MARINE ENGINEERING

By

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Lecture2

Basics of Thermodynamics

Now first I will start with thermodynamics. This thermodynamics course actually most probably you have studied in your first year's course. If you have not gone through it, so please go through before studying this whole course. And this first week course, I'll be summarizing the whole thermodynamic course. And I'll be giving some example problems.

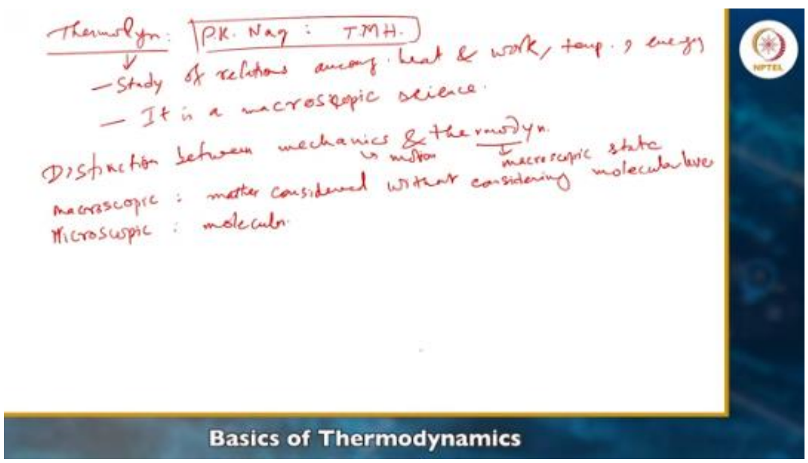
A similar problem will be given in your assignment, in your file exam. So, go through this lecture. And if you think something is not there, you have to go back to your basic fundamental thermodynamic books. I have taken the maximum material from PK Nag book. Nag basic and applied thermodynamic books this is basic part okay and this is Tata McGraw book and if I take any other material I will give definitely so what is thermodynamics thermodynamics is basically study of relations between heat and work

temperature, and energy. Instead of heating, I will write among heat, work, temperature, and energy. It is a macroscopic science. It does deal with bulk system and does not deal with molecular constitution of matter. For example, random vibration of motion, Brownian motion that we are not discussing in this course.

We are discussing about bulk, fluid or volume, certain volume I will take. So that volume will be compressing, decompressing, increasing temperature, reducing temperature. So whatever process we do, so we are not considering molecular, but we are taking bulk property. So, distinction between machines and thermodynamics, mechanics and thermodynamics, distinction between mechanics and thermodynamics. mechanics concentrated on motion of particle of bodies under force or torque okay so mechanics will be motion of particle motion of particle under force or torque but in thermodynamics in thermodynamics it will be like concern concerned with internal my macroscopic state of the body

Okay, so these two differences you should know. So what is macroscopic approach? Macroscopic approach, a certain quantity of matter is considered without considering molecular level. So matter considered without considering molecular level considering molecular level okay macroscopic microscopic now microscopic

matter is composed of millions of molecules for example you have Brownian motion so particles are moving so the discussion will be done through microscopic theories and macroscopic we are discussing so here is the slide you see harmonic means one term is the term and dynamics okay so term Actually, the term is temperature and dynamics means force. So, combining these two terms, the thermodynamic word is being created. So, here is the definition properly written here. Microscopic thermodynamic properties are the relationship between large-scale bulk properties of a system.



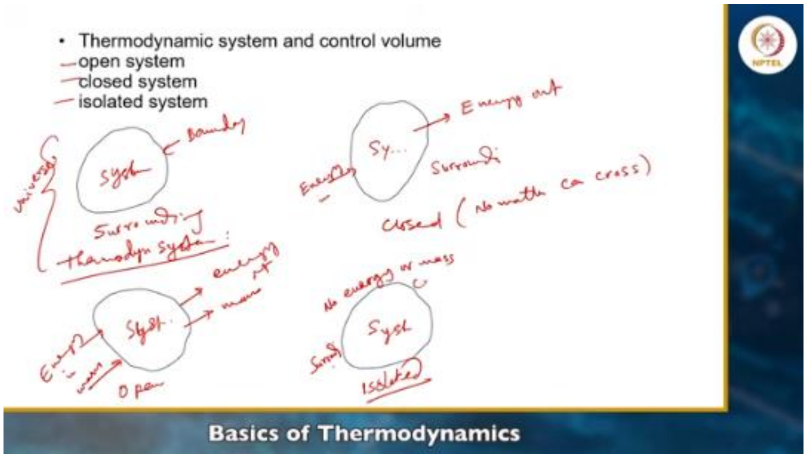
Microscopic system is the relationship between small-scale properties of a system. Now, thermodynamic system and control volume. We will discuss open system, closed system, isolated system. So, this is system. okay all are systems okay this is also system this is also system okay so this is called boundary okay and this is surrounding okay uh the definition thermodynamic system a quantity of matter or a region in space upon which

