Engineering Mechanics
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Module - 09
Lecture - 01
Motion in Uniformly Accelerating Frames

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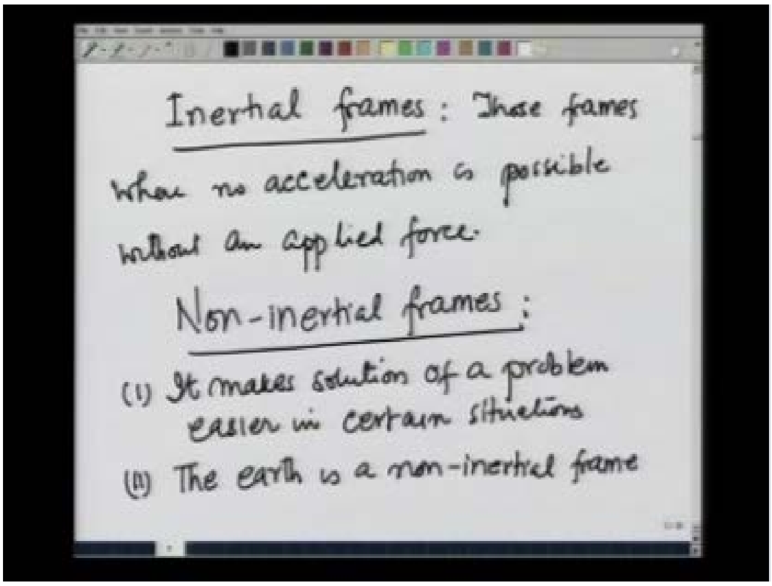

In the problems that we have been solving so far, in dynamics we have been working an inertial frames by inertial frames we mean those frames of references, where no acceleration is possible without an applied force. As I have commented in the past this of course, is an idealization. On the other hand, it is sometimes useful to work in non-inertial frames where you would see that particles are accelerating without an applied force. The reason for working in non inertial frames are 2 force number 1 and it makes solution of a problem easier in certain situations and 2 as I already commented the inertial frame idea of inertial frame is an ideal 1 and most in real life the frames are non inertial and sometimes their effect is measureable and for example, the earth because of its rotation is a non-inertial frame and therefore, it has effects that are measurable and that are significant.

So, for these 2 reasons we will now work on how to solve problems in non-inertial frames. We will be considering 2 kinds of frames.

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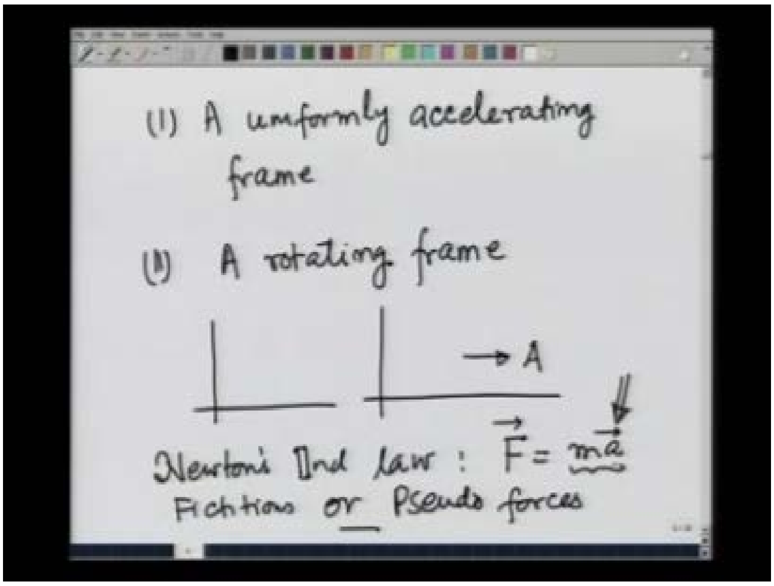

1 a uniformly accelerating frame and 2 a rotating frame. How an acceleration can arise in such frames without an apparent force? Can be seen if you see a form a frame which is uniformly accelerating frame. Suppose, you are in a car which is accelerating in a particular direction with acceleration A, as it is moving you will be seeing other things outside car accelerating backwards although there may be no force on those, but you will see them as if they are accelerating backwards and therefore, you see qualitatively how

sitting in a non-inertial frame or an uniformly accelerating frame you see things accelerating positive, but without any other any force being applied on them.

