Introductory Laboratory

Throughout the course, you will be using a computer data acquisition system that will enable you to acquire video images of phenomena, select and digitize the location of points on each image in a time sequence, and transfer the time and position information to a spreadsheet for analysis of physical phenomena.

In each laboratory session, you will be addressing several Problems. Each Problem is posed in a fashion much as it might arise in your professional life. There is a method by which we approach problems in science. You first try to define the problem in terms of physical quantities that you can measure. Then you try to use the physics that you know (or are learning!) to make predictions about how the physical quantities should behave in the situation of the Problem.

Now you are ready to plan an experiment to test your predictions. In this course, we have provided you with a technical system that can be used to capture a video image of the Problem situation. The system is described in Appendix D. The video image will consist of a time sequence of still frames, recorded in a succession of equal time steps. You will need to learn how to adjust the focus and field of view of the video camera to optimize the image for each Problem situation. You will also need to plan the point or points in each still frame for which you will want to digitize the location, and devise a means to recognize that precise point in each frame. We will refer to such points as *targets.*

You will be able to analyze the frames of a video image using a simple application in LabView™, a software environment for data acquisition and control. You do not need to know how to program in LabView™; the application is resident on your PC and you can launch it by executing the program *VideoCapture1*. LabView™ is a powerful data acquisition and control environment that is widely used in experimental science and engineering. If you wish to learn how to program in LabView, there is a free class offered every semester.

Once you have recorded a video image, you will select the targets and digitize them. Each time you cursor-select a target, its x-y screen coordinates will be transferred to an EXCEL spreadsheet along with the time of that frame. *The x-y coordinates and the time relative measurements – the x-y coordinates are the pixel location on the 640x480 screen display, the time is the number of frames since the video sequence began.* Part of your task is to devise a procedure to calibrate the location and time recorded in the spreadsheet, and convert it into the physical space and time of your experiment. This short introductory laboratory is designed to familiarize you with that part of the program.

EXPLORATION

Log onto the computer using the username and password assigned to your laboratory section. Create a directory in which you will save the files that your group creates during the laboratory. Keep all files (image buffers, EXCEL files of position/time that you want to save in that directory.

Open the control screen of the video camera. Familiarize yourself with how to select and adjust the frame rate, the brightness and contrast, the focus, and the field of view.

Open the *VideoCapture1* program by double-clicking its icon on the desktop. You will be asked to select the number of frames to be recorded, and the number of targets to be digitized in each frame.

Once you accept the settings, the first of the sequence of frames will be displayed on the screen. Cursor-select each of the points that you plan to digitize. You should begin by digitizing points for calibration of the distance scale. Place a meter stick in the field of view of the camera, and begin your coordinate measurement by cursor-selecting two points on the meter stick whose separation you know in real space.

Note: if you are digitizing more than one target, it is vital that you cursor select them in the same order as you analyze each image. You can move backwards or forwards through the images as you wish, until you reach the end of the selected sequence. When you finish the sequence, give the new EXCEL spreadsheet a name that will enable you to identify the file for further analysis. You may wish to save the video sequence itself until the end of the laboratory period. *Note: the video files are large, and you will not be able to save video image strings through the semester. It is important that you extract all information from the video images by the end of each lab period.*

Now open the EXCEL spreadsheet that contains your space/time data. It should contain an array of data, in which the data from each frame is contained in a single row, and the data for x, y, and t of each cursor-selected target is contained in 3 columns. EXCEL provide a simple-to-use means to analyze this data and graph results. If you do not know how to use EXCEL, please see your teacher during the first lab session. We will arrange a tutorial session for all students who need help with EXCEL at the end of the first week of the course.

METHOD QUESTIONS

1. Select and measure the locations of a series of points along a meter stick. Here you will only need a single video frame for analysis. Use a spirit level to precisely orient the meter stick so that it is horizontal. Adjust the field of view of the camera so that the meter stick extends through the full field of view.
2. Calibrate the scale of the video image. Measure the uniformity of the scale across the field of view. *Note that you can minimize scale variation across the image by orienting the camera so that line of sight from camera to image is perpendicular to the plane of your problem (minimum parallax).* To measure scale uniformity, you compare the spacing in x-y screen coordinates to the spacing of targets at a succession of locations along the meter stick. Plot the scale factor (real length/screen length) as a function of screen coordinate.
3. Do the series of measured points form a straight line or does it bend? If the curve bends, does it have a parabolic shape, an exponential shape, or a repeating pattern? Is the meter stick oriented parallel to the x-axis of your camera, or is there a non-zero slope (this would indicate that the x-axis of the camera is not parallel to the meter stick)?
4. Now stretch a string so that it sags to form a sagitta. Digitize a sequence of points along the string, and plot the x-y coordinates. Do the points fit any standard curve?
5. Calibrate the time scale that is recorded by the camera. Place a timer within the field of view of the camera, start the timer, and plot the time recorded by the camera *vs.* the time shown on the timer. Is the camera time scale in accord with real time as measured by the timer?
6. Now roll a car along its track and record its trajectory (position *vs.* time). You will need to calibrate length scale each time you re-position the camera or change the image distance, focus, or field of view. Plot the position *vs.* time in real coordinates. Describe the motion, and give your best explanation for aspects of the motion that you observe.

   When dealing with a real physical situation, you can usually estimate these constants from what you observe. To do this you must be aware of which physical quantity that each of the constants represents.

CONCLUSIONS

State your conclusions from each of the above explorations: the straightness of the meter stick, the scale uniformity of the camera image, what shape does a catenary form, what is the nature of the motion of a car coasting on a surface?