# Irrigation and Drainage
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**Lecture - 05**
**Tutorial I**

Friends, welcome to lecture number 5 of Irrigation and Drainage lecture series. So, in this we are going to solve some you know problems, some of them may be you know the part of your GATE examination and I consider this as a tutorial ok. So, we are going to solve here the 6 problems. So, and whatever theory we learned during this last I mean week or this week. So, we are going to see this solving some of the problems here.

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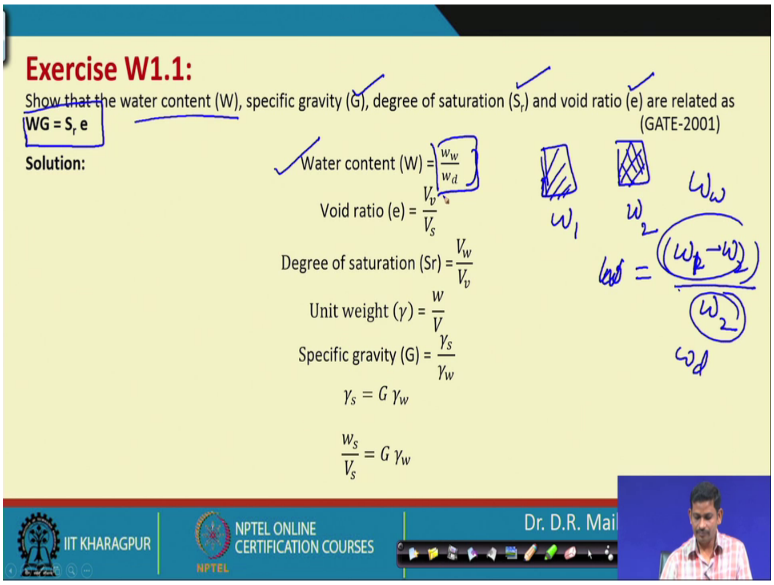


So, exercise 1 if you see. So, this is the kind of a derivation ok. So, the first thing is let us show that, the water content that is W and specific gravity that is G, and degree of saturation that is S r, void ratio that is e are related as W G is equal to S r into e. So, this is the question. So, you have to show that W G is equal to S r into e.

So, here the previously what we learned, we can get some you know feedback from those lectures like if you see the water content, here the water content is written as W which is

W w by w or d. So, this is how do we get this? W w by w d. Suppose if you remember the gram metric, you know method for doing the motion measurement. So, suppose you have initial soil sample, which is the moist soil sample right let us say that is the w 1, then after that you kept this in a oven right and then you measure the weight after drying. So, that is w 2.

Now, the moisture content that is capital W, which is equal to w 2 minus sorry w 1 minus w 2 right this is the moisture right present in the soil sample divided by w 2, the dry sample. So the same thing here if you see so, this is W w right and this is W d; this dry sample. So, that way we got this ok.

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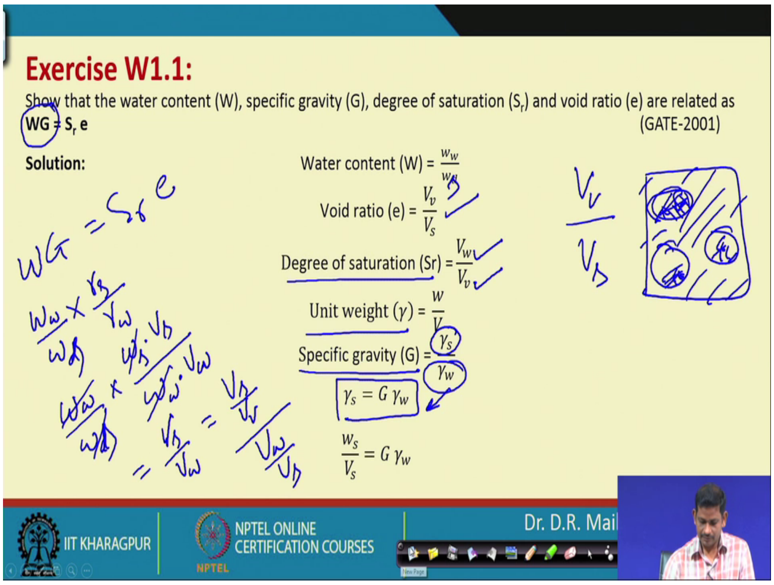


So, then there is a void ratio. So, void ratio is volume of voids by volume of solids ok. So, this is known and degree of saturation S r this is a volume of voids by a volume of water divided by volume of voids so; that means, you have like a voids right. You have voids these are the voids, and this is the soil, this is soil and since this is the void. So, some portion will be filled with water and this is also water this is also some portion of the water and some portion will be void.

