Traction Engineering
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Lecture 05
Tutorial - 1

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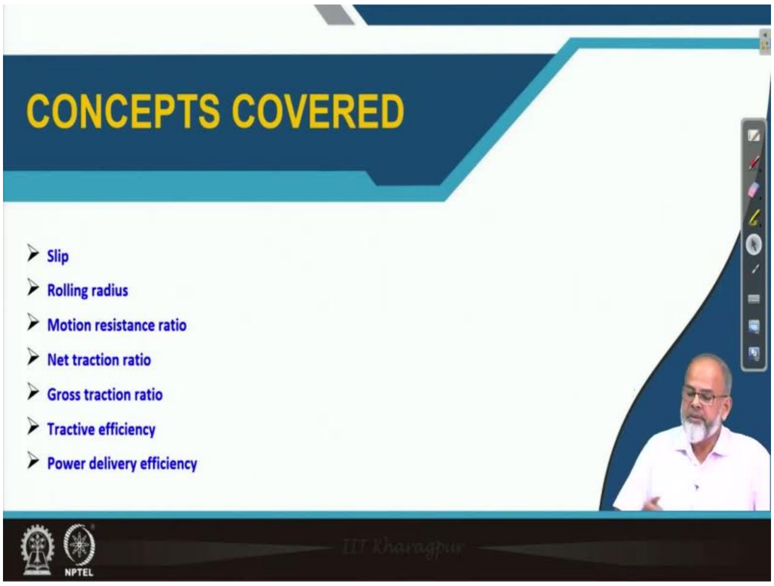

Hi everyone, this is Professor H Raheman from Agricultural and Food Engineering Department, IIT Kharagpur. I welcome you all to this lecture 5, which will be related to the tutorial. Whatever concepts, we have covered in lecture 1 to lecture 4 that I will try to further clarify with the help of using these problems. So, the concepts which we have covered so far is, slip, rolling radius, how to measure rolling radius, how to measure motion resistance ratio, then what is net traction ratio, gross traction ratio, then tractive efficiency and power delivery efficiency. All these parameters I am going to give you using these questions.