attention is concentrated in the analysis of a problem okay so one system will have boundary and outside the system is called surrounding okay now this is called thermodynamic system s y s system okay so all these are thermodynamic system so I'll define different types of systems so it's your closed system so this closed system is like this the boundary is there that energy out out energy in okay and this obviously surrounding A system and its surrounding is called universe. The boundary can be fixed or moving boundary. For example, you have piston cylinder arrangement.

So piston is moving. the boundary is creating cylinder and piston so piston can be moving so boundary can be moving or it boundary can be fixed for example you take a bottle and this is fixed volume you increase temperature reduce temperature this is fixed boundary volume but in certain cases boundary can be moving okay or changing shape uh so closed system no matter can cross no matter can mass or matter can cross cross the boundary Okay. But in open system, this is let us say draw one open system. Open system energy going, energy in, energy out, mass in, mass out.

So in open system both can interact, energy and mass. But in closed system only energy can interact, mass cannot change. Another can be isolatory system. In isolatory system what is happening? This is surrounding.

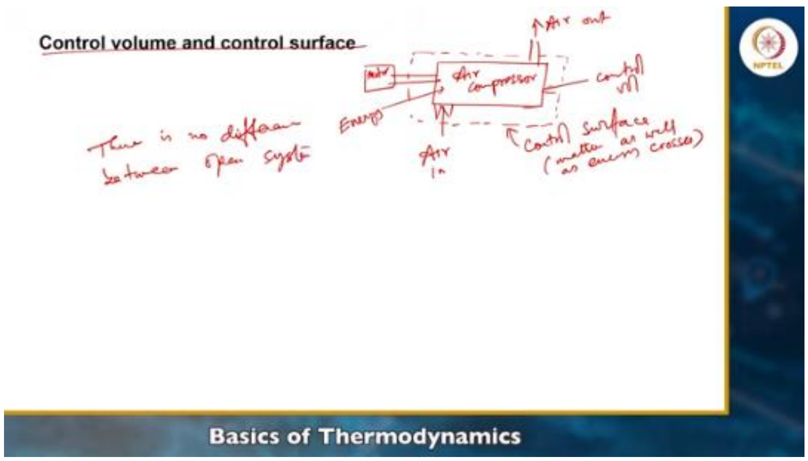
From surrounding there will be no mass or energy transfer. So no energy or mass can cross the boundary. So you should know the definition. So a system will have one boundary and it will be interacting with surrounding. If it is not interacting or no mass or energy getting transferred then it will be called as isolated system.



Control volume and control surface. So first draw one figure like this. and one motor is here and work is getting transferred motor is working you are giving electricity so motor is giving work or it is giving rotational motion or anything inside the system okay here compressor okay this is system and then you are giving energy so when you are giving energy temperature will be increasing or it will be expanding something will happen right and air out air in and this is called control volume and control volume covering the boundary called control surface okay So control volume fixed identified region in space through which fluid flows through the boundary of the control volume.

It's called control surface. Fluid flows through the boundary. It's called control surface. Okay. And control volume is fixed identified region in space through which fluid flows.

Okay. Matter as well as energy crosses the control surface. Matter as well as energy crosses but in closed system volume can change when matter flows this is matter flows the system is called control volume so there is no difference between open system control volume there is no difference between open system and control volume okay because volume can change when a matter flows this the system is control volume okay so closed system and control volume



Open system and control volume, there is no difference. It is a matter of getting transferred. Pharmacologic properties, process and cycles. Several definitions will be there. State.

