Lecture - 10
Friction 2

Welcome back to the course of mechanics of solids. As you are discussing in the last lecture the friction part right. So, and we have seen that how we can draw the free body diagram of the different components, which are involved to develop some friction frictional force right. If you look at so in the last lecture we showed this figure right.

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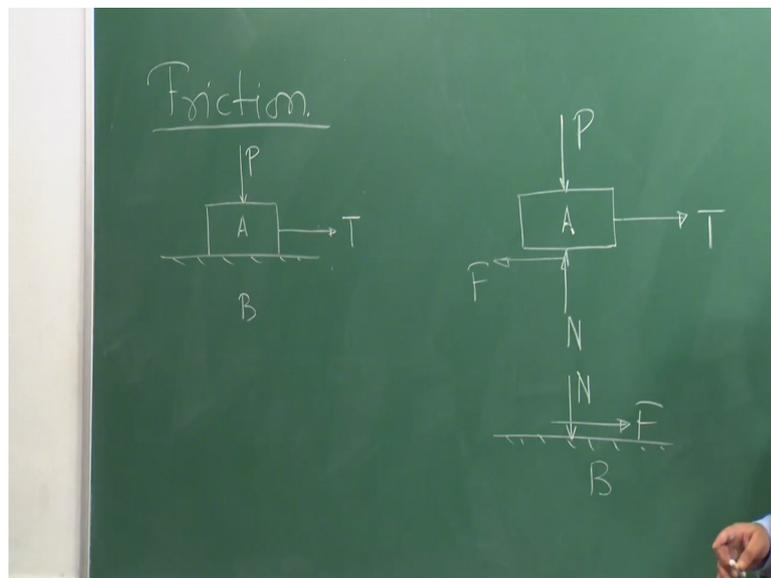
So, if you look at block A. So, these are the forces are acting on block A fine. So, this F basically we are now going to find out and you know how to find out though that force, but just for sake of completeness we are going to discuss this friction. And I hope you are quite familiar to this force friction. And then similarly you can draw the free body diagram of surface B in such a way that these are the forces are acting on surface B.

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So, now if there is no relative motion, because what we are we are we are doing here we are trying to pull this block A over the surface B, but immediately it will not I mean see this, T force you are gradually increasing this T force and you will observe at certain

point the block will on the verge of sliding right. Till then there was no relative motion between A and B right. Why because you are you are applying some force T. So, the block A immediately you T will slide right, but that is not happening actually. Why it is not happening because the frictional force that is F force is trying to resist that kind of relative motion right. So, if there is no relative motion then the static friction static friction force can be given as F s equal to T right.

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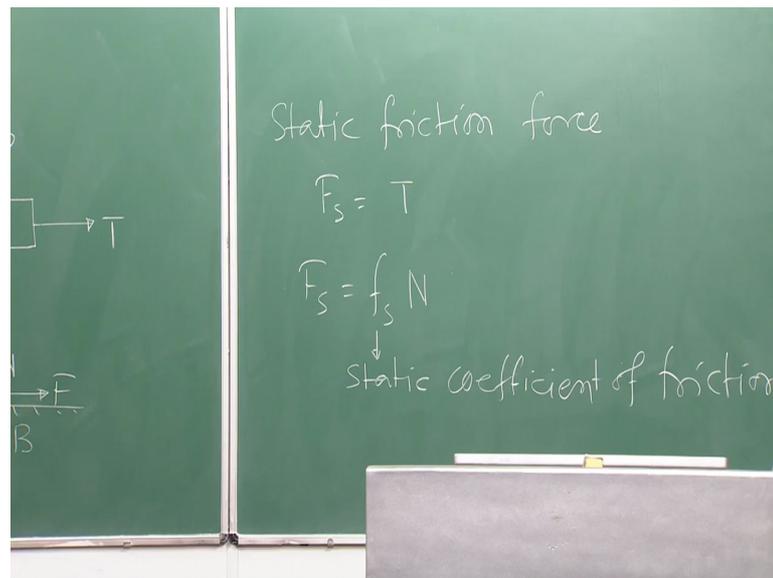
So, F s that is your static friction force is equal to T as long as your T that is the pull out force that is the pulling force is equal to your static friction force F s, you will not be getting any relative motion of the block A right. And this static friction force can be obtained as you know where F s is nothing, but your static coefficient of friction that is your static coefficient of friction I these are the things are quite known to you anyway and N is a normal force as shown in this figure.

