STAEDTLER® No. 937 811E Engineer's Computation Pad

77 Figure 14-58 shows a *siphon,* which is a device for removing liquid from a container. Tube *ABC* must initially be filled, but once this has been done, liquid will flow through the tube until the liquid surface in the container is level with the tube opening at *A*. The liquid has density 1000 kg/m³ and negligible viscosity. The distances shown are $h_1 = 25$ cm, $d = 12$ cm, and $h_2 = 40$ cm. (a) With what speed does the liquid emerge from the tube at *C*? (b) If the atmospheric pressure is 1.0×10^5 Pa, what is the pressure in the liquid at the topmost point *B*? (c) Theoretically, what is the greatest possible height h_1 that a siphon can lift water?

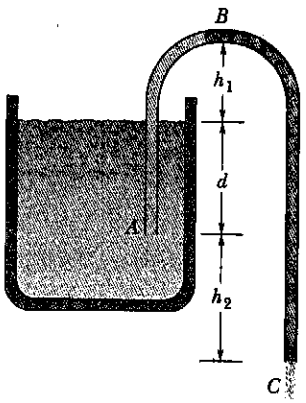


FIG. 14-58 Problem 77.

THIS PROBLEM ASKS US ABOUT THE DYNAMICS OF A FLUID TRAVELING THROUGH A PIPE SYSTEM: THE PIPE HAS A LARGE APERATURE AT ONE END - THE OPEN TO THE AIR SURFACE OF THE VESSEL = 1, AND A SMALL APERATURE AT THE OTHER END — THE OPEN TO THE AIR SIPHON END = 2, THIS IS A JOB FOR THE — BERNOULLI EQUATION:

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2$$

$P_1 = P_2 = P_0 = P_{AIR}$

$v_1 \approx 0$ IF THE VESSEL HAS A LARGE VOLUME

$$\Rightarrow \frac{1}{2}\rho v_2^2 = \rho g(y_1 - y_2) = \rho g(d + h_2)$$

$\Rightarrow$ DEFINITELY A RESULT OF ENERGY CONSERVATION WHERE GRAVITY IS THE DRIVING FORCE.

a) $v_2 = \sqrt{2g(d+h_2)} =$

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = P_B + \frac{1}{2}\rho v_B^2 + \rho g y_B$$

$$P_B = P_{AIR} + \frac{1}{2}\rho(v_1 \approx 0)^2 + \rho g(y_1 - y_B) - \frac{1}{2}\rho v_B^2$$

BY THE CONTINUITY EQUATION: $(A_c v_c = A_2 v_2) = A_B v_B$

WE HAVE $v_B = (A_2/A_B = 1)\, v_2 = \sqrt{2g(d+h_2)}$

$$P_B = P_{AIR} - \rho g h_1 - \rho g(d + h_2) = P_{AIR} - \rho g(h_1 + h_2 + d)$$

b) $P_B =$

$P_B = 0$ FOR d & h_2 close to Zero when $P_{AIR} = \rho g h_1$

$$\Rightarrow h_1 = P_{AIR}/\rho g = \frac{1.01 \times 10^5\ N/m^2}{1.00 \times 10^3\ kg/m^2} \frac{1}{9.80} = 10.3\ m$$

NOTE $10.3\ m = \rho_{MERCURY}(760\ torr = 760\ mm\ Hg = 0.76\ m)$

$= 13.55\,(0.76) = 10.3\ m$

0.76 m IS PRACTICAL FOR A BAROMETER

10.3 m IS NOT