MATH AND SCIENCE @ WORK

AP* STATISTICS Student Edition

SPACEWALK TRAINING

Background

The Neutral Buoyancy Laboratory (NBL) is a 202 ft (62 m) long, 102 ft (31 m) wide and 40 ft (12 m) deep pool located inside the NASA Sonny Carter Training Facility in Houston, Texas. The NBL allows astronauts to train for spacewalks in an environment resembling microgravity (weightlessness). Due to the size of the NBL, two different training activities can be performed at either end of the pool simultaneously. The NBL is large enough to hold full-sized mockups of the space shuttle cargo bay, flight payloads (like the Hubble telescope) and the International Space Station (ISS). Astronauts wear pressurized Extra-vehicular Mobility Unit (EMU) suits, which weigh approximately 280 lbs (127 kg) while training in the NBL. They are assisted by at least four professional scuba divers wearing regulation scuba gear. For every hour the astronaut plans to spend on a spacewalk, the team will spend seven hours training in the water. On a training day at the NBL, astronauts normally spend up to six consecutive hours in the pool. The scuba divers, however, are limited to five hours of dive time per day and this time is broken into at least two different dives.

Figure 1: Neutral Buoyancy Lab (NBL) located in the Sonny Carter Training Facility in Houston, TX

Figure 2: An astronaut trains in the NBL and is assisted by professional scuba divers.

Neutral buoyancy is the term used to describe an object that has an equal tendency to float as it does to sink. In water, items can be made neutrally buoyant using a combination of weights and flotation devices. In such a state, even a heavy object can be easily manipulated, as is the case in the microgravity of space. However, there are two important differences between neutral buoyancy as achieved in the NBL and the weightlessness of space. First, suited astronauts training in the NBL are not truly weightless. While the suit/astronaut combination is neutrally buoyant, the astronauts feel their weight while in the suit. The second is that water drag hinders motion, making some tasks easier to perform in the NBL than in microgravity and other tasks more difficult. While these differences are recognized by spacewalk trainers and astronauts, neutral buoyancy is currently the best method available for astronauts to train for spacewalks.

Problem

Even though we may not realize it, pressure is always acting on our bodies due to the weight of the air in the atmosphere we live in. At sea level, 14.7 pounds per square inch (psi) of atmospheric pressure is acting on our bodies. Our body compensates for this pressure by pushing back with the same force. When we surround ourselves with water instead of air, the weight of the water produces additional pressure on our bodies. The deeper we go, the more pressure we feel. During training in the NBL, astronauts and the scuba divers that assist them are in water as deep as 40 feet while experiencing varying pressure on their bodies. Astronauts' suits are pressurized at the same pressure as they are when they are working in space on a spacewalk. This means that astronauts have more pressure acting on them than scuba divers at the same depth. Table 1 shows the pressure gage values experienced by scuba divers and astronauts at different depths of water. It is important to note that pressure gage readings do not take into account the 14.7 psi of atmospheric pressure at sea level.

Table 1: Pressure gage values of scuba divers and astronauts

Water Depth (feet)	Scuba Diver Pressure Gage Reading (psi)	Astronaut Pressure Gage Reading (psi)
29	12.6	16.8
30	13.0	17.2
31	13.4	17.6
32	13.9	18.1
33	14.3	18.5
34	14.7	18.9
35	15.2	19.4
36	15.6	19.8
37	16.0	20.2
38	16.5	20.7

A. Plot the gauged pressure experienced by scuba divers (psi) vs. the water depth (ft). Determine the correct mathematical model to fit the data and give statistical evidence to support your decision by answering the questions that follow.

   I. Interpret the slope and *y*-intercept in the context of the problem.

   II. Determine the correlation coefficient and interpret its value.

   III. The plotted data shows what type of association between depth and pressure?

IV. Graph a residual plot and describe the association based on the residuals of the graph.

V. Is a linear model appropriate for the plotted data? Explain in statistical terms.

B. Plot the gauged pressure experienced by astronauts (psi) vs. the water depth (ft). Determine the correct mathematical model to fit the data and give statistical evidence to support your decision by answering the questions that follow.

I. Determine the correlation coefficient and interpret its value.

II. The plotted data shows what type of association between the depth and the water pressure?

III. Graph a residual plot and describe the association based on the residuals of the graph.

IV. Is a linear model appropriate for the plotted data? Explain in statistical terms.

C. Create a plot showing both sets of response variables on the same axes. Label both graphs with appropriate equations.

I. What transformation value changes the value of the pressure felt by astronauts and scuba divers? Explain how you determined that value.

II. What do you notice about both sets of data? What accounts for the difference between the graph of the astronauts' data and the graph of the scuba divers' data?

III. Predict the pressure experienced by an astronaut in the NBL at a water depth of 45 feet.