

Ch 12.3-5

Buoyancy & Fluid Flow

PHYS 1210 -- Prof. Jang-Condell

Which grading system do you prefer for your final grade?

- A. Letter grades only (A, B, C, D, F)
- B. Plus/minus grading (A, A-, B+, B, B-, etc.)
- C. Don't care

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PI A PROF

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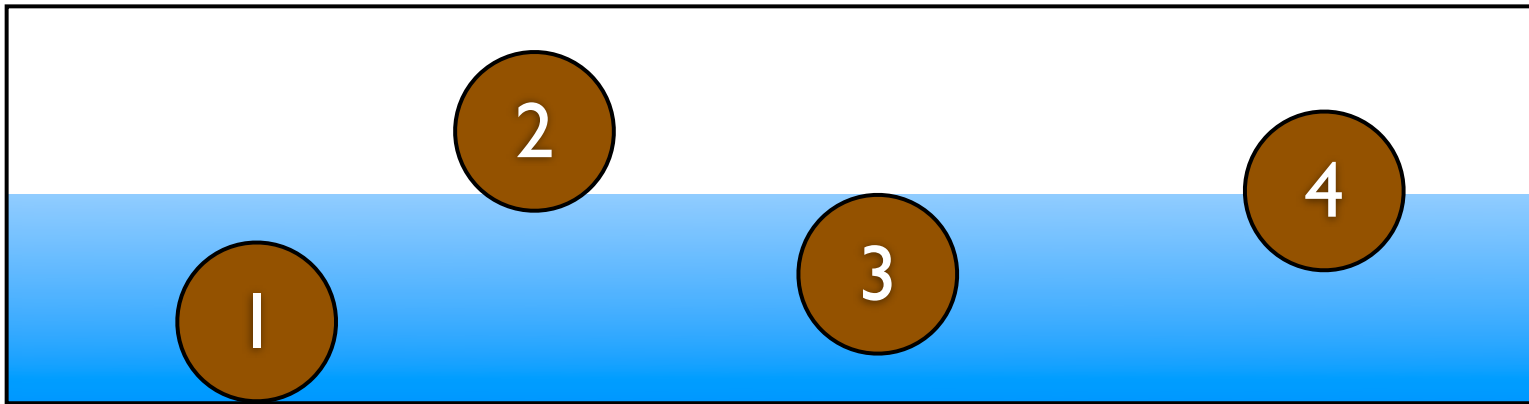
Goals for Chapter 12

- To study the concept of density
- To investigate pressure in a fluid
- To study buoyancy in fluids
- To compare laminar versus turbulent fluid flow and how the fluid speed depends on the size of the tube
- To learn how to use Bernoulli's equation to relate pressure and flow speed of a fluid

- The **gauge** pressure is the pressure above atmospheric pressure. The **absolute** pressure is the total pressure.
- When you measure your bike tire's pressure to be 40 pounds per square inch (psi), that is its **gauge** pressure.
- If the air pressure in Laramie is 0.77 atm, what is the **absolute** pressure of the bike tire?
- If you ride your bike to Ft. Collins, where the air pressure is 0.85 atm, what is the **gauge** pressure of the tire?

Buoyancy

Rank these objects in water from smallest to greatest density.



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Archimedes

ca. 287-ca. 212 BCE



Ancient Greek mathematician

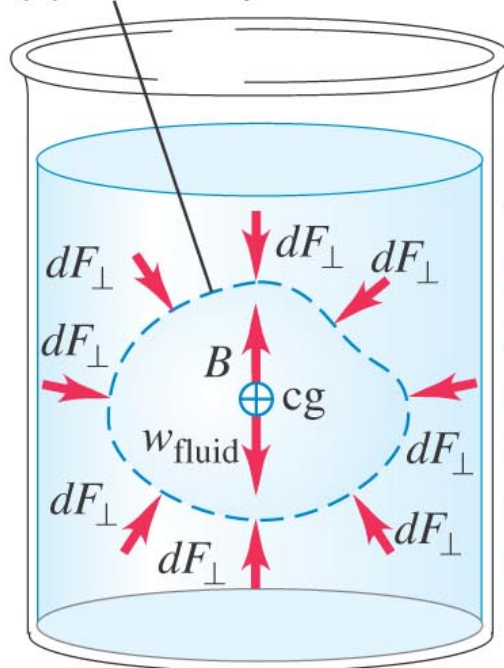
Eureka!