So, what I mean to say as long as your T because you are gradually increasing the T right. So, in the process up to a point when T is equal to the your static friction force F s there is no relative motion immediately the T crosses this F s, then you will be getting the motion right the block will try to slide over surface B. So, that kind of situation happens.
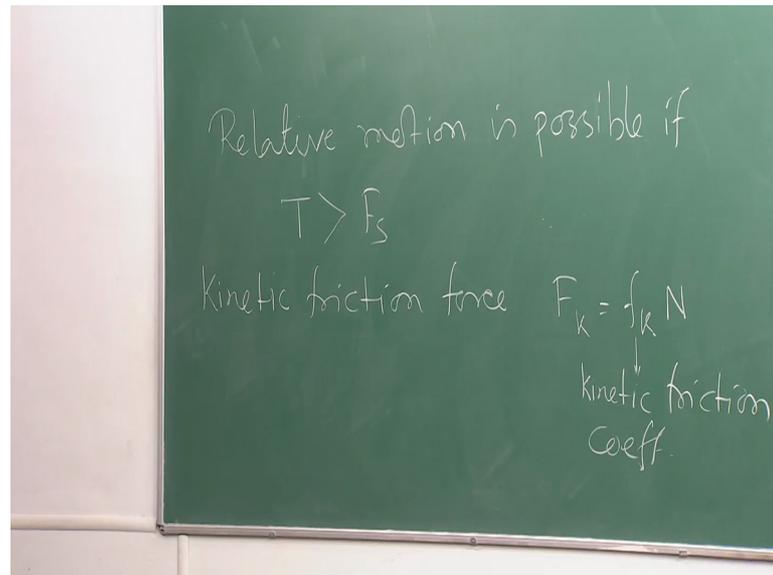
So, your relative motion is possible, if your T becomes greater than (Refer Time: 04:18) F s as long as T is equal to F s there is no relative motion, but once T crosses this limit then basically you will be getting the relative motion. And at that time your body A will be sliding over the surface B as you know and that is defined by your kinetic friction force right. So, that is known as your kinetic friction force. And this is your kinetic friction coefficient or kinetic coefficient of friction.

So, this way basically the movement initiates right. So, initially you will not be getting any movement and suddenly I mean as your T is going on increasing. So, basically you will be getting this condition and finally, the kinetic friction will govern the movement. So, now, there are few properties of this frictional force we should know few inherent properties of these frictional force what are those.
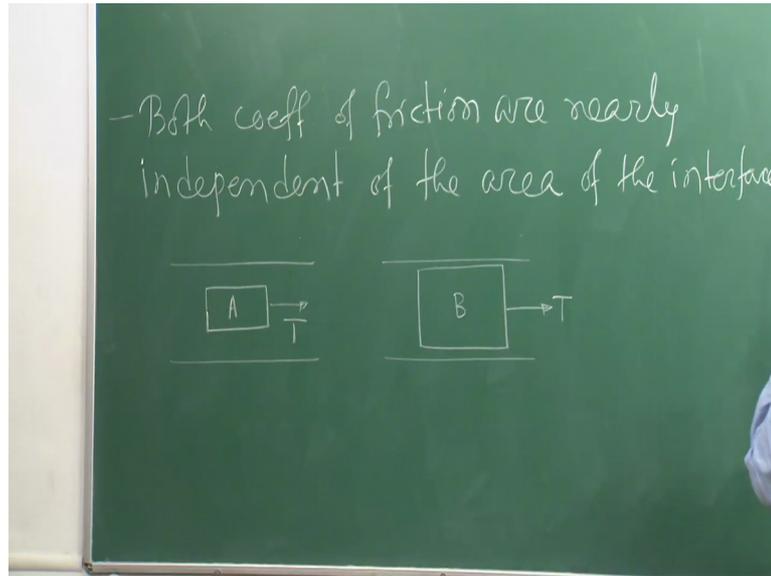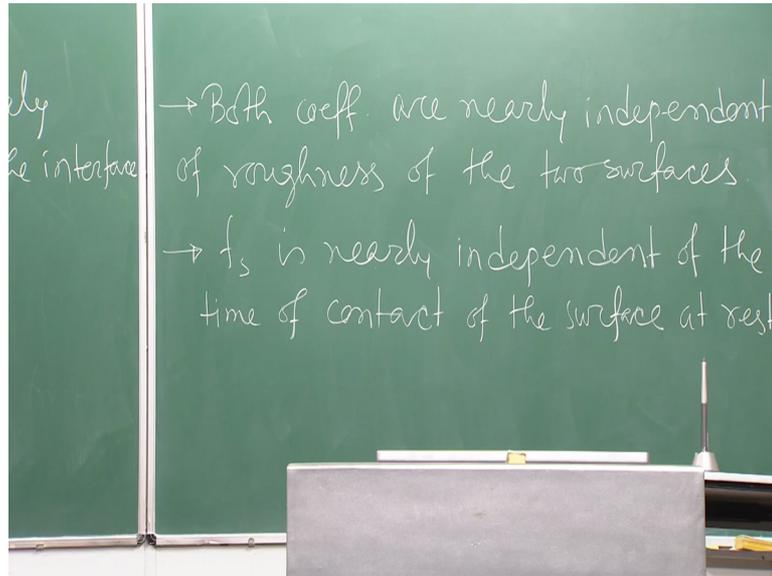
The first property is that both coefficients both coefficients means static friction coefficient as well as kinetic friction coefficient both coefficients of friction are nearly independent of the area of the interface. What does it mean? The first property says that both coefficients of friction are nearly independent of the area of the interface. What does it mean suppose in the plan view? Suppose this is one surface and this is a block say block A, we are trying to pull this block A with a force T and on the same surface. You are taking another block which is really bigger than block A and you are trying to pull this block with a force T and the both the blocks are giving same amount of reaction force N. N is same for both the blocks block A as well as block B what is N as already you have seen in the in the previous figure that N is the reaction vertical reaction at the surface or the at the interface right.

