Fluid Mechanics Practice Items

1. A bar of lead has the dimensions $2 \times 3 \times 5$ cm^3 and mass 330 gm. What is the specific gravity of lead?

A. 1
B. 10
C. 11
D. 50

2. If the bar of lead in problem #1 were submerged in water, what would be the apparent loss of weight on the bar?

A. 1/11 N
B. 0.3 N
C. 1 N
D. 300 N

3. In recreational scuba diving, the maximum depth limit is 40 meters. What is the pressure at that depth?

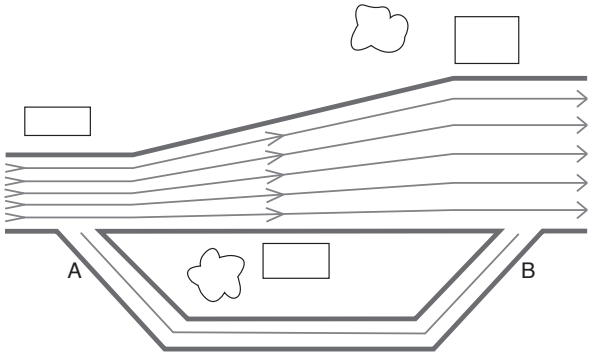
A. 4.0×10^3 Pa
B. 7.6×10^4 Pa
C. 4.0×10^5 Pa
D. 5.0×10^5 Pa

4. In laminar flow

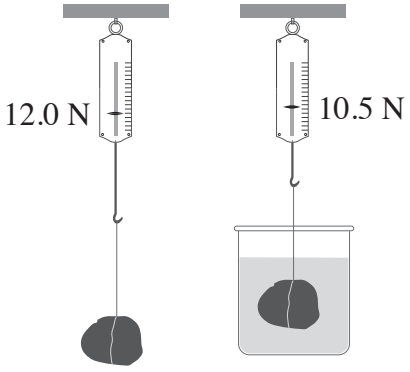
A. momentum is rapidly interchanged within the fluid.
B. the Reynolds number is greater than 2000.
C. eddy currents exist.
D. none of the above.

5. The figure below depicts the bird's eye view of a section of a canal system of uniform depth. The flow through the large canal moves left to right in a steady, streamline manner. The secondary flow in canal AB

A. moves left to right
B. moves right to left
C. does not move
D. must be turbulent



6. The weight of a sample of mineral ore was measured using a spring scale and found to equal 12.0 N suspended in air. Submerged in water the ore weighed 10.5 N. What is the specific gravity of the ore?

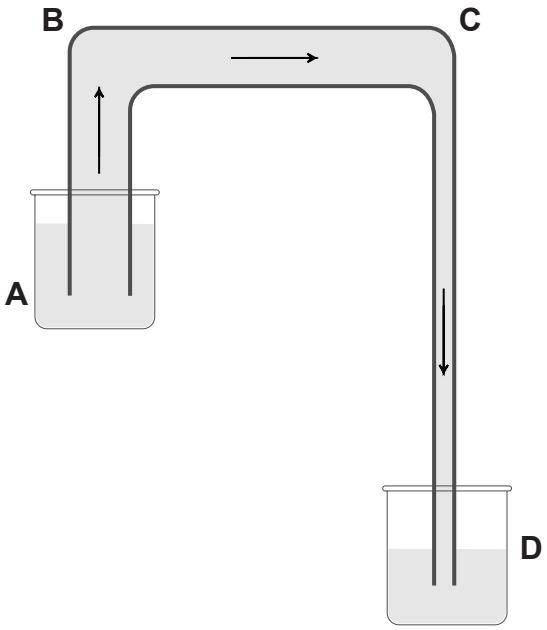


A. 1.1
B. 4.4
C. 8.0
D. 8.8

The following passage pertains to questions 7 - 10.

In the construction of a siphon, a tube is filled with liquid and the end of one arm of the tube is immersed in the liquid to be moved. Flow will occur up one arm of the siphon and then down the other. It is necessary in constructing a siphon for the arm drawing off the liquid to be shorter than the arm into which the liquid will flow, and that the end of the short arm of the siphon be kept at a level higher than the end of the long arm.

Flow through the siphon occurs because the column of liquid CD exerts more pressure at D than the column of liquid AB exerts at A.



7. If atmospheric pressure were to increase, the flow rate through the siphon above would

A. decrease
B. remain the same
C. increase
D. cease

8. The diameter of tube segment AB is 3 cm. The diameter of tube segment CD is 1 cm. When the flow speed through AB is 2 cm/s, what will the flow speed be through CD?

A. 6 cm/s
B. 9 cm/s
C. 15 cm/s
D. 18 cm/s

9. What is the approximate maximum height of segment CD in a functioning siphon in which the liquid is water?

A. ¾ m
B. 5 m
C. 10 m
D. 30 m

10. If instead of ordinary water, we were siphoning deuterium oxide (heavy water) which of the following differences would we observe in our system?

