Preparation Notes for Chapters 1-4 (two classes)

Note: we go through this part of the material very quickly, because the students should have seen it in high school and we need to get going. However, I found in 1999-2000 that, particularly second term, the students were still having trouble using the kinematics equations i.e. dividing up the problem into the x and y components and solving them separately.

Reading 1-3, 4.1-4.3; Problems 4.17, 4.23

(1) Instructor presents brief summary of key concepts for this part of the course: displacement = change in position (x), $\Delta x = x_f - x_i$; velocity = rate of change of position, $v = \Delta x/\Delta t$, $v = dx/dt$ is instantaneous velocity; and so on for acceleration; give relations between them both in terms of $\Delta x/\Delta t$ and dx/dt; also remind them that vectors have both magnitude and direction.

(2) In-class discussion of every day examples of displacement, velocity, acceleration. Ask the students to work in groups of 3-4 and describe particularly the velocity and acceleration, and any *change* in these quantities with time. You may need to disallow cars as examples to encourage them to use their imaginations!
Goals: discussing a real-life situation should encourage students to think again about these fairly familiar concepts; also introduces them in a non-threatening way to the discussion side of the course.

(3) Exercise 2: Projectile Motion. **You will need a ruler, a tennis ball, and about 10 stop watches.** Take a tennis ball and toss it across the room from the students' left to their right. Toss it as high and as far as you can without hitting the ceiling or facing wall. Discuss with the class what quantities we would need to measure to determine how fast I threw the ball initially. Divide the students into three groups (roughly) and assign each student in a group to write down an estimate one of the time, horizontal distance, and initial angle thrown (the time group will need to collect stopwatches from the front). Discuss what units of measurement the angle and distance people are going to use (including the convention for measuring the angle). Throw the ball again. Collect the numbers for each estimate and take the median as the best estimate; you can also explain to the class that having a number of estimates in each group is similar to having one group doing the experiment several times and having many estimates should help us get a better measure of the true value.

Use these numbers to calculate the speed with which the ball left your hand (it is straightforward to calculate the horizontal speed and then the angle gives you the total speed). Now invert the problem and use the speed you've calculated to estimate g by analyzing the motion in the vertical direction. How well does the value of g compare to the known value? Discuss uncertainties in a general way.
Goals: use to introduce significant figures, cartesian coordinate systems, vector components; covers 2-D motion with constant acceleration via projectile motion; this is a rather long exercise (takes most of a class) but has lots of good material in it.
Variations/extensions: what units should height etc be estimated in (meters; blocks; floor squares; etc.)? is or is not the ball constantly accelerating and why? how important

to the calculation is the estimate of the angle? what could we do without the angle (get a lower limit)? sources of error in our estimates? likely sizes of errors on estimated quantities?

For Tutorial: I think it is important to work carefully through a kinematics problem in the tutorial, illustrating how the analysis must be divided into the vertical and horizontal components of motion. Probably this could be done using one of the practice problems assigned on the first day.

Other possible exercises

(1) Exercise 1: Graphical exercise. Draw the three attached graphs on the blackboard. Ask the students to sketch the corresponding plots of velocity versus time and acceleration versus time. Collect the results and discuss any differences that arise; differences can generate a lot of discussion!
Goals: explore the students' understanding of the three key concepts; introduces interpretation of graphs; could be a good tutorial exercise ...
Variations/extensions: ask the students to sketch the displacement, velocity, acceleration of one of the everyday examples (i.e. a car traveling from one stop sign to the next); toss a ball straight up in the air and catch it: ask them which graph corresponds to the ball's motion

(2) Exercise 2: Toss a ball in the air and catch it. Ask the students to sketch what the velocity and acceleration vectors look like (a) half-way up (b) at the top (c) at the bottom. Then ask them to compare their drawing to that of their neighbor and discuss any inconsistencies. Then collect some answers and discuss any differences.
Goals: introduction to freely falling objects; can highlight students' confusion about acceleration being present even when there is (instantaneously) no motion; this discussion may come out naturally in the discussion of everyday examples of displacement
Variations/extensions: you could then make a brief presentation on "Freely Falling Objects" as an example of what a student presentation should be like, using the sample handout.

(3) In the first class, you could ask them if they have had any bad or good experiences with physics before and if so, what they were.

Hints for Starting Discussions in Class

A good way to start a discussion is to have the students talk among themselves in groups of 3-4 and then to collect the answers. This method is particularly helpful early in the course before the students are used to active participation. I always write up ALL the answers (in point form) on the board before identifying which answers are correct and why, and which are wrong, and why. This makes it a bit less intimidating, because it's not obvious right away which groups got it wrong. (Sometimes, none of them will get it right, which is interesting too!) A variant on this method is to have them work by themselves on a task for a couple of minutes, and then to compare their results to their neighbor's results and try to resolve any differences. This is useful particularly if you expect confusion on a topic.

Content of Chapters 1-4

(1) displacement, velocity, acceleration
- formal definitions
- everyday examples
- graphical exercise

(2) projectile motion example
- cartesian coordinate system
- vector components
- order of magnitude
- significant figures
- one and two-D motion, constant acceleration

(I have also laid this out in the form of a "Concept Map", which shows a bit more clearly how I see these things fitting together; see attached figure)

Goals for Chapters 1-4 ("Learning Outcomes")

– to *understand* concepts of displacement, velocity, acceleration – TOO VAGUE!
  – to describe in words the motion of an object based on a graph of displacement
  – to describe the motion of a real-life example of one or two dimensional motion
  – to draw graphs of **v, a** from initial **x** graph
– to make order of magnitude estimates
– to break a vector down into its component vectors in a Cartesian coordinate system
– to round a final answer to the correct number of significant figures
– to solve problems involving projecting motion
– to describe the displacement, velocity, or acceleration of an object in motion
– to break down the two-dimensional motion of an object into separate descriptions and equations for the x and y axes

In principle, organizing the content (maybe even making a "Concept Map") and goals for a section should help you to figure out what instructional strategy to use in teaching the material. In actual fact, I prepared the exercises after making an edited list of what I thought was the key material from these four chapters, and only then went back to list goals and make a concept map.