We want to solve problems in these frames applying Newton’s second law that states that force equals m times the acceleration therefore, if you see things accelerating without any apparent force to account for this apparent acceleration you have to introduce certain forces and we call these forces the Fictitious or Pseudo forces. For example, if you are sitting in a uniformly accelerating frame you will have to imagine as if there is a force pulling things backwards opposite in the direction in which you are accelerating and that would be an a fictitious force which is equal to m times a.

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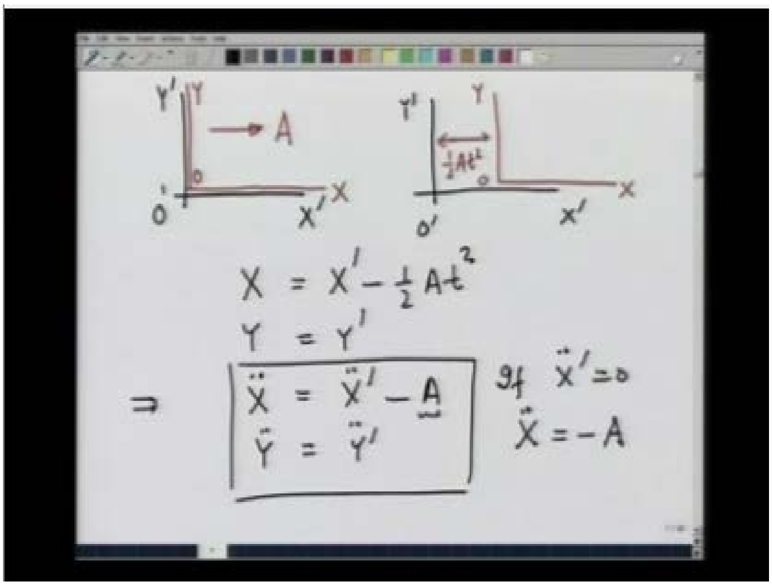

Let us see this quantitatively. Suppose, there is a fixed inertial frame let me call this X prime, Y prime with origin at O prime and let us have another frame which at time t equal to 0 is coincident with these axis X, Y with origin O, but this frame is accelerating to the right with an acceleration A. If that is the case, you can write the transformation equations as after time t what you would see is that the original frame is fixed where it is. But the accelerating frame has moved forward by distance of 1 half A t square in time t and therefore, you can write that X would be equal to X prime minus 1 half A t square Y equals Y prime and if there is a Z axis Z equals Z prime; Therefore, for a particle being observed in the 2 frames, X double prime would be equal to X prime or X double dot that is the acceleration and the accelerating frame would be X prime double dot minus A. Y double prime would be equal to Y prime Y double dot would be Y prime double dot.

So, you see acceleration in the accelerating frame has decreased by an amount A, if X prime double dot is 0 that is; the acceleration in the fixed inertial frame is 0 you see that X double dot is equal to minus A. That is you will see, things moving past you accelerating backwards and the way we explain it as I said earlier is by introducing a Pseudo force let us see, how that comes along?

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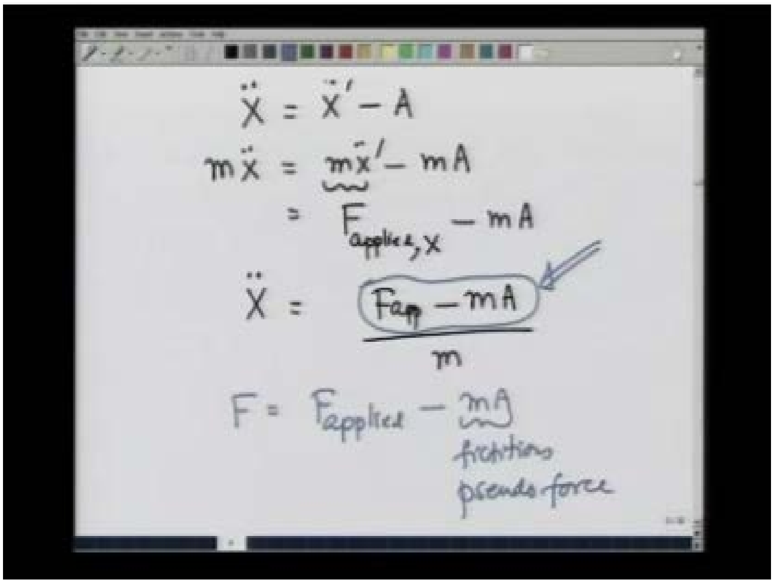