I. For a siphon of given dimensions, flow rate would decrease
II. For a siphon of given dimensions, flow rate would increase.
III. The likelihood of turbulent flow would increase.

A. I only
B. II only
C. III only
D. both II and III

The following passage pertains to questions 11 - 16.

The dynamics of blood flow through an abnormal narrowing or stenosis in an artery can be approached at a fundamental level via Poiseuille's law and Bernoulli's principle. Poiseuille's law states a linear relationship between volumetric flow rate and pressure gradient in a real, Newtonian fluid

$$Q = \frac{\Delta P \, \pi \, r^4}{8 \, \eta \, l}$$

Q - volumetric flow rate
ΔP - pressure gradient
r - inner radius of the vessel
l - length of the vessel
η - blood viscosity

Bernoulli's principle describes how energy is conserved in the steady flow of an incompressible non-viscous fluid through interchange between kinetic energy, gravitational potential energy, and pressure along the flow-line.

$$P + \tfrac{1}{2}\rho v^2 + \rho g y = \text{constant}$$

P - pressure
ρ - density
v - flow speed
g - acc. due to gravity
η - height

In a stenosed vessel, the more rapid flow of blood through a narrower lumen decreases the pressure gradient across the constriction. When pressure drops in any segment of the arterial system, it is due to both resistance from the stenosis and the conversion of potential into kinetic energy.

At some degree of narrowing, however, the affects of viscous dissipation outweigh continuity of volume flux in determining flow speed, and flow speed slows. Excess pressure can build up proximal to the stenosis until a critical stenosis is reached, defined as the percent stenosis at which intravascular flow approaches zero and the pressure approaches its maximum value. The critical stenosis is unique to vessel geometry and hemodynamics but has been shown to occur generally at approximately 80% to 85% obstruction of the major vessels in the human vasculature. At the point of critical stenosis, a sharp decrease of flow rate is observed as a result of the increased turbulence proximal to the stenosis.

If turbulence does not occur the pressure at the narrowed part will be substantially lower, which may result in caving in or even completely closing of the vessel. Then the flow velocity will slow down due to the frictional resistance, the kinetic energy will be converted to pressure and the vessel will reopen. This phenomenon will repeat itself causing the fluttering of the vessel.

Blood must be in continual motion to function properly. As blood flow is reduced through the stenosis, recirculation zones form distal to the stenosis, causing the flow to become stagnant. The stagnation of blood in these zones can trigger clotting mechanisms that lead to thrombosis. The mechanism by which blood clots as a result of reduced motion is termed stasis, and the resultant clot is the thrombus. It should be noted that the thrombus does not adhere strongly to the vessel wall and itself can be dislodged into the blood stream as an embolus and result in stroke.

11. A vascular surgeon carried out the graft of a section of the medial circumflex femoral artery substituting an autologous vessel of the same length but with twice the diameter. Assuming the pressure drop across the graft retains the same value it held prior to the surgery, how does flow speed through the graft compare to the old vessel?

A. 1/4 as great
B. the same
C. 4 times greater
D. 16 times greater

12. Based on the information contained in this passage, what is the best prediction in the change in the flow speed within a short stenosis of a large blood vessel after 30% narrowing has occurred. Turbulence does not occur and viscous dissipation is minimal?

A. flow speed approximately doubles
B. flow speed remains the same
C. flow speed decreases by 40%
D. flow speed decreases by 90%

13. As stenosis progresses to occlusion in a horizontal vessel, the pressure drop across the stenosis reaches 100% of the maximum and the flow rate is zero. At this stage

A. a thrombus will form distal to the stenosis.
B. turbulent flow will result distal to the stenosis.
C. the viscous dissipation of energy will be at a maximum.
D. the prestenotic pressure will equal the pressure at the origin of the parent vessel.

14. Which of the following, if present, reduces the descriptive relevance of **both** Poisseuile's law and Bernoulli's principle?

A. turbulent flow
B. viscous dissipation
C. vessel narrowing
D. a Newtonian fluid

15. An aneurysm is caused by the weakening of the arterial wall where a bulge occurs and the cross-section of a vessel increases considerably. At the cross-section of an aneurysm

A. flow velocity will be reduced and the pressure will be reduced.
B. flow velocity will be reduced and the pressure will increase.
C. flow velocity will increase and the pressure will be reduced.
D. flow velocity will increase and the pressure will increase.

16. If blood were less viscous

A. turbulent flow would occur less often in the circulatory system.
B. systolic blood pressure would increase.
C. pressure before a stenosis would more closely equal pressure after the stenosis.
D. separation between systolic and diastolic blood pressure would increase.