Density, pressure, and force

13-7 The average density of the body of a fish is 1060 kg/m^3. To keep from sinking, the fish increases its volume by inflating an internal air bladder, known as a swim bladder, with air. By what percent must the fish increase its volume to be neutrally buoyant in fresh water?

Compare the fish's density to that of fresh water. What density should the fish be to be "neutrally buoyant"?

Compare the density of air to that of water. Do you think the air in the swim bladder increases the fish's mass enough to matter?

2. A suitcase (m = 16 kg) is resting on the floor of an elevator. The side of the suitcase in contact with the floor measures 0.50 m x 0.15 m. The elevator is accelerating upward at 1.5 m/s^2. What pressure does the suitcase exert on the floor beneath it?

13-48 You need to check the air pressure in your tires, but you cannot find a tire gauge. Fortunately, you have taken physics, and you do have the owner's manual and a ruler. From the owner's manual you learn that the car's mass is 1500 kg. It seems reasonable to assume that each tire supports one-fourth of the weight. With the ruler you find that the tires are 15 cm wide and that the flattened segment of the tire in contact with the road is 13 cm long. What is your tire pressure, in (a) N/m^2 and (b) in psi?

A table of common units for pressure, and conversion factors between them, is on p406

4. A barber's chair with a person in it weighs 2100 N. The output plunger of a hydraulic system begins to lift the chair when the barber's foot applies a force of 55 N to the input piston. Neglect any height difference between the input and output (the reason for this statement will be clear later). What is the ratio of the radius of plunger to piston?

Thinking forces and/or kinematics, what does it mean that the plunger "just begins to lift the chair"?

13 – 7 Fish has $\rho = 1080 \ kg/m^3$.

Needs $\rho = \rho_{WATER} = 1000 \ kg/m^3$ to not sink.

∴ Increase overall volume by inflating air chamber.
(Adding air does not change fishes mass)

$$\rho_{AIR} = 1.20 \ kg/m^3$$

$$\rho_{TOT} = \frac{m_{TOT}}{V_{TOT}}$$

$$m_{TOT} = m_{FISH} = \rho_{FISH} V_{FISH}$$

$$V_{TOT} = V_{FISH} + V_{AIR\ POCKET}$$

↳ call this "$V_{INFLATED}$"

want $\rho_{TOT} = 1000 \ kg/m^3$, so

$$1000 \ kg/m^3 = \frac{\rho_{FISH} V_{FISH}}{V_{INFLATED}}$$

$$1000 = \frac{1080 \ V_{FISH}}{V_{INFLATED}}$$

$$\frac{V_{INFLATED}}{V_{FISH}} = \frac{1080}{1000} = 1.08$$

Inflated Volume is 8% greater than ordinary volume

13-7 Fish $\rho = 1080$ kg/m^3.

Needs to make $\rho = 1000$ kg/m^3

Now: $m_{FISH} = \rho V = 1080 V_0$

Inflated: $m_{FISH} = 1000 V_F$

Adding air does not change mass.

$$1080 V_0 = 1000 V_F$$

$$\frac{V_F}{V_0} = \frac{1080}{1000} = 1.08$$

8% increase in volume.

2. Suitcase:

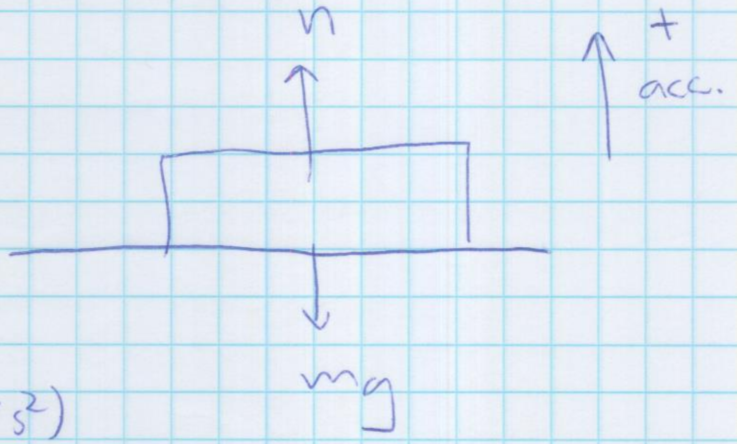
$\Sigma F = ma$

$n - mg = ma$

$n = m(a + g)$

$n = (16 kg)(1.5 + 9.8 m/s^2)$

$n = 181 N$



Is force with which floor pushes on suitcase.

3rd Law: Suitcase pushes against floor with 181 N force.

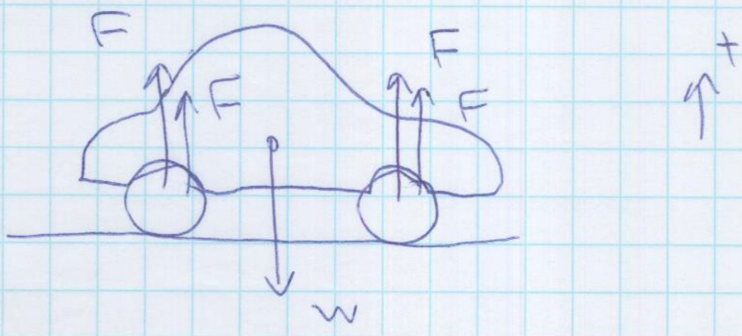
Pressure on floor is

$$P = \frac{F}{A} = \frac{181 N}{(0.50 \times 0.15) m^2}$$

$$P = 2410 N/m^2$$

13 - 48

2 Front tires,
2 Back tires!



Each should supply 1/4 of the force needed to support weight of car.

$$\Sigma F = ma$$

$$4F - w = 0$$

$$mg = 4F \quad \text{and} \quad F = PA$$

$$mg = 4PA$$

$$(1500\,kg)(9.8\,m/s^2) = 4P(0.15 \times 0.13\,m^2)$$

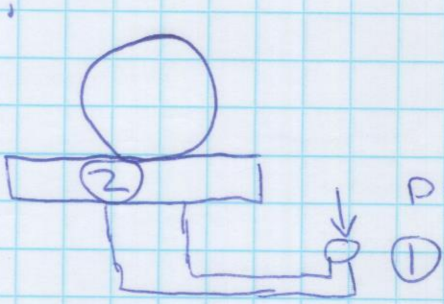
$$P = 1.88 \times 10^5\,N/m^2$$

$$1\,Atm = 14.7\,psi$$
$$1.013 \times 10^5\,N/m^2 = 14.7\,psi$$
$$1.88 \times 10^5\,N/m^2 = x\,psi$$

$$x = 27\,psi$$

Sounds reasonable.

4.



(mg) CHAIR + PERSON = 2100 N.
F_2.

PEDAL.

Your push: F_1.

Neglecting any difference in height between input & output.

$$P_1 = P_2 \qquad \text{Pascal's Pr.}$$

$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$

$$\frac{F_1}{\pi r_1^2} = \frac{F_2}{\pi r_2^2}$$

$$\left(\frac{r_2}{r_1}\right)^2 = \frac{F_2}{F_1} = \frac{2100\ N}{55\ N}$$

$$\frac{r_2}{r_1} = 6.2$$