So, just talking in this 1 dimensional case, X double dot which is the acceleration in the accelerating frame is equal to X prime double dot minus A. If I multiply both side by m mass this is m X prime double dot minus m A this we call is a true force F applied because X prime double dot is the acceleration in the inertial frames. So, this is real F applied force in the X direction minus m A and therefore, the acceleration in the accelerating frame I write as F applied minus m A divided by m.

This entire thing is like a new force which is calculated by F equals F applied or external minus m A which is a fictitious or a pseudo force introduced to account for this kinematic effect. The kinematic effect is because, I am sitting in a frame which is accelerating I will see things accelerating passed me for no apparent reason. So, reason I attach is, I introduce a force and now I have got my equation of motion.

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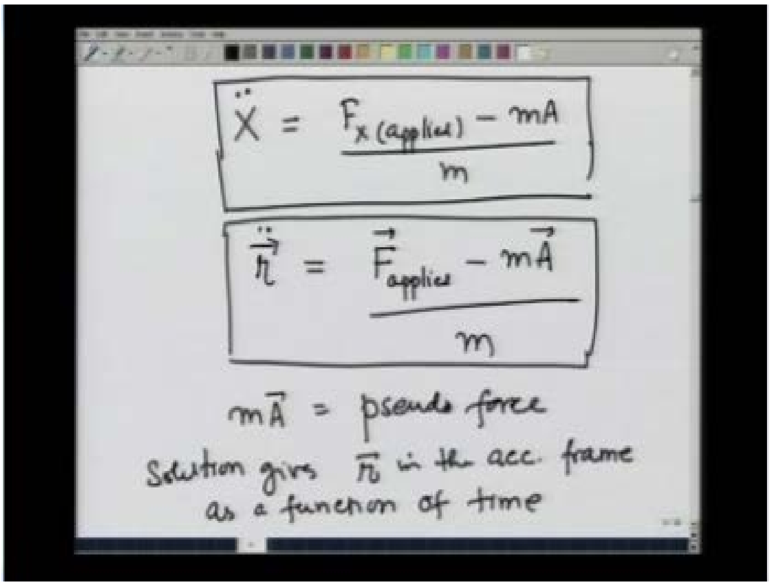

And that is in the accelerating frame how would describe the change in the X coordinate as F in the X direction applied minus m A and that should solution of divide by m. So, solution of this should give me X as a function of time. In general, let me write r double dot in the accelerating frame as F in the accelerating frame F external or F applied minus m A vector, where A is the direction of acceleration of the uniformly accelerating frame divided by m.

This is going to be my equation of motion in the accelerating frame. I emphasize again the force that we have introduced m A is a pseudo force it does not exist its nature, but we feel as if things are accelerating pass. So, introduce this force and solution of this gives solution gives r in the accelerating frame as a function of time. One comment about this pseudo force that we have introduced.

