Preparation Notes for Chapter 5 (Newton's Laws; 3-4 classes)

Note: Don't try to do any reports in Chapter 5 – it is too hard to get it organized, what with the class enrolment fluctuating and all

Note: tell the students to discuss in groups of 3-4; better discussion that way; also, I should wander the class room to listen to what they are saying, be ready to answer questions, etc.

Introduction and Newton's First Law

Reading: Chapter 5.1-5.4; practice problems 5.5, 5.21

(1) Exercise 1: Students work in groups of three to come up with a verbal definition of force. (causes acceleration) Remind them that acceleration is change in velocity. Ask for a description of types of situation where we have a change in velocity (from rest to motion; from one speed to another (in straight line); from one direction to another (constant speed); from one direction AND speed to another) If force causes acceleration, what does it mean if we have no acceleration (no NET force) Point out this is Newton's First Law: $a = 0$ iff $F_{net} = 0$.

(2) Discussion 1: Instructor defines inertial frame of reference – one that is not accelerating; in which Newton's first law holds. Ask the students to come up with one everyday example of an inertial frame and a non-inertial frame, and to try to figure out how you could tell you were in the non-inertial frame.

Variations/Extensions: Is the surface of the Earth an inertial frame? why/why not?

Newton's Second Law and Gravity

(3) If we have a net force, then we have acceleration. "Discuss what happens (a) if we apply the same force to two different objects or (b) if we apply different forces (one at a time) to the same object." (Good to have this bit on an overhead, lots of words.) Newton's second law, $F = ma$; can lead into a verbal definition of mass. Can also discuss "contact force" i.e. force from two surfaces in contact. (Note: this idea may come out already in the previous discussion of a definition of force.)

(4) Demo 1: have a heavy book and a sheet of paper that is smaller than the book. Ask the students to discuss in their groups what will happen if you put the piece of paper on top of the book and drop them together, and why? Then do it. (This is a slightly unexpected version of the classic Galileo-style experiment that is unusual enough to catch the students' attention.)

Newton's Third Law and Normal Force

Reading: Chapter 5.5-5.8; practice problems 53,67,73

(1) Exercise 3: Instructor introduces and defines Newton's Third Law. Ask the students to stand up, pair off, put their hands together and push each other. You can demonstrate yourself with a student partner first. After they sit down, ask them to discuss the following: "If you were pushing on your partner, why didn't he or she fall over?" and then collect the answers. This leads nicely into a discussion of a simple Free Body Diagram. You can have the students tell you what forces to draw on your figures and emphasize the rules for

FBDs along the way.
(2) Exercise 4: Draw three cases of a book on a table (a) by itself (b) being pulled upward by a string (but still in contact with the table) (c) being pushed downward. Have the class help you draw the freebody diagram for the book for each situation. Also write the equations below. (emphasizes that magnitude of normal force depends on what other forces are acting on the object; can also be used to emphasize direction of normal force)

Topics to make sure are introduced along the way: mass versus weight, tension

The force of friction: THIS NEEDS WORK, TO DO WITHOUT PRESENTATIONS!
(3) Kinetic Friction: slide something (the textbook) across the floor; comes to a halt; why? kinetic friction; contact force (surfaces must be in contact); operates to oppose the sliding motion (that's why the book stops); $F_{fr} = \mu_k F_N$
(4) Problem 48: A problem with an inclined plane with kinetic friction. Make sure to introduce the tilted coordinate system.

(I sometimes do problems interactively by letting the students look at the problem and asking them how to proceed: draw free body diagram; what of; what forces go on; coordinate system; do we have all the forces?; is there a net force? and so on. Once we have the problem down to an equation, then I carry it through from there to the end without the students helping.)
(5) Static Friction: place something on your book and tilt the book up; object doesn't slide down; draw FPD; missing force to oppose gravity; static friction; $F_{fr} \leq \mu_s F_N$; a variable force (like normal force); acts to oppose motion (i.e. counteracts other forces on the system) but cannot CAUSE motion (that's why it is variable in magnitude)
Variations/extensions: (a) discuss everyday examples where friction is present. is it static or kinetic? (b) discuss frictional forces for the case of a car driving down a road; what happens when the car skids? hits ice? draw free-body diagram for tire for case where car is accelerating or decelerating
(6) Problem 3: A problem with friction. I like 51 from Serway (even though it is worked out for them in the study guide) or 67 (one of the practice problems; has static friction in it).

Other ideas (not used in Winter 2000)
Variations/extensions: you can bring in a light and a heavy ball with a bat or a ruler. One "whack" is one unit of force. Hit the light ball then the heavy ball. Leads naturally into Newton's second law F=ma and then units of force.
(4) Exercise 2: Drop a ball. Does it accelerate? (yes, from zero velocity initially). What is the force? (no contact force – force of gravity). Now throw the ball up. Ask them to sketch what the force vectors look like (a) half-way up (b) at the top (c) at the bottom. (Or this could be done by anonymous voting – ask them to hold up a piece of paper saying up or down and if they think none, do not hold up anything.) Then collect some answers and discuss any differences. Ask them what this means for the acceleration vector – reinforce the idea that the acceleration is downward even when the motion is upward.

(6) Discussion 3: Ask the students in groups of three to discuss the difference between mass and weight. As a hint, have them think about an astronaut on the moon. If they need more hints, you could say he weighs less on the moon or that acceleration due to gravity was 1/6 smaller on the moon. (Illustrates that weight is a force that depends on gravity and mass is a basic property of the object.)
Variations/extensions: Since g falls off as $1/r^2$, estimate by how much your weight changes between the surface of the Earth and flying in an airplane. Would you be able to measure this change in weight with a standard bathroom scale (digital or analog)?
(10) Discussion 4: Consider a head-on collision between a car and a truck. Which experiences the greater force? Which experiences the greater acceleration? What would be different if the truck were traveling twice as fast and ran into the back of a parked car? (Optional)
(11) Problem 2: Problem 55 from Serway. Nice illustration of Newton's third law and freebody diagrams. (Optional)
(13) Discussion (4): (a) hold a heavy book against a wall. Ask the students to sketch the freebody diagram for the book. Have them discuss their results in pairs; collect the results; discuss any differences and questions. (b) hold the book against the wall as before, but this time slide it across the wall. Repeat the freebody sketch and discussion. The frictional forces in this case are a bit non-intuitive.

Possible Presentation Topics (not advised, too early in semester)

(1) kinetic friction

(2) static friction

Content of Chapter 5

force and relationship to acceleration
Newton's first law
    inertial frames of reference
Newton's second law
    mass
    contact force
    gravity –> weight
Newton's third law
    freebody diagram
    tension
    normal force
Friction
    static
    kinetic

(Concept Map also available, if you're interested)