Worksheet 10.1: Fluid Mechanics - Statics

Pressure: P = F/A (memorize area of circle, and rectangle)
1. A force of 23,450 N is exerted on a rectangular window that measures 2.30 m by 0.980 m. What is the pressure? (1.04E4 Pa)
2. What is the force of 2100. psi over a circular flange with a radius of 8.5 inches? (476658 lbs ≈ 4.8E5 lbs)
3. What is the total area in m^2 of some snowshoes, if a 75 kg person does not exert a pressure greater than 1.2 x 10^3 Pa? (0.61 m²)

Pressure conversions
Converting units of pressure.
1.00 atm = 1.013x10^5 Pa = 101.3 kPa = 760. Torr = 14.7 psi
4. Convert 450. Torr to Pa. (6.00E4 Pa)
5. Convert 3.20 ATM to Pa. (3.24E5 Pa)
6. Convert 835 Torr to psi (16.2 psi)

7. Convert 35 psi to Pa. (2.4E5 Pa)
8. Convert 16.7 kPa to Pa. (1.67E4 Pa)
9. Convert 2350 Pa to psi (0.341 psi)

Gauge and absolute pressure: P = P$_G$ + 1 atm
10. What is 0.45 atm gauge in absolute? (1.45 atm)
11. What is 34.0 psi gauge in absolute? (48.7 psi)
12. What is 4.50 psi absolute in gauge? (-10.2 psi)
13. What is 3.415 x 10^5 Pa in absolute in gauge? (2.402E5 Pa)

14. What is 3.60 atm absolute in gauge? (2.60 atm)
15. What is 45.0 psi absolute in gauge (30.3 psi)
16. What is 34,500 Pa gauge in absolute? (1.358E5 Pa)

Gauge and unit conversions (on the assessments)
17. What is 12.0 psi gauge in Pa absolute? (1.84E5 Pa)
18. What is 78.0 kPa absolute in Torr gauge? (-175 Torr)
19. What is 34.5 psi gauge in atm absolute? (3.35 atm)
20. What is 0.835 atm absolute in Torr gauge? (-125 Torr)
21. What is 8.45 psi gauge in kPa absolute? (160. kPa)

22. What is 34,500 Pa absolute in atm gauge? (-0.659 atm)
23. What is 1.30 atm gauge in kPa absolute? (233 kPa)
24. What is 7810 Pa absolute in kPa gauge? (-93.5 kPa)
25. What is -34.9 kPa gauge in psi absolute? (9.64 psi)
26. What is 512,000 Pa absolute in Torr gauge? (3081 Torr)

Density ρ = m/V (memorize volume of rectangular solids, cylinder)
27. What is the density (in kg m^{-3}) of a cube that is 11.0 cm on a side, and has a mass of 894 grams? (672 kgm⁻³)
28. What is the mass of a gold brick that measures 26.0 cm x 8.00 cm x 12.0 cm? (ρ = 19.3x10^3 kgm^{-3}) (48.2 kg)
29. A sphere that contained 45.0 kg of air would have what radius? (ρ = 1.29 kgm^{-3}) (2.03 m)
30. What is the density of a shot put that has a diameter of 12.0 cm and a mass of 7.26 kg? (8020 kgm⁻³)
31. What is the mass of mercury (ρ = 13.6x10^3 kgm^{-3}) in a (cylindrical) cup that is 9.00 cm tall, and 11.0 cm in diameter? (11.6 kg)

Pascal's Principle: F/A = F/A
32. An engineer designs a hydraulic jack to lift 4560 kg. If the output cylinder is 8.20 cm in diameter, and the input cylinder is 0.420 cm in diameter, what input force is required? (117 N)
33. A hydraulic jack lifts 620. kg of mass with an input force of 24.0 N. What is the diameter of the input cylinder if the output cylinder has a diameter of 12.6 cm? (0.791 cm)
34. If you exert 4.45 N on the 0.920 cm diameter input cylinder of a hydraulic jack, what force does the 6.80 cm diameter output cylinder exert? (243 N)
35. A brake cylinder exerts 342 N of force with an input force of 55.2 N. What is the diameter of the brake cylinder if the master cylinder has a diameter of 1.21 cm? (3.01 cm)
36. A brake cylinder exerts 416 N of force on the rotor. What is the input force if the master cylinder has a diameter of 2.30 cm, and the brake cylinder is 4.50 cm in diameter? (109 N)

Hydrostatic Pressure: $P = P_o + \rho g d$

Simple:

37. What is the pressure at a depth of 125 m in the ocean? ($\rho = 1025$ kgm^{-3}) Assume there is 1 atm above the water. (1.36x10^6 Pa)

38. What is the gauge pressure at a depth of 1.67 m in mercury? ($\rho = 13.6$x10^3 kgm^{-3}) Assume there is 1 atm above the surface. (2.23x10^5 Pa)

