Chemical Process Instrumentation
Prof. Debasis Sarkar
Department of Chemical Engineering
Indian Institute of Technology, Kharagpur

Lecture – 60
GATE Questions (Contd.)

Welcome to lecture 60. This is the last lecture of the course Chemical Process Instrumentation. In lecture 59, we have reviewed the GATE questions that are relevant to our course for the year 2018 to 2011. In this final lecture of the course we will review the GATE questions for the year 2010 to 2000 yeah 2000.

So, basically, we try to review the GATE questions that are relevant for our course a chemical process instrumentation that appeared during the period year 2000 to year 2018.

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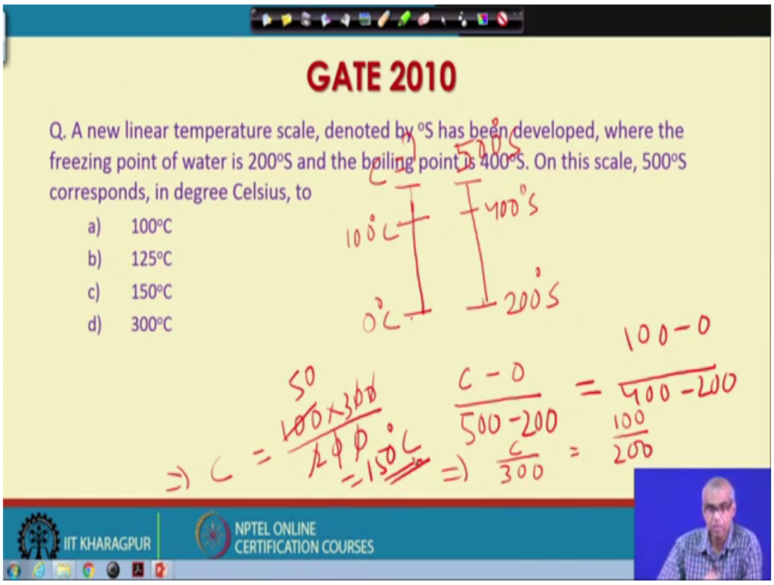

So, let us start with year 2010. A simple question a new linear temperature scale denoted by degree S has been developed where the freezing point of water is 200-degree S and the boiling point is 400-degree S.

On this scale 500-degree S corresponds to in degree Celsius to 100 125 150 or 300-degree Celsius. So, the new temperature scale is a linear scale so linear interpolation will hold true. So, you can easily answer this question by making use of linear interpolation.

So, what will you do is let us say the freezing point this is the 0-degree Celsius and in the new temperature scale this is 200-degree S.

The boiling point 100-degree Celsius corresponds to 400 degree S. So, 500-degree S corresponds to what degree Celsius that is the question. So, you can write C minus 0 by 500 minus 200 is equal to 100 minus 0 by 400 minus 200. So, this will become C by 300 equal to 100 by 200; So, which means C equal to 100 into 300 divided by 200 which is 150-degree Celsius.

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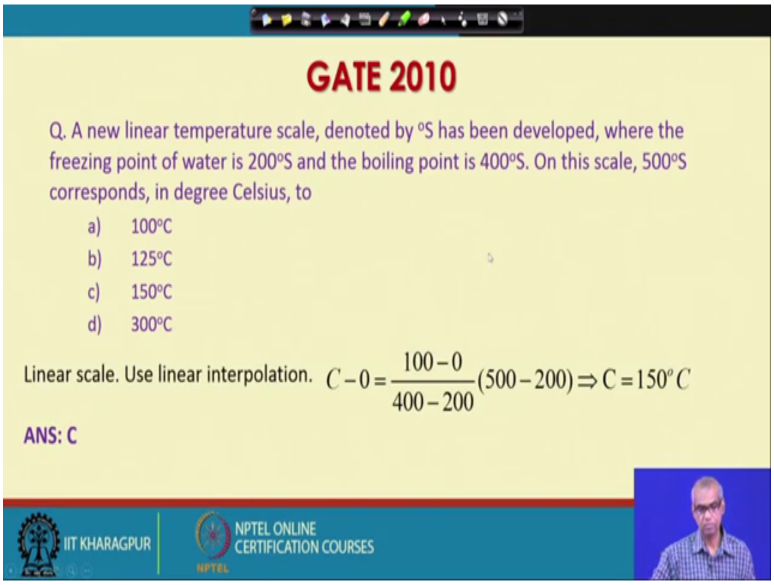

So, that should be the answer 150 degrees Celsius of cincy is the correct answer.

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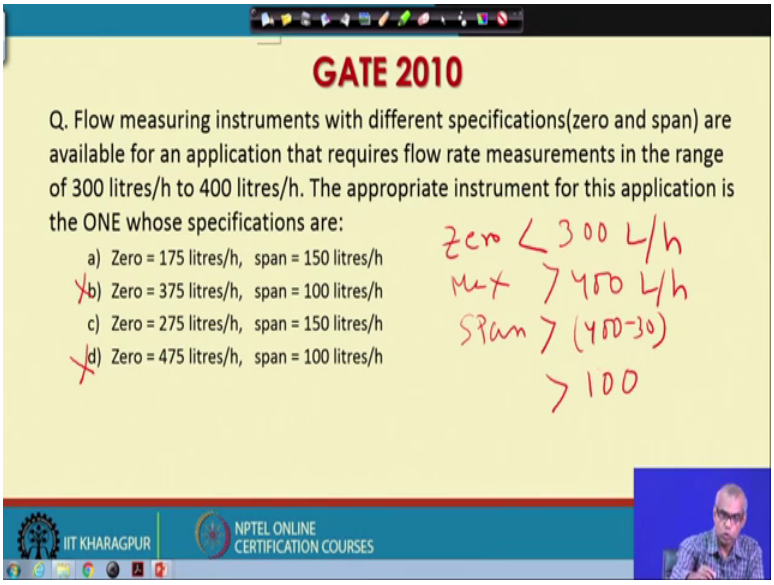

Let us move on to the next question in year 2010 flow measuring instruments with different specifications 0 and span are available for an application that requires flow rate measurements in the range of 300 liter per hour to 400 liter per hour.