King Hiero II had a gold crown made for himself, and asked Archimedes to determine if it was pure gold. Thinking about this while taking a bath, Archimedes realized that the volume of water displaced would be the volume of the crown.

Archimedes Principle

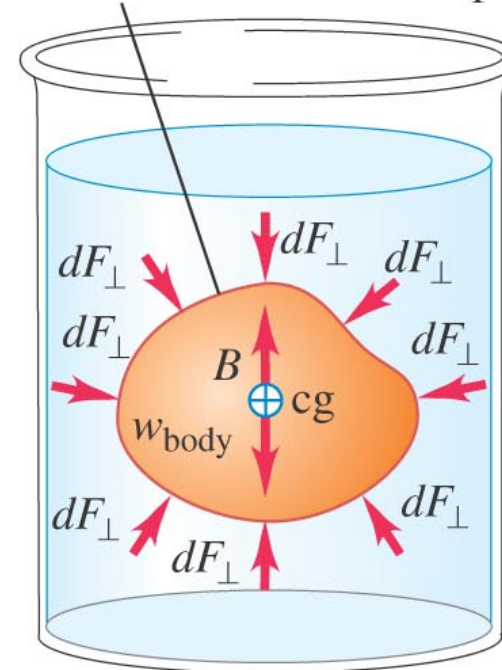
- *Archimedes' Principle*: When a body is completely or partially immersed in a fluid, the fluid exerts an upward force (the “buoyant force”) on the body equal to the weight of the fluid displaced by the body. (See Figure 12.11 below.)

(a) Arbitrary element of fluid in equilibrium



The forces on the fluid element due to pressure must sum to a buoyant force equal in magnitude to the element's weight.

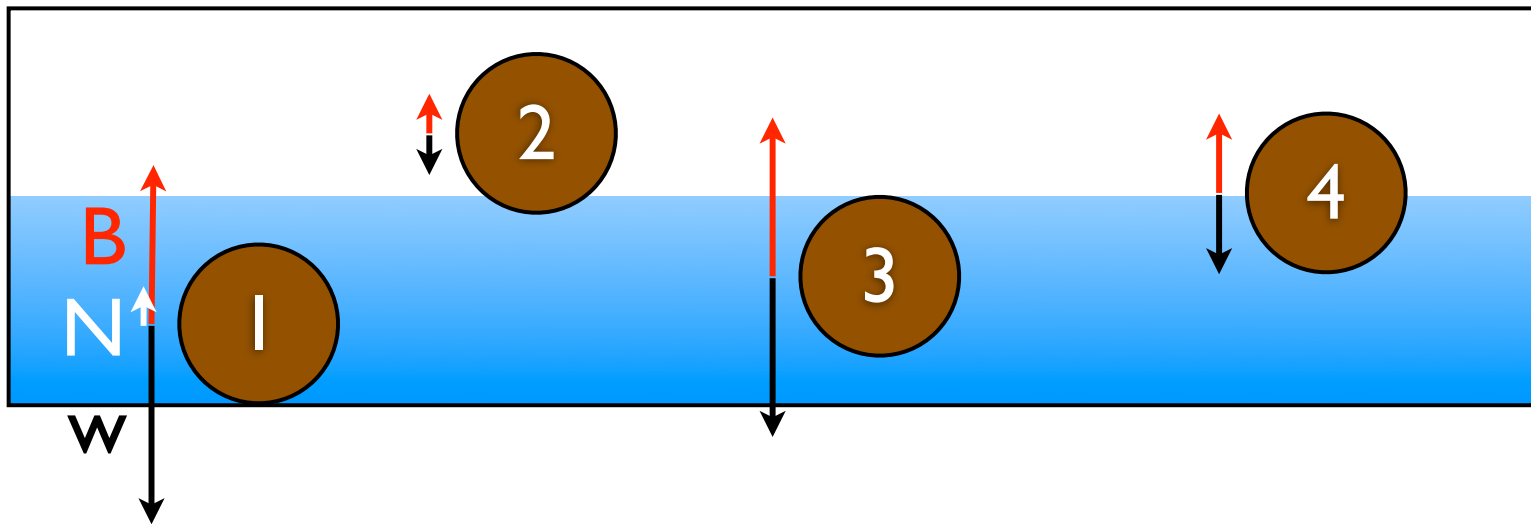
(b) Fluid element replaced with solid body of the same size and shape



The forces due to pressure are the same, so the body must be acted upon by the same buoyant force as the fluid element, regardless of the body's weight.

