**The Conceptual Problem**

Cindy, a 40-year old high school teacher, is planning a summer trip with her teenage nieces trekking along the Continental Divide Trail in Colorado and Wyoming. According to the Trails.com web site (<http://www.trails.com/continental-divide-trail.aspx>),

*The Continental Divide Trail might well be the most extreme of the three major National Scenic Trails. The “CDT” covers the greatest distance at approximately 3,100 miles, reaches an ultimate high point of 14,270 feet at Grays Peak, Colorado, and has a low point of 4,280 feet, less than 2,400 feet below the highest point on the Appalachian Trail.”*

The trip Cindy and her nieces have selected will be very strenuous and in high altitude. Is Cindy’s healthy enough to safely complete the trip? That is the question her physician must answer.

**Cindy’s Health History**

In high school, Cindy ran cross-country track and was in very good shape. After college she became a high school teacher in Lexington, KY (elevation 978 feet) and has not had much time to exercise and stay in good physical health. She has not been eating the most nutritional meals over the last several years and as a result has gained considerable weight. Cindy really wants to go on this trip with her nieces, but she wants to make sure she is “healthy enough” to do so. She has scheduled a visit with her physician for a check up before beginning her training for the trip.

**Cindy’s Physical Check Up**

Upon learning of Cindy’s plans to hike the Continental Divide, the physician performed a complete physical. She measured Cindy’s weight and blood pressure, checked her pulse, listened to her lungs as Cindy breathed, tested her reflex reactions, and examined her abdominal region. The physician drew blood and ordered a complete blood work up, including a complete lipid panel to check Cindy’s cholesterol and triglycerides. The physician was concerned because Cindy was 5’5” and weighed 175 pounds, bordering on obesity levels. She was greatly concerned about Cindy’s ability to function normally in the high altitudes of the Continental Divide.

The results from the physical were of concern. A comparison of Cindy’s blood pressure at her ankle and brachial arteries measured greater than 15mmHg difference (ABI, ankle-brachial index, measured by dividing the higher of the two blood pressure measurements at the arms by the higher of the two measures near the ankle). Cindy’ blood pressure in the right arm is 160/95 and she is considered overweight by 40lbs for her height and body structure. The physician ordered a Doppler ultrasound and a stress test to assess her circulatory and cardiac function.

Upon her follow up visit, the physician reported to Cindy the lab and test results along with specific recommendations. Cindy’s blood analysis revealed a HDL of 40 mg/dL and an LDL of 165 mg/dL. The total cholesterol is 210 mg/dL. The hemoglobin level is 11 gm/dL with a hematocrit of 36%. The ABI was 0.80, which indicated poor blood flow to the ankle or brachial arteries. Doppler ultrasonography revealed poor circulation in Cindy’s femoral and carotid arteries. Cindy’s right femoral artery was about 50% occluded and her carotid arteries were both about 25% occluded due to plaque build up. The physician suggested a conventional angiography of her circulatory system to examine for severe problem points in her circulatory system as well as examine her coronary arteries because she performed poorly on the treadmill stress test.

The physician advises Cindy that she is not physically fit in health for the strenuous hiking trip along the Continental Divide at such an altitude. The physician recommends medications to start reducing the plaque build up in her arteries and dietary control of lipid and cholesterol intake. The physician also suggests another test to determine if Cindy has a nutritional deficiency in iron and B12 or if she has an underlying disease responsible for the low hemoglobin and hematocrit values.

**Designing a Demonstration Model**

Cindy is in denial about her health status. She explains to the physician that she will just start walking in her classroom more while teaching and will walk each evening for the next month to get her self back in shape as she feels this should be good enough training for a mountain hiking a month and half away. She said she does not think the narrowing of her arteries should have much impact. She does not understand the physician’s concern that the blood pressures in her leg and arm are so different. She does think a better diet would be good and she plans to start on this modification right away but she see’s no need to take the drugs the physician called a “statin”. She informed the physician that it was good to have thin blood with a low hematocrit so the blood will flow better at high altitude. Since she was planning to go stay with her nieces in Denver, CO for 1 week before starting the hike, maybe her blood would be thicker as she heard that blood becomes thicker when one stays in the mountains.

The physician is very frustrated with Cindy’s denial of her health status. When Cindy returns for her follow-up appointment, the physician is determined to demonstrate to Cindy with visual models what is happening within her blood vessels, the potential reasons for the underlying disease accounting for the low hemoglobin and hematocrit values, and why hypertension is bad. The physician also plans to demonstrate with the models the impact of altering her hematocrit with her present conditions. With the help of her brother, a physics teacher at the local high school, the physician recruits a group of high school physics students to design models that can be used to demonstrate the issues involved in the problems mentioned (ankle-brachial index, arthrosclerosis, and viscosity of flow in constricted tubes). The group of students that designs the most cost efficient and effective model to demonstrate the main points related to the health conditions would win a cash prize of $200.

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<http://en.wikipedia.org/wiki/Bernoulli's_principle>

(similar) <http://www.scribd.com/doc/36240138/Bernoulli-s-Principle>

<http://www.angieslist.com/articles/why-does-my-toilet-water-level-drop-when-it%E2%80%99s-windy.htm>

Why does my toilet water level drop when it’s windy?

Movie: <http://blog.thinkwell.com/2009/09/physics-in-action-bernoullis-principle.html>

<http://mysite.du.edu/~jcalvert/tech/fluids/bernoul.htm>

Pressure drop: <http://www.ehow.com/how_7715606_calculate-pressure-drop-pipe-fittings.html>