So, now both the blocks are providing me same amount of N if they are providing me same amount of N. Then basically from the figure it is clear that a is much smaller than block B that is a area wise, but that will not affect the friction force which is getting developed at the interface. So, this friction force as we have we have told here that both coefficients of friction static coefficients as well as kinetic coefficient are nearly independent of the area of the interface. So, now, for block as long as block A and block B both are giving same amount or both are generating same amount of N. So, the frictional force are not getting affected or frictional force is completely independent of the surface area the area on which the block is resting.

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Now, the next property is both coefficients are nearly independent of the roughness of the 2 surfaces. So, the friction force is not dependent on the roughness of the surface. So, people have or people generally have a very a wrong impression that if you have very rough surface it will give me higher friction. It is not the friction force is the independent of your roughness of the surface. That is the next property.

 next property is f s, that is a static coefficient of friction is nearly independent of the time of contact of the surface at rest, F s is nearly independent of the time of contact of the surface at rest. So, at rest condition I mean how much time the block A is resting on the surface B it is not giving any kind of say dependency on friction A, friction is rather friction is not getting affected by the time of contact between block A and surface B that you can see from this figure.

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Schematic representation of the variation of friction coefficients
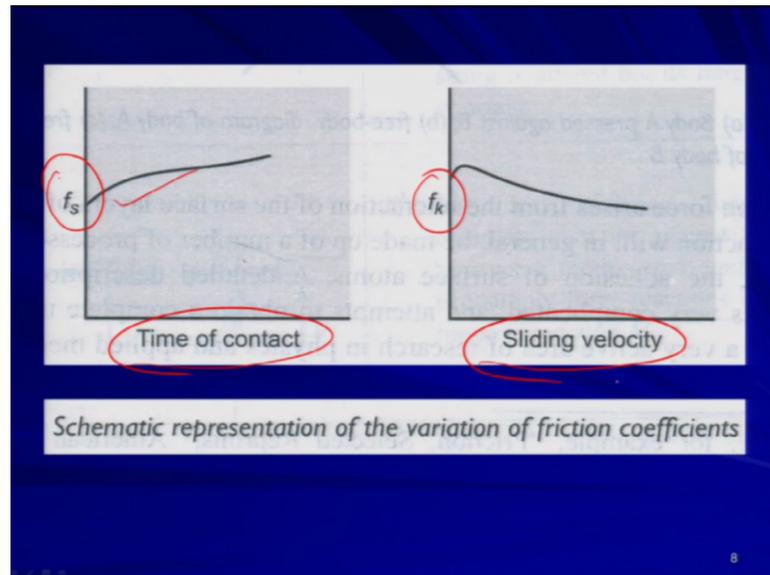
If you come back to this figure you will see that this is your static coefficient of friction and this is your time of contact between 2 surfaces. And you see that this variation is like this. So, this is the variation. So, it is almost clear that the F s is independent of your time of contact.