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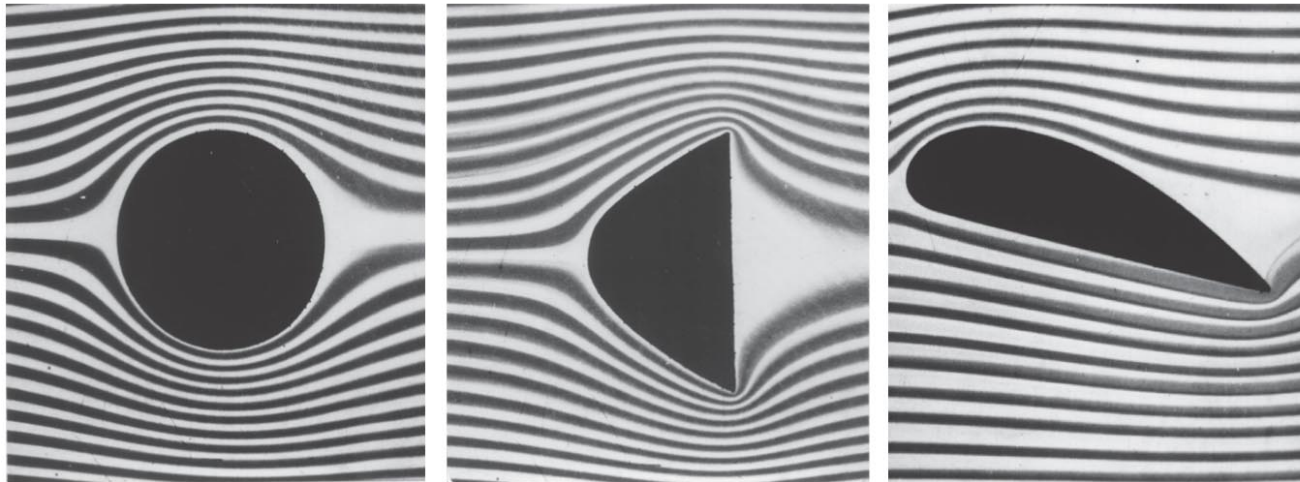


$$B = g\rho_{\text{fluid}}V$$

Fluid flow

Fluid flow

- The flow lines in the bottom figure are *laminar* because adjacent layers slide smoothly past each other.
- In the figure at the right, the upward flow is laminar at first but then becomes *turbulent flow*.