39. At what depth in fresh water ($\rho = 1000.$ kgm^{-3}) is the absolute pressure 2.31x10^6 Pa. Assume there is 1 atm above the water. (225 m)

More Complex: (These are like the assessment questions. Use Pa, and $P = F/A$)

40. At what depth below the ocean ($\rho = 1025$ kgm^{-3}) is the absolute pressure 100. psi? (Assume the pressure above the surface is 1 atm) (58.5 m)

41. A submarine is 45.2 m below the surface of a lake ($\rho = 1000.$ kgm^{-3}). What is the net force exerted on a 85.0 cm diameter hatch. Assume there is 1 atm above the water, <u>and</u> in the submarine? (2.52x10^5 N)

42. There is a gauge pressure of 812 Torr at a depth of 14.2 m in a fluid. What is the density of the fluid? Assume there is 1 atm above the fluid. (777 kgm^{-3})

43. At what depth in the dead sea ($\rho = 1240$ kgm^{-3}) does the water exert a force of 23,500 N on a 9.20 cm diameter porthole? Assume there is 1 atm above the water. (282 m)

44. A tank contains Liquid nitrogen ($\rho = 808$ kgm^{-3}). At a depth of 13.5 m there is an absolute pressure of 313.7 kPa. What is the pressure at the top of the liquid in psi? (30.0 psi)

Buoyancy ($B = \rho_f V_f g$)

Simple: (I walk you through all the steps with separate questions)

45. What is the buoyant force on a block of wood that is 2.95 cm x 4.50 cm x 4.50 cm submerged in fresh water? ($\rho = 1000.$ kgm^{-3}) If the wood has a density of 362 kgm^{-3}, what is its mass? What is its weight? What downward force would you need to exert to hold it under the water? (0.586 N, 0.0216 kg, 0.212 N, 0.374 N)

46. A 0.120 kg aluminium ($\rho = 2680$ kgm^{-3}) mass is submerged in alcohol with a density of 789 kgm^{-3}. What is the volume of the aluminium mass? What is the buoyant force acting on the mass? What is the weight of the mass? If the mass is resting on the bottom of the beaker, what is the normal force the beaker exerts on the mass? What is the apparent "mass" of the aluminium? (The mass that would weigh what the normal force is...) (4.48E-5 m^3, 0.347 N, 1.18 N, 0.831 N, 0.0847 kg)

47. A rectangular block of wood has a density of 345 kgm^{-3} and measures 85.2 cm x 64.2 cm x 20.0 cm. It floats in water ($\rho = 1000.$ kgm^{-3}) with a large face down in the water. What is its mass? What volume of water must it displace to float? (What is the volume of water that has this mass?) How far up the 20.0 cm side does the water come so that the block displaces this volume of water? (85.2 cm x 64.2 cm x X = volume) How much of the 20.0 cm dimension sticks up above the water? (37.7 kg, 0.0377 m^3, 0.069 m or 6.90 cm, or 13.1 above)

More Complex - I just ask you the last part.

48. What downward force would you need to exert to keep a 14.0 cm radius sphere with a density of 253 kgm^{-3} submerged in a fluid with a density of 965 kgm^{-3}? (80.3 N)

49. What upward force would you need to exert on a 52.1 kg piece of basalt (2920 kgm^{-3}) submerged in the dead sea where the water has a density of 1240 kgm^{-3} to keep it from sinking? (294 N)

50. A 13.25 gram hydrometer is a 1.12 cm diameter tube weighted on one end so it floats upright in a liquid. If it is 25.0 cm long, but floats with 7.80 cm exposed to air, what is the density of the liquid? (782 kgm^{-3})

51. A hot air balloon is 8.74 m in radius (assume it is spherical) and contains hot air with a mean density of 0.9486 kgm^{-3}. Calculate the lifting capacity of the hot air if it is surrounded by air with a density of 1.34 kgm^{-3}. (10,740 N)

52. A glass (2580 kgm^{-3}) cylindrical stirring rod is 5.02 mm in diameter and 18.0 cm long. What force do I need to exert on it to hold it vertically at rest with the tip submerged in acetone (791 kgm^{-3}) to a depth of 11.0 cm? (7.33x10^{-2} N)

53. A rectangular piece of wood that measures 13.0 cm x 15.2 cm x 3.78 cm floats face down in a fluid with a density of 893 kgm^{-3} with 2.93 cm of the 3.78 cm dimension submerged. What is the density of the wood? (692 kgm^{-3})

54. A 5.34 kg piece of rock can be supported by a force of 40.4 N when submerged in water with a density of 1008 kgm^{-3}. What is the density of the rock? (4406 kgm^{-3})

55. A 1.28 kg piece of Styrofoam float material can be held under water ($\rho = 1000.$ kgm^{-3}) with a downward force of 328.7 N. What is the density of the Styrofoam? (36.8 kgm^{-3})