The appropriate instrument for this application is one whose specifications are Zero 175 meter per hour, span 150 liter per hour option b Zero 37 5 meter per hour, span 100 liter per hour. You can drop the unit for this span Zero 275 meter per hour, span 150. Zero 475 meter per hour; span 100. So, the way to answer this question will be look at the requirement for the flow measurement the range 300 liter per hour to 400 liter per hour.

So, 0 should be less than 300. So, definitely this cannot be answered this cannot be answered. So, 0 should be less than 300 liter per hour, maximum reading should be greater than 400 liter per hour and span should be greater than 400 minus 300 that is span should be greater than 100.

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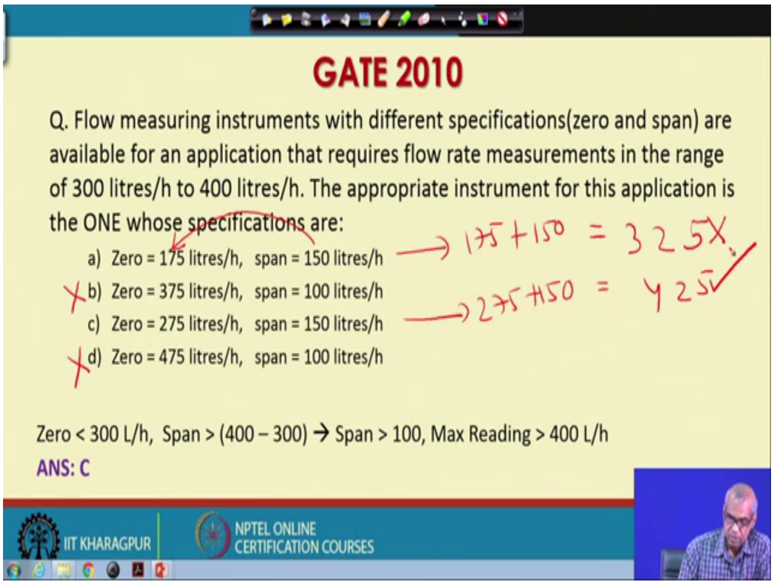

So, considering all this option c is the correct answer, because a and c were probable b and d were not probable.

Now, if you add 150 to 175 the maximum becomes 175 plus 150 equal to 325 where as this becomes 275 plus 150 equal to 425. So, these cannot cover the maximum range whereas, this satisfies both 0 span and maximum reading.

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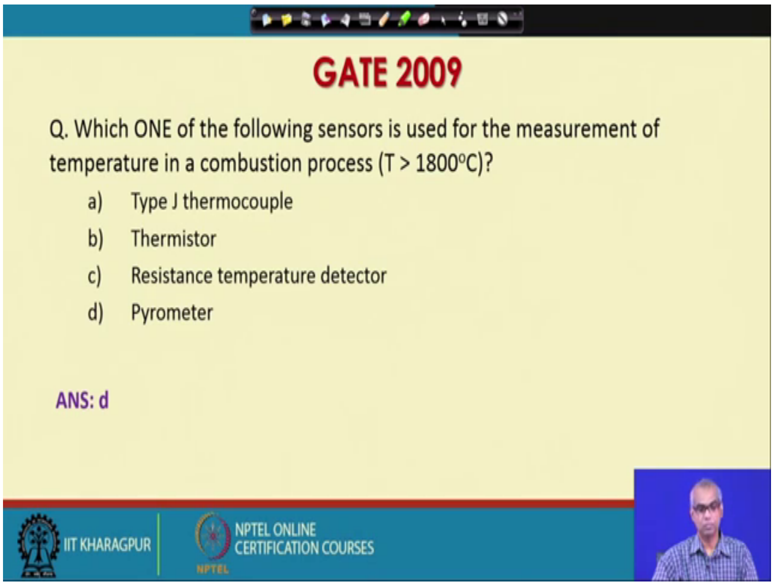

So, option c is the correct answer. Which ONE of the following senses is used for the measurement of temperature in a combustion process where temperature is greater than 1800-degree Celsius option?

Options are Type J thermocouple, Thermistor, Resistance temperature detector and Pyrometer for such high temperature we normally use pyrometer. So, option d is the correct answer.

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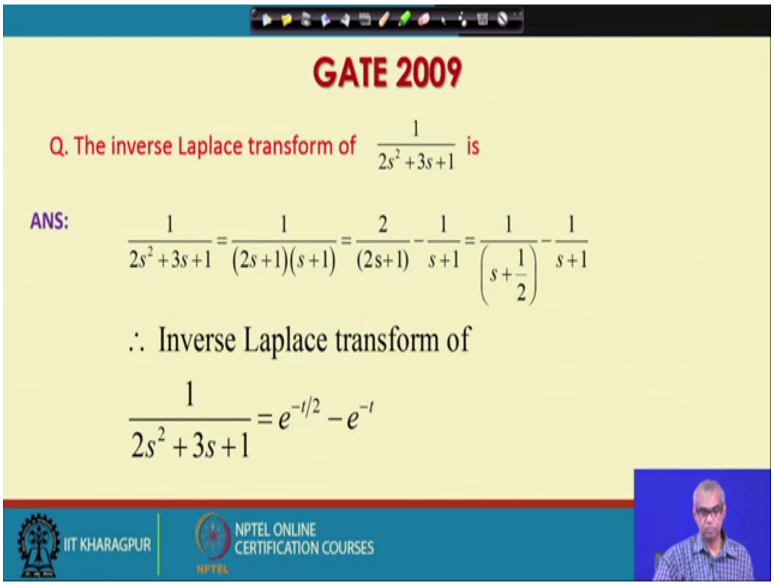

Another question from the GATE 2009; The inverse Laplace transform of 1 by 2 s square plus 3 s plus 1 is. So, you need to find out the inverse Laplace transformation of 1 by 2 s square plus 3 s plus 1. So, let us follow the partial traction method and you have been able to write down 1 by 2 s square plus 3 s plus 1 as 1 by s plus half minus 1 by s plus 1.