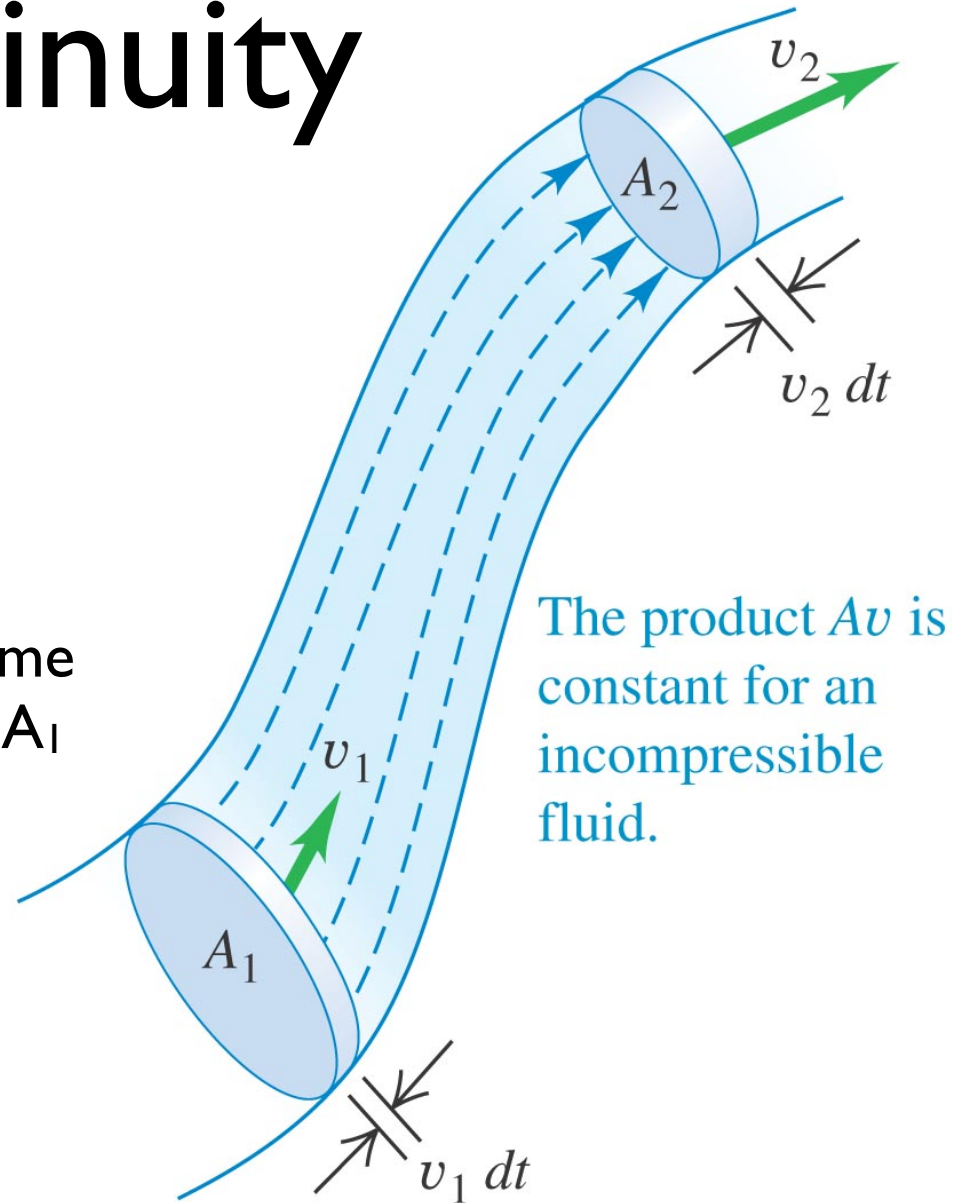


Continuity

Consider a pipe with varying cross-sectional area.

Over a time interval dt , the same amount of fluid flows through A_1 as A_2 .