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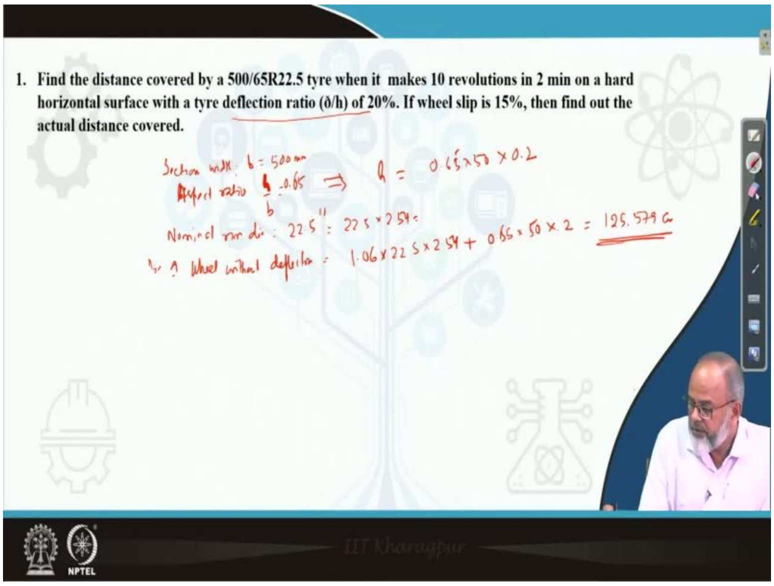
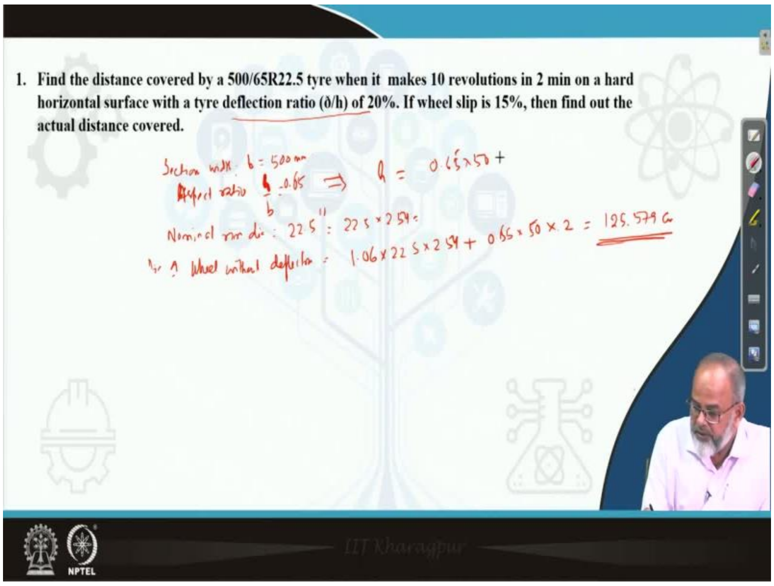
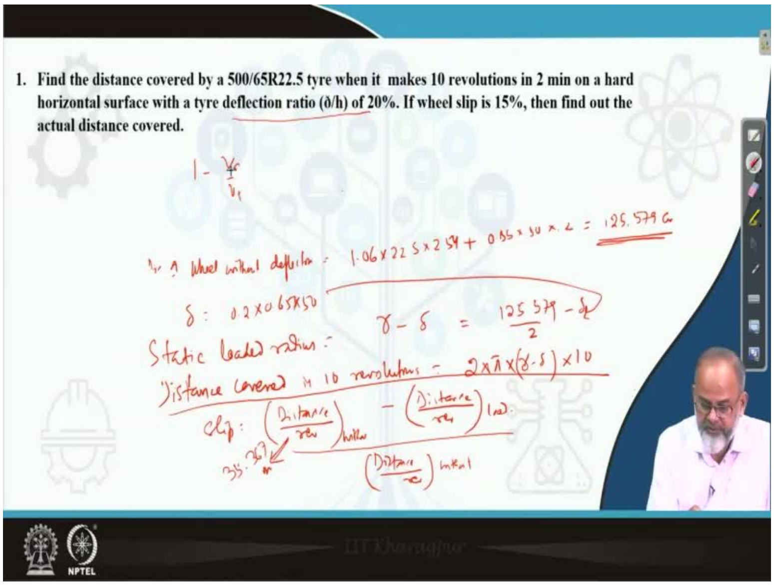
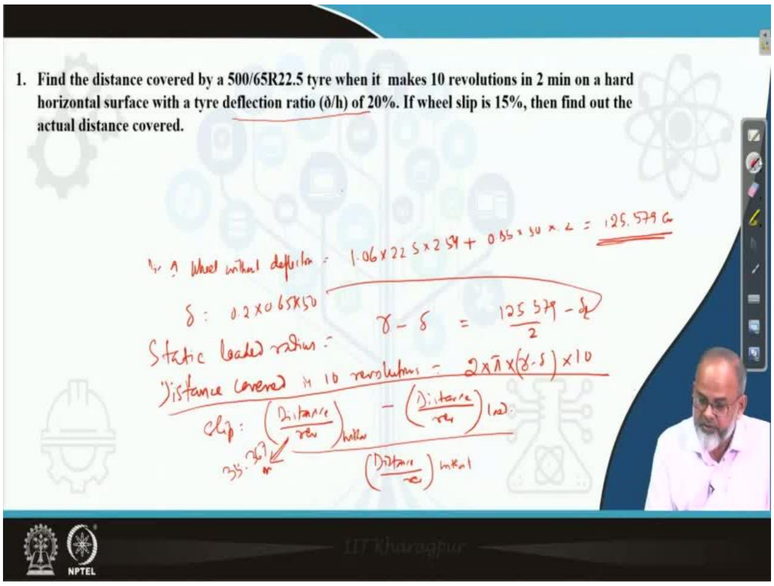