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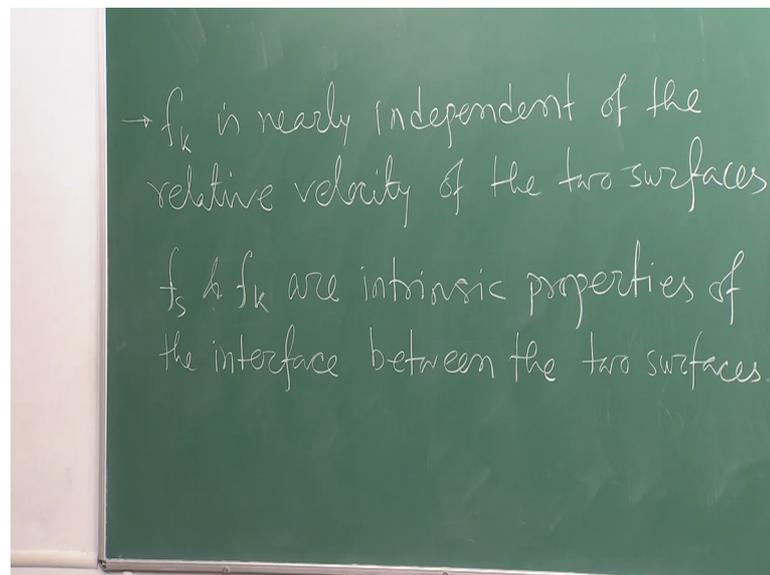
Now, next point is next point is f k that is kinetic coefficient of friction is nearly independent of the relative velocity of the 2 surfaces; f k is nearly independent of the relative velocity of the 2 surfaces. So, it does not depend on the relative velocity; that

means, relative velocity means if your B is stationary if the B surface is stationary if the a is moving right. So, there is some relative velocity getting developed between these 2 bodies, but that f k is completely independent of the relative velocity. Now e that you can see from this figure if you come back to this figure you will see that, this is your f k that is the coefficient kinetic coefficient of friction and this is a sliding velocity.

So, as I mean once your kinetic friction is getting developed at that time it does not depend on the velocity of the sliding block. So, as you can see it is merely independent fine. So, now, this F s and f k therefore, we can say F s and f k are intrinsic properties of the interface between the 2 surfaces. So, finally, we can conclude or we can say or we can see that F s and f k that is a static friction as well as kinetic friction both are intrinsic properties of the interface between the 2 surfaces. So, that is the intrinsic properties of the interface means block A and block B both are having some common surface right. That is that interface is a I mean the intrinsic properties of that interface will govern F s and F k.

So, now we will take some numerical problems to understand whatever we have discussed so, far in this particular chapter.