$$dm = \rho A v dt$$



The continuity equation

- The *continuity equation* for an incompressible fluid is

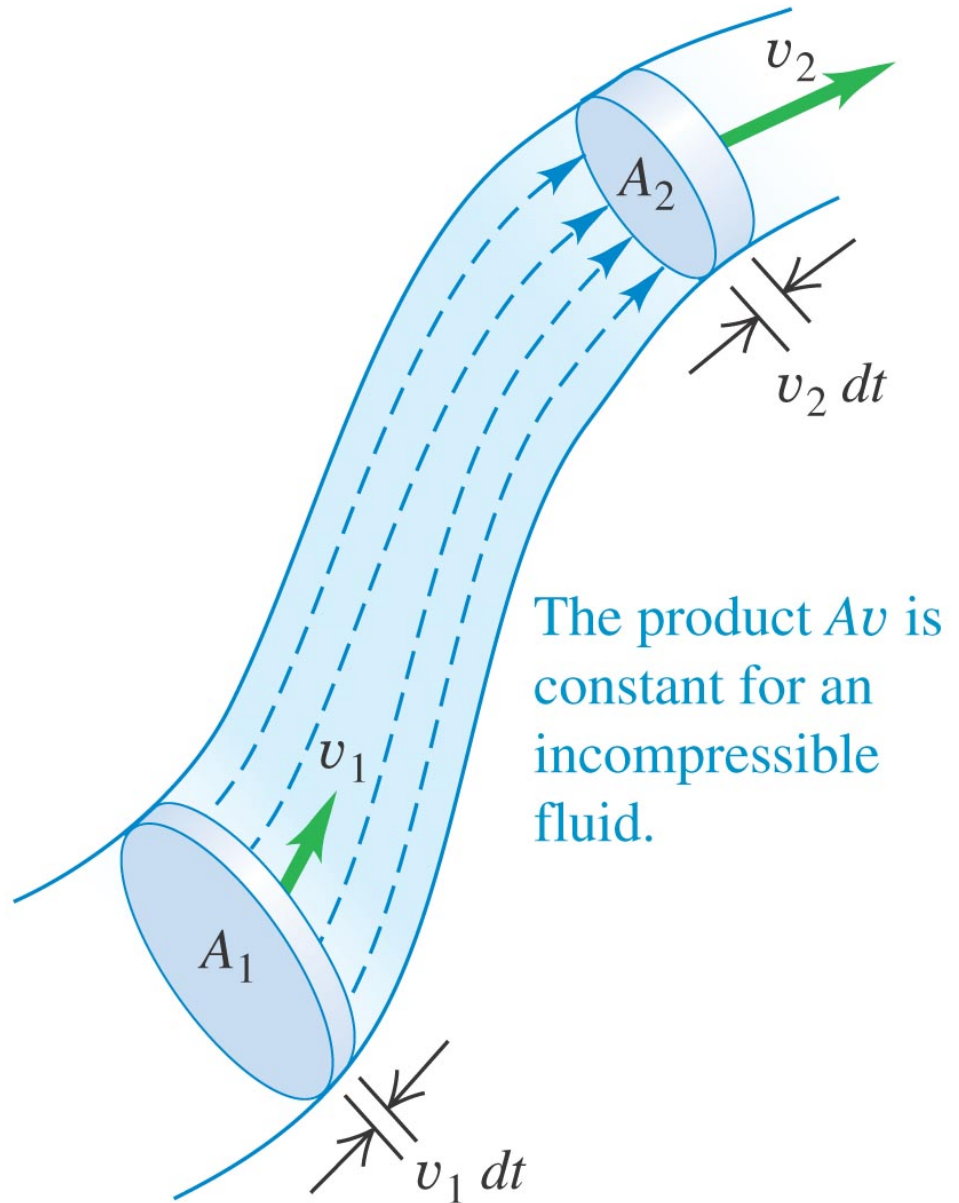
$$A_1 v_1 = A_2 v_2.$$

- The *volume flow rate* is

$$dV/dt = Av.$$

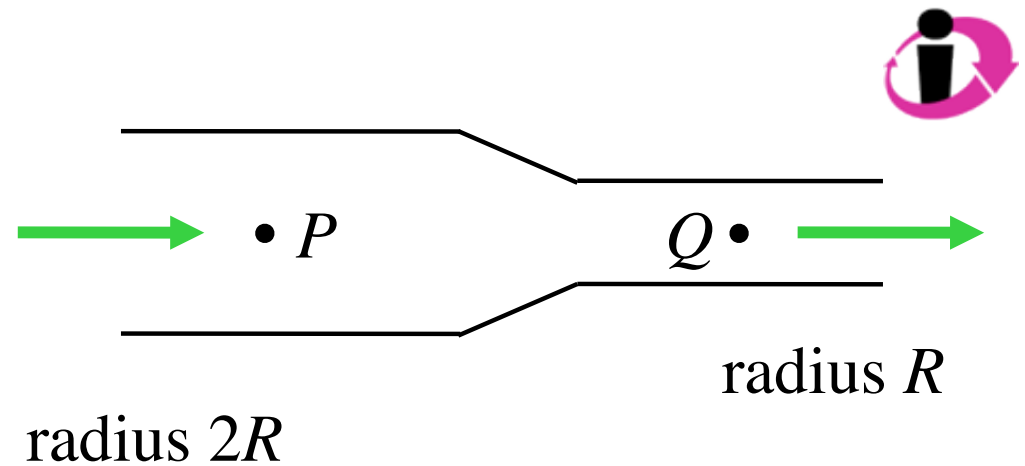
- For a compressible fluid (e.g. some gases), the continuity equation is

$$\rho_1 A_1 v_1 = \rho_2 A_2 v_2$$



Q13.5

An incompressible fluid flows through a pipe of varying radius (shown in cross-section). Compared to the fluid at point P , the fluid at point Q has



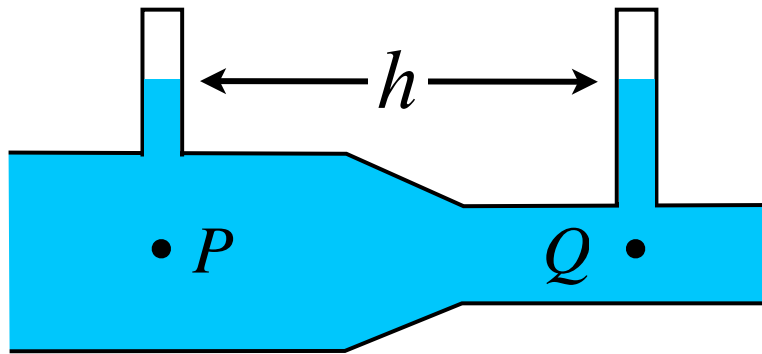
- F. 4 times the fluid speed.
- G. 2 times the fluid speed.
- H. the same fluid speed.
- I. $1/2$ the fluid speed.
- J. $1/4$ the fluid speed.

