Guided tour of the slides in the talk "Using Mathematica in Advanced Undergraduate Physics and Astrophysics Instruction and Research"

To get the slide show to work on my slow laptop machine and keep the file size down below 15 megs you should note that some of the dynamical displays are copies from the last of a series of chained notebooks that were longer than the slide notebook itself. Thus Mathematica has to manufacture some of the book "demos" from the copies that were cut and paste and it does that by reformatting those slides and that initially takes some significant time on the laptop as does even saving the file. I found for the presentation I will have to load the notebook and then run through the slides just prior to giving the talk. Then I have to avoid closing the slide file until after the talk is given. The laptop has no separate graphics processor and that is likely the problem with the reformatting speed. On my desktop machine I have two gigs of graphics memory and that is equal to the entire laptop memory ! Thus the reformatting is very fast. Here are the steps for sequentially running the demos in the notebook using the slow machine as the reference.

1) When the notebook comes up you will notice that it is in "regular mathematica " mode. To get into slide show mode click the icon at the far right. The slide controls are at the top of each slide. Selecting individual slide titles is done from the left set of controls.

1) Do NOT evaluate the whole notebook as that will just mess things up. Go from slide to slide using the arrow controls and then activate the dynamic features section by section.

2) Many of the slides have parts beyond the bottom and these can be reached with the scroll bar sliders.

3) Those slides with no active features should switch quickly. The first active one is the synchrotron radiation taken from the book. On my laptop the bar that wants you to activate the dynamical features shows up. To go further I have to click on the bar's button. The dynamical formatting occurs and this may or may not take a while. (On my desktop machine at home this is automatic.) Once the formatting is done the section needs to be run by passing the cursor over to the far right where a vertical bar shows up. Select this bar with a mouse click. Hit the usual shift return and that will activate the active manipulations. On slow machines this may take a while as Mathematica may have to format the whole notebook at this point.

4) Use the scroll bar to see the first active demo. If the slider is moved then the radiation pattern of a linear accelerator is displayed. Beta is the v/c. As v-> c, the beams get closer to the velocity direction, but they do not merge until very close to c.

5) To see the cyclotron case scroll down. There you will see two additional slider bars. If both sliders are to the left, then the radiation pattern as controlled by the beta slider resembles the top plot. The second slider is the angle between the velocity and the acceleration vector. The first slider is the viewing angle phi of the vertical plane. If phi is 90 degrees then the plane is viewed from the top and appears as a line. If the ip is 90 degrees that means the velocity and acceleration are perpendicular and the beam falls along the velocity vector. The display is the configuration for a cyclotron beam at various beta. It can be seen that the radiation beam moves ahead of the velocity. And hence is the same regardless of speed.

6) Click the slide advance button to go to the next slide. Here we show a section of the WMAP microwave background. Below that (scroll down) is the 2D Fourier Power Spectrum. The upper half of the power spectrum is the mirror image of the lower half. Like any FFT there are redundancies in the frequencies displayed.

7) The central spot is around (0,0) with plus y frequencies starting low and increasing vertically up and plus x frequencies running from zero increasing horizontally to the right. The wavelength scale is therefore not linear being compressed at long wavelengths near the origin with shortest wavelengths at the other end of the diagonal. The positive frequencies have structure which means many of the features have correlated sizes and orientations. So the pattern is not of random shapes.

8) Scrolling down shows a 3D (rotatable, but don't move it unless you want to have the plot reformatted and that may take awhile) plot of the wavelet packet. In this case the scales (analogs of wavelength) are shown. Thus close to the origin (lower left) are the short scales (high frequencies) and long scales (low frequencies) at the upper right. So this is a different way of examining the power spectrum at the upper right of the FFT.

9) Click the slide advance arrow to go to the next slide and there is a pause while the next slide is built including formatting the contents. On my laptop it takes a minute or two so I will have to go through the slides one at a time BEFORE the talk to build each slide from scratch. Then the time for presentation will be shorter.

10) Once the slide comes up it will have a Hubble image of the Orion Nebula with the Trapezium cluster circled.

11) Scrolling shows two "movie" frames booth with the same star pattern. These were cut and pasted from the original movies. They are 3D figures that are set to show the view from the earth, but please to not attempt to rotate them as you will cause a reformating of each frame and that will hang things for quite a while. So how do you work these ?

12) You may show the movies manually (like the old flip pack movies) by simply moving the slider. In the top frame the slider is clear to the right on the bottom frame the slider is all the way to the left. The pattern shown in both cases is the present. To see the pattern a million years ago move the slider to the left. To see the pattern a million years in the future move the lower frame slider to the right.