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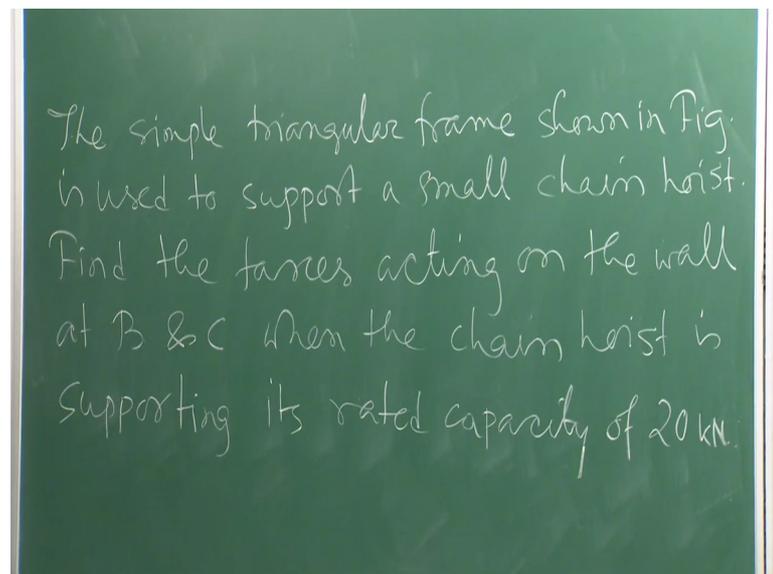
So, let us take this numerical problem. Problem says the simple triangular frame shown in figure is used to support a small chain hoist. Find the forces acting on the wall at B and C when the chain hoist is supporting, it is rated capacity of 20 kilo Newton.
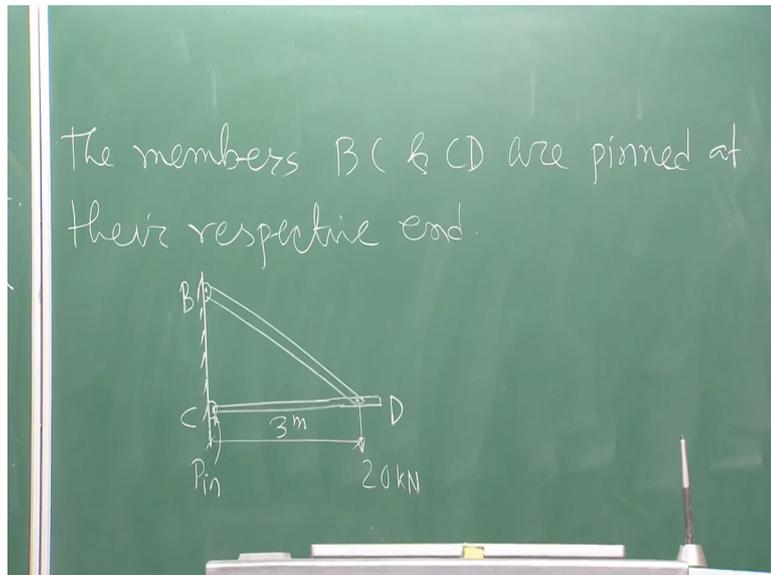
The members B D and C D are pinned at their respective ends. The figure is looking like this. So, this is the problem. What the problem says the simple triangular frame as shown in the figure is used to support a small chain hoist. This is the small chain hoist, the find the forces acting on the wall. So, wall is here. So, this frame is basically mounted on a wall at B and C when the chain hoist is supporting it is rated capacity of 20 kilo Newton as shown in the figure the members B C and C D are pinned as shown here. So, these are all pin joints frictionless pin joints. And you know; what to what is the speciality of pin joints at their respective end. So, what are the things you have to find out find the forces acting on the wall at B and C. So, you need to find out the reactions developed at point B and C. When the chain hoist is supporting it is rated capacity and the members are pin joints. So, the joints are pin.

So, let us let us solve it. So, what is your first job as we have promised already or we have omitted to that my first job is to draw the free body diagram of the whole frame, my first job is to draw the free body diagram of the whole frame.
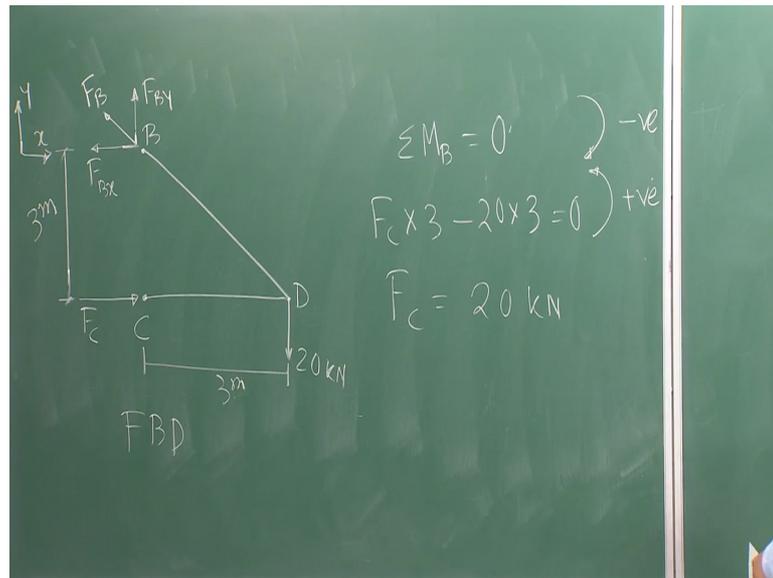
So, this is the free body diagram B D and C. So, this is the reactive force F C and this is the reactive force. So, if I say this is my x y this is given as 3 meter and this is also given as 3 meter fine. So, this is my free body diagram agreed.