So, this is the total void, void volume and volume of water. So, that is degree of saturation. So that means, out of total voids how much volume is occupied by water. So, that is that and unit weight which is gamma that is weight by volume unit weight or you can also called the density. So, the density is volume weight by volume and specific gravity G. So, this is unit weight of the solid divided by unit weight of water that is specific gravity of water.

So, with these information so, let us define gamma s which is equal to from this, you can get gamma s is equal to G into gamma rho and W s by. So, our aim is W G. So, our aim is W G is equal to S r into e is not it. So, W you can put here W w, W d into G is rho s divide by rho w ok.

So and now let us I mean define rho s W w by W d into. So, rho s can be written in this term like density terms ok. So, that is called W s into V s divided by W w into V w ok. So, I would even I would put here without any confusion let us put W s ok. So, then this will be W s this will be W s.

So, now so, here W w gets cancels out V s V s gets cancels out. So, finally, you get V s by V w ok. So, then what you do; V s by V v divided by V w by V ok. So, we divided both sides by V v. So, V s by V v, so, V w by V v; so, we need V s right W s by W v wait here r s is gamma s is sorry ok. So, here let me see.

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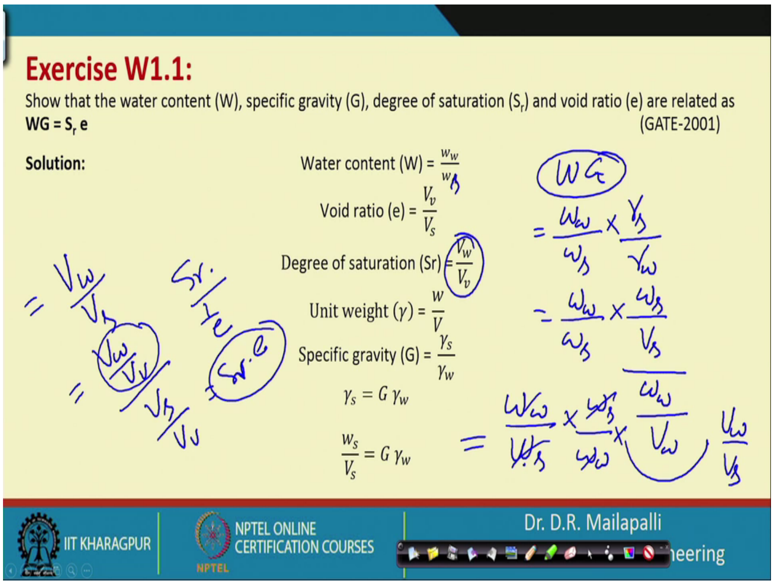


So, W G is equal to W w by W s let us put s without any confusion, and G is s divided by r w is not it. So, W w by W s into r s, r s means W by V right. So, I would put W s by V s and divided by r w W w by r w W w by V w, W by V w ok.

So now, W w by V s W s into W s W w into; so V w by V s; V w by V s. So I will write down here V w by V s which is equal to. So, now, I am going to get these things cancels out and finally, I got V w by V s so, now, as I mentioned before so, V w by V v and V s by V v ok.

So, V w by V v so, this one; so, this gives S r and V s by V v, so, that is V s by V v; that means, 1 by e ok, so, which is equal S r into e right. So, so in this way so, we started with W G and end with S r into e ok.