Bernoulli's Equation

$$p_1 + \rho g y_1 + 1/2 \rho v_1^2 = p_2 + \rho g y_2 + 1/2 \rho v_2^2$$

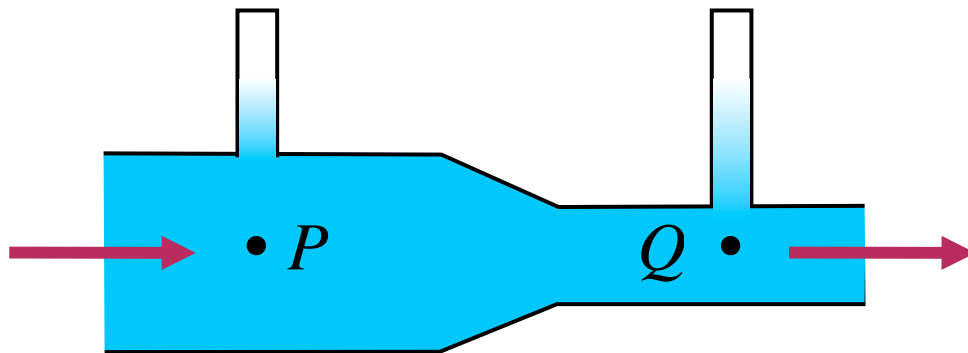
Venturi meter

fluid at rest



radius $2R$

radius R

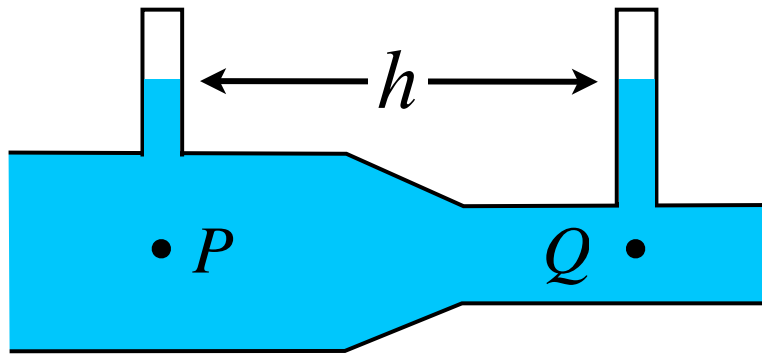


fluid in motion

How does the pressure compare at points P & Q ?