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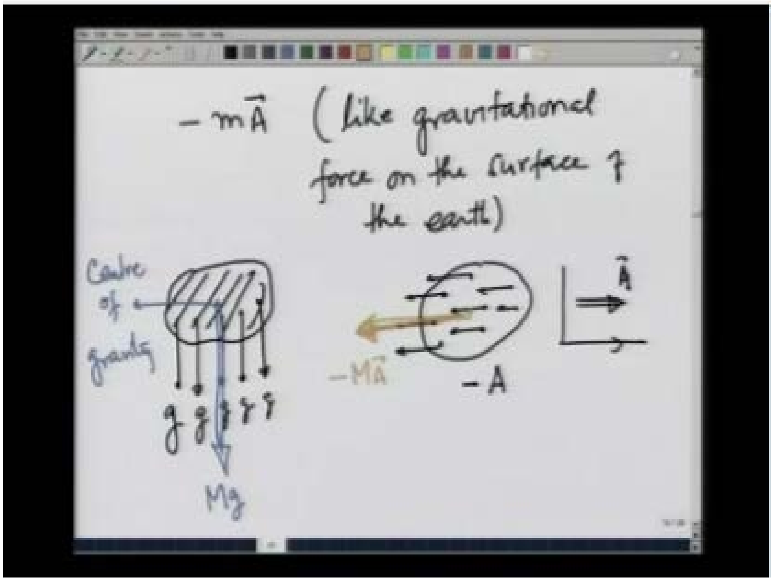

Minus m A it is like gravitational force on the surface of the earth it is a there is direction is slightly different. Recall that, if I have a body on the surface of the earth all parts of it are pulled towards the earth by a uniform acceleration g. Similarly, in this case if I observe an object form a frame which is moving say towards the right with the acceleration A all the parts of this body are accelerating backwards with the same acceleration A. So, it is as if the body is an effective gravitational field with gravitational acceleration minus A. Just like the force out here the net force in this case acts on the centre of gravity which we call the net force is Mg and its act acts at the centre of gravity in exactly the same manner out here also.

Since, the force is uniform acceleration for each particle it will also be acting on the centre of gravity towards minus A direction and the total force of the MA minus MA, but it will work at the centre of gravity. So, that is the sort of similarity between the pseudo force observed in a uniformly accelerating frame and the gravitational force. The way we can use this fact that things in an accelerating frame appear to be being pulled by a gravitational kind of force we can use them to solve problems in much easier way in certain situations and this I will best illustrate through examples.

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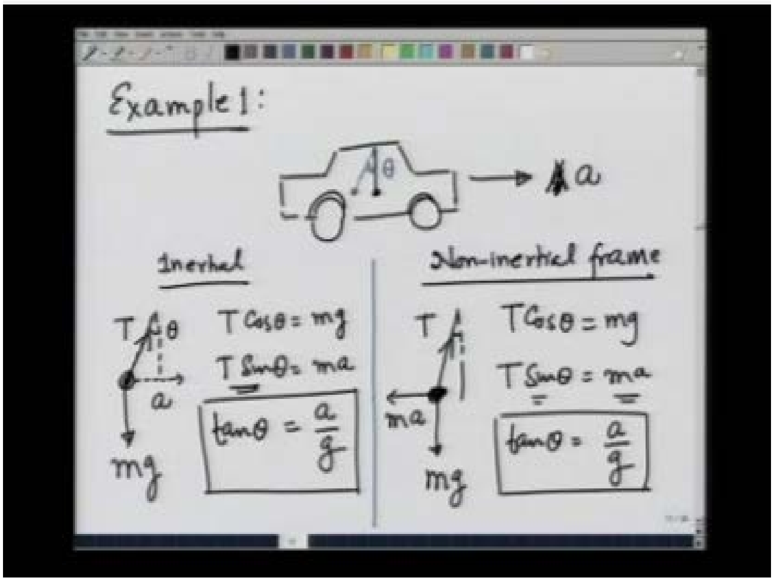

Let us take the first example where, whether I solve in an inertial frame or non-inertial frame it does not matter if I take a car and I have a pendulum in it and the car is accelerating to this side with an acceleration A let me use a what could be the position of the pendulum in this car? You can almost feel that the pendulum is going to be like this if the car is accelerating, but why it should it be with this angle here theta. We solve this problem both in the non-inertial and the inertial frame.

In the inertial frame that is frame from outside the free body diagram of the pendulum in this position is that on the bob there is a tension T force mg pulling it down and as a result of these 2 forces the bob is accelerating to the right with an acceleration a because the car is accelerating and the bob is stationary in the car. If this angle is theta then you can see that, T cosine of theta is equal to mg because the ball is not moving up and down and T sin of theta is equal to ma because the bob is accelerating towards the right with an acceleration a and that gives you tangent of theta equals a over g.