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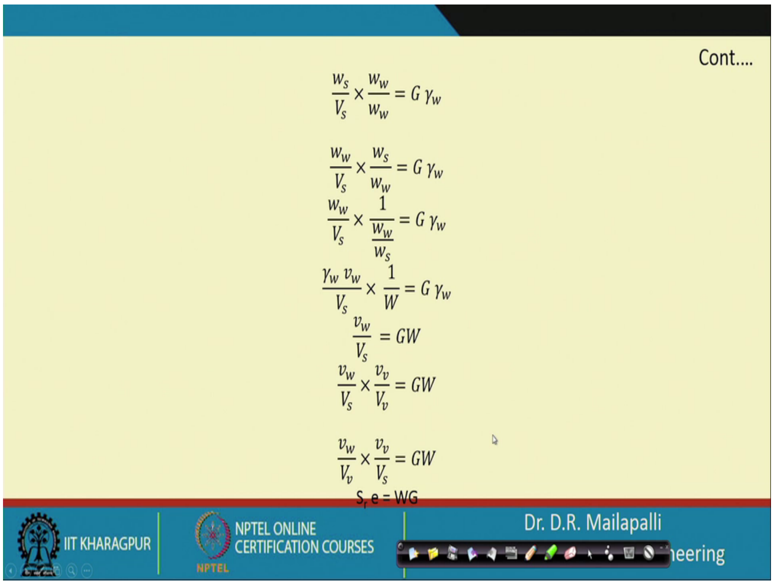


So, this is you can go through this. So, it is all procedure I have mentioned and then the second exercise.

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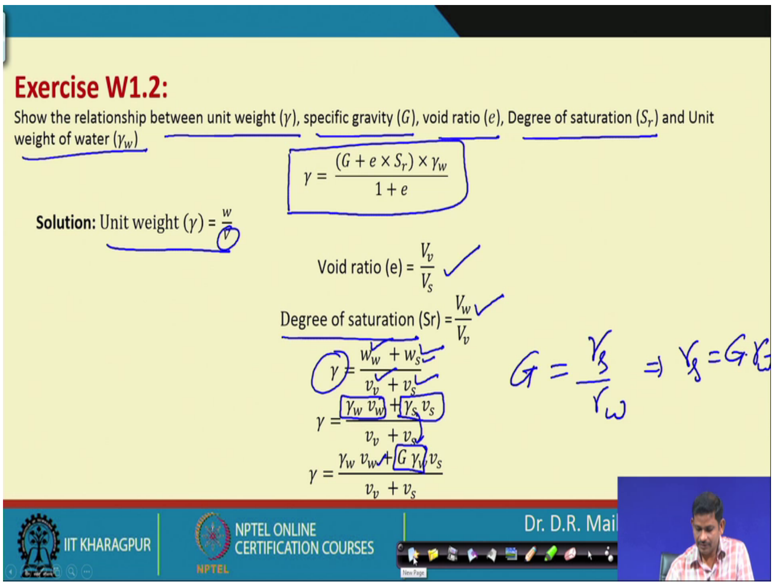


So, that shows the relationship between unit weight, specific gravity, void ratio, degree of saturation and unit weight of water ok. So, these as a big relationship if you see these the relationship looks like this. So, gamma is equal to G plus e into S r into r w by 1 plus e ok.

So, here before that as we did the previously. So, unit weight is w by v, void ratio V s by V v by V s and degree of saturation V w by V v ok. So, let us start with you know gamma. So, the gamma is equal to v w by v ok. So, that can be written as since this is a total weight. So, the weight of water and weight of solid and this is the total volume and weight of sorry volume of voids and volume of solids ok.

So, then so, what we do? W w can be written like this ok. So, how would be write because this is density, this is the volume; density into multiplied by volume, we will get weight. Similarly density multiplied by volume of solid, you get weight of solids and you keep the rest of the things. Now gamma is equal to r w v w and here so, G has where is G? So, look at this r w V w plus so, G is you know what is specific gravity ok.

So, the specific gravity G can be written as r s by r w right. So, now, r s is equal to G into r w. So, that is what you got here right G into r w for r s and then v s, similarly that and then we next what we go to the next.