1. Find the distance covered by a 500/65R22.5 tyre when it makes 10 revolutions in 2 min on a hard horizontal surface with a tyre deflection ratio (∂/h) of 20%. If wheel slip is 15%, then find out the actual distance covered.
NPTEL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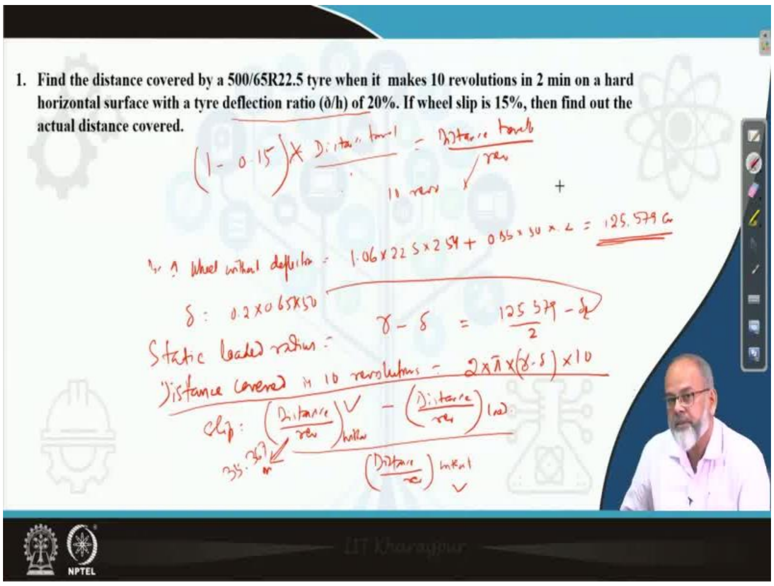
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The first question is, find the distance covered by a 500 by 65R22.5 tyre when it makes 10 revolutions in 2 minutes on the hard horizontal surface with tyre deflection del by h as 20 per cent. So, if wheel slip is 15 per cent, then find out the actual distance covered. So, here the concept what you have done for measuring the diameter of the wheel when the specification of the wheel is given, that will be utilized. Then, how to find out the rolling radius then, how to measure, how to find out slip. These are the three concepts which will be tested here.

But I said, 500 by 65R22.5 that means, this is a radial tyre and 500 is the section width which is your b. So, this is 500 millimeters. Now 65, the aspect ratio is your 65. Aspect ratio which is nothing but h/b is 65 per cent. So, I can write as 0.65. Now, nominal rim diameter 22.5 inches that means 22.5×2.54 that will give you in centimeter. Now, to find out the diameter of the wheel without deflection, dia of the wheel without deflection. This will be equal to, the formula is

$$1.06 \times nominal\ rim\ diameter\ (22.5) \times 2.54 + 0.65 \times 50 \times 2$$

500 is millimeters so, rather so, write in centimeter so, 50 into 2.

So, this will give you around 125.579 centimeters. This is the diameter, but in the question, it is given that there is a deflection by 20 per cent. So, how to find out the static loaded radius, that is important. So, 60 per cent, sorry 20 per cent. So, h was, how much? So, if I write here,

$$h = 0.65 \times 50$$

So, 20 percent of that, 0.2, so that becomes your deflection. This is the h value. Now, δ would be

$$0.2 \times 0.65 \times 50$$

So, this will be your δ. So, now static loaded radius, this will be equal to ‘r-δ’. If dia without deflection is this, so

$$r = \frac{d}{2} - \delta$$

So, r will be 125.579 by 2 minus delta. δ is this value. So, you will get the static loaded radius. Now, in 10 revolutions, how much distance it is covering, that we have to find out. So, distance covered in 10 revolutions,

$$2\pi \times static\ loaded\ radius\ (r - \delta) \times 10$$

Now, if you look at the slip definition, so, slip definition says,

$$slip = \frac{(distnace\ travelled)_{without\ load} - (distance\ travelled)_{with\ load}}{(distance\ travelled)_{without\ load}}$$

The distance which you are getting here, is the distance without load. So, in 10 revolutions you are getting this much, in one revolution, this divided by 10 that you will get around 35.367. So, distance without load will be around 35.367. This is in centimeter, sorry, this is in meter.

