DIGITAL EDUCATION
MARTCOST

MECHANICAL ENGINEERING

Thermal

Hand Notes For GATE, IES, PSUs & Competitive Exam

Hand Notes

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THERMAL

$F \propto ma$

$F = \frac{ma}{g_c}$

$\frac{1}{g_c}$ = proportionality constn

g_c = universal constant

$F = 1\ kgf$

$m = 1\ kg.$

$a = 9.81\ m/s^2$

$1\ kgf = \frac{1\ kg \times 9.81\ m/s^2}{g_c}$

$g_c = 9.81\ \frac{kg.m}{kgf\ sec^2}$ - m.k.s.

$1\ kgf = 9.81\ N.$

$g_c = \frac{9.81}{9.81}\ \frac{kg\ m}{N\ sec^2}$

$= 1\ \frac{kg\ m}{N\ sec^2}$ (SI)

weight of body

$w = \frac{ma}{g_c}$

$g_c = 9.81$ or $g_c = 1$
SI M.K.S M.K.S S.I

weight of body vary place to place

mass of body does not vary place to place.

Specific volume : It is defined as volume per unit mass.

$S.V.(v) = \frac{volume}{mass}\ \left(\frac{m^3}{kg}\right)$

Density $(\rho) = \frac{mass}{volume}\ \left(\frac{kg}{m^3}\right)$

$\boxed{\rho\, v = 1}$

Density is reciprocal of specific volume and specific volume reciprocal of density

Relative density or specific gravity

It is defined as ratio of density of substance to density of water.

$\rho_{water} = 1\ gm/c.c$

$= 1000\ kg/m^3.$

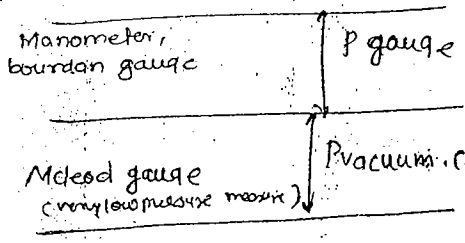
pressure : It is defined as force per unit area.

$P = \frac{Force}{Area}\ \left(\frac{N}{m^2}\right)$ or pascal.

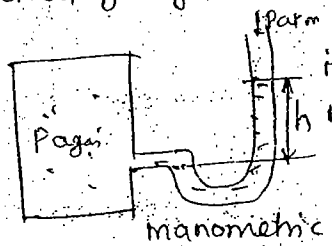
pascal is very small unit of pressure hence we using kpa and Mpa higher units of pressure.

$P_{abs} = P_{atm} + P_{gauge}$

$P_{abs} = P_{atm} - P_{vacuum}$.



Mcleod gauge based on boyles law.



if $P_{gas} > P_{atm}$ liquid rise in open limb if $P_{gas} < P_{atm}$ the liquid rise in closed limb. A height of rise of a manometric liquid gives an indication of the pressure

$P_{abs} = P_{atm} + P_g$. $\quad P_{abs} = P_{atm} - P_{vacuum}$.

$= P_{atm} + \frac{\rho g h}{g_c}$ $\quad = P_{atm} - \frac{\rho g h}{g_c}$.

1 Patm = 101.325 kPa = 760mm of Hg column

= 76 cm of Hg column.

= 10.33 of m of H_2O column.

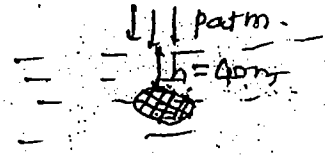
1 torr = 1 mm of Hg column.

= 133.33 Pa

= 0.13333 kPa.

1 bar = 10^5 Pa. = 100 kPa. = 752.6 mm of Hg column

A Rock is submerged in sea water at a depth of 40m what is the pressure acting on the top of the rock



⇒ $P = \rho g h$:

ρ sea water = 1100 kg/m3

$P_{abs} = P_{atm} + P_{gauge}$

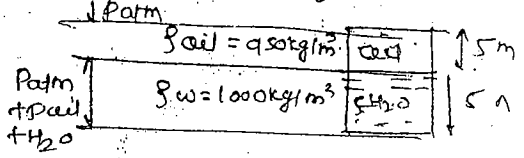
$= P_{atm} + \frac{\rho g h}{1000 g_c}$

$= 101.325 + \frac{1100 \times 9.8 \times 40}{1000 \times 1} = 532.64$ kPa.

uge

cuum.

water is poured at a height 5m in cylindrical vessel above that oil of S.G 0.95 is poured for another 5m. what is difference in pressure acting on the bottom and top of vessel



⇒

pressure in difference

$\Delta P = p_{oil} + p_{water}$

$= \frac{\rho_o g h_o}{1000 g_c} + \frac{\rho_w . g h_w}{1000 g_c} = \frac{950 \times 9.81 \times 5}{1000 \times 1} + \frac{1000 \times 9.81 \times 5}{1000 \times 1}$

$= 95.64$ kPa.