What if I look at the same problem in non-inertial frame and what frame do I choose, I choose the frame which is attached with the car and moving to the right with it. In this frame you see the bob in equilibrium under the force mg tension T and a fictitious force ma to the left. Notice that when, I am sitting in the car the bob on the pendulum is in equilibrium position because, with respect to the car frame it is not moving at all the three forces are to be balanced for equilibrium and that gives you T cosine of theta equals mg and T sin of theta is matrix. Notice the difference in the inertial frame T sin theta gives an acceleration towards the right. In the non inertial frame T sin theta balances the fictitious force with the final result of course, being the same that tangent theta is a over g.

So, you see two way of looking at the same problem and of course, I should get the same final answer same effect. As I commented earlier that I can think of this, the force fictitious force in an uniformly accelerating frame as a gravitational force is illustrated beautifully by this example.

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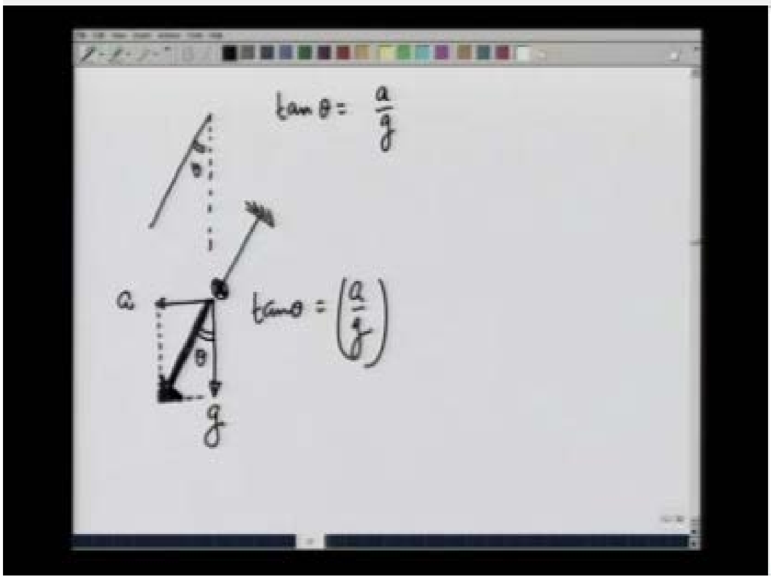

Because now, the pendulum is at an angle theta from the vertical and that tangent theta is given by a by g. If I look at it from the gravitational field point of view the pendulum is actually in a gravitational field which is the sum of these 2 gravitational fields. Acceleration g this way and acceleration a this way; so, the net gravitational field is a sum of these 2 and that is in this direction which is shown here by the big arrow. And this is at an angle theta with tangent theta equals a over g any pendulum in its equilibrium aligns with the gravitational field.

So, no wonder that the pendulum is aligned with this in its equilibrium position that is the explanation for this. So, we can see that thinking of this field in an the pseudo force or pseudo field in a no-inertial frame is like a gravitational field is meaningful and gives you the right answer. Using this now, we will solve a slightly more complicated problem which will show you that actually going to non-inertial frame sometimes makes life very very easy.

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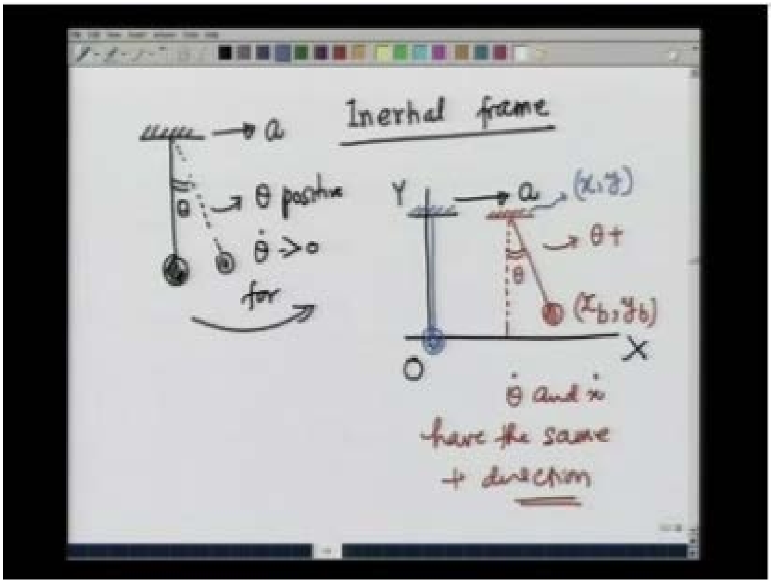