Now, you may ask me, I am showing F B like that so our objective for this problem our objective is to find out F B and F C. Those are the support reactions now you may ask me or; obviously, it is coming to your mind. Now that I have shown F B in this direction and F C in horizontal direction, or who is telling me to take this these directions right. So, the obvious question is arising in your mind and the answer is that C D and B D both are 2 force members right. Because the way this is a frame structure this is very much similar to your truss system. And the members can be idealized as a 2 force members, now if the members are 2 force members say C D as well as B D both are 2 force members then the reaction force will be acting along the axis of the member yes or no. Already we have seen that thing when we are discussing about 2 force members and 3 force members like that at the time we discuss the same now this F B will be acting along the line B D and F C will be acting along the line C D therefore, this F B is inclined with the horizontal and we can resolve this F B force in 2 components F x and F y F B x and F B y. So, for our convenience of course, if it is I mean it is not required, but for our convenience we are taking these components and later on we can take the result and to find out F b. So, F B is the resultant of F B x and F B y fine.

Now, another thing you may ask me that is also coming to your mind that I am showing F C as compressive from left to right whereas, F B, I am showing tensile right, if you recall whatever we have discussed when we are talking about the truss members the tension member and compression member. So, F C is shown as the compressive force whereas, F B is shown as a tensile force. Now who is telling me to take F B as tension and F C as compression nobody is telling me and as I told you and do not scratch your head or do not think too much the direction of F C and F B, whatever I have shown I have shown are from my assumption say let us say F C is compressive F B is tension.

Now, after the solution, if I get the same I mean positive value of F B and F C in whatever direction I have considered, that is correct if they are opposite then whatever direction I have considered initially that is wrong. So, we should not think much about the direction or the nature of force. So, now, once we have drawn the free body diagram. So, this is your free body diagram of the whole frame now what we can consider. So, now, we know this frame whole frame is under equilibrium. So, we can satisfy the equilibrium condition. So, first one we are considering moment equilibrium with respect to point B moment equilibrium with respect to respect to point B. So, and we are considering clockwise moment as negative and anti-clockwise moment as positive this is my convention you can choose different conventions, but you stick to the convention throughout the problem we do not change your convention in between. So, this is my convention clockwise moment is pos negative and anti clockwise moment is positive.

So, now if I want to take the moment equilibrium with respect to point B, so, what are the forces are causing moments F C as well as this 20 kilo Newton. So, F C is giving me anti clockwise moment. So, F C multiplied by 3 and this 20 kilo Newton is giving me clockwise moment 20 into 3 is simply 0. So, from here I get 20 kilo Newton. So, F C is obtained.

Now, let us talk about now similarly if you take the moment equilibrium with respect to point C then basically you will be getting F B x into 3 minus 20 into 3, once you are taking moment with respect to C. So, F C will not be participating. So, F B x into 3 and 20 into 3 this 20 kilo Newton will be giving you the moment and F B y is not giving me any moment because that is passing to point C from this you may get F B x equal to 20 kilo Newton. Similarly, if you satisfy this condition summation of F y is 0 then basically from this you will be getting F B y minus 20 is equal to 0 F B y is in the upward direction 20 kilo Newton is acting downward direction. So, these are 2 forces only in the y direction. So, from this you will be getting F B y equal to 20 kilo Newton. So, therefore, F B I can write simply F B x square. So, that is coming 28.2 8 kilo Newton.

So, your support reactions F B equal to 28.28 kilo Newton positive; that means, whatever direction I consider that is correct similarly F C, I got 20 kilo Newton here that is also positive. So, therefore, whatever direction we considered initially that is the compression that is also coming perfect. Now you can check this problem by taking F C in the opposite direction and F B in the opposite direction and then you will see these values numerical values will be coming same, but they will be in in the negative value. So, that we that will tell you that directions whatever you have consider initially that is not correct fine.

So, thank you very much I will stop here today. So, in the next class we will be taking some more numerical problems to understand this particular chapter.

Thank you very much.