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Practice Problems Worksheet Answer Key

Show complete solutions to the following problems and box final answers with units.

1. **A sample of an unknown material weighs 300 N in air and 200 N when submerged in an alcohol solution with a density of 0.70 x 10^3 kg/m^3. What is the density of the material?**

Given:

$F_{g(air)}$ = 300 N

$F_{g(alcohol)}$ = 200 N

$\rho_{alcohol}$ = 0.7 x 10^3 kg/m^3

Unknown:

$\rho_{material}$ or ρ_o

Solution:

$F_B = F_{g(air)} - F_{g(alcohol)}$ = 300 N – 200N

F_B = 100 N

$F_{g(air)} / F_B = \rho_o / \rho_{alcohol}$

$\rho_o = F_{g(air)} / F_B * \rho_{alcohol}$ = (300 N / 100 N) * 0.7 x 10^3 kg/m^3

ρ_o = 2.1 x 10^3 kg/m^3

2. **A 40-cm tall glass is filled with water to a depth of 30 cm.**
   a. **What is the gauge pressure at the bottom of the glass?**
   b. **What is the absolute pressure at the bottom of the glass?**

Given:

h = 30 cm = 0.3 m

g = 9.81 m/s^2

ρ_{water} = 1.0 x 10^3 kg/m^3

Uknown:

a) P_{gauge}

b) $P_{absolute}$

Solution:

a) $P_{gauge} = \rho gh$ = (1.0 x 10^3 kg/m^3) (9.81 m/s^2) (0.3 m)

P_{gauge} = 2.9 x 10^3 kg/m^3 Pa

b) $P_{absolute} = P_{atm} + P_{gauge}$

$P_{absolute}$ = 1.01 x 10^5 Pa + 2.9 x 10^3 kg/m^3 Pa

$P_{absolute}$ = 1.04 x 10^5 Pa

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3. **Water circulates throughout a house in a hot water heating system. If the water is pumped at a speed of 0.50 m/s through a 4.0-cm diameter pipe in the basement under a pressure of 3.03×10^5 Pa, what will be the velocity and pressure in a 2.6-cm diameter pipe on the second floor 5.0 m above?**

Given:

$v_1 = 0.50$ m/s — $v_2 = ?$

$h_1 = 0$ m (basement) — $h_2 = 5.0$ m

$d_1 = 0.04$ m — $d_2 = 0.026$ m

$A_1 = \pi (d_1 / 2)^2 = 0.0004\pi$ — $A_2 = \pi (d_2 / 2)^2 = 1.69 \times 10^{-4}\pi$

$P_1 = 3.03 \times 10^5$ Pa — $P_2 = ?$

Unknown:

v_2

P_2

Solution:

$A_1 v_1 = A_2 v_2$

$v_2 = A_1 v_1 / A_2 = (0.0004\pi * 0.50 \text{ m/s}) / 1.69 \times 10^{-4}\pi$

$v_2 = 11.83$ m/s

$P_1 + ½ \rho v_1^2 + \rho g h_1 = P_2 + ½ \rho v_2^2 + \rho g h_2$

$P_2 = P_1 + ½ \rho (v_1^2 - v_2^2) - \rho g h_2$

$P_2 = (3.03 \times 10^5 \text{ Pa}) + ½ (1.0 \times 10^3 \text{ kg/m}^3) [(0.50 \text{ m/s})^2 – (11.83 \text{ m/s})^2] – (1.0 \times 10^3 \text{ kg/m}^3) (9.81 \text{ m/s}^2) (5.0 \text{ m})$

$P_2 = 1.84 \times 10^5$ Pa

4. **The small piston of a hydraulic lift has an area of 0.20 m^2. A car weighing 1.2×10^4 N sits on a rack mounted on the large piston. The large piston has an area of 0.90 m^2. How large force must be applied to the small piston to support the car?**

Given:

$A_1 = 0.20 \text{ m}^2$ — $A_2 = 0.90 \text{ m}^2$

$F_1 = ?$ — $F_2 = 1.2 \times 10^4$ N

Unknown:

F_1

Solution:

$F_1 / A_1 = F_2 / A_2$

$F_1 = F_2 / A_2 (A_1) = (1.2 \times 10^4 \text{ N} / 0.90 \text{ m}^2) * 0.20 \text{ m}^2$

$F_1 = 2.7 \times 10^3$ N

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5. Calculate the absolute pressure at an ocean depth of 1.0×10^3 m. Assume that the density of the water is 1.025×10^3 kg/m^3 and that $P_0 = 1.01 \times 10^5$ Pa.

Given:
$h = 1.0 \times 10^3$ m
$\rho = 1.025 \times 10^3$ kg/m^3
P_{atm} or $P_o = 1.01 \times 10^5$ Pa

Unknown:
$P_{absolute}$

Solution:
$P_{absolute} = P_{atm} + P_{gauge}$
$P_{absolute} = P_{atm} + \rho gh = 1.01 \times 10^5 \text{ Pa} + (1.025 \times 10^3 \text{ kg/m}^3)(9.81 \text{ m/s}^2)(1.0 \times 10^3 \text{ m})$
$P_{absolute} = 1.01 \times 10^7$ Pa

6. A water tank has a spigot near its bottom. If the top of the tank is open to the atmosphere, determine the speed at which the water leaves the spigot when the water level is 0.5 m above the spigot.

Given:
P_1 = Patm = 1.01 x 105 Pa = P_2 (both are open to atmosphere)
$v_1 = 0$ (negligible)
$h_1 = 0.5$ m
$h_2 = 0$ m

Unknown:
v_2

Solution:
$P_1 + \frac{1}{2} \rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2} \rho v_2^2 + \rho g h_2$
$P_1 + \rho g h_1 = P_2 + \rho g h_2$
$v_2 = \text{sqrt}(2gh_1)$
$v_2 = \text{sqrt}(2 (9.81 \text{ m/s}^2) (0.5\text{m}))$
$v_2 = 3.13$ m/s