When properties of the system have definite values, the system is said to exist at a definite state. Now, change of state. Changes any operation in which one or more properties of system changes is called change of state. So, this definition you should go through and there will be lots of books available and you can learn from the books. Intensive property.

So, intensive property is like independent of mass. Independent independent independent of mass so what are the independent of mass properties like pressure temperature specific volume specific volume or sp volume or spv i can write specific internal energy specific internal energy When something is per kg of mass, so that becomes intensive property because that becomes independent of mass actually. So, energy, specific entropy, specific entropy, specific enthalpy, enthalpy, specific volume, specific internal energy, specific enthalpy, specific entropy, all this comes under

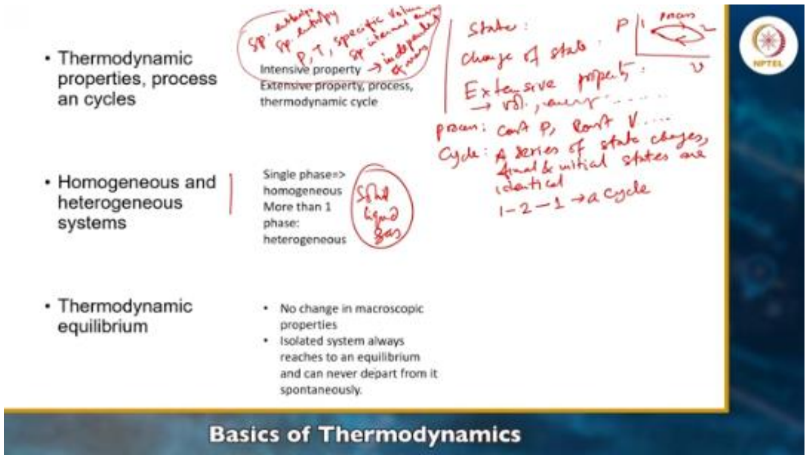
intensive properties okay now extensive property extensive property when you are talking about extensive property when you're talking about this comes like volume energy or anything related to mass so that's called extensive property okay now we'll go to process okay process when when changing state path is defined it is called a process for example constant pressure process constant pressure constant volume okay cycle A series of state changes and final and initial state are identical. For example, one process is happening 1 to 2 and 2 to 1, 2 to 1, like this. So, this is cyclic process.

Process starts from 1 to 2, again it returns back to 1. So, it is called cyclic process. A series of state changes. State changes and initial states are identical. Changes final and initial states are identical.

So, state already I have shown here, like if I draw it in V-P diagram, so A to B is a process, 1 to 2 is a process, 1 to 2 is a process, 2 to 1 also process, but if I go to 1 to 1, sorry, 1, 2, then 2 to 1 again, then it is called cyclic process. C-I-C-L-E cycle. Now homogeneous and hydrogen system. Every substance can exist in any of the three forms, solid, liquid, gas. okay now single phase homogeneous i mean only one phase is there but if you have heterogeneous that means multiple phases may be presenting presented for example solid liquid liquid gas the mixture can be possible so that you call heterogeneous mixture or heterogeneous phase

Thermodynamic equilibrium. The definition is like this. No change in macroscopic properties. Isolated system always reaches to an equilibrium and can never depart from it spontaneously. A system is supposed to exist in a state of thermodynamic equilibrium when no change in any macroscopic property is registered.

So, macroscopic property is not changing if the system is isolated from its surroundings. always isolated system reaches to an equilibrium state and never depart spontaneously no spontaneous change in macroscopic property in the system that are found in equilibrium state because we'll be dealing with lots of force calculation and different calculations so for that there will be several units in SI units in FPA units so you should remember the units actually force normally we use the term Newton but there will be other units also you should remember especially SI unit it is must to remember but other like FPS unit or other unit if somewhere it is being used so that's also you have to remember okay so force will be like dying also where Newton will be there or maybe mega Newton will be there so you should remember so mass also you will have like kg pound okay so that units you have to remember torque newton meter okay and other units also you should remember flow rate so meter cube per second and sometimes we use gpm gallon per minute if oil industry if you work then it will be working as a barrel per day barrel per day and many other units may be possible power unit will be there, what energy will be joule.