The problem that we solve now is suppose, there is a pendulum and its support is suddenly accelerate to the right with an acceleration a which way would the pendulum move and by how much angle that is a question that we want to answer. First, let us solve this problem in the inertial frame attached to the ground. I am solving it for two reasons; 1 you will see how we would solve a difficult problem and two when you compare the solution in an inertial frame compare to the solution in a non-inertial frame you will see the effectiveness of solving problems in a non-inertial frame sometimes.

So in this case, when this accelerates to the right let us assume that the pendulum also swings to the right with this angle being theta I am choosing it to swing to the right. So that, this way is theta positive and theta dot will be greater than 0 for pendulum to this swinging to the right. This I do because, now I am going to fix my frame like this X and Y and initially let the pendulum I plotted with blue be here, with the bob at the origin and as the pendulum is its base accelerates. Its pivot point is accelerated to the right with a… we are assuming that after sometime t the pendulum would look like this, with it having rotated by an angle theta to the right with respect to vertical.

As I commented earlier I choose this direction as theta positive because, then theta dot and x dot have the same positive direction and that is important otherwise, I will may I may have to change sign along the way. Let me write for the bob position its coordinate as xb and yb and for the support let me write x and y. So, let me make this picture once more what we have is this.

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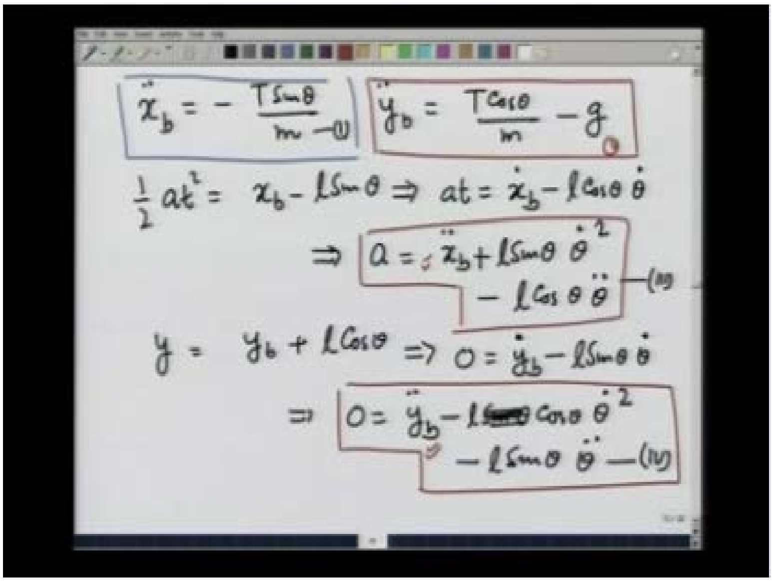

Frame at T equal to 0 this is the way the pendulum is and after time t the base has moved here the pendulum has moved this way by an angle theta. This distance is 1 half a t square because, the base or the support of the pendulum is moving with an acceleration a this is xb, yb and y of the support does not change let the tension in the string be T.

Let us write the equations of motion for the ball. I am going to have xb double dot is equal to minus T sin theta divided by m that is my equation one. I am going to have yb double dot is equal to T cosine of theta over m minus g that is my equation 2 because, in the bob in the vertical direction is T cosine theta component and a g component. How many unknowns do I have? I have unknown have xb, I have unknown yb, I have unknown theta and I have tension T four unknowns.

