Dalhousie University
Program titles and descriptions

Most of the following programs are used as part of the weekly assignments given in a first year physics class(calculus based) at Dalhousie University. The remaining programs, Quantum Well, Wave Packet and Joe Magnets are used in 2nd and 3rd year classes :-

Instructions for students are in the folder, "**Instructions**".

The programs are seperated into three sections:

Package 1. Mechanics
Package 2. Waves
Package 3. E & M

Package 1. Mechanics:

Bar:

"Torques on a bar". Given a uniform bar, 1) pivoted about one end, with three forces applied to the bar. The magnitudes and directions of the forces are given. Find the torque produced by each force, the net torque and the magnitude and direction of a fourth force which will put the bar into equilibrium.

2) repeat for a pivot at the centre of the bar.

Basketball:

A basketball is thrown towards a wall, distance, d, away. Given d, the initial speed, initial height and direction of the basketball, calculate the initial x- and y-velocities, the time of flight to hit the wall, the height of impact on the wall, the final x- and y-velocities and the final speed.

Then you have the option of going directly on to an Interactive Physics program, "BBall IP" which is a simulation of the basketball being thrown.

Ladder:
There are actually two programs, A & B. The student is assigned A or B, depending on their ID number.

A. A ladder is leaning against a wall. You are given the angle of inclination, the ladder length and mass, and the mass and location of a person standing on the ladder. On the screen, you must place all the forces on a free body diagram of the system and choose an origin about which to take torques. Expressions must be completed for the clockwise and counterclockwise torques. *The force exerted by the wall must be calculated, also the vertical and horizontal forces exerted by the floor.* The maximum friction force must be calculated and a prediction made as to whether the ladder will slide or not. Finally the student must explain in words why the ladder will or will not slide.

B. This program is identical to A except that the location of the person is not given at first. The sentence in italics...is changed to: *The vertical force exerted by the floor and the maximum possible friction force must be calculated. You must calculate the maximum height the person can climb before the ladder slips. For a certain location of the person on the ladder, the student is asked if the ladder will slip.* Finally the student must explain in words why the ladder will or will not slip.

Paul's Uncertainty Thing:

An exercise in finding the mean and uncertainty of a group of measurements, finding the slope of a graph and the uncertainty in the slope, and finally finding the uncertainty in a calculated result. We use this in a 1.5 hour computer lab.

Pie Toss:

A pie is thrown from a window to the ground. Given the initial speed, time of flight and the direction of the throw, calculate the initial x- and y-velocities, the horizontal distance, the height of the window, time to maximum height, the final x- and y-velocities and the final speed of the pie.

Simple Harmonic Motion:
The displacement of a mass on a spring is given by $x = A \cos(\omega t + \varphi)$, where A, ω, and φ are given. Find the velocity and acceleration at $t = \pi/2$, the maximum speed, earliest time of maximum speed, the maximum acceleration, the maximum force, the earliest time of maximum acceleration, the spring constant, and the total energy. Also predict what happens if the spring were to be cut, when the speed is maximum, when the speed is mimimum.

SlopeFinder:
This program is a graphing utility. Students can enter data (x,y) with uncertainties δx, δy into a spread sheet. The graph is plotted live in a window as the information is entered. SlopeFinder can be used to plot any type of distribution; however it is most useful for straight line fits. These are done by dragging three lines: one line to give the best fit to the data and error bars(To help with this the sum of the residuals, R, is displayed.), a second line to give the greatest possible slope line, and the third line to give the lowest possible slope line. The program gives the y-intercept, best-fit slope, and ± the uncertainty in the slope.
Data for this program can be transfered to and from other programs such as Cricket Graph and spread sheets like Excel. δx and δy can be entered as constant values or as constant percentage values. x and y values can be interchanged.
This program was designed to allow students to see the data graphed as they enter it and to permit them visually to fit a straight

line to the data, thus giving the user a real feeling for how the best fit line is chosen. We wanted to avoid having students blindly entering data into a software package which gives the results automatically.

Suitcase:
A suitcase is on a flat, horizontal floor with friction. A force, F, is applied pulling to the right at an angle theta above the horizontal.You are asked to find the vertical component of F, the horizontal component of F and the normal force exerted by the suitcase on the floor. Find the work done by F, the work done by the normal force and the work done by the friction force. Find the change in Kinetic Energy and the final speed.
Finally, for a suitcase with different forces from the suitcase above, explain in your own words why this suitcase would rise off the floor or remain on the floor.

Package 2. Waves:

Wave Programs:

Phase Angles:
The waveforms and equations for two travelling waves are shown on the screen.
You are asked to complete the the equation for the sum of the two waves, and then to calculate the displacements of the two waves and their sum at a certain value of x and t.
There is a simulation in which you can vary the wave frequency, the amplitude of one wave and the time base.

