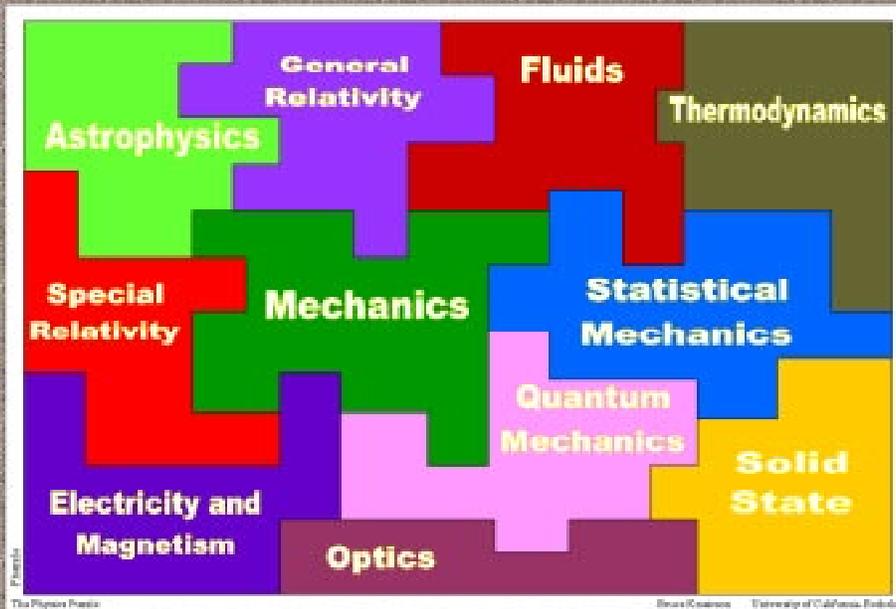


Phuzzle



Photo

The Physics Puzzle

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The Physics Puzzle

Fluids

Definitions

Fundamental Quantities

A fluid consists of a large number of particles with random velocities, and mass m .

$\rho = \frac{dm}{dV}$ The mass density

$\vec{v} = \frac{d\vec{r}}{dt}$ The velocity vector

$\vec{v}_m = -\frac{1}{\rho} \nabla p$ The mechanical momentum

$\vec{T} = -P\vec{e}_x\vec{e}_x + \vec{T}_{xy}$ The stress tensor

$d\vec{S} = \rho dV + \frac{1}{2} \rho^2 dV^2$ The internal energy

$\vec{v} \cdot d\vec{S} = \rho \vec{v} \cdot d\vec{S}$ The heat flux

$\vec{v} \cdot d\vec{S} = \rho \vec{v} \cdot d\vec{S}$ The work done on the fluid

The free surface condition is a fluid in contact with a solid surface. The free surface condition is that the normal velocity is zero.

$v = \frac{\partial \psi}{\partial t}$ The stream function

An incompressible fluid satisfies $\nabla \cdot \vec{v} = 0$ and $\nabla \cdot \vec{v} = 0$

Steady flow satisfies $\frac{d}{dt} = 0$ and $\frac{d}{dt} = 0$

$\vec{v} = \frac{\partial \psi}{\partial t}$ The dynamic pressure is the pressure due to the velocity of a stream.

Observations

Conservation of mass: $\frac{dM}{dt} = 0$

The force on a fluid element may be written $\vec{F} = \vec{F}_m + \vec{F}_p$

Conservation of momentum: $\frac{d\vec{p}}{dt} = \vec{F}$

Stokes' theorem: $\oint_C \vec{v} \cdot d\vec{r} = \int_S \nabla \times \vec{v} \cdot d\vec{S}$ relates the circulation to the vorticity.

Bernoulli's law of flow: In a steady flow, the total energy per unit mass is constant: $\frac{1}{2} v^2 + \frac{p}{\rho} + \phi = \text{const}$

The only boundary condition is that the velocity is zero at the boundary.



Why do many towns have a water tower? Why not just pump water directly?



Using physical and physiological arguments, can a hippopotamus float?



How quickly must an eagle move through the surrounding air in order to stay aloft?



The angle of a duck's wake is surprising constant from duck to duck. Can you compute the angle? Next time you find yourself at the side of a pond, check to see if you are correct.



I played Ultimate (frisbee) while I was in college, and this in large part sparked my interest in fluid mechanics. Anyone who has thrown a frisbee knows that a frisbee's rotation is crucial for proper flight. Why?



Astronauts sometimes practice maneuvers underwater, where buoyancy simulates a weaker gravitational force. How well does this approximate the gravitational force on the moon? What conditions could you change to improve this approximation?



Shown here is a 10'x10' supersonic wind tunnel at the NASA Glenn Research Center in Cleveland, Ohio. Since pressure waves cannot move faster than the speed of sound, how can you possibly build a supersonic wind tunnel?



Baseball would be much more exciting if pitchers did not have such good control of the ball. A well-thrown curve ball can curve up to half a meter or more during its sixty foot flight to home plate, while a fastball may come straight in. Perhaps we can modify the baseball itself in order to increase the number of hits and decrease the number of times I yawn during a typical game?



Transportation engineers often describe traffic flows using concepts from fluid mechanics. How might we apply each of the Fluid Definitions and Observations to model the traffic here on Interstate 101 in California?



The person here is in the process of trying to recover data from a crashed computer disk. Work of this type goes on in a Class 10 clean room. What does “Class 10” mean? What class clean room do you think you could achieve if you were given a week and commonly available materials?



The physically realizable slope of a sand dune is bounded from above. Roughly what is this bound?



Estimate the vorticity of this tornado. What causes tornadoes to die out?



When viewed from above, a thick layer of clouds can look almost like snow-covered ground. What conditions cause this flat vapor-scape?



What causes waves to break?



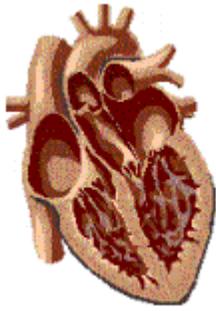
I have a friend that has instructed his two-year-old not to fly her kite on days with a stiff breeze, for fear that she might be lifted off her feet and injured. How stiff must the breeze be for this to be a concern?



Using physical and physiological arguments, how fast can a human swim?



Water flowing through a horizontal cylindrical pipe obeys *Poiseuille flow*. If you had to discharge a cubic meter of sewer water per minute through a pipe ten meters long and with an opening the size of a baseball, could you do it?



Much of the material studied in a fluids course is inapplicable to blood flow. What assumptions do we typically make about fluids and their containers? How do these assumptions need to be modified to model the flow of blood?