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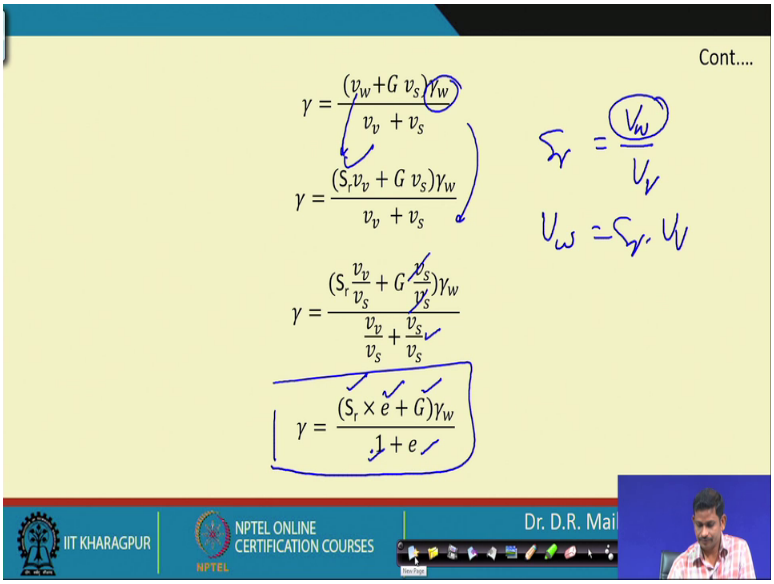


So, here if you see; so, this is from previous thing, so, v w plus G into v s; so, we took r w common both sides. So, then so S r so, you know S r degree of saturation which is equal to V w by V v ok.

So, then V w is equal to S r in to V v. So, that is what here ok. So, V v e S r into V v and G v s and rest of things are same and gamma now S r by so, just divide by V s on both sides, V v by V s G into V s by V s right and also denominator V v by V s and V s by V s. So, the finally, you get S r and V v by V s is e and G and this gets cancels out and rho w divided by and this will be 1 here and V s by sorry V s by V s, so, this is 1 and V v by V s is e. So, that way you get gamma equal to S r into e plus G into r w divided by 1 plus e ok.

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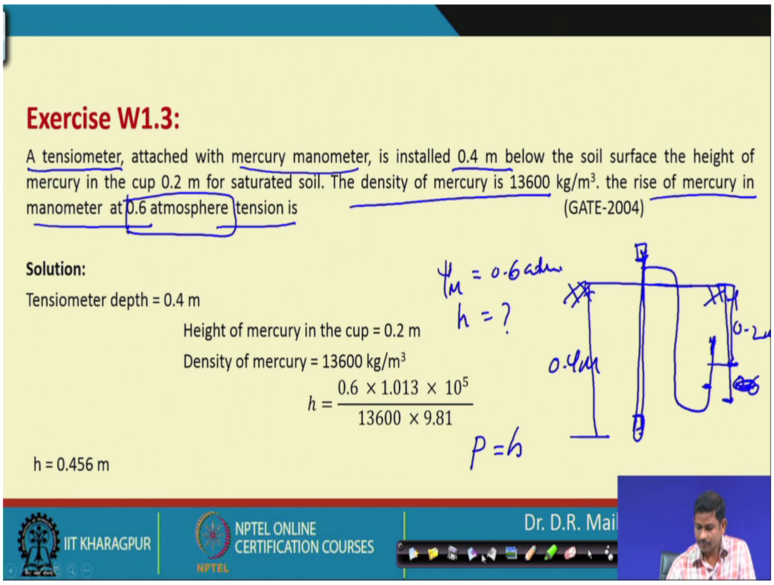


And this is third example see and third example let us consider a tensiometer, attached with a mercury manometer we have seen that, and installed at 0.4 meter below the ground. So, if this is the ground ok. So, the tensiometer is installed down ok. So, here is the bulb ceramic cup ok. So, here this is a manometer which is installed. So, installed at how much? 0.4 meter this one soil surface, height of mercury cup 0.2 meter from saturated soil this is the mercury cup. So, height of mercury in the cup is 0.2 meter from here to here initially this is 0.2 meter for saturated soil from the saturation.

The density of mercury is given, the rise of mercury in manometer is 0.6 atmosphere tension is. So, suppose if this is rising 0.6 meter atmosphere, what would be the rise of you know these water level; when it is 0.6 rise of water level when it is a 0.6 atmosphere ok.

So, when let us say psi M is equal to 0.6 atmosphere ok. So, what would be h? So, we know the formula is called P is equal P by h sorry let us put this ok.