Venturi meter

fluid at rest



When the fluid is in motion,

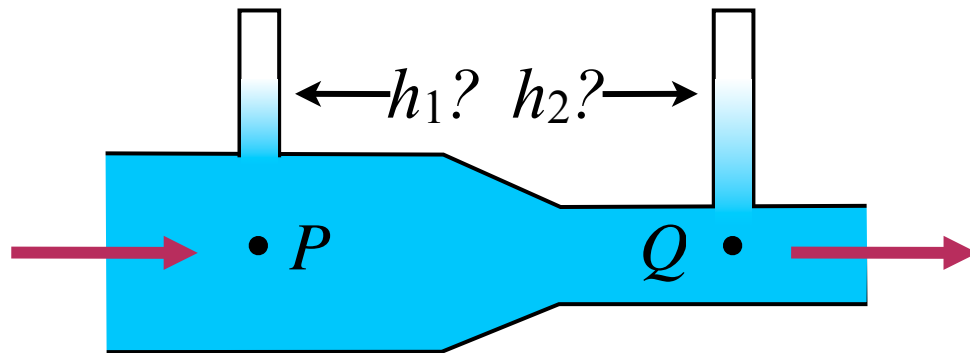
K. $h_1 = h_2$

L. $h_1 < h_2$

M. $h_1 > h_2$

N. None of the above

radius $2R$ radius R

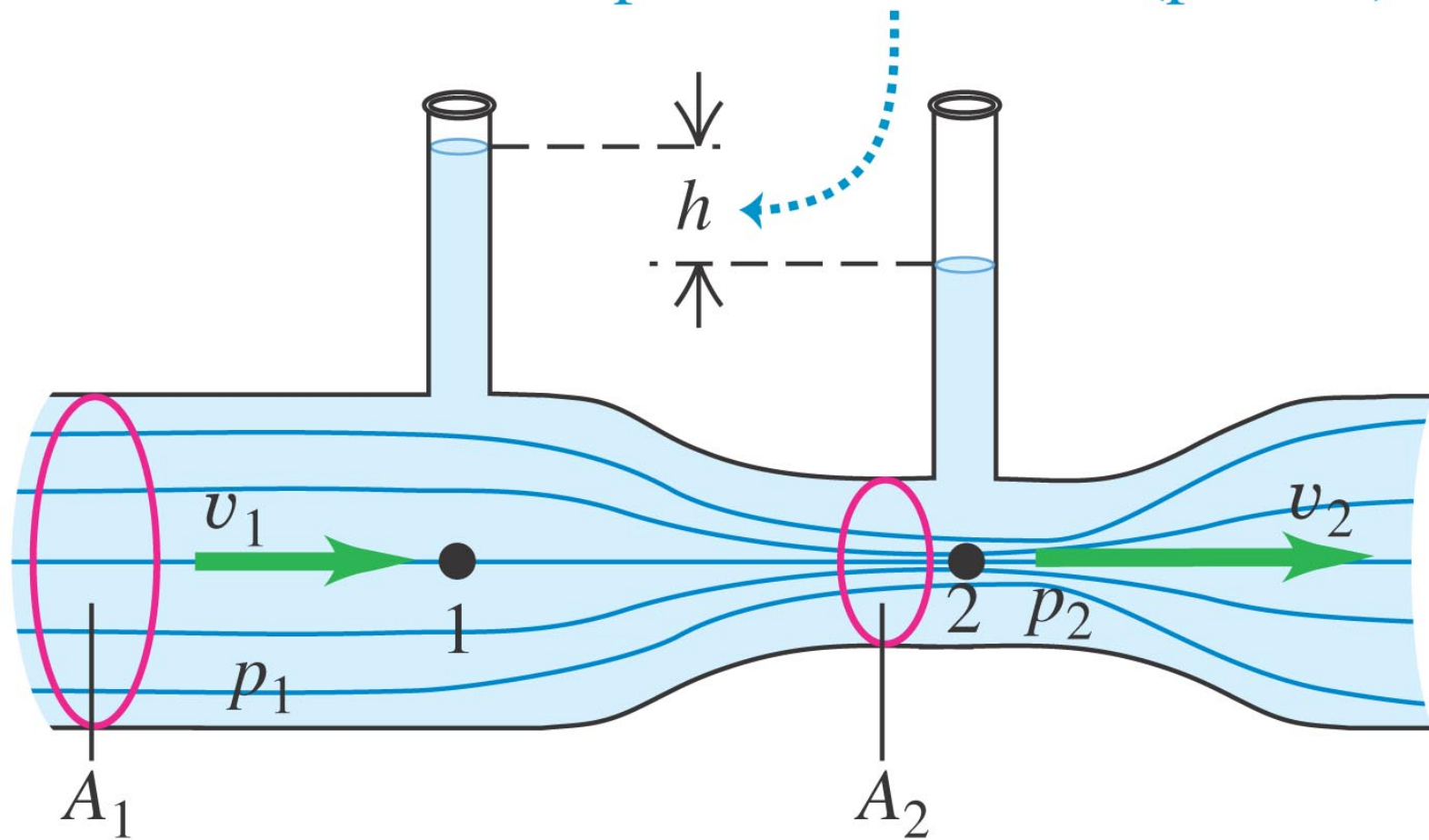


fluid in motion

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22333

The Venturi meter

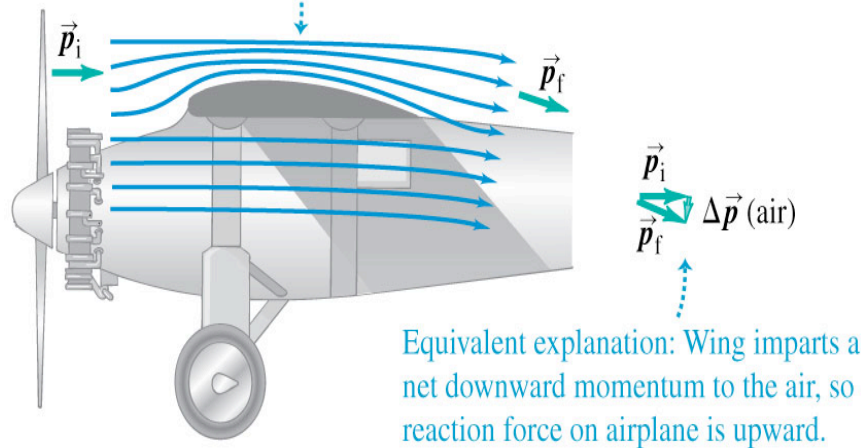
Difference in height results from reduced pressure in throat (point 2).