These are common units I am writing. Other units are also possible. So, you should remember. Whenever you are working or learning the marine engineering subject, sometime I will be using the terms and I may not define later stage. So, better you remember all these terms.

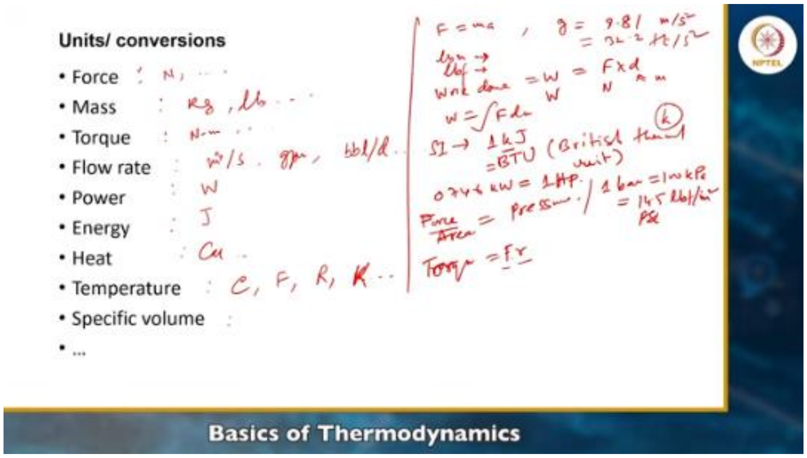
Heat will be like calorie and it can be joule also. Temperature, different scales are there. For example, centigrade or Celsius, Fahrenheit, Rankine, Kelvin. So, how to convert from one form to another form, you should remember the conversion also. Specific volume, when specific term is coming, so divide by something will be there.

Specific volume is part kg. Similarly, specific enthalpy, specific entropy, so those terms also you should remember. So, I have not given all the list here, but what are the common units for used in thermodynamics, any normal standard book you see. So, those units you should remember, even you should remember how to convert from one unit to another unit also. okay so some definition i can give force equals ma uh these are very basic equations you should remember actually and g value equals 9.81 if i do not give any problem you should remember a meter per second square okay so you should remember unit also but if you are using fps unit then 32.2 feet per second square okay uh pound mass lbm

lbm we say pound mass so when you pound force lbf l lbf pound force we say okay pound mass m so mass and force are different actually okay force value when you are talking about uh force mass means certain matter work done work done w equals f into distance okay so distance can be m so f is joule and force is newton w is joule and f is newton and d is meter okay if force is constant and distance varying then w can be like integral form of f dx okay SI unit 1 KJ kilo joule here every time you should note down this K means kilo this K is small letter if you're writing K capital the meaning will be different okay normal SI unit says K should be small letter okay so you write small K and heat transfer you use BTU also British thermal unit okay it's called British unit and conversion 0.746 kilowatt equals 1 hp okay this also should remember and force and pressure force means uh pressure means force per unit area okay so force per area equals pressure Okay.

So force, pressure will be like one bar or atmosphere. So that sort of unit you have to remember. One bar equals 100 kPa, Pascal equals 14.5 pound force per inch square. Inch square or psi, pound per square inch we say. Okay.

Torque. F into R. Force and radius you multiply. Torque means like shaft is there, you are twisting. So your shaft is there, you are twisting. Twisting means engine is producing power and propeller is running.



So actually because of torque transfer, shaft is transferring torque. So how to measure the torque? Torque means radius of the shaft and how much force you are applying. So that is called torque. specific volume and density density density kg per meter cube okay so specific volume is again per kg it will be a heat heat formula is like m s t t or del t m is mass s is specific heat

So here I am using specific heat. Later I will be using S as entropy. So don't be confused. So just for temporary heat. Temporarily I am using S as specific heat.