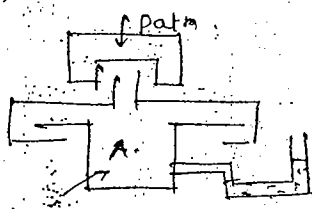
en ums

In closed

he pressure

A pressure cooker is designed for a pressure of 1 bar gauge the opening available in the head of cooker is 4 mm^2. what should be weight that should be kept above with hor withstand the pressure

⇒



$P_{inside} = P_{external}$

$P_{atm} + \frac{\rho g h}{conv g_c} P_{gauge} = P_{atm} + \frac{mg}{A}$

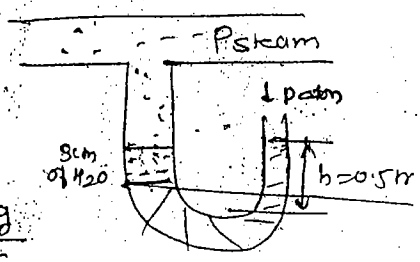
$P_{atm} + P_{gauge} = P_{atm} + \frac{mg}{A}$

$105 = \frac{m \times 9.81}{4 \times 10^{-6}}$

$\boxed{m = 40.8 gm}$

urm.

Steam is flowing in the main pipeline a mano meter is connected with mercury as the manometric liquid which has a density of 13600 kg/m^3, what is the pressure of steam in the mains.



n of Hg column

⇒ For balance

$P_{steam} + P_{H_2O} = P_{atm} + P_{Hg}$

$P_{steam} + \frac{\rho_w . g . h_w}{1000 g_c} = P_{atm} + \frac{\rho_{Hg} . g . h_{Hg}}{1000 g_c}$

of 40m rock

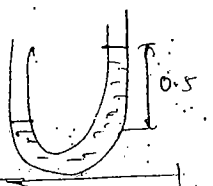
n.

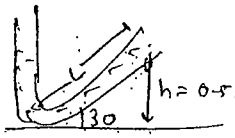
$P_{steam} + \frac{1000 \times 9.81 \times 3 \times 10^{-2}}{1000 \times 1} = \frac{101.325 + 13600 \times 9.81 \times 0.5}{1000 \times 1}$

$P_{steam} = 167.168$ kPa

The height of rise of mercury in u tube manometer it is replaced with inclined manometer which an angle of 30° up to what length the Hg should flow on inclined plane to measure the same pressure.

Ans (1)





$\frac{h}{L} = \sin\theta$

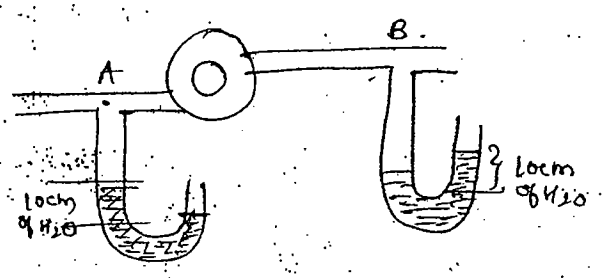
$L = \frac{h}{\sin\theta} = \frac{0.5}{\sin 30} = 1$

when a fluid of density of 2gm/cc the height of rise is 0.2m if it replaced with fluid of density 10gm/cc what is height of rise.

$\Rightarrow h \propto 1/\rho \quad \rho h = \text{constant} \quad \rho_1 h_1 = \rho_2 h_2$

$\Rightarrow 2 \times 10 = 2 \times 0.2 = 10 \times h_2 \quad \boxed{h_2 = 0.04m}$

Across a flow two manometer are connected as shown in the figure calculate difference in pressure in B and A in kPa.



$\Rightarrow$

$P_B - P_A = 10 - (-10)$

$= 20$ cm of H_2O

$= 0.2$ m of H_2O

$= \frac{0.2}{10.23} \times 101.325$

$= 1.98$ kPa

In thermodynamics we will be taking of system

Open system: It in this energy transaction interaction as well as mass interaction

eg: water flow through pipe line:

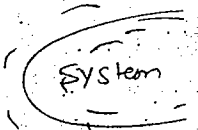
When water is flow in pipe the mass crosses the System boundary as well as energy crosses the system boundary.