So, I need two more equations. Those equations are provided by the relationship between xb, yb and the coordinate of the support. The support has moved by distance 1 half at square and that is equal to xb minus if the length of the pendulum is l it is going to be minus l sin of theta. Similarly, I am going to have y of the support equal to yb this is yb plus l cosine of theta this is my equation three and equation 4. I have gotten 4 equations, four unknowns and I can solve for them. So, let us do that. Let me rewrite the equations once more and then we will solve for the problem.

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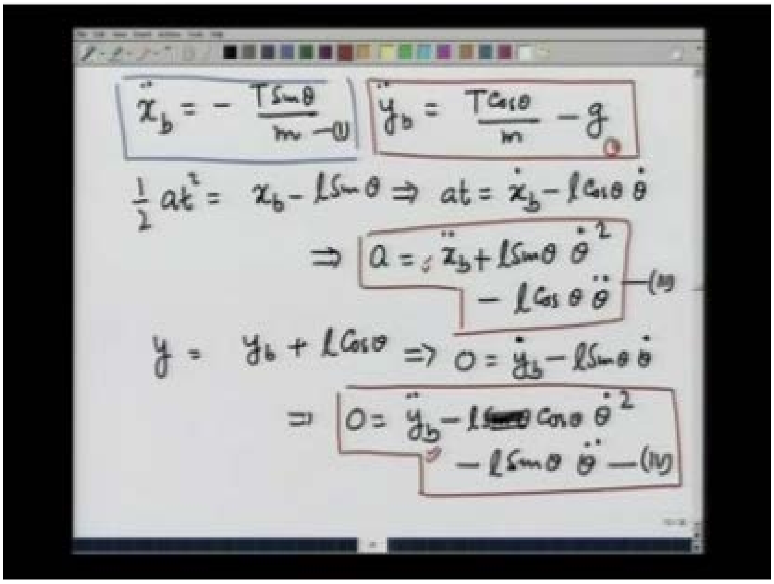

So, I have xb double dot equals minus T sin theta divided by m, I have yb double dot equals to T cosine theta divided by m minus g, I have 1 half a t square equals xb minus l sin of theta if I differentiate this once it gives me at equals xb dot minus l cosine of theta theta dot. If I differentiate it once more it gives me a equals xb double dot minus minus plus l sin theta theta dot square minus l cosine of theta theta double dot and let me call this equation number 3.

Similarly, y equals yb plus l cosine of theta gives me y dot is 0 zero equals yb dot minus l sin theta theta dot. Differentiating it once more I get 0 equals to yb double dot minus l sin theta or minus l cosine theta theta dot square minus l sin theta theta double dot let me call this equation number 4. So, I have equation number 1 here, we box them this is equation number 1, equation number 2, equation number 3 and equation number 4. Let me substitute for xb double dot in terms of T and yb double dot in terms of T in equation number 3 and 4 and what do I get?

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I am going to get xb double dot which is minus T sin theta over m plus l sin theta theta dot square. Let me confirm that, plus l sin theta theta dot square minus l cosine of theta theta double dot is equal to a and for the y equation I get let me again see this yb double dot minus cosine theta theta dot square minus l sin theta.

So, I am going to get yb double dot which is T cosine theta over m minus g minus l cosine of theta theta dot square minus l sin of theta theta double dot is equal to 0. Let me call, this equation number 5 and equation number six. Multiply equation number 5 by cosine of theta and multiply equation number 6 by sin of theta and add. If I add, if I do that I get the first term T minus T sin theta cosine theta plus T cosine theta sin theta that cancels; Second term, l sin theta theta dot square cosine theta minus l cosine theta sin theta theta dot square that cancels. So, I get minus g sin of theta these 2 terms; give me minus l cosine square theta plus sin square theta that is 1 theta double dot is equal to a cosine of theta.

In other words, l theta double dot is equal to minus a cosine of theta minus g sin of theta that is my equation for theta. I have done my job I solve this equation and I can get all the answers let us do that.

