

Ch 15 Recitation Problems

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1.1 Problem 3**Given**

A 6m x 12m swimming pool which slopes linearly from a 1.0m depth at one end to a 3.0m depth at the other end.

Find

The mass of water in the pool. M_{H_2O}

Plan

Simply find the volume of the pool and multiply by the density of water.

$$M_{H_2O} = \rho \cdot V$$

$$V = A_{trapezoidalside} \times Width$$

Calculations

$$V = \frac{3+1}{2} \times 12 \times 6$$

$$V = 24 \times 6$$

$$V = 144m^3$$

$$M_{H_2O} = 144m^3 \times \frac{1000kg}{m^3}$$

$$M_{H_2O} = 144000kg$$

Solution

The mass of water in the pool is $1.44 \times 10^5 kg$

1.2 Problem 5**Given**

The deepest point in the ocean is 11 km below sea level.

Find

The pressure in atmospheres at this depth.

Plan

The hydrostatic pressure at a depth, d is $P = P_o + \rho g d$. I just need take care with the units.

Calculations

$$P = 1atm + 1030 \frac{kg}{m^3} \times 9.8 \frac{N}{kg} \times 11000m \times \frac{1atm}{1.013 \times 10^5 Pa}$$

Solution

The pressure at 11 km below sea level is 1097 atmospheres.

1.3 Problem 9

Given

A submarine with a 20 cm diameter window which is 8.0 cm thick. The manufacturer says it can stand forces up to $1.0 \times 10^6 N$. The pressure inside the submarine is maintained at 1.0 atm.

Find

The maximum safe depth for the submarine.

Plan

Since $P = \frac{F}{A}$, I can just find the depth at which the pressure will reach the manufacturers maximum force for the area of the given window. Again, paying close attention to the units. The fact that the inside of the submarine is maintained at 1.0 atm allows me to use $P_{max} = \frac{F_{max}}{A} = \rho g d$ and solve for d .

Calculations

The area of the window is,

$$\pi \times (0.10m)^2 = \frac{\pi}{100} m^2$$

So the maximum pressure for this window is,

$$\frac{(1.0 \times 10^6 N)}{\frac{\pi}{100} m^2} = 3.183099 \times 10^7 Pa$$

The depth at which this pressure is reached is,

$$\frac{3.183099 \times 10^7 Pa}{1030 \frac{kg}{m^3} \times 9.8 \frac{N}{kg}} = 3153.5m$$

Solution

The submarine can descend to a depth of 3150 meters.

1.4 Problem 11

Given

A water barometer at atmospheric pressure.

Find

The height of the water column in the barometer.

Plan

I'll apply Bernoulli's equation ignoring the small vapor pressure at the top of the closed tube. Choose the open fluid as one point (P_o) and the top of the water column (P_1) in the closed tube as the other point when evaluating Bernoulli's equation. Set the height at P_o to zero [$h_o = 0$].

Calculations

Bernoulli's equation is,

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho gh = P_o + \frac{1}{2}\rho v_o^2 + \rho g(h_o)$$

Plugging in values for the density of water, atmospheric pressure and gravitational field strength,

$$\begin{aligned} 0 + \frac{1}{2}1000 \left[\frac{kg}{m^3} \right] 0^2 + 1000 \left[\frac{kg}{m^3} \right] \cdot 9.8 \left[\frac{N}{kg} \right] h = \\ 1.013 \times 10^5 Pa + \frac{1}{2}1000 \left[\frac{kg}{m^3} \right] 0^2 + 1000 \left[\frac{kg}{m^3} \right] \cdot 9.8 \left[\frac{N}{kg} \right] 0 \end{aligned}$$

Solving this for h gives,

$$h = \frac{1.013 \times 10^5}{1000 \cdot 9.8} = \frac{1013}{98} m \approx 10.34m$$

Solution

The height of the water column in a barometer at atmospheric pressure is approximately 10.34 meters.

1.5 Problem 19**Given**

A 100 cubic centimeter block of aluminum with density $\rho_{Al} = 2700 \frac{kg}{m^3}$, suspended in Ethyl Alcohol (ETOH) by a string.

Find

The tension in the string.

Plan

I'll use Archimedes principle and a force diagram (Newton's second law) to solve for the tension in the string.

Calculations

The tension in the string will equal the weight of the aluminum block minus the buoyant force. The buoyant force is equal to the weight of the displaced fluid. In this case the weight of 10 cm^3 of ETOH.

$$T = W - F_b$$

$$T = \rho_{Al} \cdot 100[\text{cm}^3] \cdot \left[\frac{m}{10^2 \text{cm}} \right]^3 \cdot g - 10[\text{cm}^3] \cdot \left[\frac{m}{10^2 \text{cm}} \right]^3 \cdot \rho_{ETOH} \cdot g$$

$$T = 2700 \cdot \frac{100}{10^6} \cdot 9.8 - \frac{100}{10^6} \cdot 790 \cdot 9.8$$

$$T = \frac{100}{10^6} \cdot 9.8 [2700 - 790]$$

$$T = 1.872N$$

Solution

The tension in the string which is suspending the fully immersed aluminum block equals 1.872N

1.6

Given

Find

Plan

Calculations

Solution

