**Mechanical Measurement Systems**
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**Lecture – 01**
**Basic Concepts of Measurement**

Hello, I welcome you all in this course on mechanical measurement systems. Today we will discuss basic concepts of measurement, and in today's lecture we will cover the concept of measurement, fundamental units, application of measurement.

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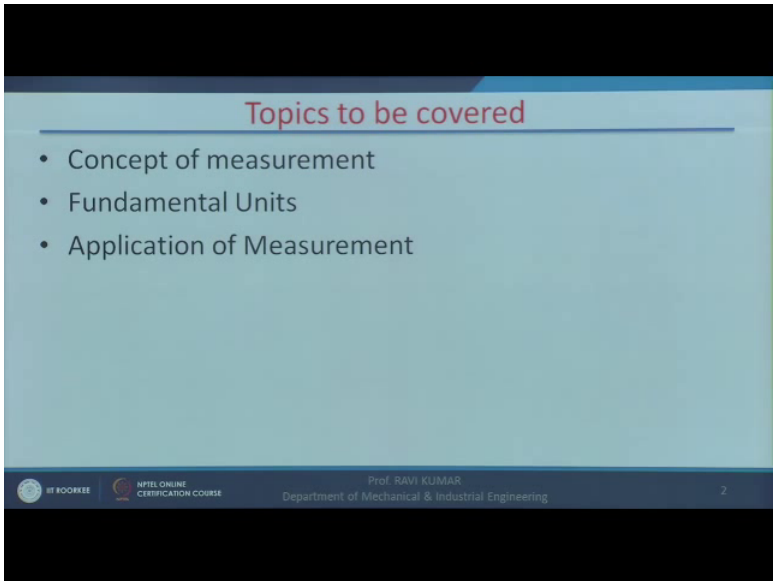


So, anything which is which is existing in this universe is existing in some amount for example, distance. Distance is existing in some amount, mass is existing in some amount; temperature is existing in some amount. So, these units have to be measured, I mean if you compare you want to compare one length to other length. So, both the lengths have to measured and their different units of measurement.

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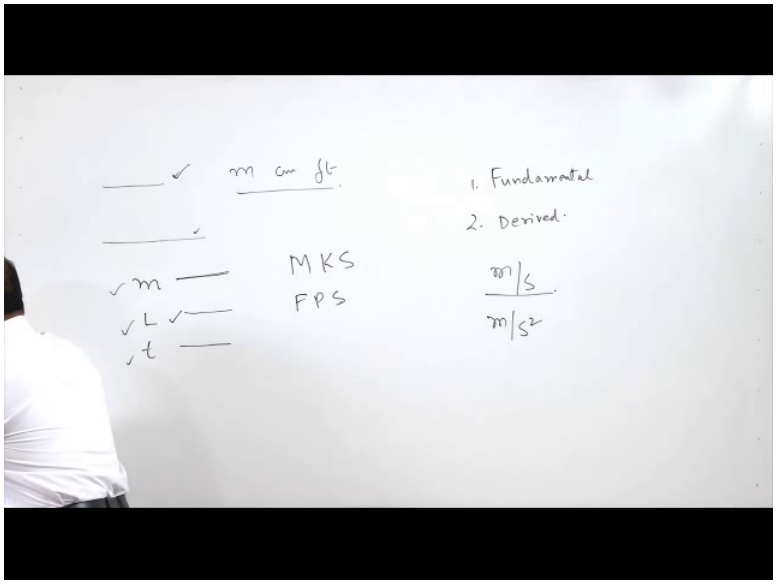


They can be measured in terms of metres, they can be measured in terms of centimetres, they can be measured in terms of feet. In fact, your hand can also be a measuring tool.

So, the process of measurement is compare a parameter with the (Refer Time: 1:25) standard. Yes, you must have studied at the school level there are 3 fundamental units for mass, unit for length and unit for time. Your hand can be a unit for length, but the distance. So, this length may vary from person shall vary from person to person.

So, therefore, there has to be some standard length, there has to be some standard metre for the act of measurement. There has to be some standard mass for the act of measurement, there has to be some standard time for the act of measurement.

So, there are certain systems out of those systems very popular system is MKS systems because, these units are known as fundamental units. There 2 types of units fundamental units and another one is derived units. Units derived out of these units are known as derived in this for example, speed. Speed is metres per second it is a derived unit. Acceleration metres per second square it is a derived units.

So, there are certain systems for measurement like MKS system then, there is a FPS systems. In MKS system, the unit of mass is kg sorry. The unit of length is meter, this is length mass and seconds. So, we will replace this length by mass L M.

