Things you should be able to answer for Exam III:

From the Lab, *Chaos*:

1. How does the heart rate sensor work? Is the signal the same as an ECG? What does a voltage-time graph look like for resting data? For data just after exercise? Be able to estimate a heart rate from a voltage-time graph.
2. How many data points are there on a voltage-time graph in a one-second interval? Why? About how many data points are there per second on a heart rate-time graph? Why? What does a heart rate-time graph look like for "resting" data? For just after exercise?
3. What is a "first return map?" Sketch first return maps for heart rate data for normal heart rates and for pathological cases.
4. What is meant by low- and high-dimensional chaos? In particular, what is meant by one-dimensional, two-dimensional, and three-dimensional chaos? How do first return maps differ for low- and high-dimensional chaos?
5. Be able to explain how the Ricker Equation is used to generate output as a function of time. In the laboratory the Ricker Equation is used as a *mathematical model* for heart rates; is it a precisely accurate model? What is a primary difference between heart rate chaos and chaotic output from the Ricker equation?
6. Define what is meant by "fixed point" and "N-cycle." Are these examples of chaos? Be able to identify the value of N for an N-cycle from a graph of output as a function of time. Describe *carefully* what is meant by the "period-doubling route to chaos." This route is navigated by changing something; what?
7. Describe what is meant by "sensitive dependence on initial conditions." Does the Ricker Equation display such sensitivity for **all** values of b? What happens when two initially close values of x are iterated for $b = 6$, say, versus $b = 18$?
8. Would you expect any difference in the first return maps for chaotic output from the equations

$$x_{k+1} = bx_k \exp(-x_k) - cx_k$$

and

$$x_{k+1} = bx_k \exp(-x_k) - cx_{k-1}?$$

Explain.
9. What feature of chaos is exploited in the control method used in the lab? Once control is established can the system be left alone. Be able to interpret a graph of output versus time for an "on, then off" control situation.

From Chapter 11:

14. Define mass density. Define pressure. What are the units and dimensions of both? Why does pressure increase with depth in a static fluid? Given that atmospheric pressure is about 10^5 N/m^2 at sea level and that the density of air is about 1 kg/m^3 determine (roughly) the height of the atmosphere. Why do astronauts suffer from reduced amounts of blood fluid while they are in orbit?
15. How can pressure be measured in *mm of Hg*? What is the difference between *absolute* and *gauge* pressure?

16. State Archimedes' Principle. What is the origin of the *buoyancy*? How does a steel boat float? A cork floats in water with half of its volume above the surface; would it rise, sink, or stay the same if g were made larger (as on the surface of Jupiter) or lower (as on the surface of the moon)?
17. What is meant by *streamline* flow? How does streamline flow differ from *turbulent* flow? When a fluid is flowing elements of it obey Newton's Laws of Motion *plus* a supplementary relation known as the Equation of Continuity. What is the Equation of Continuity (in general, and for an incompressible fluid) and on what principle is it based? Why isn't it a consequence of Newton's Laws? How does the Equation of Continuity enter into problems of fluid flow? Explain why narrowing the orifice of a hose makes the water squirting from it speed up.
18. Be able to write down Bernoulli's Equation. What does Bernoulli's Equation describe? Under what conditions is Bernoulli's Equation valid? To what result in particle mechanics is Bernoulli's Equation analogous? Is the pressure-depth relation discussed in Question 14 independent of Bernoulli's Equation? If not, how are the two related? Use Bernoulli's Equation to explain how an airplane can stay aloft, why an aneurysm is dangerous, and why *partial* clogging of an artery can lead to complete stoppage of flow.
18. What is viscous flow? How is Bernoulli's Equation modified to account for viscous flow for the case of a circular pipe of radius R and length L? Why is a "heart" necessary in a "circulatory" system?
19. Be able to answer Conceptual Questions 1, 7, 15, 18, 20, and 25.

From Notes on Chaos:

20. *Chaos* is behavior that appears at first to be *randomly* irregular but is actually *deterministic*. What does that mean? What does chaos have to do with fluid flow? How is turbulence used in taking blood pressure readings?
21. Chaos often appears in systems that display *period doubling*. In what experimental set-up does period doubling appear in fluid flow?
22. What is a *dynamical system*? An absolute necessity for producing chaotic behavior is that the dynamical system under consideration contains *nonlinearity*. What does nonlinearity mean? Where is the nonlinearity hidden in fluid flow?
23. What is a *control parameter*? What is the primary control parameter for producing turbulence in fluid flow? When the control parameter of a dynamical system is adjusted to just the right value the system's behavior can become *unstable*. What does that mean? What does the phrase "chaos is a continual, recurrent, ever-failing pursuit of periodicity" mean? How does *chaos control* differ from *brute force control*?

From Chapter 12 (and 15.2):

24. How do you convert between the Fahrenheit, Celsius, and Kelvin temperature scales? How is the Kelvin scale defined?
25. What is *internal energy* and how can the internal energy of a system be changed? What is *thermal equilibrium*? What is meant by *thermal contact*? What is *heat*—in terms of temperature? What do the ideas of thermal equilibrium and heat imply for making a good thermometer? Define *heat capacity*. What is the Zeroth Law of Thermodynamics?