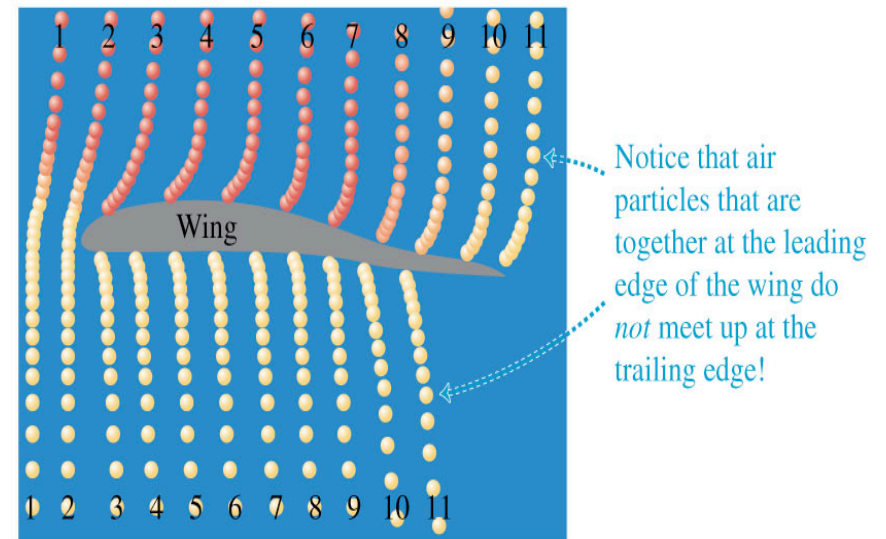
Lift on an airplane wing

(a) Flow lines around an airplane wing

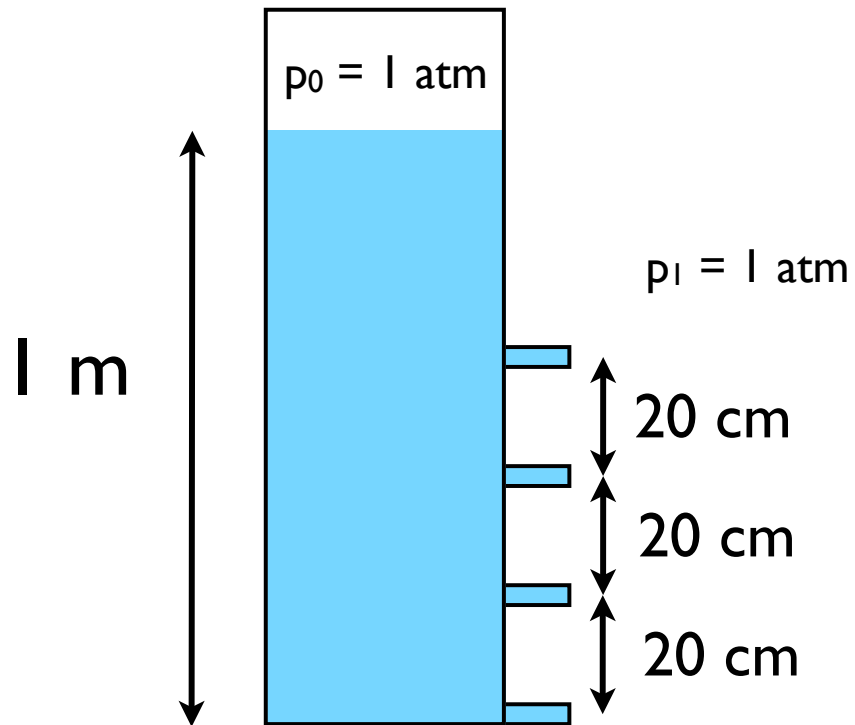
Flow lines are crowded together above the wing, so flow speed is higher there and pressure is lower.



(b) Computer simulation of air parcels flowing around a wing, showing that air moves much faster over the top than over the bottom.



The Leaky Tower



Each pipe has a diameter of 1 cm . At what speed will the water come out from each pipe?