Leo Yan 8216772

Assignment #3

Physics 2 Spring 2020
Instructor: Prof. Dirk Bouwmeester
Due: 04/19/20 5pm PST

Comments: Each problem is worth three points. If the problem has multiple parts the points breakdown is delineated in the problem.

1 Flat tire

You have probably noticed that the lower the tire pressure, the larger the contact area between the tire and the road. Why?

$P = \frac{F}{A}$, $PA = F$, F constant, P++, A--, P--, A++

2 Gold brick

You win the lottery and decide to impress your friends by exhibiting a million-dollar cube of gold. At the time, gold is selling for \$1706.40 per troy ounce, and 1.0000 troy ounce equals 31.1035 g. How tall would your million-dollar cube be?

$\rho_{gold} = 19.32 g/cm^3$ $\quad \rho = \frac{m}{v}$

$$\sqrt[3]{\frac{\frac{1000000}{1706.4} \times 31.1035}{19.32}} = 9.80785 \text{ cm}$$

3 Oceans on Mars

Scientists have found evidence that Mars may once have had an ocean 0.500 km deep. The acceleration due to gravity on Mars is 3.71 m/s^2. (a) What would be the gauge pressure at the bottom of such an ocean, assuming it was freshwater? (b) Without any calculation, do you think you'd have to go deeper in Earth's ocean to experience the same gauge pressure? Why? (c)Now do the calculation and verify that your expectation is correct.

Each part is 1 point.

$P = \rho g h$
$= 1000 \times 3.71 \times 500$
$= 1855$ kPa

No, Earth's gravitational acceleration is much higher than Mars.

$\frac{1855000}{1000 \times 9.81} = 189.1$ m

or ρ use 1030 instead which gives about 185 m

4 Floating objects

An object of average density ρ floats at the surface of a fluid of density ρ_{fluid}. (a) How must the two densities be related? (b) Now suppose the object is not fully submerged. In terms of ρ and ρ_{fluid} what fraction of the object is submerged and what fraction is above the fluid? Check that your answers give the correct limiting behavior as $\rho \to \rho_{fluid}$ and as $\rho \to 0$. (c)In view of the answers to parts (a) and (b), how can steel ships float in water?

Each part is 1 point.

$\rho < \rho_{fluid}$

$F = \rho_f g V_m$

$\rho_o V g = \rho_f g V_m$

$\rho_o V_o = \rho_f V_m$

$\frac{\rho_o}{\rho_f} = \frac{V_m}{V_o}$

hence $\frac{\rho_o}{\rho_f} V_o$ is in the fluid &

$(1 - \frac{\rho_o}{\rho_f}) V_o$ is not Submerged.

if $\rho_o \to \rho_f$, the object all covered hence $V = V_m$ True,

$\rho_o \to 0$, $V = 0$ Also expected.

Steel is denser than water itself but is made hollow into a ship shape. So the average density ρ_s will be smaller than ρ_w.

5 A shower head

A shower head has 20 circular openings, each with radius 1.0 mm. The shower head is connected to a pipe with radius 0.70 cm. If the speed of water in the pipe is 3.0 m/s, what is its speed as it exits the shower-head openings?

$3 \times \pi \times \left(\frac{0.7}{100}\right)^2 = 20 \times \pi \left(\frac{1}{1000}\right)^2 \times V$

$V = 7.35$ m/s

6 City water mains

What gauge pressure is required in the city water mains for a stream from a fire hose connected to the mains to reach a vertical height of 12.0 m? (Assume that the mains have a much larger diameter than the fire hose.)

$P = \rho g h = 1000 \times 9.81 \times 12$

$= 117.7$ kPa

7 Clogged artery

Viscous blood is flowing through an artery partially clogged by cholesterol. A surgeon wants to remove enough of the cholesterol to double the flow rate of blood through this artery. If the original diameter of the artery is *D*, what should be the new diameter (in terms of *D*) to accomplish this for the same pressure gradient? (Hint: Assume that the volume flow is proportional to the $\underbrace{\text{pressure gradient}}_{\text{rate } \Delta P}$).

$\frac{dv}{dt} = \frac{\pi r^4}{8\eta} \times dp$

$\frac{dv}{dt} = \frac{\pi D^4}{128\eta} dp$

dp constant, $D \uparrow$, $\frac{dv}{dt}$ --

$dp = \frac{128\eta}{\pi D^4}\left(\frac{dv}{dt}\right)$,

$\frac{dv}{dt} = \frac{\pi D_1^4}{128\eta} \times \frac{128\eta}{\pi D^4} \times \left(\frac{dv}{dt}\right)$,

$\frac{dv}{dt} = 2\left(\frac{dv}{dt}\right)$,

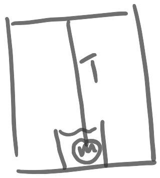
$2 = \left(\frac{D_1}{D}\right)^4$

$2^{\frac{1}{4}} D = D_1$

8 A rock, a bucket, and a rope in an elevator

A rock with mass m is suspended from the roof of an elevator by a light cord. The rock is totally immersed in a bucket of water that sits on the floor of the elevator, but the rock doesn't touch the bottom or sides of the bucket. (a) When the elevator is at rest, the tension in the cord is T. Calculate the volume of the rock. (b) Derive an expression for the tension in the cord when the elevator is accelerating upward with an acceleration of magnitude a. (c) Derive an expression for the tension in the cord when the elevator is accelerating downward with an acceleration of magnitude a.

Each part is 1 point.



$F = mg$

$T = mg - \rho g V$

$\frac{T}{g} - m = -\rho V$

$V = \frac{(m - \frac{T}{g})}{\rho}$

$F = ma$

$F_R = ma$

$F_R = T + F_f - mg$

$ma + mg = T + F_f$

$T = ma + mg - \rho g V - \rho a V$

$F = ma$

$F_R = ma$

$F_R = mg - T - F_f$

$T = mg - ma - \rho g V + \rho a V$

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