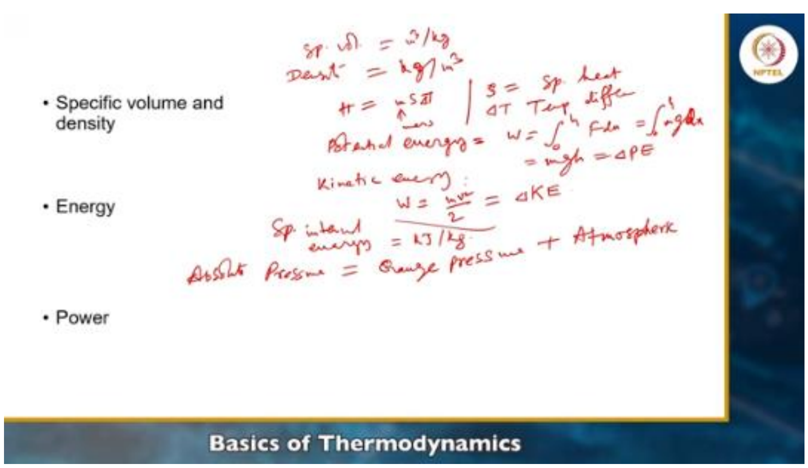
You can use some other symbol also. ΔT is temperature difference. So, you take certain amount of water, increase 10 degrees to 30 degree temperature and how much heat you have to give to increase the temperature. So, you have to know the mass, you have to know specific heat of water and you have to know temperature difference like 10 to 30 degrees, 20 degree temperature increasing. So, my H calculation I can get.

So, that from there... Okay, this one S unit, you can get H unit also. S if is given in joule, then you can get H value in joule. So, potential energy. So, potential energy ENV.

Potential energy W equals integration of 0 to H F dx equals 0 to H mgh. mg dx. How much distance from surface is there? So that is h actually. So this distance is changing.

That will be dx. And gravitational force is there g. So it will be mg dx. So finally it is coming mgh. del pe potential energy you can write kinetic energy kinetic energy w equals mv square by 2 mv square by 2 equals del ke okay a specific volume i already told specific volume meter cube per kg just opposite of density specific internal energy internal energy equals kg per kg when you are talking about specific normally it will be divided by something so divided by kg here

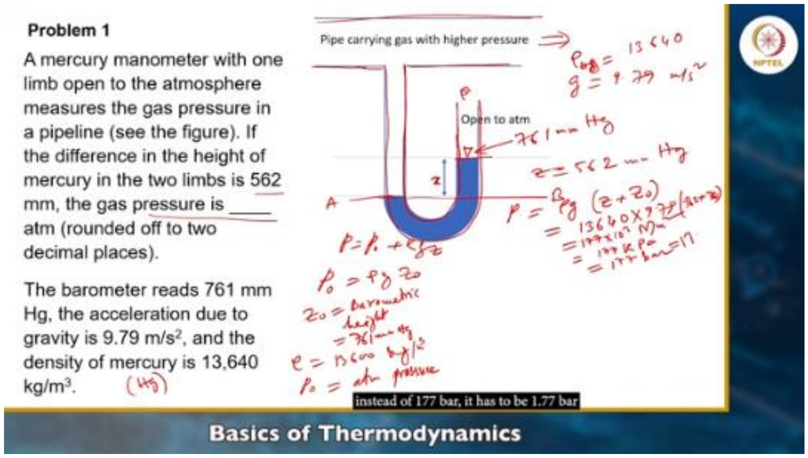
So absolute pressure, pressure absolute equals gauge pressure, pressure plus atmospheric pressure. Atmospheric pressure. Now, we will go to some basic calculations you may have done already in from your plus 2 also doing intensive examination or similar basic calculation you can do so that you can remember all the units and how to convert how to calculate. So, here one problem is that a mercury manometer with one limb open to the atmosphere. So, this is one pipe.



carrying gas with high pressure and one limb is open to atmosphere so this limb is open this limb okay and other is limb is connected to the pipe okay if the difference in the height of mercury here mercury difference is given z okay uh between two limbs 562 millimeters so z equals 562 millimeter hg okay mercury given so you need to know mercury density uh the barometer reading is given seven six one millimeter that means their pressure is working atmospheric pressure this is 761 millimeter hg okay and acceleration due to gravity different gravity is given okay so g value is given 9.79 okay if g is not given so you should take actually 9.81 but here just to confuse you it is given 9.79 the density of mercury is given rho hg is given 13640 hg means mercury this chemical symbol you can remember okay this is hg actually chemical symbol now how to calculate it so gas pressure now you take one plane ab a b okay and here p equals p o plus rho g z so p o equals rho g z o z o is barometric pressure barometric pressure or height barometric height equals seven six one millimeter

hg okay rho is 13600 kg per meter cube and p zero has more atmospheric pressure okay p-r-e-s-s-u-r-e okay now p is rho g z plus z o so that becoming 13 six four zero into nine point seven nine z one plus z two point five six two plus point seven six one so this is becoming one seven seven point uh ten power three newton per meter square now newton i got now i want to get resulting atmospheric so so we have to convert it So, it will be like 177 kPa. Now, I got Pascal, kilopascal. Now, from kilopascal, I have to convert to atmospheric.

