Fall 13 - Homework Assignment #1 – Due: Thursday, 4 September

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1. List five everyday examples of the application of fluid mechanics. Please provide comprehensive details of how fluid mechanics is involved and list appropriate references.
   1. water towers

Fluid statics is applied to the design of water towers. The purpose of a water tower is to provide pressure that will maintain a safe supply of water to an entire town or building. They are usually placed at very high elevations because this will provide the most pressure [1]. This is because concepts from fluid statics state that pressure is directly proportional to change in height. So an increase in elevation means an increase in pressure [2].

* 1. race cars

The design of a race car applies concepts from both fluid mechanics and Computational Fluid Dynamics (CFD). Fluid Dynamics is used in the design of chassis and the front and rear wings. CFD is used to model the airflow over the car. This model is deed for figuring out the aerodynamic efficiency and for achieving the most effective race car design [3].

* 1. Hydraulic machines

Pascal’s principal is applied in hydraulic machines. A basic hydraulic machine consists of two cylindrical pistons with a fluid inside, typically oil. Fundamentally, hydraulic machines operate on something known as “hydraulic multiplication” [4]. In terms of the piston machine, hydraulic multiplication involves two pistons of unequal sizes and the forces exerted on both of them. Applying a force on one piston will cause a greater force to the other piston. This happens because Pascal’s principal states that “Pressure is transmitted undiminished in an enclosed static fluid” [5]. Since the fluid inside a hydraulic machine is at rest, this means that the pressure inside the machine can be assumed to be constant. So applying a force to a smaller piston produces the larger force on the larger piston.

* 1. submarines

Concepts from fluid statics are applied when a submarine descends underwater. As the submarine descends it experiences a lot of pressure and forces on its exterior walls. One of those forces is the buoyant force. This force prevents the submarine from sinking all the way down to the ocean floor. When diving down underwater the ballast and trim tanks are filled with water to increase the submarine’s density. This increases the submarine’s overall weight, countering the upward buoyant force. As a result the submarine descends [6].

* 1. airplanes

Fluid dynamics has widespread applications in airplane flight. One way the fluid dynamics is applied is in the study of drag and airflow over an airplane while it is in flight. Drag is an aerodynamic force that opposes the airplane’s motion and it is caused by a difference in the speed of the airplane and the speed of the air [7]. The value of drag depends on the viscosity of the air [7]. The more viscous the air is the lesser the drag. The Reynolds number is used to study the airflow. A higher Reynolds number means the airflow is more turbulent because the viscous forces acting on the air is small [8,9]. Turbulent airflow is what cause the airplane to jolt around and producing the phenomenon known as “turbulence”.

1. Solve the problems below that relate to the conversion of units from one system to another. Please show details of your work.

1.20, 1.21, and 1.22

**Problem 1.20:**

Part a:

Part b:

Part c:

Part d:

Part e:

**Problem 1.21:**

Part a:

Part b:

Part c:

Part d:

Part e:

**Problem 1.22:**

Part a:

Part b:

Part c:

Part d:

Part e:

References

[1] Marshall, B., n.d., “How Water Towers Work” from <http://www.howstuffworks.com/water.htm>

[2] TutorVista.com, "Pascal's Law.", n.d., from <http://www.tutorvista.com/physics/pascal-s-law-for-kids>

[3] Quora, “How are Thermodynamics and Fluid mechanics involved in an F1 racecar”, n.d. from

<http://www.quora.com/Formula-1-1/How-are-Thermodynamics-and-Fluid-mechanics-involved-in-an-F1-racecar>

[4] Marshall B., n.d., “How Hydraulic Machines Work”, from <http://science.howstuffworks.com/transport/engines-equipment/hydraulic.htm>

[5] from <http://hyperphysics.phy-astr.gsu.edu/hbase/pasc.html>

[6] Marshall B. and Freudenrich C. Ph.D, n.d., “How Submarines Work”, from

<http://science.howstuffworks.com/transport/engines-equipment/submarine.htm>

[7] National Aeronautics and Space Administration, n.d., “What is Drag”, from <http://www.grc.nasa.gov/WWW/k-12/airplane/drag1.html>

[8] National Aeronautics and Space Administration, n.d., “Reynolds Number”, from <http://www.grc.nasa.gov/WWW/k-12/airplane/reynolds.html>

[9] from <http://www.efm.leeds.ac.uk/CIVE/CIVE1400/Section4/laminar_turbulent.htm>