Now, slip is given as 15 per cent. So, if I write slip, slip is nothing but

$$1 - \frac{V_a}{V_t}$$

So, better we write slip directly, slip is equal to, slip is this much. So, slip is 0.15 that is equal to this. Now, this value is known, so, this value is calculated. So,

$$distance\ travelled\ per\ revolution\ with\ load = (1 - s) \times distance\ travelled\ without\ load$$

So, that will give you 0.85 times this thing. So, that will give you distance traveled with load per revolution. So, that will give you the total distance covered.

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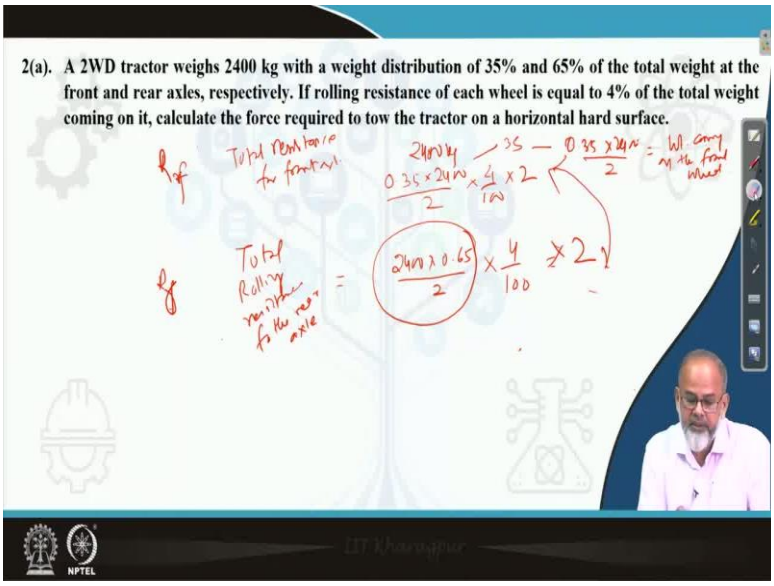

A two-wheel drive tractor which is weighing 2400 kg with a weight distribution of 35 per cent and 65 per cent of the total weight at the front and the rear axle. If rolling resistance of each of the wheel is equal to 4 per cent of the total weight coming on it. calculate the force required to tow the tractor on a horizontal hard surface that means, we have to find out the rolling resistance.

So, in a tractor there are four wheels so, each one will contribute some rolling resistance. Assuming that the two rear wheels and the two front wheels, they contribute equal rolling resistance. So, first, you have to calculate the rolling resistance for the rear wheels then you have to calculate rolling resistance with the front wheels and then summation of these will be total rolling resistance. So, if you are calculating rolling resistance of one of the rear wheels, then what you have to do is, the weight which is coming now 2400 kg is the total weight out of 35 percent is on the front axle. So, 35,

$$0.35 \times \frac{2400}{2}$$

so, that will give you weight coming on, so, this is front wheel sorry, weight coming on the front wheel, each of the front wheels.

Similarly, weight coming on the each of the rear wheels

$$= 0.65 \times \frac{2400}{2}$$

Now, coefficient of rolling resistance is equal to 4 per cent of the total weight. So, whatever value you are getting here multiply 4/100, that will give you rolling resistance of each of the wheels of the rear axle. So, then you multiply with 2, so that will give you total rolling resistance for the rear axle, rear axle.