Standing Waves:
The waveforms for two waves of equal amplitude,

frequency and wavelength are shown. The two waves travel in opposite directions. You are asked to find the wave period and the velocities of propagation. Complete the equation for the sum of the two waves. Find the location of the first 3 nodes in the sum, to the right of the origin. Find the maximum value of the sum at location, x_1. Find the value of the sum at x_1 and time t_1. A simulation displays the two waves and their sum. In the simulation, you can vary the propagation direction and amplitude of one of the waves.

Beats:
Two waves with slightly different frequencies are displayed. You are asked to complete the equation for the sum of the two waves and to find the two possible frequencies for a note which is beating with another note of known frequency.
A simulation follows: you can play(on the computer speaker) sounds of the two contributing frequencies and you can play the sound of the sum.

Quantum Well (2nd year program)

This program draws the wave functions for an electron in either a single or a double potential well. The depth and width of the well can be adjusted, as can the width of the middle barrier in the case of a double well. Once a well is chosen, the energy levels can be calculated, and the waves can be displayed.

Wave Packet (2nd year program)

Demonstrates the difference between the Quantum Mechanical and Classical models of a particle oscillating in a box.

Package 3. E & M

Circuit:
Asks you to solve a two loop circuit (containing 3 batteries and 3 resistors) using Kirchhoff's Laws. You must label the currents and current directions. You must complete the current continuity equation and write 2 loop equations by entering the coefficients in the boxes. (Students who have difficulty with this process can use a built-in tutorial.) Now solve for the currents in the two loops. The program marks the student's values and equations.

C.L. #3
An exercise involving electric fields and potentials. We use this in a 1.5 hour computer lab. The program asks the student to find the electric field vector due to a dipole, to initiate the plotting of electric field lines around a dipole, to plot points of constant potential, and to draw a potential energy profile for a path in the vicinity of a dipole. Written in True Basic. Teachers can e-mail Forest Fyfe for the necessary password. Caution - prone to

crashing on a Power Macintosh.

Electric Spheres:
Asks the user to calculate the charge distribution on a system of concentric spheres.The user is also asked to calculate the electric field (and its direction), and the potential at several points in the system.

Joe Magnets (Used in a third-year class.):

A 16x16 array of arrows representing a non-interacting spin system is shown on the screen.The temperature and magnetic field can be controlled by scroll bars, and the array responds by showing the appropriate number of "up" or "down" spins to give a visual picture of the magnetisation.
The program has been used both as a lecture demonstration, and as the basis for an assignment where the student is asked to deduce the magnetic moment by plotting the magnetisation as a function of (H/T). The largest H and smallest T are insufficient to saturate the "sample" so the initial slope of the plot is the most

reliable way to proceed. Random fluctiuations in the magnetisation, and the magnetic moment on each run are built in so that each student does a unique problem.

Mass Spectrometer:
In a mass spectrometer, you are given the particle charge, the accelerating voltage, the magnetic field strength and the diameter of the path. Calculate the mass of the particle. Convert the particle mass into grams/mole. Calculate the particle's kinetic energy, speed and time of flight. When you print out your answers, the printout will include the name of the isotope fired into your Mass Spectrometer. You must give a derivation for all equations you use. A simulation of the particle moving in the mass spectrometer is given. In the simulation the particle moves in scaled time and the accelerating voltage and the magnetic field strength can be varied using scroll bars.

Oscilloscope:
An oscilloscope simulation is given with scroll bars to control the accelerating and deflecting voltages. You are given values of these voltages, the length of the deflecting plates and the distance to the screen.
Calculate for an electron: the acceleration, final speed, time of flight, vertical component of velocity at the screen, vertical deflection as the electron leaves the electric field, and the vertical deflection when the electron hits the screen.

Power Line:
Given the peak power and voltage for a power line, calculate the peak curent.
Given the direction of this current, calculate the x,y and z components of B at your head, located directly below the power line by a distance, d. A second wire is directly above the first . The

vertical distance between the wires is given. What are the x,y and z components of B at your head due to the top wire alone? You move a distance,d to the East (or West), what are the x,y and z components of B at the location of your head now? You will be asked to enter the vector B due to the upper wire graphically. The resultant vector B is displayed.

Resistor and Capacitor:

A capacitor,C, is charged by a battery,V. The battery has an internal resistance R_B. C and the final charge,Q are given. The Calculate V and the initial charging current. Then the capacitor is discharged through a resistance, R (R is given.). Calculate the discharge current after a certain time, also the maximum discharge current and the maximum power dissipated in R.

Resistors:
Given a network containing six resistors and a battery. Find the equivalent resistance of various resistor groups. Find the current in the battery and in each resistor.

RLC A:
Given a parallel RLC circuit connected to a sine wave generator, $V(t)=V_o \sin\omega t$.
You are asked to complete equations for i_C, i_L, and i_R. You are asked to compute i_C, i_L, i_R, and i_G at a time t_1, at an off-resonance frequency, also to compute the resonance frequency. A simulation with strip chart recorders displaying the four currents follows. In the simulation, generator frequency and the time base on the recorders can be varied. Next compute i_C, i_L, i_R, and i_G at a time t_1 and at the resonance frequency.

