* **56.** (II) Assuming a constant pressure gradient, if blood flow is reduced by 75%, by what factor is a blood vessel decreased in radius?

* **57.** (II) Poiseuille's equation does not hold if the flow velocity is high enough that turbulence sets in. The onset of turbulence occurs when the **Reynolds number**, Re, exceeds approximately 2000. Re is defined as

$$Re = \frac{2\bar{v}r\rho}{\eta},$$

where $\bar{v}$ is the average speed of the fluid, ρ is its density, η is its viscosity, and r is the radius of the tube in which the fluid is flowing. (*a*) Determine if blood flow through the aorta is laminar or turbulent when the average speed of blood in the aorta $(r = 1.2\,\text{cm})$ during the resting part of the heart's cycle is about 40 cm/s. (*b*) During exercise, the blood-flow speed approximately doubles. Calculate the Reynolds number in this case, and determine if the flow is laminar or turbulent.

* **58.** (III) A patient is to be given a blood transfusion. The blood is to flow through a tube from a raised bottle to a needle inserted in the vein (Fig. 10–55). The inside diameter of the 4.0-cm-long needle is 0.40 mm, and the required flow rate is 4.0 cm^3 of blood per minute. How high h should the bottle be placed above the needle? Obtain ρ and η from the Tables. Assume the blood pressure is 18 torr above atmospheric pressure.

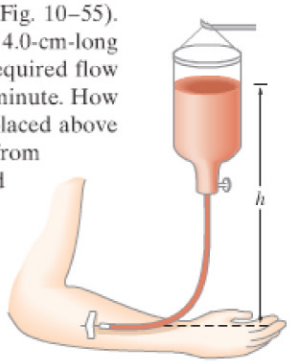

FIGURE 10–55
Problems 58 and 63.

* 10–13 Surface Tension and Capillarity

* **59.** (I) If the force F needed to move the wire in Fig. 10–35 is $5.1 \times 10^{-3}\,\text{N}$, calculate the surface tension γ of the enclosed fluid. Assume $L = 0.070\,\text{m}$.

* **60.** (I) Calculate the force needed to move the wire in Fig. 10–35 if it is immersed in a soapy solution and the wire is 18.2 cm long.

* **61.** (II) If the base of an insect's leg has a radius of about $3.0 \times 10^{-5}\,\text{m}$ and the insect's mass is 0.016 g, would you expect the six-legged insect to remain on top of the water? Why or why not?

* **62.** (II) The surface tension of a liquid can be determined by measuring the force F needed to just lift a circular platinum ring of radius r from the surface of the liquid. (*a*) Find a formula for γ in terms of F and r. (*b*) At 30°C, if $F = 8.40 \times 10^{-3}\,\text{N}$ and $r = 2.8\,\text{cm}$, calculate γ for the tested liquid.

General Problems

63. Intravenous infusions are often made under gravity, as shown in Fig. 10–55. Assuming the fluid has a density of $1.00\,\text{g/cm}^3$, at what height h should the bottle be placed so the liquid pressure is (*a*) 55 mm-Hg, and (*b*) 650 mm-H_2O? (*c*) If the blood pressure is 18 mm-Hg above atmospheric pressure, how high should the bottle be placed so that the fluid just barely enters the vein?

64. A 2.4-N force is applied to the plunger of a hypodermic needle. If the diameter of the plunger is 1.3 cm and that of the needle 0.20 mm, (*a*) with what force does the fluid leave the needle? (*b*) What force on the plunger would be needed to push fluid into a vein where the gauge pressure is 18 mm-Hg? Answer for the instant just before the fluid starts to move.

65. A bicycle pump is used to inflate a tire. The initial tire (gauge) pressure is 210 kPa (30 psi). At the end of the pumping process, the final pressure is 310 kPa (45 psi). If the diameter of the plunger in the cylinder of the pump is 3.0 cm, what is the range of the force that needs to be applied to the pump handle from beginning to end?

66. Estimate the pressure on the mountains underneath the Antarctic ice sheet, which is typically 3 km thick.

67. What is the approximate difference in air pressure between the top and the bottom of the Empire State building in New York City? It is 380 m tall and is located at sea level. Express as a fraction of atmospheric pressure at sea level.

68. A hydraulic lift is used to jack a 970-kg car 12 cm off the floor. The diameter of the output piston is 18 cm, and the input force is 250 N. (*a*) What is the area of the input piston? (*b*) What is the work done in lifting the car 12 cm? (*c*) If the input piston moves 13 cm in each stroke, how high does the car move up for each stroke? (*d*) How many strokes are required to jack the car up 12 cm? (*e*) Show that energy is conserved.

69. Giraffes are a wonder of cardiovascular engineering. Calculate the difference in pressure (in atmospheres) that the blood vessels in a giraffe's head have to accommodate as the head is lowered from a full upright position to ground level for a drink. The height of an average giraffe is about 6 m.

70. When you ascend or descend a great deal when driving in a car, your ears "pop," which means that the pressure behind the eardrum is being equalized to that outside. If this did not happen, what would be the approximate force on an eardrum of area $0.50\,\text{cm}^2$ if a change in altitude of 950 m takes place?

71. One arm of a U-shaped tube (open at both ends) contains water, and the other alcohol. If the two fluids meet at exactly the bottom of the U, and the alcohol is at a height of 18.0 cm, at what height will the water be?