Now, we know we know the inverse Laplace transform of 1 by s plus half or 1 by s plus 1 in general 1 by s plus a. So now, we can find out easily the inverse Laplace transform as follows.

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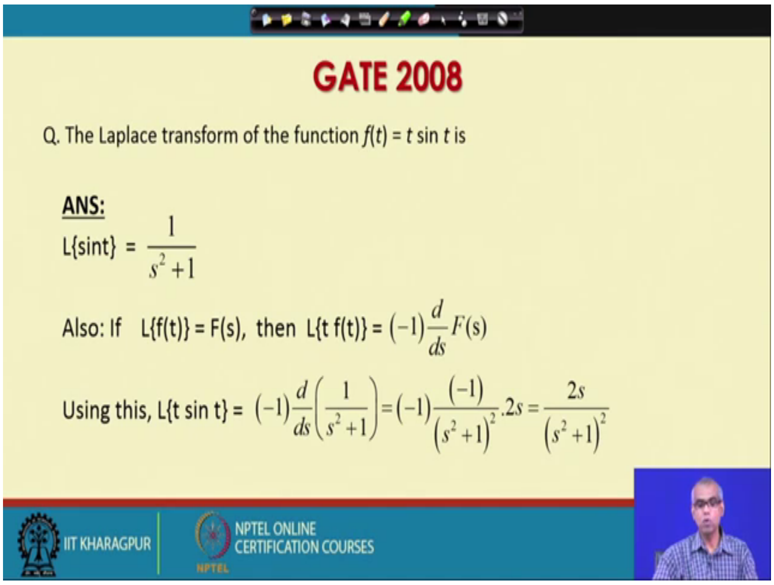

Let us now move on to GATE 2008 another question on Laplace transformation you have to find the Laplace transformation of the function f t equal to t sin t. Laplace transformation of sin t is 1 by a square plus 1 and we know if Laplace transformation of t is Fs then Laplace transformation of t ft equal to minus 1 into d d s of F of s.

So, let us make use of this relationship and then we can find out the Laplace transformation of t sin t as this which finally, can be simplified to this.

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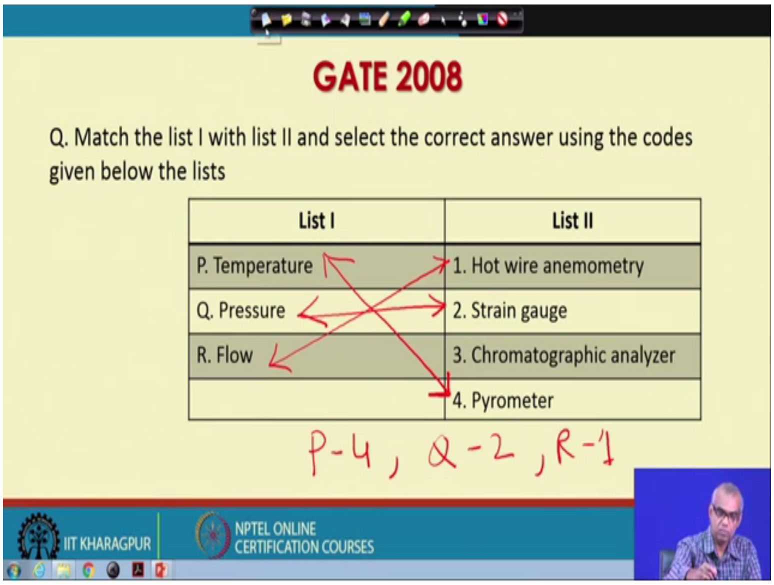

Another question from here, 2008 match the list 1 with list 2 and select the correct answer using the code given below the list. Basically, you have to match temperature pressure flow from list one with the measuring instruments mentioned in list 2.

So, temperature can be measured using pyrometer from the options given pressure can be measured using strain gauge and flow can be measured using or to a anemometer note that chromatographic analyzer can be used to measure composition which is not listed under list 1. So, correct answer will be P 4 Q 2 and R 1, so, P 4 Q 2 R 1 P 4 Q 2 and R 1.

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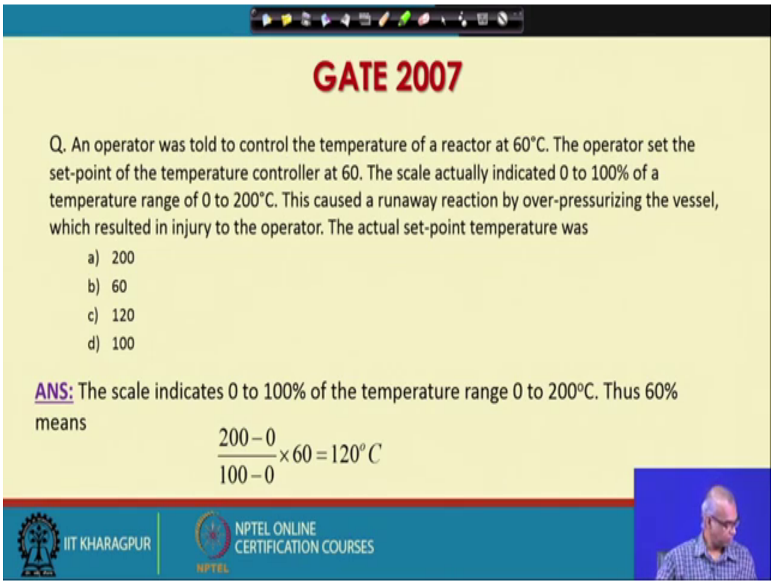

Let us move on to GATE 2007 an operator was told to control the temperature of reactor at 60-degree Celsius. The operation said the set point of the temperature controller at 60. The scale actually indicated 0 to 100 percent of a temperature range of 0 to 200-degree Celsius. This caused a run of a reaction by over pressurizing the vessel, which resulted in injury to the operator. The actual set point temperature was 200 60 120 or 100. Let us read the question carefully an operator was told to control the temperature of reactor at 60-degree Celsius.