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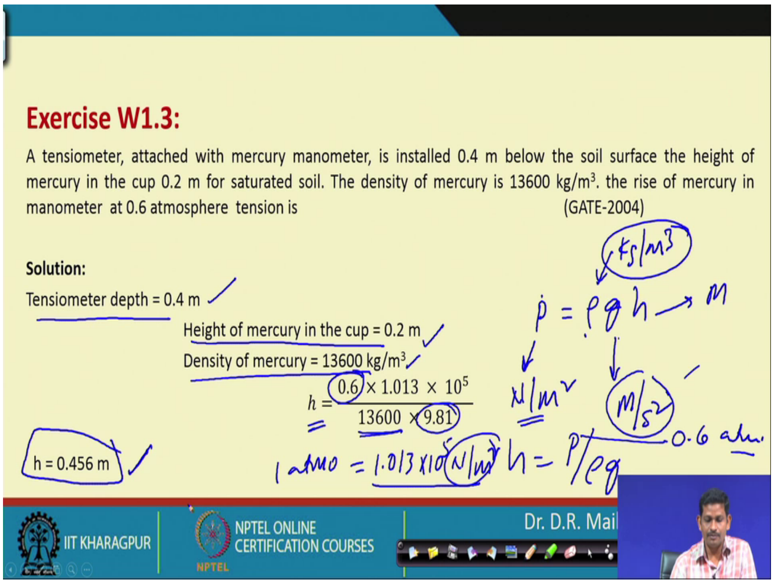


So, we have like P is equal to rho g h ok. So, this is the formula where P, it is a pressure ok. So, pressure. So, that is in Newton per meter square and rho this is the density, it is kg per meter cube and g acceleration due to gravity meter second square and h in meter. So, this is the formula you are going to use here ok.

So, the tensiometer depth 0.4 meter, that is we are not going to use that, and height of mercury in the cup 0.2 meter and density of mercury is given. So, density is given g we know 9.81 and pressure 0.6; this pressure 0.6. So, we going so, substituting this here, h is equal to P by rho g rho g. So, the P is 0.6, P is 0.6 atmosphere. So, atmosphere you have to convert this unit ok.

So, 1 atmosphere which is equal to 1.013 into 10 power 5, Newton per meter square or 1 pascals; 1.013 10 power 5 pascals or Newton per meter square. So, this is given I mean you can convert that you can convert this by Newton per meter square that is a unit ok, that is the unit and then density is given 13600 that is in kg per meter cube it is already given, 9.81 this is in meter per second square. So, I mean substituting everything you get h into h is equal to you get 0.456 meters ok. So, simply this exercise gives how to convert an atmospheric you know pressure into height of water column ok.

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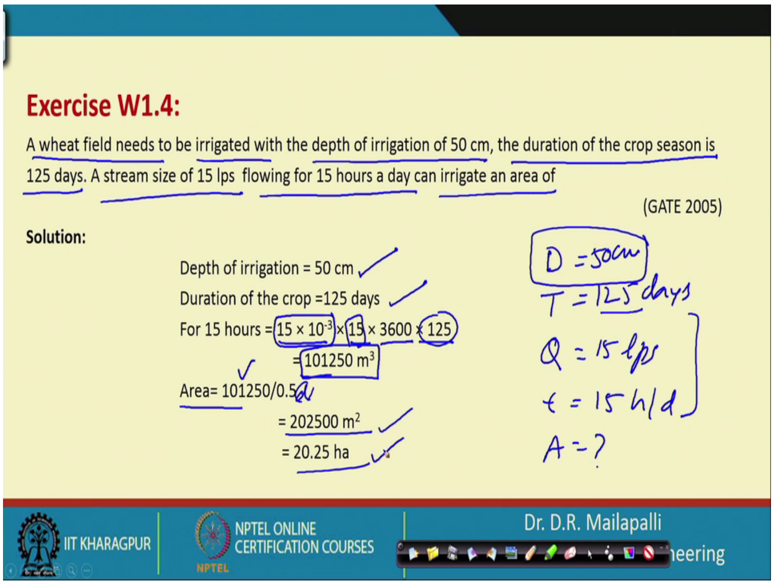


So, the fourth problem here is you have a wheat field that needs to be irrigated with the depth of irrigation 50 centimeter ok. So, depth of irrigation so, the D which is given 50 centimeter, the duration of crop season is 125 days ok. So, let us say the duration which is 125 days, the stream size 15 lps. So, the Q which is equal to 15 lps and following for 15 hours a day. So, the time is 15 hours per day an irrigated area of what could be the area ok. So, that is the problem.

