the focus: when a command or option button has the focus, a dashed rectangle surrounded its caption; when a scroll bar has the focus, its thumb starts to blink; when a text box has the focus, a cursor inside the text box blinks.

When an object has the focus you can use the keyboard, instead of the mouse, to control this object. With a command or option button, pressing Enter/Return (or the space bar) has the same effect as clicking the button with the mouse pointer. With a scroll bar you can use the left and right arrow keys to move the position of the thumb.

If you have two windows open, as shown in Figure II, you can move the window focus by pressing Ctrl-F6, together. When a window has the focus (its border is shaded) you have access to all its controls using the Tab or Alt keys as before.

Certain command buttons respond to the Esc key irrespective of which control has the focus. These are the <u>E</u>xit buttons in the text windows and the <u>O</u>K buttons in the Help windows and *ERROR!* dialogue boxes. For example if a text window had the focus and the Esc key was pressed, the program responds as if the <u>E</u>xit button was clicked and so terminates.

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Introduction

There is a second method for navigating through 'Lancaster Particle Physics'. Instead of using the <u>Next and Back buttons one can click on the Options menu</u>, displayed on the menu bar of the main window as shown in Figure III. The program responds by dropping down a list of all the options/exercises contained in 'Lancaster Particle Physics'. A check mark indicates which option is currently open. Hence by clicking on an option one can 'jump' to that particular section without having to go through the previous exercises. (Note: this is only recommended for experienced users of 'Lancaster Particle Physics'; beginners should work through each option, because each exercise is designed to follow on from the last) The Options menu can also be used to terminate the program by clicking the option <u>E</u>xit.

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Run <u>L</u> ifetime		
Run <u>A</u> LEPH		¢°
<u>E</u> xit		
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respectively, and the final velocity of the		v1 (m/s)
white ball v1.		
>Use this information, and your knowledge of the equations of		
conservation of energy and momentum,	+	1
to calculate the mass m <sub>1</sub> of the incident		
white ball. > Enter your calculated value for minim the		Your value
data box and press return to display the		for m1
Answer.		
You can change the relative masses of m <sub>1</sub> and m <sub>2</sub> by clicking on the <b>Option</b>		
buttons. You can change the incident		Answer
velocity ut of the white ball by using the		
scroll bar. Experiment with different settings; calculating mass mileach time.		$\mid$
> To proceed onto the next graphics click	l	Options
the <b>Next</b> button. (See the <b>Help</b> menu)		● m1>m2
Exit < Back Next > Graphics	Fire + u1 (m/s): 3	Õ m1=m2
	Fire + u1 (m/s): 3	○ m1 <m2< th=""></m2<>

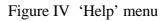
Figure III 'Options menu'

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## **Help pages**

The menu bar also contains the <u>H</u>elp menu. Clicking this produces a drop-down list of help pages for each option, as shown in Figure IV. These help pages are very important because they contain additional information on how to run each exercise, including hints and answers. In some instances it may be beneficial for the user to read these pages first, before starting an exercise.

- Lancaster Particle Physics				
<u>O</u> ptions	<u>H</u> elp			
	About <u>B</u> illiards	Billiards		
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<u>Note</u>: the Help pages for each option are only available when that option is open; the other help options being disabled and appearing dimmed. To open a Help page click on the menu title; this will open the help window as shown in Figure V. Click on the <u>OK</u> button to close the help window. In the later options/exercises the help windows have more than one Help page; these can be viewed by clicking the <u>Sector</u> buttons found at the bottom right hand corner of the window.

-	Lancaster Particle Physics	▼ ▲	
<u>O</u> ptions <u>H</u> elp			
Billia	About Billiards		
<ul> <li>ELASTIC collision ball (white) with r stationary ball (red) wi Click the <b>Graphics</b> b <b>Fire</b> button to see this</li> <li>The data boxes sh the white and red b initial direction, after respectively, and the white ball v1.</li> <li>Use this inform knowledge of the conservation of energy to calculate the mass white ball.</li> <li>Enter your calculate data box and press r Answer.</li> <li>You can change the m1 and m2 by clicki buttons. You can c velocity u1 of the white scroll bar. Experin</li> </ul>	> Clicking the <b>Fire</b> button, with the mouse pointer, causes the white ball to move on a collision course with the stationary red ball. > Use the scroll bar to change the initial velocity of the white ball, by clicking on the arrow keys or by dragging the central button. > Click on the round <b>Option</b> buttons to select the relative masses of the two balls: $m_1 > m_2$ $m_1$ has a variable mass > 3 Kg and ≤ 30 Kg. $m_1 = m_2 m_1$ has a fixed mass of 3 Kg. $m_1 < m_2 m_1$ has a variable mass ≥ 0.1 Kg and < 3 Kg. Remember $m_1$ is different on each new firing sequence (except when $m_1 = m_2$ ); its value will lie in the range specified by the option buttons. > Note: To obtain the Answer you must first enter your calculated value in the data box (containing the flashing cursor) and press return. The Answer will then be displayed in red. > Click <b>QK</b> to continue, and then <b>Fire</b> for fresh graphics.	θ° φ° v1 (m/s) X Your value for m1 Answer	
settings; calculating mass m1 each time.         > To proceed onto the next graphics click         the Next button. (See the Help menu)         ● m1>m2			
Exit       Exit       Eraphics       Fire       u1 (m/s): 3       0 m1>m2         Image: State of the state of			

Figure V 'Help window'