GEOL/ATOC 3070 Learning Goals: Far beyond memorizing facts and figures, a good education in oceanography should allow you to explain and illustrate concepts, interpret data, and make predictions. This document lists some of the things that you should be able to do during and after taking this course. It is organized around 21 fundamental concepts that form the core of the science that you must learn in order to understand the basic processes operating in the oceans. This list of Learning Goals *by no means covers everything that you are expected to learn*, but rather forms a foundation of fundamental principles and ideas. Some of the concepts will probably be familiar to you, but perhaps their application to oceanography will be new. You will find that many of the concepts are applicable to multiple aspects of oceanography, and will appear repeatedly during the course. Concepts are listed in the order of their first major appearance.

1. **Electromagnetic spectrum:** Explain why sound is the best means of 'seeing' through seawater. Describe the fate of solar radiation as it enters the ocean. Relate this fate to the Greenhouse effect in the atmosphere.
2. **Density stratification:** Explain the layering of the Earth's interior as a function of composition. Characterize the buoyancy level that most fish attain.
3. **Pressure and phase:** Explain why the Earth's inner core is solid while its outer core is liquid. Contrast this behavior with that of ice and liquid water. Explain why the hot water emerging from black smokers is rarely boiling.
4. **Isostatic equilibrium:** Predict how Earth's surface topography would vary with crustal density and thickness. Explain how isostatic equilibrium accounts for the behavior of ships and icebergs.
5. **Heat and temperature:** Distinguish between temperature and heat. Predict how temperature and heat should change as pressure increases with depth in the Earth's interior. Appraise the importance of water's heat capacity and latent heats of fusion and vaporization in moderating Earth's surface temperature.
6. **Convection:** Describe the conditions necessary for the development of a convection cell. Identify the driving forces behind convection of the mantle and the atmosphere.
7. **Particle transport:** Calculate the settling rate of a spherical particle according to Stokes Law. Describe the sediment sizes and modes of transportation for terrigenous particles reaching the deep sea floor.
8. **Seawater density:** Predict how the density of seawater would change with temperature, salinity, and pressure. Contrast the influence of temperature on pure vs. salty water. Compare the relative influence of salinity in warm vs. cold seawater.
9. **Steady state and residence time:** Explain why the concept of steady state is useful for understanding Earth's surface temperature. Describe the conditions that must be met under the assumption of steady state for a given substance. Predict how residence time would vary with input/output rate and concentration.
10. **Coriolis effect:** Illustrate why Coriolis deflection is said to depend on the frame of reference. Describe how the direction and magnitude of the Coriolis effect vary with latitude and velocity.
11. **Geostrophic circulation:** Draw vectors to illustrate the balance of forces around a pressure high or low. Use the latitudinal variation of Coriolis to explain why western boundary currents are more intense than eastern boundary currents.
12. **Ekman transport:** Draw vectors to illustrate the balance of forces associated with wind stress on the sea surface. Predict whether or not upwelling will exist along a given coast given a prevailing wind direction.

13. **Thermohaline circulation:** Explain why (and what) energy is ultimately required to drive the thermohaline circulation, and under what surface conditions deep waters may form. Describe the movement of heat during the formation of North Atlantic Deep Water.
14. **Deep vs. shallow water waves:** Distinguish between deep water and shallow water waves on the basis of wavelength and water depth. Name the variable that the velocity of each wave type depends on. Calculate the arrival time of a tsunami.
15. **Tide generating force:** Predict how the gravitational attraction between two objects varies with mass and distance. Sketch the lunar and solar contributions to Earth's tidal bulges for different phases of the moon.
16. **Ocean acidification:** Write a chemical reaction for ocean acidification caused by CO_2 addition. Explain how calcifying organisms are harmed by ocean acidification.
17. **Biogeochemical cycling:** Describe the role of electron transfer in photosynthesis and respiration. Explain the importance of nutrient cycling through seawater, biota, and sediments.
18. **Food chain efficiency:** Explain why mass transfer across increasing trophic levels is inefficient. Calculate the percent biomass transferred from algae to a given trophic level.
19. **Toxicity:** Explain why the acceptable concentration for a particular chemical is difficult to define. Give an example of an element that is required at low concentrations but toxic at high concentrations.
20. **Limitations on productivity:** Identify specific nutrients and other factors which may limit marine photosynthesis. Predict where and when these factors may become limiting.
21. **Maximum sustainable yield:** Summarize the basic population dynamics that allow for a healthy fishery. Explain why harvesting older fish has both benefits and risks.