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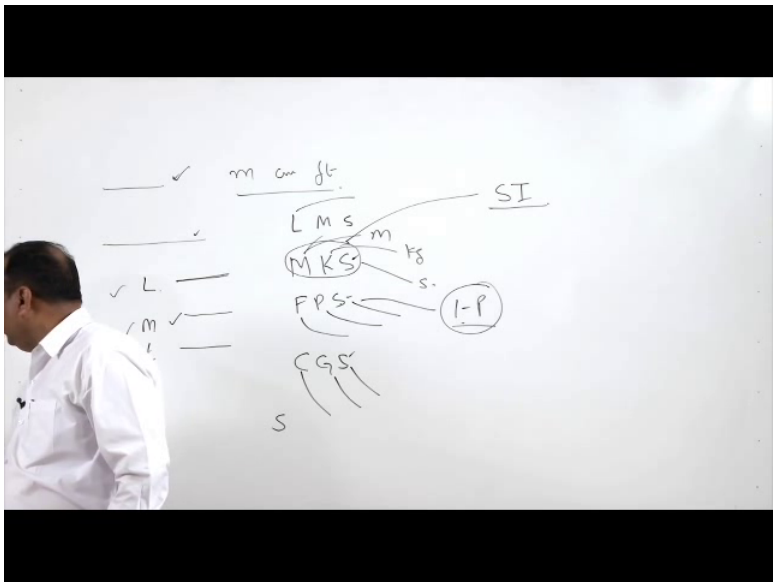


So, length is meter, this is kilogram and this is second MKS unit. FPS unit foot pound second. There is another system which is known as CGS system, which is not very popular nowadays. This is length for length it is centimetres, G is mass for mass it is grams, and S for seconds. So, you will find that for time in all these 3 the unit is seconds, for mass it is varying. So, FPS system is also known as inch pound system nowadays, I-P system inch pound system.

But, for many years we have been for many years, we have been using this MKS system in India, but now, we have switched over to SI system in fact, India and Europe. The SI system interracially standard system is followed, which is close to the MKS system, and in US they normally follow the inch pound system. So, as a mechanical engineer or any engineer of any other branch of engineering, or graduate of any other branch of engineering, you should be well conversant with the conversion of units from one system to another system. So, you should be very comfortable for converting units from one system to another system.

Now, we will start with the standards, the standard for length. What we will call a standard for length, earlier the standard of length was the distance or the length of the rod. There was a platinum iridium rod in interracial bureau of weights and measurements in Paris.

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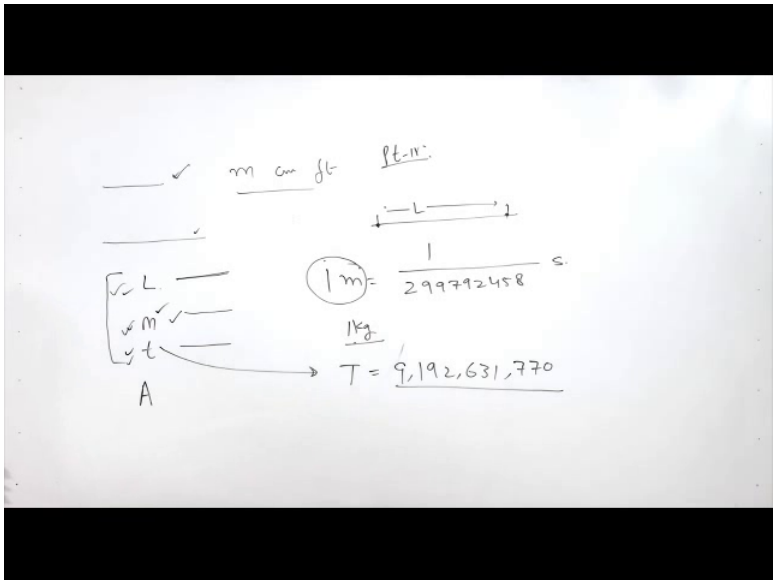


So, length of that rod between 2 points was considered 1metre length, but now, this is standard has changed. Now the 1 metre length is, the distance travelled by light in vacuum in 2 9 9 7 9 2 4 5 8 seconds. So, this distance is 1 metre length as per the interracially standards. A standard of a mass, a standard of a mass is the same mass of this rod between these 2 points, or the mass of this rod is the standard mass of 1 kg it is remaining same 1 kg. And standard for time, earlier the standard of time was derived from the movement of relative movement of sun and the earth.