So, 15 hours per day how many days? 125 days if you can multiply these 2 right you get number of hours ok. Then multiply with Q you get the volume right and the volume divided by the depth of irrigation we get the area. So, that the same thing. So, depth of irrigation is 50 centimeter, duration of crop 125 days 15 hours ok. So, the total for 15 hours 15 into 10 power minus 3 into 15 these are. So, these are conversion 125 days and you converter; so, this is a meter cube right this is in meter cube and 15 days sorry 15 hours a 125 days.

So, everything if you convert is the convert into volume. So, 101250 meter cube volume and then area. So, this is the volume divided by the depth right. So, depth you get this is in area and this is in hectare. So, meter square and if you can divide with 10 by 10,000 you get an hectares ok.

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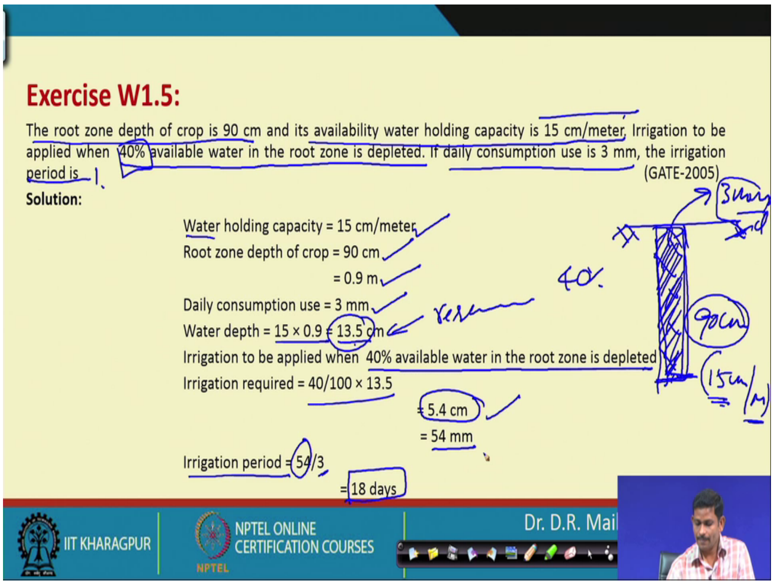


So, then the next example, so, here the root zone depth of a crop is given 90 centimeter and it is available water holding capacity is 15 per meter. Suppose this is the field right. So, it has a root zone depth of 90 centimeter and you have 15 centimeter per meter, it is water content, a water holding capacity ok. And irrigation to be applied when 40 percent available water in the root zone is depleted ok.

So, now what you have to find out? So, what is the moisture holding capacity with 90 centimeter? For 1 meter, 15 centimeter, for 90 centimeter how much? So, that is the number 1 step you have to do. So, with that so, that is your reservoir that is a your water reservoir.

Now, you think about 40 percent is a available water of this one the water reservoir is depleted and then if the daily water consumption I mean withdrawal. So, withdrawal from here is 3 mm per day from this reservoir 3 mm per day. So, then irrigation period is.

So, how many days you need to give irrigation? So, in other word so, how long it is go into take to remove 40 percentage of this reservoir water at the rate of 3 mm per day ok.

So, then simply you have to divide this 40 percent of reservoir by 3 mm you get in days ok. Here you see water holding capacity 15 centimeter per meter, root zone depth 90 centimeter or that you convert into 0.9 meter ok. So daily water consumption 3 mm so, water depth 15 into. So, this is what total root zone depth 15 into 0.9 meter. So, 13.5 centimeter of water, which is available throughout the root zone depth 90 centimeter. So, this is your kind of a reservoir water right.

And then irrigation to be applied when 40 percent available water in the root zone is depleted ok. So, now, get 40 percent reserve this, and you get 5.4 centimeter that is 40 percent of that. So, if 5.4 centimeter is depleted in the rate 3 mm, so, how long it is going to take? So, that is simple. So, 54 mm you convert that and irrigation period 54 mm divided by 3 mm right everyday you get 3 mm is going to deplete. So, total it takes 18 days to deplete this 40 percent reserve you know ah total available water right.

So, this way you can calculate the irrigation next irrigation basically. So, in the first after 18 days you have to give next irrigation to replenish that 40 percent of water.