Similarly, find out total rolling resistance for front axle. So, in that case, whatever value you are getting here

$$0.35 \times \frac{2400}{2} \times \frac{4}{100} \times 2$$

The summation of these two values will give you the total rolling resistance and that will be equal to the force required to tow the tractor. So, that value will be equal to the force required to tow the tractor. So, here the concept of finding out rolling resistance is given.

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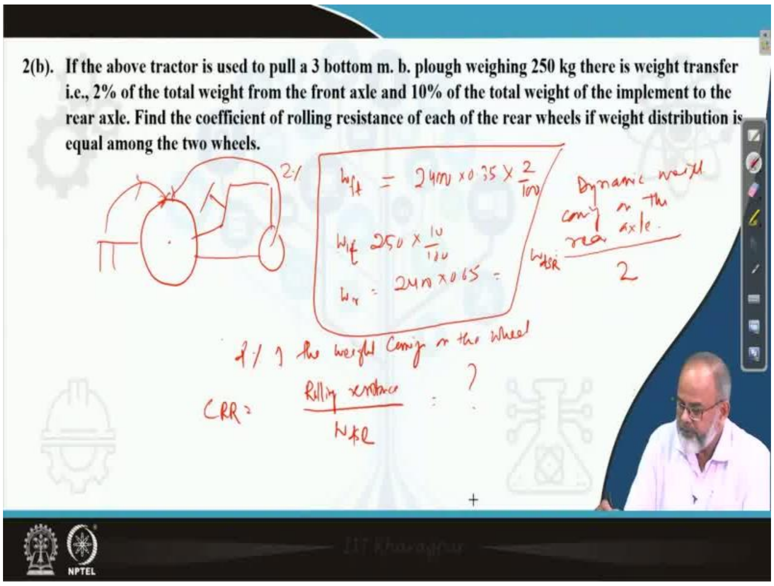

The next question is, if the same tractor is used to pull a 3 bottom m. b. plough weighing 250 kg, there is a weight transfer that is, 2 per cent of the weight is coming from the front axle, and 10 percent of the total weight of the implement is coming on the rear axle. So, there will be weight transfer. Suppose, this is a tractor, and implement is attached here. So, because of the, when we engage the implement, there will be weight transfer to this, there will weight transfer to this. So, this weight transfer is 2 per cent of the weight coming in the front axle. So, we have already calculated the weight coming on the front axle which is nothing but

$$0.35 \times 2400$$

This is the weight coming on the front axle so, 2 per cent of that. That will be transferred to the rear axle.

Now, 10 per cent the total weight of the implements, so implement weight is given as 250 kg so, 10 per cent of that will be transferred to the rear axle. So, this one from the front axle transfer, this one from the implement transferred. Now, weight on the rear axle is already there which is nothing but weight on the rear axle is

$$0.65 \times 2400$$

So, summation of these 3 will give you the dynamic weight coming on the rear axle.

So, once you know the dynamic weight, then rolling resistance is given, that is 4 per cent of the weight coming, 4 per cent of the weight coming, of the weight coming on the wheel. So, you find out the rolling resistance. So, here I have calculated the dynamic weight. So, dynamic weight divided by 2 assuming that both the wheels are experiencing the same rolling resistance.

So, these divided by 2 will give you the weight, dynamic weight of each of the wheel fitted to the rear. Now 4 per cent of that will be with the rolling resistance. So, 4 per cent of the weight which is coming here, so Wd single at rear wheel, now 4 per cent of that with the rolling resistance and coefficient of rolling resistance will be rolling resistance divided by dynamic weight. That way you find out coefficient of rolling resistance.

So here, the concept is, how to find out coefficient rolling resistance. As I said, if it is a single wheel, there will be no weight transfer. So, here the weight transfer plays a bigger role, so that the initial weight does not remain constant, it changes. So, that is the concept given here. So, while dividing the rolling resistance with weight, it should be always the dynamic weight in case of a tractor, not in case of a single wheel.