The operator set the set point of the temperature controller at 60. The scale actually indicated 0 to 100 percent of a temperature range of 0 to 200-degree Celsius note this. The scale actually indicated 0 200 percent of a temperature range of 0 to 200-degree Celsius not 0 to 100-degree Celsius This caused a runaway reaction by over pressurizing the vessel which resulted in injury to the operator. The actual set point temperature was; So, 60 percent in the range 0 to 200-degree Celsius.

So, that will be 120-degree Celsius So, the operator should have said the temperatures at 60-degree Celsius, but the operator set it at 120-degree Celsius, because it was 60 percent of the range 0 to 200-degree Celsius So, to set at 60-degree Celsius the operator should have set it at 30 percent of the range 0 to 200-degree Celsius.

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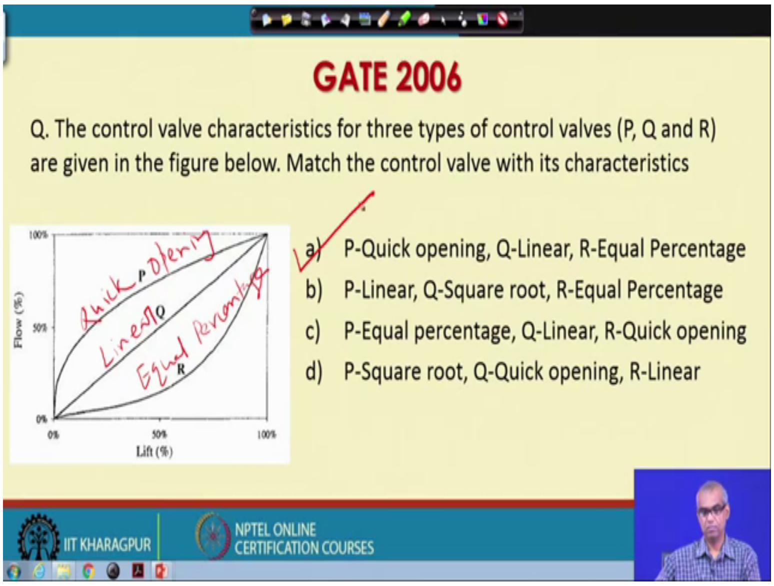

Let us now move on to year 2006 the control valve characteristics for 3 types of control valves P, Q and R are given in the figure below. Match the control valve with it is characteristics. If you remember P is quick opening Q is linear and R is equal percentage. So, P is the characteristic for the quick opening control valve Q is for linear control valve and R is for equal percentage control valve.

So, the only correct option is option a option a is the correct answer.

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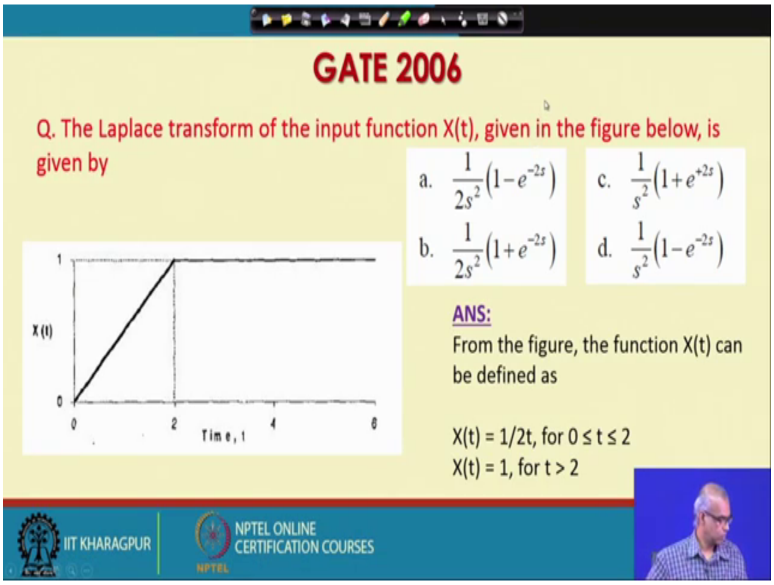

Another question on Laplace transformation from year 2006 the Laplace transform of the input function Xt, given in the figure below, is given by. There are 4 expressions given you have to choose the correct answer. So, look at the function Xt the function Xt is plotted on the horizontal axis it is time t and on the vertical axis it is Xt. So, Xt is this. So, for t equal to 0 to 2 this is Xt which is an equation like y equal to mx.

Then for time t greater than 2 this is what describes Xt which is nothing, but a line parallel to x axis. So, the Xt can be described as X equal to hop t is like y equal to mx. So, a m is half here you can see y it is half this is delta y by delta x. So, half into t t is the independent variable. So, Xt equal to half t for the range t greater or equal to 0 to t less or equal to 2. So, as long as t between 0 to 2 Xt equal to half t. And then for t greater than 2 Xt is parallel to x axis and the value is x t equal to 1.

So, Xt equal to 1 defines Xt for all t greater than 2. So, basically you have to take the Laplace transform of this which is valid between t equal to 0 to 2. And then you have to take Laplace transformation of Xt equal to 1 which is valid for the pair t greater than 2 and you have to add this up.