Nowadays, the standard of time is the time period of caesium 138 caesium 138 atom for number of vibrations 9 192, 631 770. So, for this number of vibrations for this number of vibrations the time consumed is 1 second. So, this is the standard of time nowadays but now, because, these are old fundamental units. Now, more units are added into this fundamental units and the 1 of this units is ampere. Measurement of current and in order to define 1 ampere we say that, it is the amount of current which is passed through parallel conductor in vacuum having top section area tending to 0, and force per metre length is 2 into 10 to power minus 7 Newtons per metre. If this much force is exerted electromagnetic force is exerted then, we will say that, the amount of current is 1 ampere. So, this is a new fundamental unit current.

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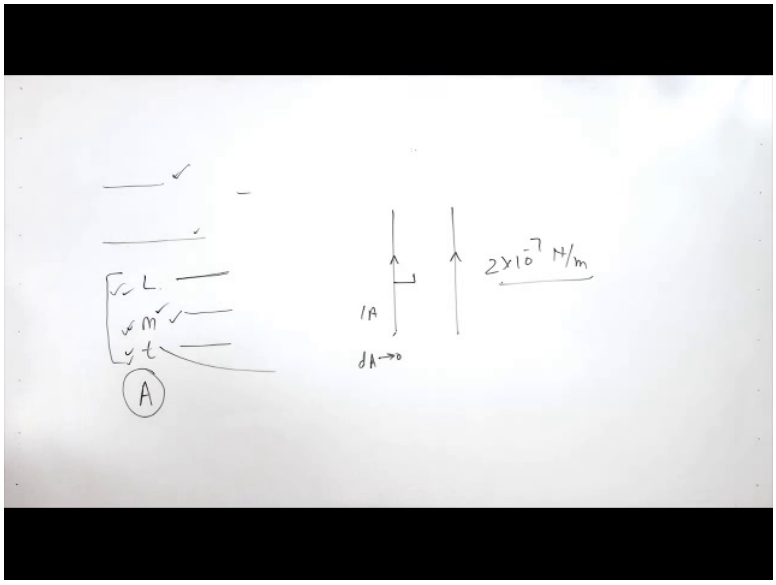


There are other fundamental units also which are because; these units cannot be converted to each other. So, length we cannot convert to mass, mass we cannot convert to time, ampere we cannot express either of L M or T, right? So, this is new fundamental units. Another fundamental unit is the unit of temperature, which is considered as Kelvin, right? And the reference point for the Kelvin is the reference point of the Kelvin is the triple point of water look.

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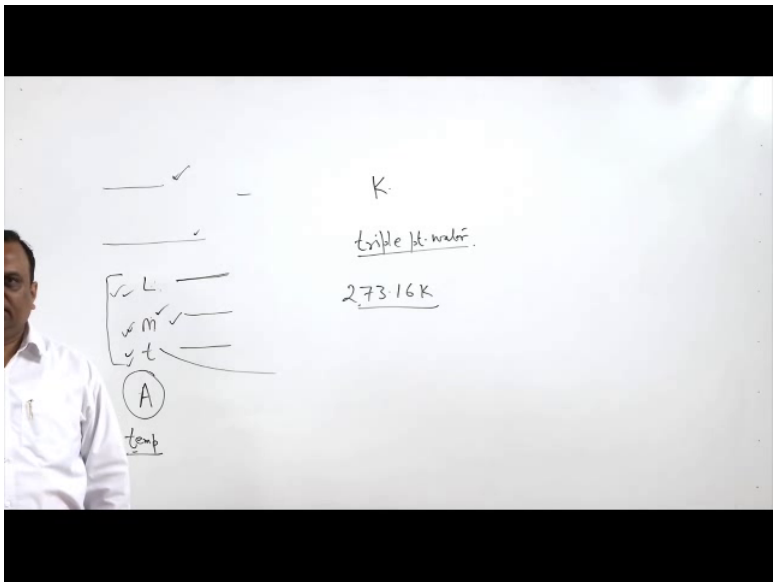


Triple point of water means, it is the pressure and temperature at which the water exist in solid, liquid and gases form, and the temperature of this triple point of water is 273.16 Kelvin. Now, other fundamental unit is the unit of light Candela.

