Indian Institute of Space Science and Technology

AE111 Introduction to Aerospace Engineering

Fluid Statics

December 6, 2022

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1. A hot air balloon (approximated as a sphere of diameter 50ft (15.24 m)) is to lift a basket load of 272.16 kg. To what temperature must the air be heated in order to achieve liftoff?

2. Scientific balloons operating at pressure equilibrium with the surroundings have been used to lift instrument packages to extremely high altitudes. One such balloon, constructed of polyester with a skin thickness of 0.013 mm, lifted a payload of 230 kg to an altitude of approximately 49 km, where atmospheric conditions are 0.95 mbar and -20°C. The helium gas in the balloon was at a temperature of approximately -10°C. The specific gravity of the skin material is 1.28. Determine the diameter and mass of the balloon. Assume that the balloon is spherical.

3. A balloon weighing 80 kg has a capacity of 1200 m^3. If it is filled with helium, how great a payload can it support? The density of helium is 0.18 kg/m^3 and the density of air is 1.30 kg/m^3. Express your answer in newtons.

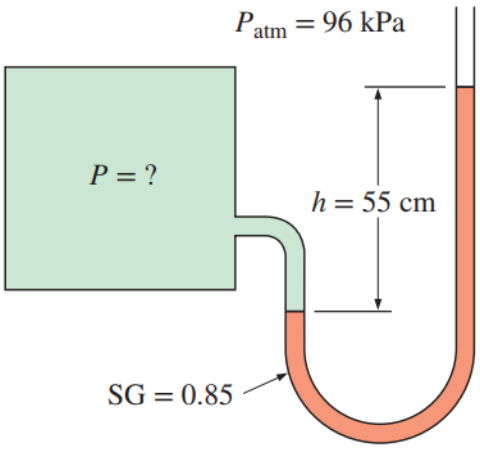
4. Hot-air ballooning is a popular sport. According to a recent article, "hot-air volumes must be large because air heated to 150°F over ambient lifts only 0.018 lbf/ft^3 compared to 0.066 and 0.071 for helium and hydrogen, respectively." Check these statements for sea-level conditions. Calculate the effect of increasing the hot-air maximum temperature to 250°F above ambient.

5. It is desired to use a hot air balloon with a volume of 320,000 ft^3 for rides planned in summer morning hours when the air temperature is about 48^oF. The torch will warm the air inside the balloon to a temperature of 160^oF. Both inside and outside pressures will be "standard" (14.7 psia). How much mass can be carried by the balloon (basket,fuel,passengers, personal items, and the component of the balloon itself) if neutral buoyancy is to be assured? What mass can be carried by the balloon to ensure vertical takeoff acceleration of 2.5 ft/s^2? For this, consider that both balloon and inside air have to be accelerated, as well as some of the surrounding air (to make the way for the balloon). The rule of thumb is that the total mass subject to acceleration is the mass of the balloon, all its appurtenances, and twice its volume of air. Given that the

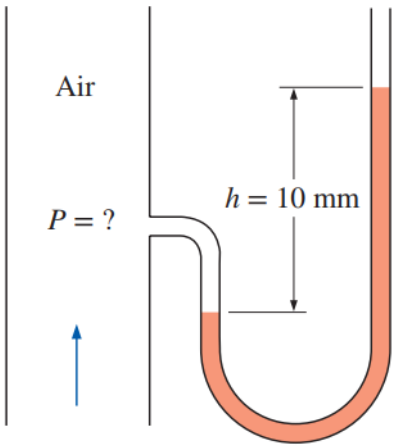
volume of hot air is fixed during the flight, what can the balloonist do when they want to go down?

6. Determine the atmospheric pressure at a location where the barometric reading is 740 mmHg and the gravitational acceleration is g = 9.805 m/s^2. Assume the temperature of mercury to be 10°C, at which its density is 13,570 kg/m^3.

7. A manometer is used to measure the pressure of a gas in a tank. The fluid used has a specific gravity of 0.85, and the manometer column height is 55 cm, as shown in Figure. If the local atmospheric pressure is 96 kPa, determine the absolute pressure within the tank.



8. A mercury manometer (ρ = 13,600 kg/m3) is connected to an air duct to measure the pressure inside. The difference in the manometer levels is 10 mm, and the atmospheric pressure is 100 kPa. (a) Judging from the given figure, determine if the pressure in the duct is above or below the atmospheric pressure. (b) Determine the absolute pressure in the duct.



9. Calculate the standard atmospheric properties (pressure, density, and temperature) at a geopotential altitude of 15 km.

10. At 12 km in the standard atmosphere, the pressure, density, and temperature are 1.9399 x 10^4 N/m^2, 3.1194 x 10^{-1} kg/m^3, and 216.66 K, respectively. Using these values, calculate the standard atmospheric values of pressure, density, and temperature at an altitude of 18 km, and check with the standard altitude tables.

11. Balloons are often filled with helium gas because it weighs only about one-seventh of what air weighs under identical conditions. The buoyancy force, which can be expressed as $F_B = \rho_{air} g \forall_b$, will push the balloon upward. Determine the maximum amount of load, in kg, the balloon described.