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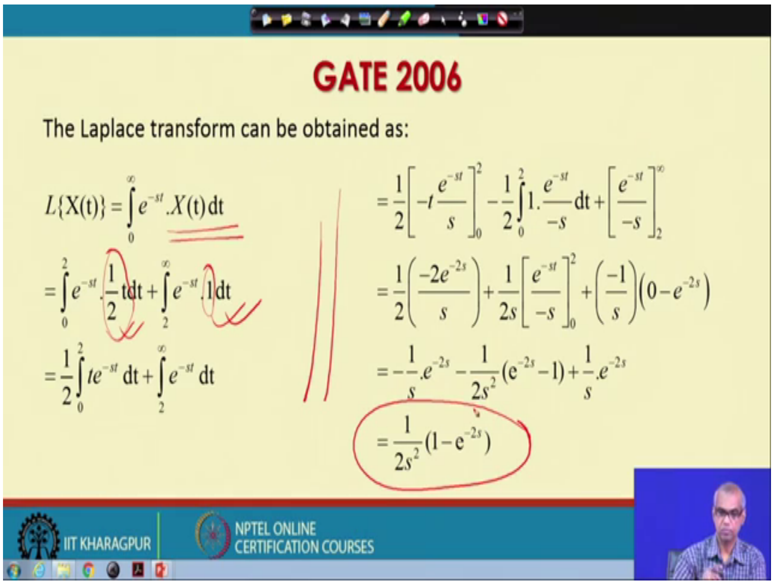

So, this is the Xt and these are those 2 parts which you first part is valid for between time 0 to 2 and Xt is half t for t greater than to Xt equal to 1.

So, you can find out the Laplace transformation by doing this algebra and ultimately get the expression as 1 by 2 s square into 1 minus e to the power minus 2 s. So, 1 by 2 s square into 1 minus e to the power minus 2 s is one of these options.

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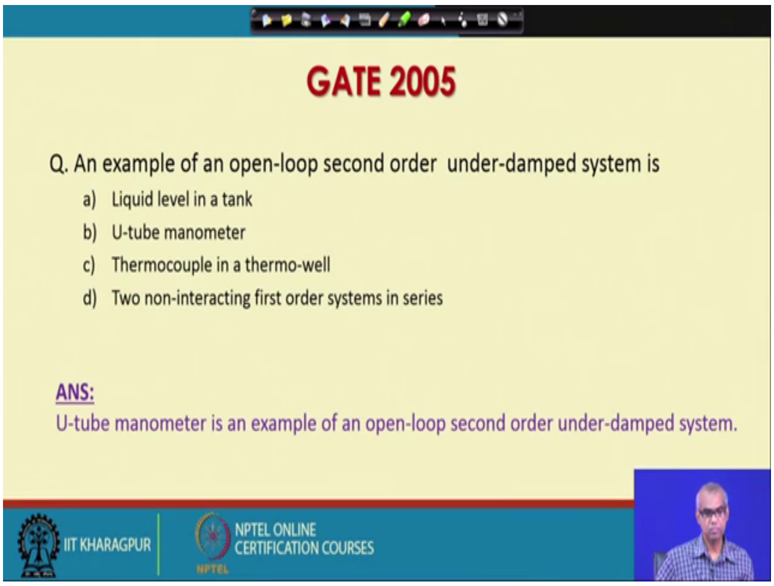

Next a question from year 2005 an example of an open loop second order under damped system is. Liquid level in a tank, U tube manometer, Thermocouple in a thermo-well, Two non-interacting first order systems in series. Liquid level in a tank is basically a first order systems, U tube manometer it is a second order systems, thermocouple in a thermo well bared thermo couple will be a first order systems where thermocouple in a thermo well will be multi capacity systems; that means, 2 first order systems in series.

Two non-interacting first order systems in series; So, only up the correct option will be u tube manometer U tube manometer is an example of open loop second order under damped system.

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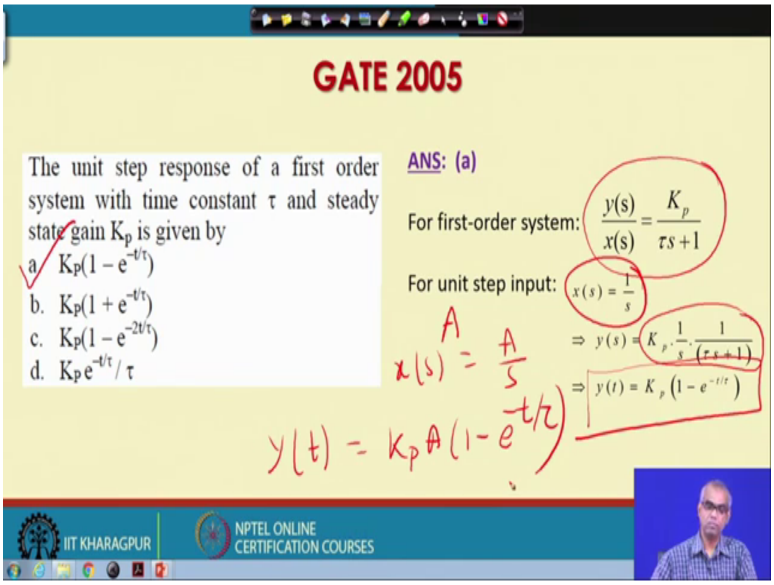

Another question from year 2005 the unit step response of a first order system with time constant tau and steady state again Kp is given by. 4 options are given you have to choose the correct option. So, this is straight forward for first order systems you know this is the transfer function y is by x is equal to Kp by tau s plus 1 per unit step input x s equal to x of s is equal to 1 by s.

So, y s is x s into Kp by tau s plus 1. So, you can write y is as this and if you take inverse Laplace transformation now you get yt equal to Kp into 1 minus e to the power minus t by tau. This is a standard expression for unit step response for a first order system.

So, Kp into 1 minus e to the power minus t by tau. So, option a is the correct answer. Instead of unit step input he would have given step input or magnitude A , then xs would have been A by s and the response would have been Kp into a into 1 minus e to the power minus t by tau. Here simply A equal to 1. So, yt equal to Kp into 1 minus e to the power minus t by tau.

