Relevant Problems on Chapter 3

PHY109-Fall2020

3.6 Relevant Problems

Problem 3.1
A living room has floor dimensions of 3.5 m and 4.2 m and a height of 2.4 m.

(a) What does the air in the room weigh when the air pressure is 1.0 atm?
(b) What is the magnitude of the atmosphere's downward force on the top of your head, which we take to have an area of 0.040 m^2?

Problem 3.2
How large a force is needed on a small piston of area 2 cm^2 in order to support a 1000 N weight resting on a piston of area 20 cm^2?

Problem 3.3
A crown is found to weigh 25.0 N when suspended in air and 22.6 N when suspended in water. Calculate the density of the crown to see if it is made of gold, as claimed by its donor. The density of water is 1000 kg/m^3.

Problem 3.4
A large drop of water is formed from 2500 small drops of water; each of diameter 10^{-6} m. What is the amount of energy released?

Problem 3.5
A capillary tube of radius 0.1mm is dipped into oil of density 800 kg m^{-3}. The surface tension of the oil is $60 \times 10^{-3} \text{ N m}^{-1}$ and angle of contact 20^o. How much height will the oil rise in the tube?

Problem 3.6
A hydraulic can crusher shown in the figure. The large piston has an area of 8 m^2 and exerts a force of magnitude $2 \times 10^6 \text{ N}$ on the cans. Calculate the magnitude of the force exerted by the small piston whose area is 10 cm^2 on the fluid. Do not ignore the fact that the large piston is 1 m higher than the small piston.

Problem 3.7
Figure below shows how the stream of water emerging from a faucet "necks down" as it falls. This change in the horizontal cross-sectional area is characteristic of any laminar (nonturbulant) falling stream because the gravitational force increases the speed of the stream. Here the indicated cross-sectional areas are $A_0 = 1.2 \text{ cm}^2$ and $A = 0.35 \text{ cm}^2$. The two levels are separated by a vertical distance $h = 45$ mm. What is the volume flow rate from the tap?

Problem 3.8
Water flows through a pipe of radius 0.10 m at a speed of 5.0 m/s.

(a) Calculate the flow rate in this pipe.
(b) The water goes down a hill with a vertical drop of 4.0m and then flows along a pipe of radius 0.080 m. Calculate the pressure of the fluid in the small pipe minus the pressure in the large pipe. The density of water is 1000 kgm^{-3}.

Problem 3.9

(a) Calculate the speed with which water flows from a hole in the dam of a large irrigation canal. The hole is 0.80 m below the surface of the water.

(b) If the hole has a radius of 2.0 cm, what is the flow rate of water from the hole?

Problem 3.10

Suppose that the speed of air over the top of the wing of a airplane is 180 m/s, that the air speed under the wing is 165 m/s, and that the density of air at the altitude where the plane flies is 0.80 kg/m^3.

(a) Calculate the pressure difference between the bottom and top of the wing.

(b) If the plane has a mass of 2.0×10^4 kg, what must be the area of the wings so that the lift can support the airplane's weight?

Problem 3.11

A air bubble of radius 10^{-5} m is rising through water. The coefficient of viscosity of water is 10^{-3}Nsm^{-2} and its density is 10^3kgm^{-3}. The density of air is negligible in comparison to water. Determine the terminal velocity of the bubble.

Problem 3.12

Estimate the air drag force on a 1130 kg compact car when moving at a speed of 27 m/s (60 mph). The cross-sectional area of the car is roughly 2.0 m^2 and the drag coefficient C_D is approximately 0.5 for a well-designed car. The density of air is 1.3 kg/m^3.

Problem 3.13

Estimate the terminal speed of a Ping-Pong ball weighing 2.2×10^{-2} N whose radius is 1.9×10^{-2} m. The ball experiences a turbulent drag force with a drag coefficient of 0.6.

Problem 3.14

A hollow spherical iron shell floats almost completely submerged in water. If the outer diameter is 2.0m and the relative density of iron is 7.8, find the inner diameter.

Problem 3.15

A block of wood floats in water with two-thirds of its volume submerged. In oil it has 0.90 of its volume submerged. Find the density of the wood and the oil.

Problem 3.16

A block of wood weighs 8.0kg and has a relative density of 0.60. It is to be loaded with lead so that it will float in water with 0.90 of its volume immersed. What weight of lead is needed (a) if the lead is on top of the wood? (b) if the lead is attached below the wood?

Problem 3.17

(a) Consider a container of fluid subject to a vertical upward acceleration a. Show that the pressure variation with depth in the fluid is given by

$$p = \rho h(g + a),$$

where h is the depth and ρ is the density.

(b) Show also that if the fluid as a whole undergoes a vertical downward acceleration a, the pressure at a depth h is given by

$$p = \rho h(g - a).$$

(c) What is the state of affairs in free fall?

Problem 3.18

What amount of work is done when a water sphere of diameter 2mm breaks up into 10^6 drops? [Surface tension of water $T = 72\times10^{-3}$ $\mathrm{N\,m^{-1}}$]

Problem 3.19

A soap bubble of radius 0.01m is expanded to a radius of 0.1m. Calculate the work done in the process. [Surface tension of soap solution $T = 26\times10^{-3}$ $\mathrm{N\,m^{-1}}$]

Problem 3.20

Calculate the error in reading of a mercury barometer whose tube has a diameter 4mm. The angle of contact of mercury with glass is 140^o, surface tension of mercury is $T = 465\times10^{-3}$ $\mathrm{Nm^{-1}}$ and density of mercury is $\rho = 13.6\times10^{-3}$ $\mathrm{kg\,m^{-3}}$.