13) Notice in both frames that the blue star and the white star start the remote past as well bound and end the remote future apparently bound but become widely separated at the present era. From a dynamical standpoint that is most unusual as one thinks from large cluster dynamics theory that the least massive star (the blue one) would gain enough interaction energy to escape completely, but in the small number case it is apparently not necessarily so.

14) What is not seen here is the motion of the red and green stars. In the model they start at opposite sides of the group then enter the central regions at the present time interact a maximum amount as they pass the center of mass of the system. and then switch sides. While this is the solution for one set of initial conditions, the dilemma is that while we know the 3D velocities we only know the 2D distances from the center of mass and those are in the plane of the sky not along the line of sight. The line of sight distances are chosen Monte Carlo fashion based a variety of geometrical assumptions. So we do not really know whether the red and green stars are really bound or not. The investigation of this dynamical system is thus very complicated and is still being worked on. The project has passed from student to student as each in turn has graduated.

15) Click for next slide. This is a title slide and goes quickly.

16) Click again and we come to the first mechanics slide Hohmann orbits. Click on the side bar and use shift-return to run the code and that recreates the animation in full. The animation can be run manually by moving the slider or if you choose open the control panel and hit the run button and it will be animated repeating continuously. The blue dot is the earth, the red Mars. They start with Mars at opposition. After a while when the planets are properly angularly separated (one on one line the other on the other) a spacecraft is launched (green dot). The spacecraft follows the transfer ellipse until it intersects Mars at a point that is 180 degrees away from the earth launch position. Getting the ellipse shape between the earth and Mars orbits is simple. What is complicated is the timing.

17) Click for the next slide and Foucault pendulum comes up. Click on the right vertical bar and then do shift return to run it. Two animations are created. They can be run by sliding or by animating. The first panel is inertial path of the bob while the second compares a frame moving with the bob with that of an inertial frame. They can be run either as an animation or by sliding the bar.

18) Click for the next slide and up come the top precession cones demo.

Select the vertical bar and run the code. A 3D panel comes up that can either be worked with the slider or done as an animation.

19) Click for the next slide gives the tennis racket demo. Click the bracket and then do shift-return to run it. The first panel has the moving reference with the momentum and velocity vectors moving with respect to the body. The second panel has the inertial frame version. These can either be run with the slider or with the animation panel. On my laptop an error message was generated, if it appears ignore it.

20) Click for the next slide gives a simple projectile motion that has four parameters to vary. It is a realistic case, but it does not include either earth rotation nor air drag. Any of the parameters can be changed or animated.

21) Click for next slide is title slide "new insights to old problem"

22) Click for next slide brings up a static pair of plots. These show an extension of true classical birthday match problem. The first graph shows the number of matches as a function of sample size. The second plot shows the probablity of one person being in one of the configuration. The interesting point is that the maximum probability of being in one of the configurations depends on the sample size. Pairs peak in probability at 360 (perhaps really one year of 365 days), triplets at double that of pairs, etc. The actual peak probability drops by a factor of two as one goes from pairs to triplets, etc. This is something that is not obvious when doing the small sample version of the problem.

23) Click for next slide brings up a long analysis of an ultrasonic diffraction experiment that was solved in record time using the NonlinearModelFit function in Mathematica. The first plot shows the results of the fit superposed on the original points. The fit is quite good as evidenced by the high correlation coefficient and the fact that each of the parameters has errors smaller than the parameters themselves. In spite of the good correlation we still see that the residuals are not random. The rest of the slide is an attempt to identify the source of this residual signal.

24) First we establish through Fourier analysis that the residuals are described by a "pink" noise spectrum, a straight line in a log plot.

25) Secondly we notice we can suppress the amplitude of this noise signal while smoothing and shaping the primary diffraction spectrum using a window function (in this case a Kaiser window). The primary spectral frequencies have significant band widths no doubt due to the fact that they are not real point sources as required by the far field theory.

26) Spectral analysis of the residuals indicates that the "noise" arises from an autocorrelation process whose correlation lengths approximate multiples of the

total extent of the source array from the outer side of one source to the outer side of the other. Thus an interaction originating in the sources themselves seems to be indicated. Perhaps microphonics through the source mounting mechanism will be found to be the ultimate cause.

27) Click for the final slide summary of our experiences with nearly 13 years of Mathematica usage at the undergraduate level.

28) Do not save the notebook after running it as any error messages will be saved also and you may have to back and clean them out.