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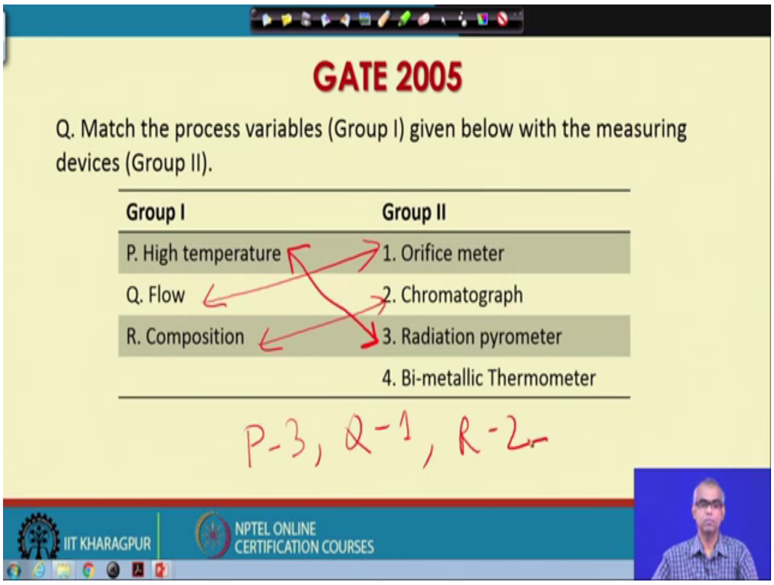

One more question from year 2005 match process variables Group 1 given below with the measuring devices Group 2.

High temperature radiation pyrometer is the correct option. Flow orifice meter composition chromatograph. So, the correct option is correct answer is P 3 Q 1 R 2; So, P 3 Q 1 R 2 P 3 Q 1 R 2.

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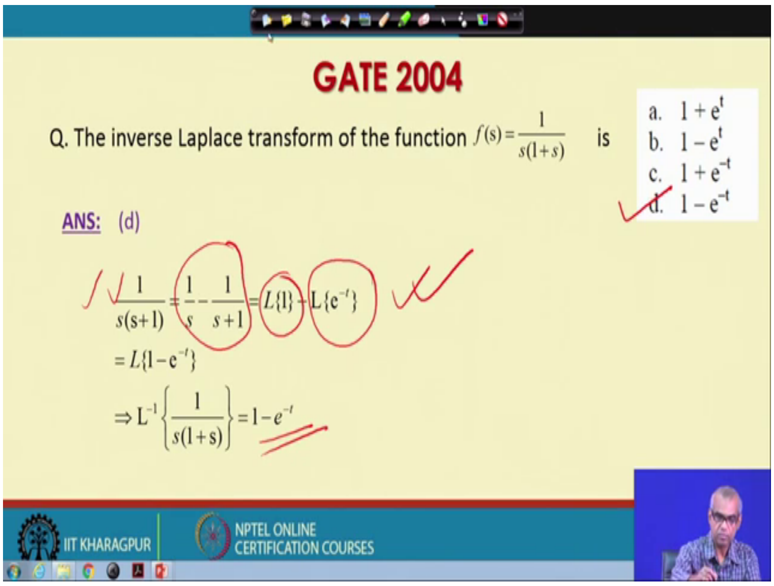

A question on Laplace transformation from year 2004; The inverse Laplace transform of function fs equal to 1 by s into 1 plus s is 1 by e to the power t 1 minus e to the power t 1 plus e to the power minus t 1 minus e to the power minus t.

You can find the inverse Laplace transformation following this. So, 1 by s into s plus 1 is first written as 1 by s minus 1 by s plus 1. 1 by s is Laplace transformation of one 1 by s plus 1 is Laplace transformation of e to the power minus t. So, basically this is Laplace of 1 minus e to the power minus t. So, inverse of this is 1 minus e to the power minus t. So, option d is the correct answer.

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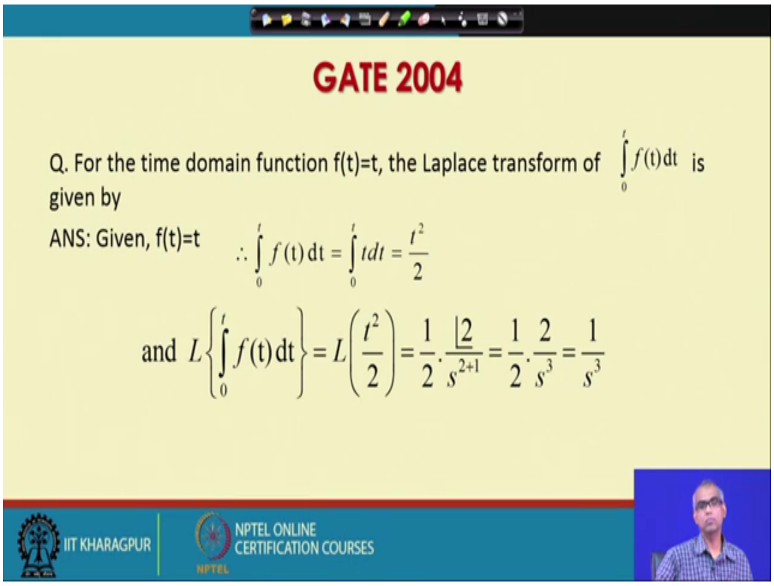

Another question from year 2004 for the time domain function f t equal to t the Laplace transformation of integral 0 to tf t dt is given by you have to compute as follows.

F t equal to t integral 0 to 2 f t dt equal to t square by 2. So now, you can take Laplace transformation of integral 0 to 2 ft dt is Laplace transformation you have to find out of t square by 2. So, that can be computed as 1 by s cube.