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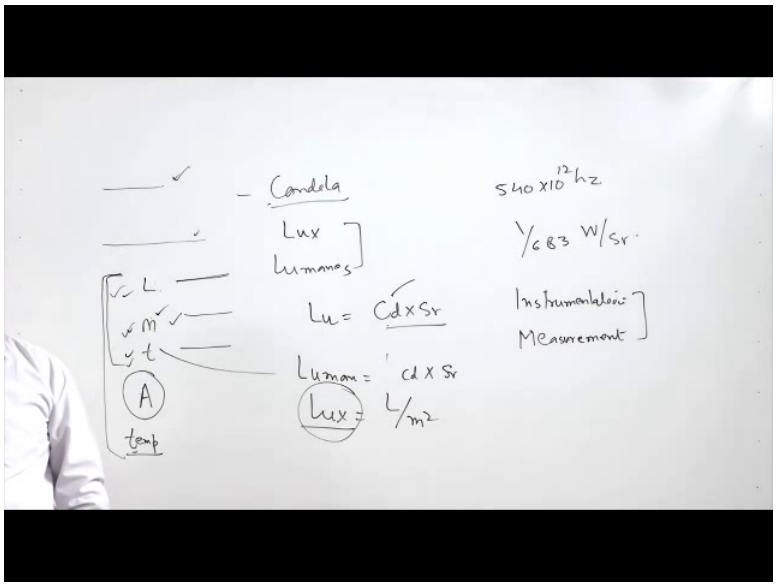


Because, the light intensity of the light it cannot be expressed with either of these. So, Candela is also because, and we have to frequently using engineering application, we have to frequently use the intensity of light. Weather in Candela or Lux or Lumanes, and Lux and Lumanes are related Lumanes are Lux are Lumanes per metre square.

So, Candela; so, the Lumanes is equal to Candela multiplied by steradian. So, first of all, we will define what is Candela. Candela is the intensity of a source that emits the monochromatic light at 540 into 10 to power 12 hertz, and radiation intensity is 1 by 683 watts per steradian. So, this is 1 candela this is the frequency of the radiation, and this the power of radiation. If this frequency monochromatic monochromatic frequency and with this power is known as 1 Candela. So, 1 Lumane is equal to 1 Candela multiplied by sorry 1 Lumanes is equal to Candela multiplied by steradian. And 1Lux is equal to 1 Lumanes per sorry Lumanes per metre square.

So, I will give you an example for example, in this room the intensity of the light maybe of the order of 700Lux, if you go outside the intensity of the sunlight is more than 10000 Lux. And higher the intensity of the light brighter will be the surroundings.

So, this is about the units of the measurement. Now, what is the use of the measurement the issue is; what is the use of the measurement or what is application of measurement? First of all, with the help of this process with the help of this process of measurement we get idea about the phenomena for example, there is a boiler, but I do not know how much

pressure is inside the boiler. So, I have to fix a pressure gauge, pressure gauge is an instrument so, instrument is a media for measurements.

So, instrumentation and measurement they go together, they cannot be separated out. So, there are 2 things instrumentation and another thing is measurement. In fact, our entire life is filled with the instrumentation after certain time; we just look at our watch. So, this is also a instrument for measuring the time we move on motorcycle or at a car speedometer is an instrument, right? If you go to the industry different type of pressure gauges thermometers they are all instruments. So, without instruments the industries cannot survive without instruments our day to day life it is difficult to survive.

So, the requirement of the measurement is first of all to understand the phenomena to monitor the process. Suppose I want to boil water at 500 degree centigrade. So, in order to boil water at 500 degree centigrade, I must have a thermometer to measure the 500 degree centigrade temperature. So, the process monitoring is also d1 with the help of measurement. Second thing is control of the process. Once we know that water is boiling at 500 degree centigrade, the pressure should not exceed. So, pressure gauge will be fixed. It will be used for control of the process if the pressure exceeds we will went off the steam. So, the pressure is maintained constant. So, not only monitoring the process the measurement, act of measurement is used also used for controlling the process. Second thing is the data are also required for engineering analysis, right? And for that purpose also measurements are required. So, in this course in subsequent lectures we will be focusing on the characteristics of the instruments also, and we will be discussing in details with different type of instruments, and different type of measurement processes.

Characteristics of the instrument are also important. For example, I want to measure the current, right? And the voltmeter is sluggish and there is a momentary flash of the current. So, the where the time the needle is deflected the current will go off. So, I will not be may able to make the correct measurement of the current, that is why the response of the instrument is also important. But, if the instrument is over sensitive in that case also the oscillations will take place, the all these things we will discuss in the subsequent lectures.

Now, I will focus on conversion of units from one form to another form which is very important for an engineer. For example, mass, Mass (Refer Time: 15:08) the popular unit pounds.

