INDIAN INSTITUTE OF TECHNOLOGY KANPUR

ESO 201A: Thermodynamics

(2023-24 I Semester)

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Tutorial -1

Question 1: On the moon, the gravitational acceleration is approximately one-sixth that on the surface of the earth. A 5-kg mass is "weighed" with a beam balance on the surface of the moon. What is the expected reading? If this mass is weighed with a spring scale that reads correctly for standard gravity on earth, what is the reading?

(Ans: 5 kg on beam balance and 5/6 kg)

Question 2: During a heating process, the temperature of a system rises by 10°C. Express this rise in temperature in K, °F, and R.

(Ans: 10K, 18°F, 18R)

Question 3: At 45° latitude, the gravitational acceleration as a function of elevation z above sea level is given by $g = a - bz$,where a = 9.807 m/s^2 and $b = 3.32 \times 10^{-6}\text{s}^{-2}$.

- **(a)** Determine the height above sea level where the weight of an object will decrease by 0.3 percent.
- **(b)** By what percentage is the weight of an airplane reduced when it cruises at 11000 m?

(Ans: (a)8862 m (b)0.37%)

Question 4: The density of mercury changes approximately linearly with temperature as $\rho_{Hg} = 13595 - 2.5T$ kg/m^3 (T in Celsius). If a pressure difference of 100 kPa is measured in the summer at 35°C and in the winter at −15°C, what is the difference in column height between the two measurements?

(Ans: 6.9mm)

Question 5: The density of liquid water is ρ = 1008 − T/2 [kg/m^3] with T in °C. If the temperature increases 10°C, how much deeper does a 1m layer of water become?

(Ans: 0.005m)

Question 6: The atmosphere becomes colder at higher elevations. As an average, the standard atmospheric absolute temperature can be expressed as T_{atm} =288 − 6.5×10^{-3} z, where z is the elevation in meters. How cold is it outside an airplane cruising at 12 000 m, expressed in degrees Kelvin and Celsius?

(Ans: 210K, -63.15°C)

Question 7: Using the freezing and boiling point temperatures for water on both the Celsius and Fahrenheit scales, develop a conversion formula between the scales. Find the conversion formula between the Kelvin and Rankine temperature scales.

(Ans: °F = °C (9/5) + 32)