Problem 3.21

A capillary tube of diameter 0.5mm is vertically dipped into a liquid of density 0.8×10^{-3} $\mathrm{kg\,m^{-3}}$ and it wets the tube. The liquid rises 3.06cm of height in the tube. Calculate the surface tension of the liquid.

Problem 3.22

Models of torpedoes are sometimes tested in a pipe of flowing water, much as a wind tunnel is used to test model airplanes. Consider a circular pipe of internal diameter 10inch and a torpedo model, aligned along the axis of the pipe, with a diameter of 2inch. The torpedo is to be tested with water flowing past it at 8ft/s. (a) With what speed must the water flow in the unconstructed part of the pipe? (b) What will the pressure difference be between the constricted and unconstructed parts of the pipe?

Problem 3.23

How much work is done by pressure on forcing $50\ \mathrm{m}^3$ of water through a 1.50cm diameter pipe if the difference in pressure at the two ends of the pipe is $15\ \mathrm{kg\,m^{-2}}$?

Problem 3.24

Water falls from a height of 60m at the rate of $10\ \mathrm{m}^3 s^{-1}$ and drive a water turbine. What is the maximum power that can be developed by this turbine?

Problem 3.25

By applying the Bernoulli’s equation and the equation of continuity to points 1 and 2 of the Venturimeter of Fig. p3.25, show that the speed of flow at the entrance is

$$v = a\sqrt{\frac{2(\rho'-\rho)gh}{\rho(A^2-a^2)}}.$$

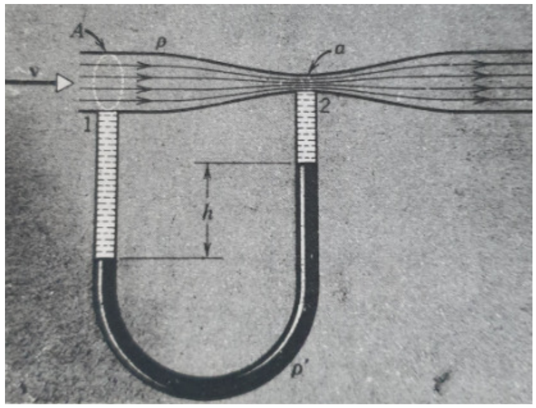

Fig. p3.25

Problem 3.26

A venturimeter has a pipe diameter of 10.0cm and a throat diameter of 5.0cm. If the water pressure in the pipe is $5.0\ \mathrm{kg\,cm^{-2}}$ and in the throat is $3.0\ \mathrm{kg\,cm^{-2}}$, determine the rate of flow of water.

Problem 3.27

Figure p3.27 shows water discharging from an orifice in a large tank at a distance *h* below the water surface. (a) Apply the Bernoulli's equation to a streamline connecting points 1, 2, and 3, and show that the speed of efflux is

$$v = \sqrt{2gh}\,.$$

This is known as Torricelli's law. (b) If the orifice were curved directly upward, how high would the liquid stream rise? (c) How would viscosity or turbulence affect the analysis?

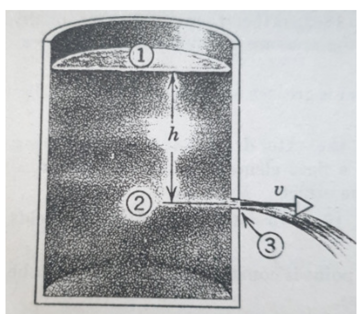

Fig. p3.27

Problem 3.28

A tank is filled with water to a height *H*. A hole is punched in one of the walls at a depth *h* below the water surface (Fig. p3.28). (a) Find the distance *x* from the foot of the wall at which the stream strikes the floor. (b) Could a hole be punched at another depth so that this second stream would have the same range? If so, at what depth?

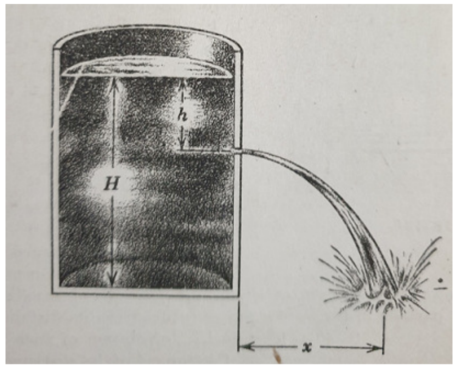

Fig. p3.28

Problem 3.29
The upper surface of water in a standpipe is a height H above level ground. At what depth h should a small hole be put to make the emerging horizontal water stream strike the ground at the maximum distance from the base of the standpipe? What is the maximum distance?

Problem 3.30
A Pitot tube is mounted on an airplane wing to determine the speed of the plane relative to the air. The tube contains alcohol and indicates a level difference of 12.45cm. What is the plane's speed relative to the air?

Problem 3.31
If the speed of flow past the lower surface of a wing is 106.68m/s, what speed of flow over the upper surface will give a lift of $97.634\ \text{kg}\,\text{m}^{-2}$?

Problem 3.32
Determine the force required to drive a copper sheet of area $10^{-2}\,\text{m}^2$ horizontally with a velocity $3\times10^{-2}\ \text{m}\,\text{s}^{-1}$ through oil of thickness $2\times10^{-3}\ \text{m}$. The coefficient of viscosity of the oil is $1.55\ \text{N}\text{s}\,\text{m}^{-2}$.

Problem 3.33
A rain drop is falling through the air with a terminal velocity $1.2\times10^{-2}\ \text{m}\,\text{s}^{-1}$. The coefficient of viscosity of air is $1.8\times10^{-5}\ \text{N}\text{s}\,\text{m}^{-2}$. What is the diameter of the drop?

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