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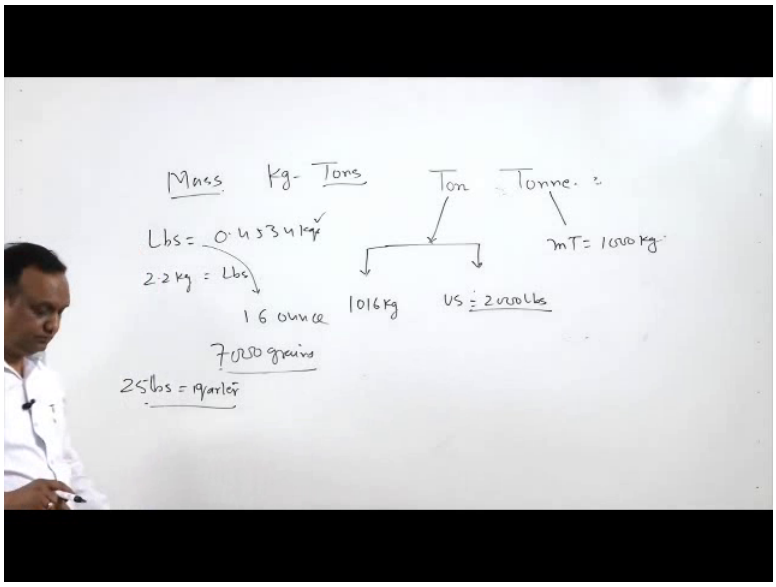


So, a pound is approximately 0.4534 kgs a pounds. Because, we are for familiar with the kilograms only or 2.2 kilograms approximately makes 1 pound, right? In a pound, there are 16 onnces, in a pond there are 7000 grains. Though these units are not being used nowadays, but we was slow as an (Refer Time: 15:24) we was slow. 25 pounds is 1 quarter. But, nowadays believe we are focusing with kgs only, kgs or tons, right? If the mass is very large then, we express in it in terms of tons.

So, then 2 types of tons, one is Ton another is Tonne both are not same. This Tonne is metric tonne and it is equal to 1000kgs, right? Now, this ton has again it is in 2 parts imperial ton, imperial ton is 1016 kgs, and US ton that is 2000 pounds. So, when we are dealing with the ton we have to be very careful, whether we are I mean dealing with metric tons, imperial ton or US ton. Similarly length, for length metre is used, and for a larger distance kilometre is used. Earlier the unit of the distance was mile if you remember the unit of distance was on mile. 1 mile is equal to 170 yards or it is if you want to express in terms of kilometres 1.61 kilometres, right?

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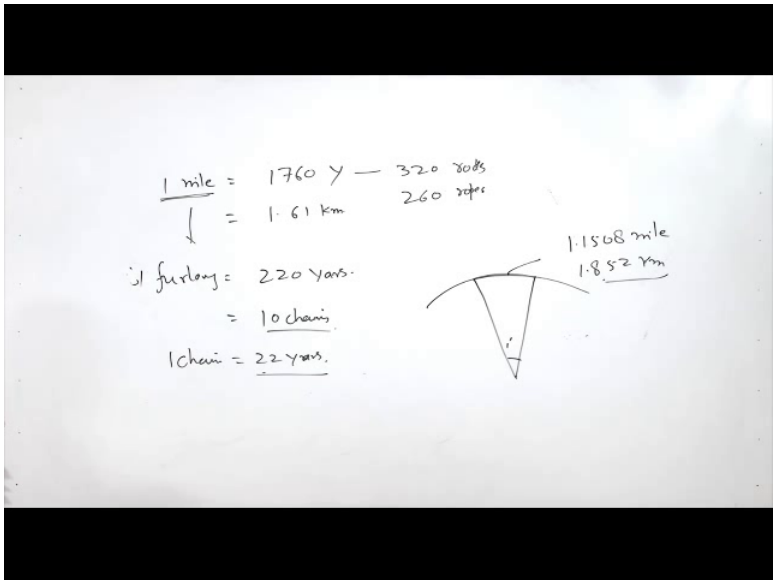


And there was a another popular unit, which was furlong, f u r l o n g. So, 1 furlong; so, 1 mile ahead 8 furlongs; so, if you divide this by 8 you will get 220 yards. So, 1 furlong is 220 yards, sorry 1 furlong 1 furlong is 2 20 yards, and 1 furlong has 10 chains. So, 1 chain is equal to 22 yards that is the length of the cricket pitch. So, I was always wondering why it is 22 yards. So, I it is wrote 20 yards or 25 yards. the reason being in those days this MKS or I means, these type of units were not these units were existing, and it was considered that the perhaps this is this is my opinion, that it was considered that the cricket pitch length should be of 1 chain that is 22 yards.