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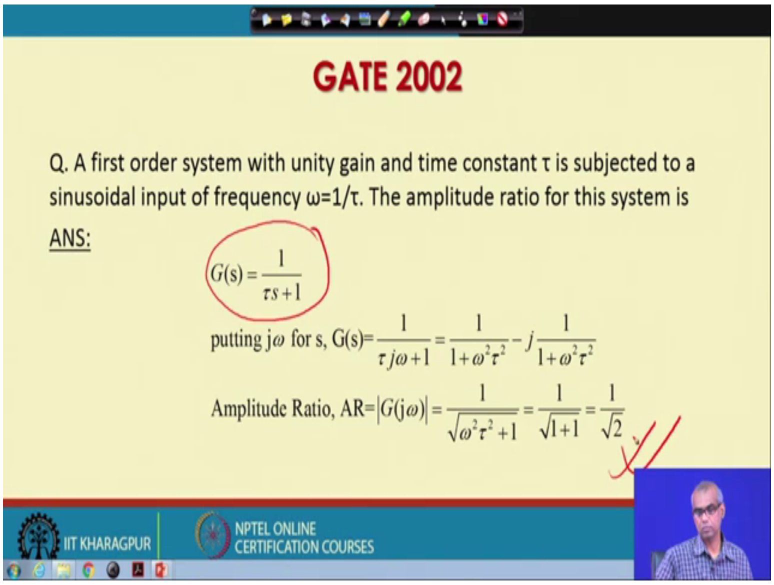

A question from year 2002 a first order system. So, in unity gain and time constant tau is subjected to a sinusoidal input of frequency omega equal to 1 by tau. The amplitude ratio for this system is. You can find out like this the first order system with unity gain and time constant tau as transfer function as Gs equal to 1 by tau s plus 1. Put j omega in place of s and then you can find out amplitude ratio as 1 by square root of 2.

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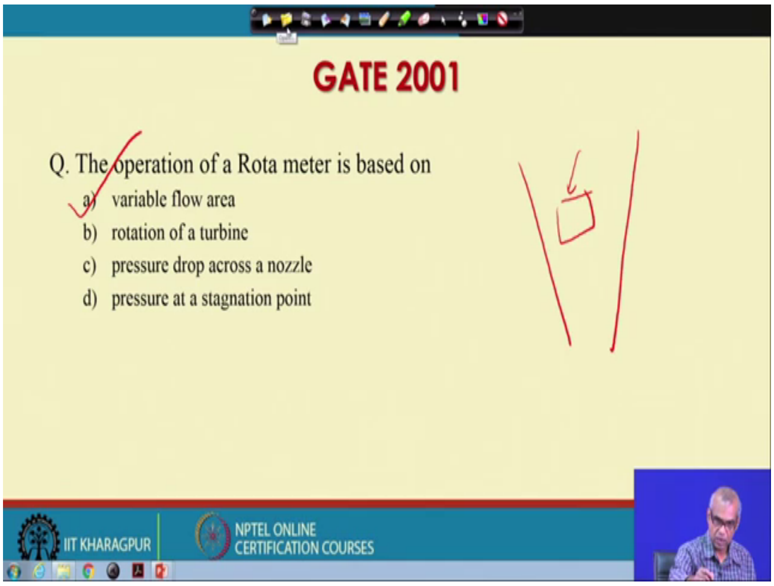

A question from year 2001 the operation of a Rota meter is based on; variable flow area, rotation up a turbine, pressure drop across the nozzle, pressure at a stagnation point.

You know Rota meter is a variable area meter and the operation of Rota meter is based on variable flow area. You know the Rota meter is the tappet tube, and as this float changes his position the annular area changes. So, Rota meter operation is based on variable flow area, option a is the correct answer.

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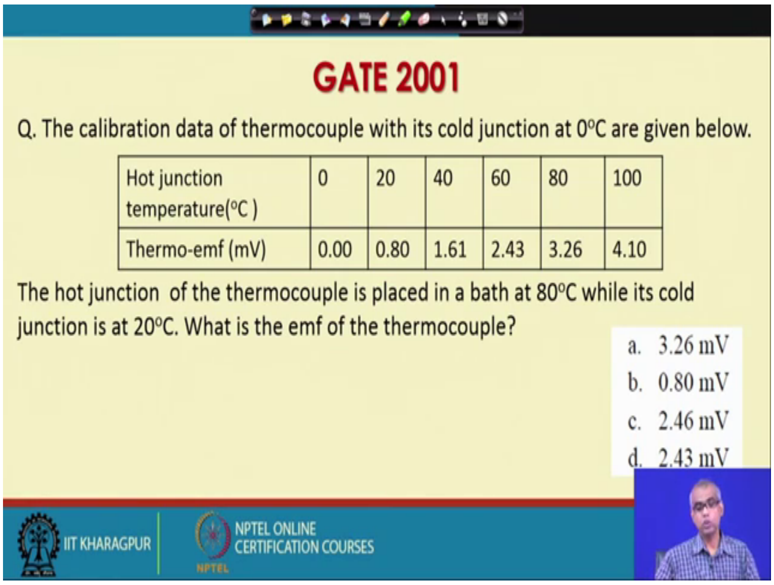

Another question on year 2001 the calibration data of thermocouple with this cold junction at 0-degree Celsius are given below. So, thermocouples cold junction is kept at 0-degree Celsius and when hot junction is kept at 0 degree you get 0 0 millivolt as thermo emf when the out junction is at 20 degree Celsius you get 0.8 millivolt as thermo emf.

Similarly, for hot junction temperature 40-degree Celsius you get 1.61 millivolt so on and so forth. The out junction of the thermocouple is placed in a bath at 80-degree Celsius while it is cold junction is at 20-degree Celsius. So, what is the emf of the thermocouple? 3.26 0.80 2.46 or 2.43.

Now, the thermo emf that is produced in a thermocouple depends on the temperature difference between the cold junction and the hot junction. Now, when the hot junction is kept at 80-degree Celsius and the cold junction is kept at 20-degree Celsius the temperature difference between these 2 is 60-degree Celsius. And from the table given I see the thermal emf produced by the thermocouple when hot junction is at different temperature and cold junction at 0-degree Celsius.

So, since the temperature difference between 80 and 20 is 60, I have to find out the thermal emf from the table obtained for the case when the cold junction is 0-degree Celsius and hot junction is 60 degrees Celsius, such that; the temperature difference is 60 degrees. So, that seems to be 2.4 3. So, the correct answer is option d.

