NAVAL HISTORY STEM-H LESSON PLAN

density of air = 1.25 kg/m^3
density of seawater = 1025 kg/m^3
1m = 3.281 feet

volume of submarine = 8650 m^3
air pressure at sea level = 1ATM = or 1.013 x 10^5 Pa

1. A) What water pressure would a submarine experience when it is 400 feet below the surface of the ocean?
   Recall that oceans consist of saltwater... ☺
   B) What is the absolute pressure that the submarine experiences at this location (combination of the water pressure with the pressure caused by the air above the water)?
   C) What percent of the absolute pressure at 400 ft is contributed by the miles of air in our atmosphere?

2. A) What is the difference in air pressure when an airplane increases its altitude by 400 feet?
   B) Is this a significant percentage of regular atmospheric pressure, such that a human would notice or be affected? Calculate it and comment.

3. A) Some Navy aircraft, like the F-35 Joint Strike Fighter, can fly at altitudes over 40,000 ft. To understand why pilots of the F-35 need to have an oxygen system to help them breathe, calculate the air pressure at 10,000 ft, where many commercial aircraft fly.
   B) What percentage of sea level air pressure is this?

4. How much water would you need to be under, such that the absolute pressure (air and water pressure) is double the regular atmospheric air pressure you experience at sea level?

5. A submarine has a mass of 6.97million kg and does not change its mass by adding or removing any water during this problem.
   Assume that:
   - The density of seawater is 1025 kg/m^3 and does not change appreciably with depth or temperature.
   - The volume of the submarine at the surface is 6758m^3
   - The volume of the compressed submarine at 800ft is 6400m^3

   A) When it is completely submerged just below the surface, calculate its density and its vertical acceleration, based solely on its weight and the buoyant force it is experiencing. Ignore any forces exerted by the water on the planes. Your solution should include a free body diagram.
   B) When it is at 800ft, calculate:
      i. the density of the submarine
      ii. the buoyant force exerted on the submarine
      iii. the sub's new vertical acceleration.
      - Your solution should include a free body diagram with arrows drawn to the same scale as those in part A.

   C) Draw a simple submarine with its planes in positions that you think would help maintain its depth in this situation. Explain your choice of positions.

Air Pressure: Conversion / Volume of a Cylinder / Pressure vs. Volume

6. A) When the submarine compresses due to the high water pressure, does the air pressure in the sub increase?
   B) If so, by how much, and would it be noticeable?

   You may assume the following:
   - When the submarine is at the surface, the air inside it is at sea level atmospheric pressure
   - Recall that PV=nRT
     - assume n (#molecules), R(gas constant), T(Temperature) are constant.
   - The submarine is a simple cylinder.
   - radius at the surface (before compression) = 198inches
   - radius after compression = 197inches
   - uncompressed length = 360 feet
   - compressed length = 359 feet 9 inches