In addition to that through the unit of rods also. So, 1 miles is 320 rods or 260 ropes. So, these are old units, right? And, but nowadays we are following SI system we are following metres kilometres, but we have to be conversant with these units also, and there was a nautical mile also in those days notice. Now, (Refer Time: 19:41) exist nautical mile is the distance because, earth surface is curved, right? And when the ships are sailing, they are not saving on a on a plain surface they are sailing on a curved surface in a larger prospective, right? So, the distance travelled for latitude. On latitude for 1 minute angle on the centre of the earth is 1 nautical mile, and 1 nautical mile is equal to 1.1508 mile or 1.852 kilo metre. So, that is a distance of nautical mile.

Now, in addition to the length, area of the surface area of the surface nowadays it is expressed in terms of betas, or yards or hectares. When yard is 100 metre square yard, 1 hectare is 100 into 100 metre square.

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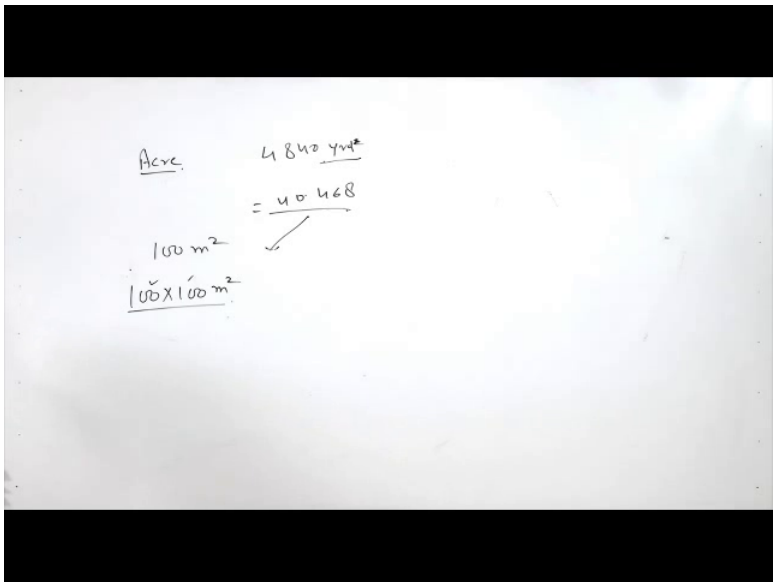


That is 1 hectare in earlier days the area was expressed in terms of a acres. Now, 1 acre is 4840 yards square or is equal to 40.468 acre sorry, yard 40.468 yard is 1 acre.

Now, gallon; now, volume now from area we will come to the volume.

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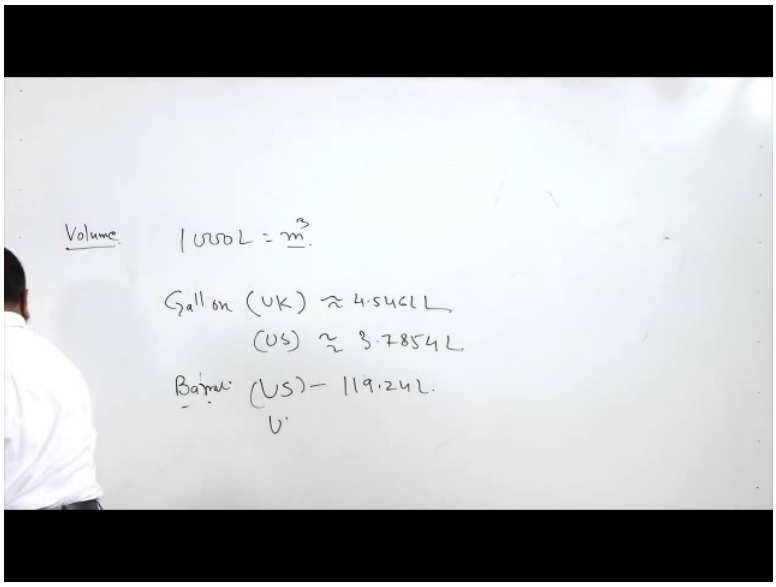


Volume; we normally express in terms of metre cube or litres. So, thousand litres together they make 1 metre cube, right? But, in some other units it is also expressed in terms of gallons, and there are 2 types of gallons the gallon of UK and gallon of US. The given of UK is approximately 4.5461 litre. The gallon of US is 3.7854 litres, they are

substantially different from each other. So, gallon of UK gallon of US similarly barrel, there is another unit of the volume is barrel barrel.

Now, US barrel is US barrel is 119.24 litre, and UK barrel is or we will right here, UK barrel first. UK barrel is 1 UK 163.66 litres, and US barrel is 119.24 litres, there is another barrel which is known as oil barrel.