RLC B:
Given a parallel RLC circuit connected to a sine wave generator, $V(t)=V_o \sin\omega t$.
You are asked to complete equations for i_C, i_L, and i_R. You are asked to compute the amplitudes of the currents, i_{C0}, i_{L0}, i_{R0} and i_{G0} at an off-resonance frequency, also to compute phase angle,phi, between the current and voltage at the off-resonance frequency.

Compute the resonance frequency. A simulation with strip chart recorders displaying the four currents follows. In the simulation, generator frequency and the time base on the recorders can be varied. Compute the amplitudes of the currents, i_{C0}, i_{L0}, i_{R0}, i_{G0} and phi at the resonance frequency.

General features of these programs:

1. Each of the programs requires the student to solve the same physics problem as every other student in the class, however every student will have different values for their problem, as determined from their own 8-digit ID number. Or you can use the program "config" to set up the programs Bar, Basketball, etc..so that a random set of parameters is provided.
2. In several of the programs the phenomena have been chosen because these are difficult or impossible to do in the laboratory or to display in lectures. "Joe Magnets", "Oscilloscope" and "Power Line" fall into this category.
3. All the programs use graphics(many of which are animated) to show the phenomena being presented.
4. All the programs give the student instant feedback about his or her work. By using the **Preview** feature, students can tell whether an answer is correct, but they can not tell what the correct answer is.
5. To encourage students to think of significant figures, full marks are given for numerical answers which are correct to within ± 5% (or similar percentage). Zero marks are given for answers outside this range. This requirement has the beneficial result that the program may accept the preliminary answers, but not later ones. For example in "Oscilloscope", the electron acceleration and final speed will be marked correct if they are stated to too few significant figures but are correct to ± 5%. However, calculating the time of flight depends on both the acceleration and final speed. Round-off error will be contributed by both, meaning the time of

flight may in error by more than $\pm$ 5%.
6. "Ladder" and "Suitcase" include questions requiring word answers.
7. Students can submit their work in two ways:
(a) By handing in a printout.
(b) By sending their answers to a dropfolder. (Our Macintosh computers are connected in an AppleTalk network.)

Technical Details:

The programs are written in Symantic Think C++, or Code Warrior and some make use of library routines.

Copies of the source code may be obtained by E-mailing Forest Fyfe(FYFE@fizz.phys.Dal.ca).

The programs were written by Paul Chapman and Johannes Graham. Many of the programs are based on chapter problems taken from the text, "Principles of Physics", by Serway. Selection, design and advice on the programs was given by Forest Fyfe, Dr. David Goble and Dr. Robert March. A great deal of useful advice was provided by the several hundred students who have worked with these programs in their assignments over the last four years. The programs are used in a lab equipped with an AppleTalk network with 14 Macintosh Plus's(with 20 meg hard drives), 6 Mac Classic 4/40's and 4 Power Macintosh 6100's. A Mac Classic II is used as the server. Appleshare 3 is used, but is not essential. Hard copy is provided by four Imagewriter II printers. For purposes of speed the programs are stored on the hard drives and only the drop folders are on the server.

Notes:

1. The instant right or wrong feedback given by the **Preview** feature leads to lots of discussion among groups of students working on the problems. Students who get the answer wrong, ask

their

colleagues how they solved the problem correctly. Quite often debates ensue about the best way to solve the problem. We have noticed that this is an excellent way to get students discussing Physics problems. The students can seek help from the tutor in our Resource Centre(which is equipped with a Mac), but quite often they work out their difficulties by themselves. Almost 98% of the student receive full marks on these computer problems, but we are pleased to give them this as we know each student has solved his or her own problem, even if they had to seek help somewhere. We have not observed any instances of a person doing a computer assignment under someone else's name, yet.

2. When a student sends their results to the dropfolder on the server, the program automatically logs the student on to the server as a "guest". The results are sent to the dropfolder and the program automatically logs off again.

3. Marking and collating marks is done largely by the computers.

(a) Student results sent to a **dropfolder** are stored as files(one for each attempt made by each student) on the server. These files contain identifying information, the student's answers and the students mark for each question. If a student is seen to be having difficulty, the marker can bring any file in a dropfolder up on the screen, or print it. We have a routine(Available on request, however to use it you need Foxbase+.) which transfers the student ID number, program name, date and total mark from each file in a dropfolder to an spreadsheet of marks. If a student has submitted more than one set of results, the set with the most recent date is automatically selected. Students can log on with "guest" access on the AppleShare network. Guests have write access to the dropfolders, but for guests everything inside a dropfolder is invisible. To prevent tampering with the files inside dropfolders, a unique (and invisible) four character code is attached to each filename. To guard against students results being lost, the programs ask the student to write down and keep a codeword which is encoded with the student's mark and can be used to resurrect that mark.

(b) The **printout** provided by each program includes student's answer and mark for each question, and total mark .

Some things have to be done by hand:

(a) Assignments which ask for derivations of a formula(e.g. "Mass Spectrometer").

(b) The word questions.

24 April, 1996