Closed sys
only en
eg. sun

Isolated sy
energy into
eg: coffee

Identify
① A founta
② A candle
③ A biogas
④ A T.V. su
⑤ transfar
⑥ A.C rai
⑦ A moon

A system
Separated
the envel



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If system
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A system
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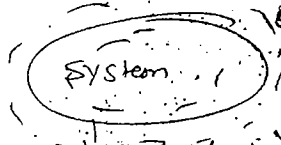
nature.

Closed system : Closed system is a system in which there is only energy interaction but no mass interaction
eg: sun.

Isolated system : Isolated system system in which there is neither energy interaction nor mass interaction
eg: coffee in a thermoflask

Identify to which category if following system belong.
① A fountain pen while writing – open system.
② A candle flame while burning – open system.
③ A biogan digestor – open system.
④ A TV switched ON – closed system.
⑤ transformer while working – closed system.
⑥ A.C railway coach – open system.
⑦ A moon in its orbit – closed system.

A system is defined as demarked volume which has been separated for the purpose of analysis observation and inferance the envelope of system is called as boundary. and volume bounded is called as surrounding. If system volume expand the work is said to be done by the system and system work is +ve, when system volume contract the work is said to be done on the system. the and workdone is given in –ve sign



if external agent does work on system the workdone is said to be -ve.

$\therefore$ $W_{system} + W_{surrounding} = 0$

If System does +ve work the surrounding will do negative work and vicaversa.

If heat is supplied to a system it is given +ve sign.
If heat is withdrawn from a system it is given a -ve sign

A system will not have heat & work will only energy in different forms. when energy system crosses boundary it may become heat or it may become work; heat and work are path function they depend upon the path followed. heat & work are inexact differential. heat & work are transient in nature. heat and work are boundary phenomenon.

$z = f(x,y)$

$$dz = \left(\frac{dz}{dx}\right)_y dx + \left(\frac{\partial z}{\partial y}\right)_x dy$$

$$\left(\frac{\partial z}{\partial x}\right)_y = M \quad ; \left(\frac{\partial z}{\partial y}\right)_x = N$$

$$\partial z = M\,dx + N\,dy$$

$$\frac{\partial M}{\partial y} = \frac{\partial}{\partial y}\left(\frac{\partial z}{\partial x}\right) = \frac{\partial^2 z}{\partial y \cdot \partial x}$$

$$\frac{\partial N}{\partial x} = \frac{\partial}{\partial x}\left(\frac{\partial z}{\partial x}\right) = \frac{\partial^2 z}{\partial x \cdot \partial y}$$

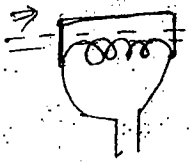
$\frac{\partial M}{\partial y} = \frac{\partial N}{\partial x}$ → exact differential

$\frac{\partial M}{\partial y} \neq \frac{\partial N}{\partial x}$ → Inexact differential

exact differentials are point function they depend on the end state but do not depend upon path followed. whereas inexact differentials are path functions and depend upon the path followed.

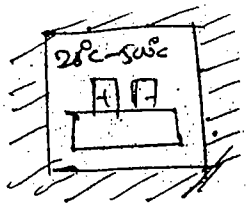
* Identify the signs of heat & work interaction in the following cases.

① A heater coil is kept in flowing water and it is connected external mean. what are the sign of heat and work and cold water enters the system leaves as hot water



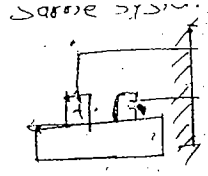
⇒ work done is -ve
heat transfer +ve!

② In a insulated rigid cylinder a battery is kept across the terminals of battery a resistor is connected and temp of air is increases from 25°C to 50°C. What are the signs of heat & work interaction.



$Q = 0$

$W = 0$



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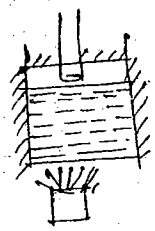

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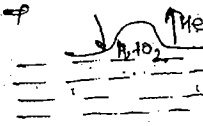

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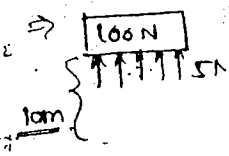

A 1 kg mas
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⇒ $W = 0$

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