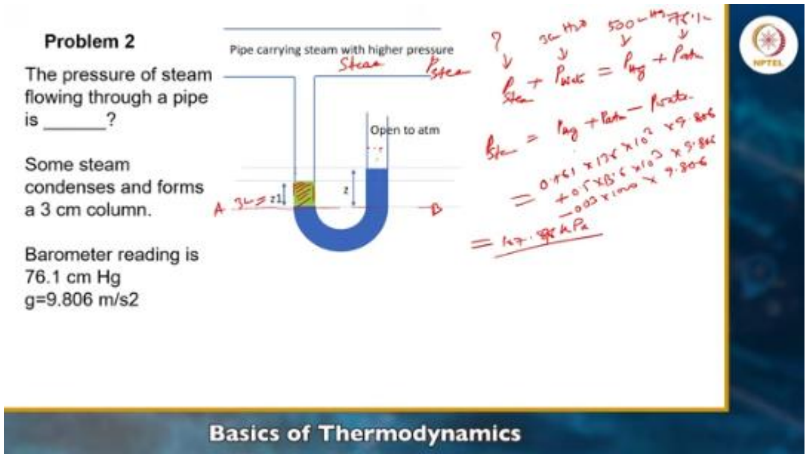
So, 177 then divided by 1.013 bar. So, it is becoming, kilopascal is bar. So, atmospheric pressure will be 1.746 atmospheres ok divided by 1.013 ok so there is similar again another problem just little bit complexity I created here it is getting steam ok steam and steam is getting condensed and getting deposited here so Z1 actually 3 cm I have given ok now A B my baseline okay this is my baseline so what is the left hand pressure or the right hand pressure you have to equate left hand pressure if this is p gas so p gas plus your three centimeter water column height three same p gas p for water okay gas or steam i should not write gas rather please steam



equals right hand side pressure uh p h g plus p atmospheric pressure okay now barometer reading 76 so here it is coming 76.1 centimeter here mercury is given uh this height is not given so just you assume 540 maybe just assume 540 centimeter hg and water is three centimeter h2o p steam we don't know okay now p steam equals phg plus p atom minus e water okay so phg means uh Okay, so finally it becomes like 0.761 into 13.6 into 10 power 3 into 9.806 plus 0.5 into 13. This is not given, 0.5, 5486, 5486. 0.5. This means 500. 0.5.

Then 13.6 into 10 to the power 3 into 9.806 minus 0.03 meter into 1000 kg per meter cube water density 9.806. So, it gives 167.876 kPa. So, now we can convert into atmospheric and other things also. And I can make more complication also. I can make maybe one another layer of some other fluid.

So, just you have to calculate left column weight pressure and right column pressure and you have to equate. So, similar problem can be created for the assignment of final exam also. This is basic thermodynamics. So, I did not go to very much difficult question as it is very simple plus two level question. So, another problem, a pump discharges a liquid into a drum at 0.032 meter cube per second.



This is flow rate is given. 0.032. The full drum holds 300 kg. So, mass is given 300 kg. the diameter and height of the drum diameter is given 1.5 meter and height is given 4.2 meter fine density and flow rate liquid handled by the pump density means fluid density so here it means volume of drum positive volume of drum okay pi by 4 into base area pi by 4 d square d square into h so pi by 4 into d means 1.5 square into 4.2 okay this is giving 7.4 to 2 meter cube

and density therefore density density equals m by volume mass is given already 3000 and volume 7.422 so this is giving 404.203 kg per meter cube and what is the mass flow rate m dot or mass flow rate so volume flow rate volume flow rate into density okay so 0.032 into 404.203 so this is coming 12.9345 kg per second so this is your mass flow rate okay so this is also very simple problem you can calculate Thank you.