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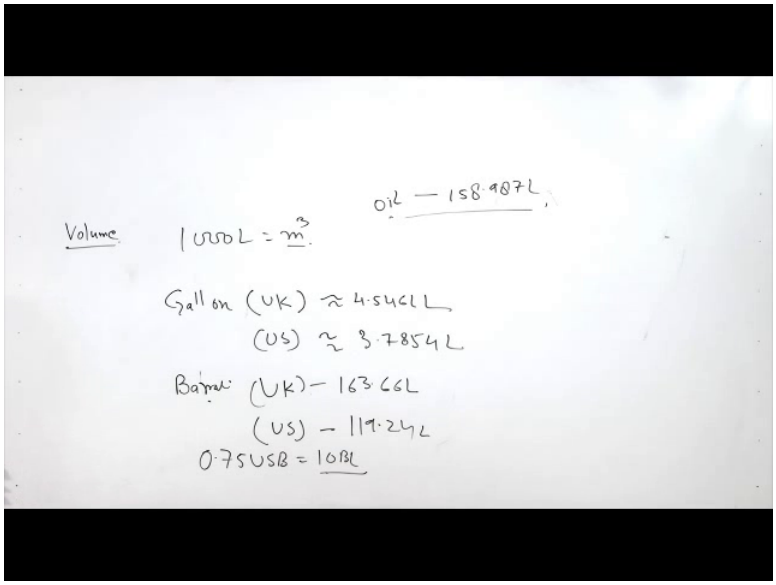


So, 0.75 SB barrel is equal to 10BL barrel. So, oil barrel is oil barrel is 158.987 litres. So, oil barrel is 75 percent of the oil barrel is US barrel. So, these are I mean, you need (Refer Time: 24:07) still frequently used in international market, and as a engineer we have to be conversant with this units. The unit of pressure pressure, atmospheric pressure as we know is 1.01325 bar or 101.325 kilo Pascal, or 1.0332 kilo gram force per centimetre square.

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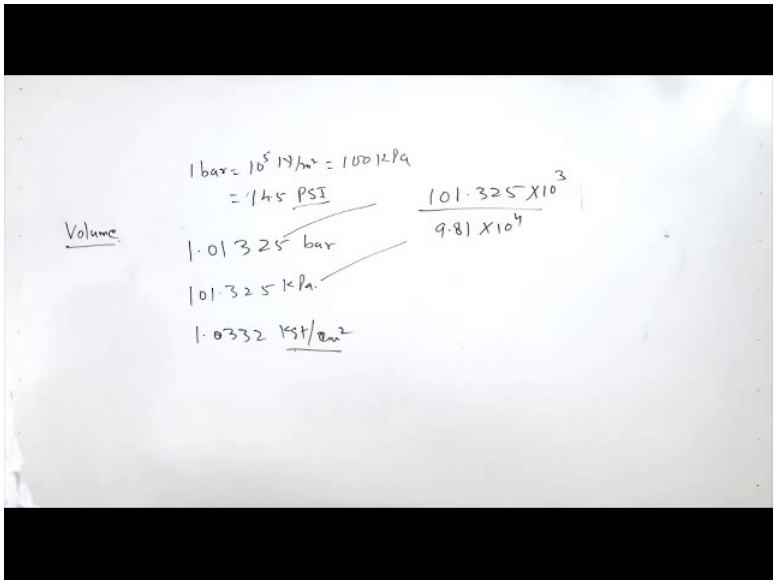


Now, this kilo grams force per centimetre square in many of the industries you will find the pressure gauges, which have pressure expressed in terms of kilograms force per centimetre square. So, you should be very convenient in converting this into this form right. So, if I want to convert this into kilogram force per centimetre square; so, 101.325 kilo Pascal. So, it is 10 to power 3 and divided by 9.81 because, this is in centimetres square this is 10 to power 4. And if you solve this will be getting this expression, right? And 1 bar pressure, 1 bar is equal to 10 power 5 Newtons per metre square or 100 kilo Pascal.

Now, 1 bar is equal to 14 point sorry 14.5 PSI. Now, in the industries you will find the number of pressure gauges, which are expressing the pressure in terms of pounds per square inch. So, 1 bar is equivalent to 14.5 pounds per square inch. And this is the gauge pressure this is the normal mistakes while doing the measurement, when we measure the pressure with the pressure gauge we consider gauge pressure absolute pressure. So, always at atmospheric pressure into the gauge pressure, and that will give you the absolute pressure in the vessel or any other confinement.