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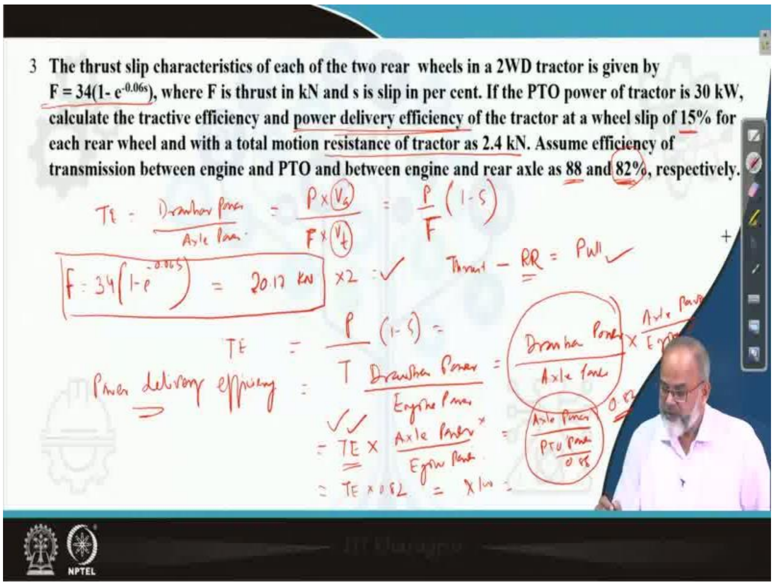

Then, we will try the concept of power delivery efficiency and tractive efficiency that will be described in one more question. The thrust slip characteristics of each of the two rear wheels in a 2-wheel drive tractor is given by

$$F = 34 \times (1 - e^{-0.06s}),$$

where F is the thrust in kilo Newton and s is the slip in per cent. Now, if the PTO power of a tractor is 30 kW, calculate the tractive efficiency and power delivery efficiency of the tractor at a wheel slip of 15 per cent for each rear wheel and with the total motion resistance of the tractor as 2.4 kN.

Some more information has been given like efficiency of transmission between engine and PTO, between engine and rear axle is 88 per cent, 82 per cent, respectively. So, first thing when we are going to calculate the tractive efficiency is, in case of tractive efficiency we require to find out the drawbar power, drawbar power by axle power. So, to find out drawbar power, you need to know the thrust value, then deducting the rolling resistance we will find out pull. So, drawbar power is nothing but

$$P \times V_a$$

axle power is nothing but

$$Thrust \times V_t$$

V_a is the actual velocity; V_t is the theoretical velocity. So, I can write this as

$$\frac{P}{T} \times (1 - s)$$

So, now, our aim will be to find out P, to find out T. So, to find to find out T, an equation is given,

$$Thrust = 34 \times (1 - e^{-0.06s})$$

Now, better I should write F here, because thrust is indicated as F is equal to 34 so, I am replacing this T with thrust. Now, slip is 10, 15 per cent given. Now, substitute here slip as 15 per cent directly, so you will get a value of trust. Thrust value is coming as 20.17 kN. This is for one wheel.

Now, for two wheels, there are two wheels in the rear axle. So, you have to multiply with the 2 to find out the total thrust. Now, total rolling resistance is given as 2.4 kN. So, thrust minus rolling resistance will give you total pull. Now pull divided so, you got the thrust value from this and rolling resistance value is given. So, you can find out pull. Now,

$$\frac{P}{T} \times (1 - s)$$

that will give you directly the tractive efficiency, one part is over.

So, here you do not have to calculate this V_a and V_t because very simply, I have converted into slip value and the slip value is given. So, immediately you can calculate. You do not have to calculate the theoretical velocity, actual velocity. Some must be wondering, nothing is given, how do I calculate. So, you do not have to worry because this can be converted to slip. So, that is why, it becomes simpler.

