Order-of-Magnitude Physics – Problem Set 11

Problem 1. Riding the Silver Dragon

Tidal bores (after the Saxon *bara*, meaning "wave") are surges of ocean water forced into narrow river channels. The world's largest tidal bore occurs near the Chinese city of Hangzhou, where the Tsien-Tang River empties into the South China Sea. During high tide, the waters of the South China Sea surge up the Tsien-Tang River and create a wall of water as high as 7.6 meters (25 feet) travelling at 24 km/hr (13 knots). The bore is at its fiercest twice a month, when it is called the "Silver Dragon."[1]

(a) Estimate the depth of the Tsien-Tang River under normal, unperturbed conditions.

(b) The Chinese have been known to use the bore to float their junks (boats) inland. Estimate the speed with which a junk can travel inland under windless conditions. Does the junk keep pace with the bore or lag behind it?

Problem 2. The Bay of Fundy

The Bay of Fundy in Nova Scotia, Canada is known for the world's largest tidal range (change in water height due to tides). Fisherman are known to catch fish simply by setting up nets during low tide, waiting for fish to be caught during high tide, and then collecting the fish during the next low tide. The range ranges from 10 feet at the mouth of the Bay to 51 feet at the end of Minas Basin (a bay that branches off the Bay of Fundy).

Take the typical depth of water in this area to be 75 m. What must the length of a bay be to enjoy the largest tidal range? Compare your answer to the actual length of Minas Basin.

Problem 3. Atherosclerosis

Arteries are elastic tubes filled with blood. Pressure waves can travel along arteries. By measuring the time a pressure wave takes to travel down an artery, doctors can non-invasively diagnose atherosclerosis, or "hardening" (thickening) of the artery wall.

The speed of pressure pulses varies with artery properties. Write down all the variables you think matter in determining the speed. Then devise a minimum number of experi-

[1] For several centuries during the Autumn Full Moon Festival, people would gather from hundreds of miles away to watch boatmen and fisherman plunge into the river and test their mettle against the Silver Dragon. Governors dating back to as early as the 11th century tried to ban this dangerous and often deadly practice, but it persisted until the 19th century. Even in the last 10 years, the Silver Dragon has swept away and killed about 100 hapless spectators. In 2008, American surfer dudes Long, Long, and Healey were granted permission by the Chinese government to surf a section of the bore (they wound up surfing outside the permitted section but were forgiven).

ments required to establish an empirical formula for the speed. Do not derive the speed from first principles, but instead approach this problem as an experimentalist with a limited budget.

Problem 4. Laser Pointer Safety

It is widely believed that laser pointers should not be directed into people's eyes, for fear of retinal burning. Justify or refute this belief using order-of-magnitude physics, supplemented by physical experiments as you deem necessary. Carefully define and quantify all variables used. It would be helpful in evaluating your solution for you to define and evaluate a dimensionless quantity (a "figure of merit") whose value (be it $\ll 1$ or $\gg 1$) indicates whether danger of blindness is significant.

For concreteness, consider the distance between the laser-wielding speaker and an audience member in a classroom the size of ours.

Problem 5. Ask Your Own Question

Ask an OOM question of your own. You don't have to answer it.