There is another unit for heat for heat transfer, that is British thermal Unit

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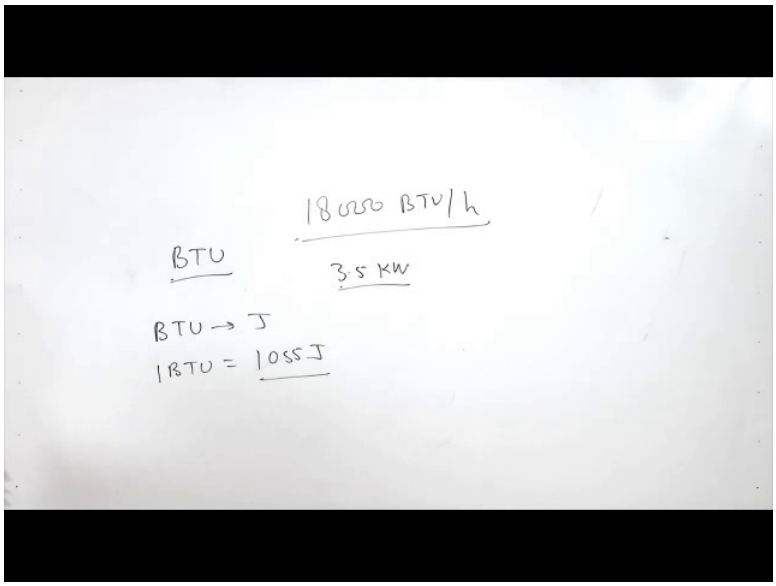


When you go to purchase your hair conditi1r or if you purchase let us say, 1.5 ton air conditi1r. So, 1.5 on air conditi1r they say they do not write normally, in the datasheet they do not write 1.5 ton, they write 18000 BTU per hour. 18000 BTU per hour is 1.5 tons of cooling or 3.5 kilowatt of heat transfer.

So, if you convert BTU into joules. So, BTU to joules; so, 1 BTU is equal to 1055 joules. So, by using this conversion you can convert BTU to the joules.

In addition to this, mass length time dimensions. I will try to tell you 1 interesting thing, if you look at the A4 size paper, if you look at the A4 size paper and if you fold the A4 size paper you will be getting the same aspect ratio.

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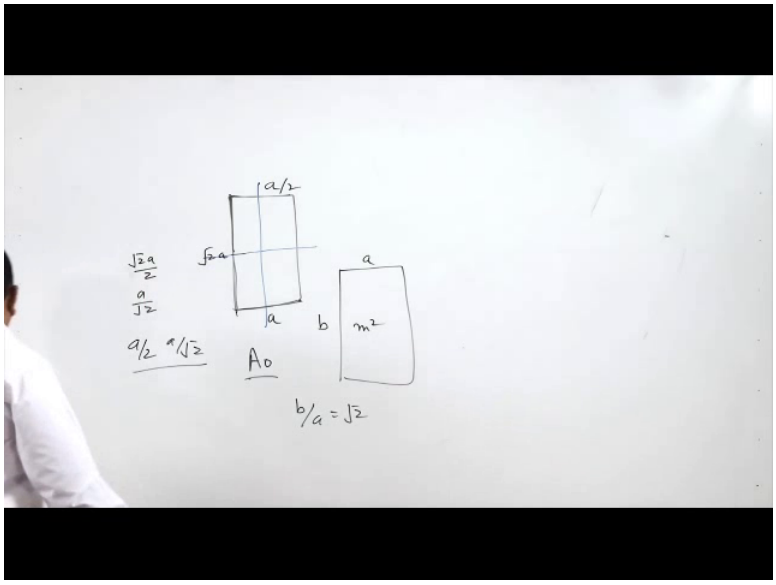


If you further fold it then again you will be getting the same aspect ratio, the reason being to the ratio of these 2 arms is under root 2. So, this is under root 2 a. So, the moment you fold it the moment you fold it this becomes under root 2 a by 2 or a by under root 2 longer this are at this remains a and this becomes longer are and the ratio is again under root 2. if you further fold it 4 times right. So, then it becomes a by 2; so, a by 2 and a by under root 2. So, ratio will always become remain this is known as (Refer time: 28: 48) ratio and when we see the Ao square Ao size of paper A0 size of paper. So, A0 size of paper is that paper which has area 1 metre square at the ratio of a and b, b by a is under root 2. If you fold it once it becomes a 1, if you fold it twice the size become a 2, if you fold it 3 times a 3 and then 4 times then it becomes a 4 size .

So, that is all for today's lecture, right? In the next class we will start with the introduction to the instrumentation.