Now, coming to the second component which is the power delivery efficiency, so, we know that power delivery efficiency is nothing but drawbar power by engine power. This is the ratio of two powers. Now, how much of the engine power is converted to drawbar power that is the aim of giving this performance parameter power delivery efficiency. Now, in this case, drawbar power is $P \times V_a$, so, we do not have V_a value so, what we will do,

$$\frac{Drawbar\ power}{Axle\ power} \times \frac{Axle\ power}{Engine\ power}$$

So, drawbar power by axle power is nothing but your tractive efficiency which I have already calculated. So, I can write this as tractive efficiency into axle power by engine power. So, tractive efficiency you have calculated, axle power is not given, PTO power is given. So, PTO power to engine power is given as 0.88 and then axle power to engine power is given as 0.82.

So, axle power I can write, the engine power is nothing but so, I can write this as axle power divided by engine power is nothing but your PTO power divided by transmission efficiency which is given as 0.88. So, that will give you engine power.

Now, engine power to axle power is given as 0.82. So, this ratio now becomes 0.82. So, this is a product of tractive efficiency which you have calculated. Now axle power by engine power I have converted into PTO power by 0.88. So, that becomes 0.82, now,

$$Tractive\ efficiency \times 0.82\ =\ Power\ delivery\ efficiency$$

If you want to express in percentage multiply 100 that will give you directly the percentage.

So, let me explain this one again, this is drawbar power, power delivery efficiency is nothing but drawbar power by engine power and drawbar power I have divided axle power and then multiplied with axle power so, that the ratio remains same. Now, drawbar power by axle power is nothing but your tractive efficiency which you have already calculated and the axle power to engine power directly it is given as 0.82. You do not have to use, convert to PTO power directly the power is given ratio is 0.82.

So, tractive efficiency into 0.82 directly if you multiply that will give you the power delivery efficiency, then multiply 100 so, that will give you in percentage. So, this gives you, this problem gives you the where have you utilize the concept, how to calculate tractive efficiency, how to calculate power delivery efficiency. So, all the concepts which you covered from lecture 1 to 4 have been they have been used in these problems. Four problems which are solved, I hope that will give you more use of these performance parameters, more use of these concepts that will clarify little more. So, that in future you may not able, you may not be in a position so that you will not confuse in future.

So, in brief, we can say, I have given four problems out of these four problems, each one is related to two, three concepts and all these concepts I have given. Yyou can try so that will help you in better understanding the performance parameters.

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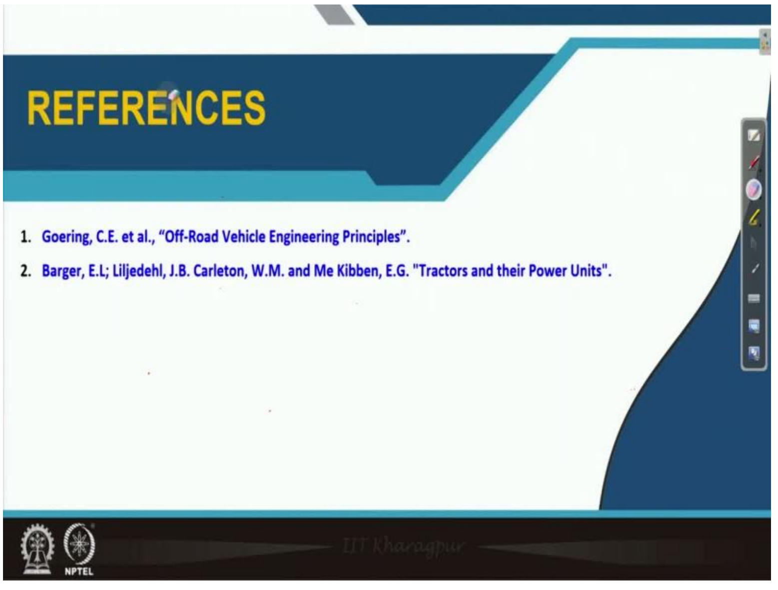

So, you can solve some of the problems which are available in some of the books which has given, which are given here. So, that will further increase your ability to solve the problems. These are the books that you can follow. Thank you.