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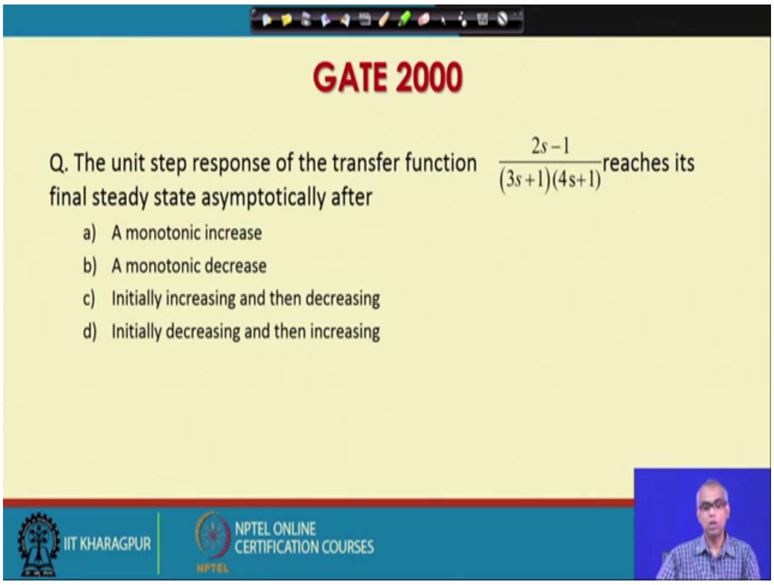

A question from year 2000 the unit step response of the transfer function 2 s minus 1 by 3 s plus 1 into 4 s plus 1 reaches it is final steady state asymptotically after; A monotonic increase, a monotonic decrease, initially increasing and then decreasing, initially decreasing and then increasing.

So, basically you have to find out first the unit step response for the transfer function to s minus 1 by 3 s plus 1 into 4 s plus 1. And from this response equation you will be able to find out which option is correct.

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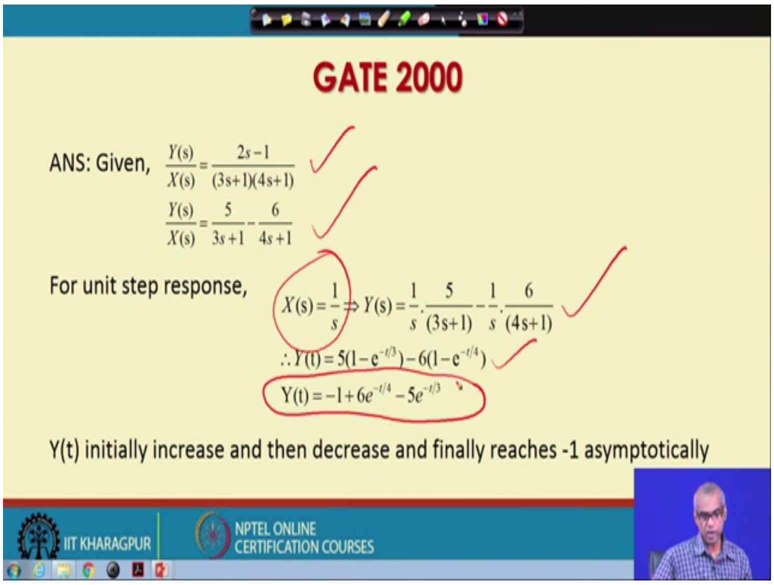

So, this is the transfer function given which you can write using partial fraction as follows. For unit step response Xs equal to 1 by s. So, Y s can be computed. And then you can take inverse to find out the response in time domain, which you obtain as this.

So, you can conclude that the response Yt initial increase and then decrease and finally, reaches minus 1 asymptotically.

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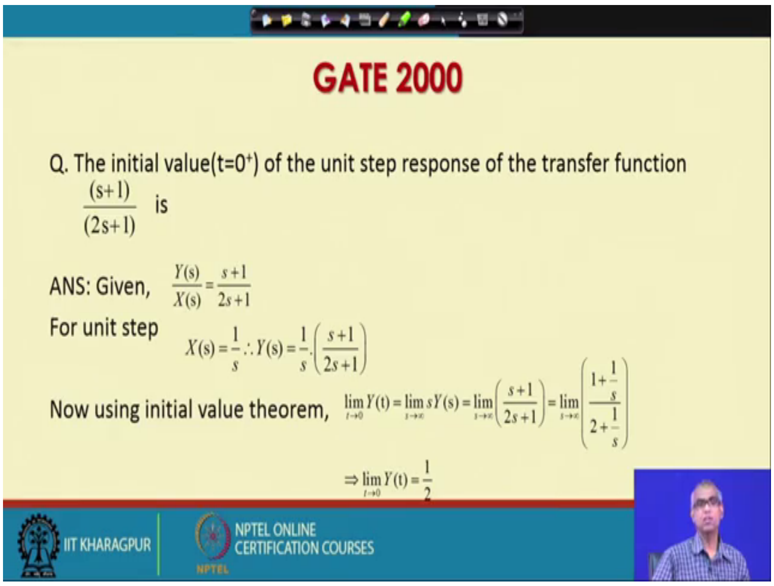

So, it increases initially then decreases and finally, reaches minus 1 asymptotically. One more question from year 2000 the initial value of the unit step response of the transfer function s plus 1 by 2 s plus 1 is you have to find out the initial value for the transfer function s plus 1 by 2 s plus 1. So, this is the transfer function given for unit step X is equal to 1 by s. So, you can find out Y s now make use of the initial value theorem. So, to find out initial value you have to find out the limit s tends to infinity s Y s if you do this you get the initial value as half.

So, that ends our discussion on the GATE questions that appeared during the year 2000 to 2010. In today's class and up to 2018 we have discussed in the previous class. So, this is the end of the course I hope the course was useful to you and if you are writing the exam good luck to you.