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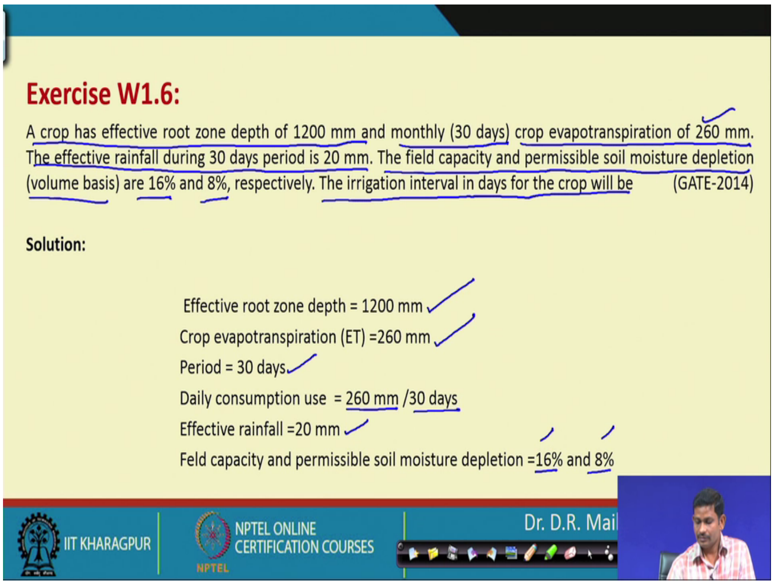

So this is the last example of this tutorial. If you see this so, in this example a crop has effective root zone depth 1200 mm and monthly 30 days as a monthly a crop evapotranspiration of 260 mm ok, the crop has effective root zone depth 1200 mm, and monthly crop evapotranspiration 260 mm, the effective rainfall during 30 days period is 20 mm, the field capacity and permissible soil motion depletion on volume basis are 16 percent 8 percent ok.

The irrigation interval in days for the crop will be. So, this I mean similar kind of question the previous 5th question. If you see this with this data so, data given is effective root zone depth 1200 mm, evapotranspiration 260 mm 30 days period, daily water consumption used 260 mm by 30 days because it is a 30 days. So, daily you get 260 by 30 and effective rainfall 20 mm, and then field capacity permissible over 16 and 8 percent. So, this field capacity command will take points.

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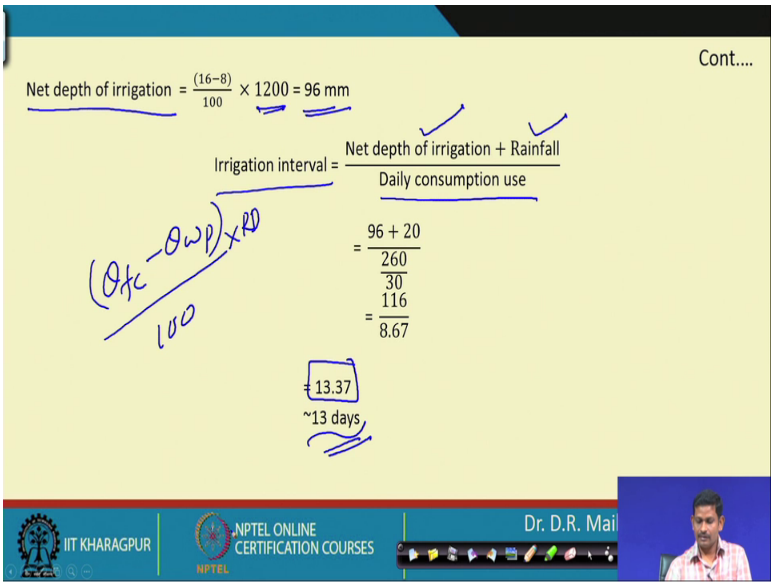


So, then; so, next what you have to do is here. So, net depth of irrigation. So, a net depth of irrigation is theta fc minus theta w p melting point divided by 100 into root zone depth R D right. So, that will be 96 mm, that is the net depth of irrigation and irrigation interval is equal net depth of irrigation plus there is a rainfall right. So and then daily consumption use so, 96 plus 20 divided by daily consumption use 260 by 30 days right.

So, 116 by 8.7 and finally, you get 13.37 or you can consider 13 days. So, in every 13 days you give irrigation this is interval irrigation interval ok. So, this tutorials will cover I mean covered already some part. So that means, soil physical properties and then irrigation interval and other things.

Thank you so much.