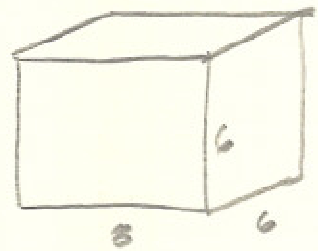
Ex.

problem statement: Determine the mass and the weight of the air contained in a room whose dimensions are 6×8×6 m. The air density is 1.16 kg/m3

schematic:



given:

$V = 6 \times 6 \times 8 = 288 m^3$

$\rho_{AIR} = 1.16 \ kg/m^3$

required:

mass of the air

weight of the air.

Analysis:

. the relationship between density, mass, volume

$m = \rho V$ eq 1

substituting into equation 1

$m = 1.16 \cdot 288$

$= 334.1$ kg.

weight of the air is the product of mass & gravity.

$W = m \cdot g$

$= 334.1 \times 9.81$

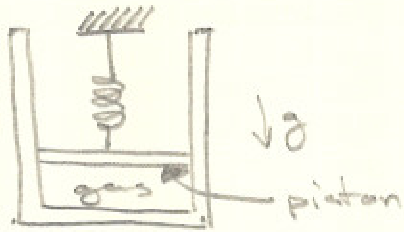
$= 3.277$ kN.

EX.

a vertical piston-cylinder device contains gas. the piston has a mass of 4000g and a cross sectional area of 35 cm^2. A compressed spring above the piston exerts a force of 0.060kN on the piston. Determine the pressure of the gas inside the cylinder. If the atmosphere pressure is 95kPa.

Assumption: friction neglected.

Schematic:



given: $P_{ATM} = 95$ kPa.

$A_p = 35\ cm^2$

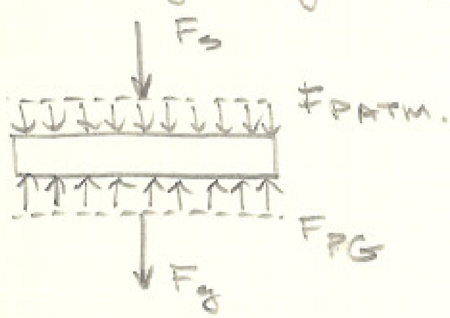
$m_p = 4000\ g$

required: P_G (pressure of gas).

analysis:

under equilibrium the free body diagram is shown

$\oplus \uparrow \Sigma F_y = 0$



$F_{pg} = F_s + F_g + F_{PATM}$

$P \cdot A_p = F_s + m_p g + P_{ATM} \cdot A_p$

$$P = \frac{F_s}{A_p} + \frac{m_p g}{A_p} + P_{ATM}$$

do the unit conversions and get

$$P = \frac{60}{0.0035} + \frac{4 \times 9.81}{0.0035} + 95000 = 123354\ Pa$$

$P \cong 123.4$ kPa.

THERMODYNAMIC PROPERTIES ARE DIVIDED INTO 2 CATAGORIES

intensive: independent of mass

ie - tempoture, Pressure, Density

extensive: dependant of mass.

ie - Volume, total energy, momentum.

REMARK: extensive properties per unit mass of the system are called specific properties and considered to be intensive properties.

ie - the specific volume is defined as

$$v \equiv \frac{\forall}{m}$$

Volume

mass

"as defied"

specific Volume

* MATHEMATICAL CONVENTION.

- Upper case letter is an extensive property
- Lower case is "divid by mass"

ex - the total energy "E" is related to the specific total energy "e" by

$$e = \frac{E}{m}$$

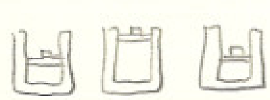
ISO -

the term iso- is often used to designate a process for which a particular property of the system remain unchanged

ie - isothermal process: means that temperature remains constant through the process.

CYCLE

a process that returns to an origanal state.

ie - process  cycle 

FORMS OF ENERGY

energy can exist as many forms.

- Thermal energy TE
- Mechanical energy ME
- Kinetic energy KE
- Potenial energy PE
- electrical energy EE
- Chemical energy CE
- nuclear energy NE

the sum of these is the Total energy

$$E = TE + ME + KE + \ldots + NE + \ldots$$

the unit for energy is Joule (J) $(= 1\,N \cdot m)$

the specific energy is, e, given by

$$e = \frac{E}{m} \quad (J/kg)$$

kinetic energy and the specific kinetic energy are given by.

$$KE = \frac{1}{2} m v^2$$

$$ke = \frac{1}{2} v^2$$

v is the velocity of the system relative to a fixed frame.

POTENIAL ENERGY & SPECIFIC POTENIAL ENERGY.

$$PE = m \cdot g \cdot z$$

elevation

$$pe = gz$$

INTERNAL ENERGY & SPECIFIC INTERNAL ENERGY.

$$U = TE + ME$$

$$u = \frac{U}{m}$$

note: that in this course we will be dealing with internal, kinetic, potential energy.

∴ TOTAL ENERGY & SPECIFIC TOTAL ENERGY.

$$E = U + KE + PE$$

$$e = u + ke + pe.$$

EX.

A location evaluated for a wind farm is observed to have a steady flowing winds at an average speed of m/s

Determine: A. the wind energy per unit mass of air
B. the wind energy for a mass of 15kg
C. the wind power for a flow rate 1200 kg/s of air.

Analysis: A.

$$ke = \frac{1}{2}V^2 = \frac{1}{2}(10)^2 = 50 \text{ J/kg}$$

B.

$$KE = m \cdot ke = 15 \cdot 50 = 750 \text{ J}$$

C.

$$P_{WIND} = \text{Rate KE} = \dot{m} \cdot ke = 1200 \cdot 50 = 60 \text{ kW}$$

CHAPTER 3 - PROPERTIES OF A PURE SUBSTANCE.

EX.

water can exist as a liquid and a vapour in the 'boiler' and the "condenser" of a steam power plant.

§ 3.1 PHASE CHANGE PROCESS.

fundamental physics of phase change: consider a system of 1 kg of liquid H_2O

see fig 3-1

SATURATATED TEMPERTURE

T_s (T_{SAT}) - the temperture. It is the temperture at which a phase change occurs in a given pressure, P. This is called the saturation Pressure (P_{SAT})

Hence,

$$T_{SAT} = f(P_{SAT})$$

Ex. for H_2O at sea level $T = 100°C$ $P_a = 0.1$ MPa

$\therefore$ $T_{SAT} = 100°C$ when $P = 0.1$ MPa.

REMARK: the relationship b/t P_{SAT} & T_{SAT} can be seen as.