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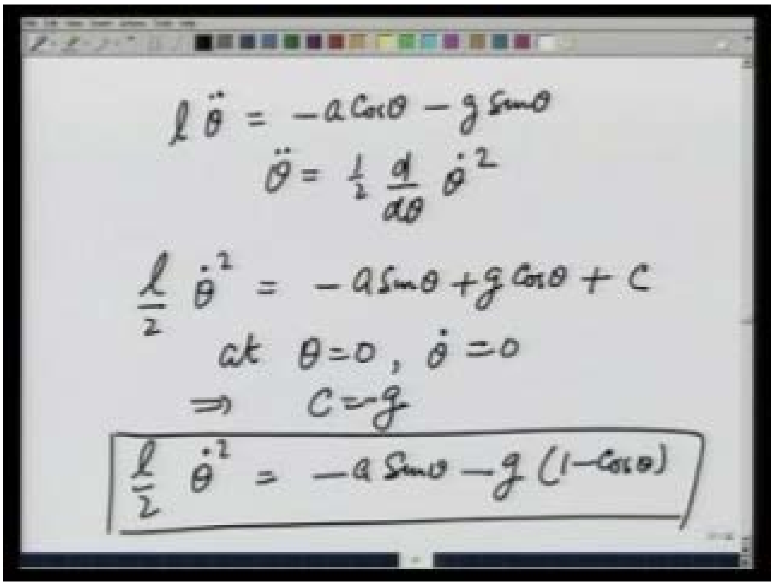

So, the equation that we have gotten is l theta double dot is equal to minus a cosine of theta minus g sin of theta let us put theta double dot equals 1 half d by d theta of theta dot square and integrate it to get l by 2 theta dot square is equal to minus a sin theta plus g cosine theta plus the constant C; However, at theta equal to 0 then it started theta dot is equal to 0 and that gives me C equals minus g and therefore, l by 2 theta dot square comes out to be minus a sin theta minus g 1 minus cosine theta that is the solution for theta dot square.

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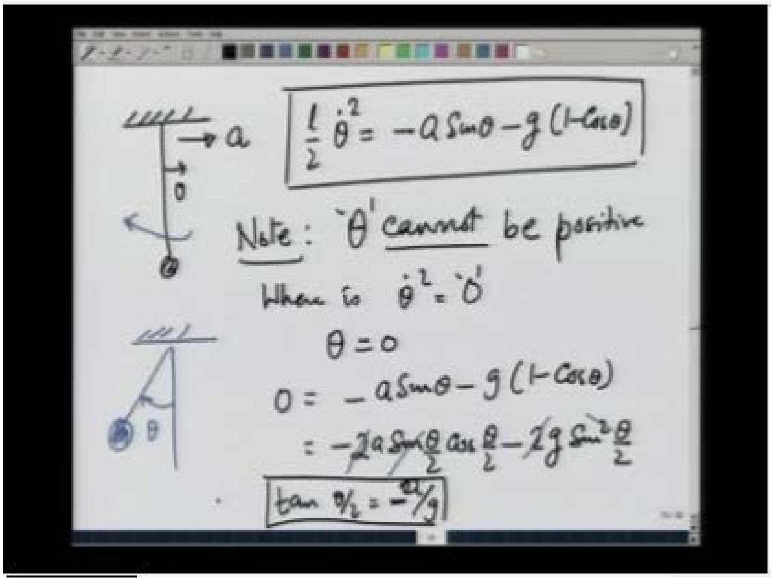

So, what we have got is when I have a pendulum had a support and suddenly the support moves with an acceleration a, I am going to have the angle of this change by l theta dot square is going to be equal to minus a sin theta minus g 1 minus cosine of theta.

Note 1: theta cannot be positive if theta becomes positive the right hand side would be negative and that will give you theta dot square to be negative which cannot happened; therefore, the pendulum has to swung in negative theta direction it has to swing back. So, after some time its position would be something like this. It would have swung in theta in negative direction and where does it stop. So, question we ask where is theta dot square 0.

One answer of course, is theta equals 0 which we point we started with and the second point is going to be 0 equals minus a sin theta minus g 1 minus cosine theta which I can write as minus 2 a sin theta by 2 cosine theta by 2 minus 2 g sin square theta by 2 and that gives you before let us see, this sin theta by 2 1 of them drops out these 2 drops out and that gives you tangent of theta by 2 equals minus a over g. So, theta dot square becomes 0 again when tangent of theta by 2 is minus a over g.

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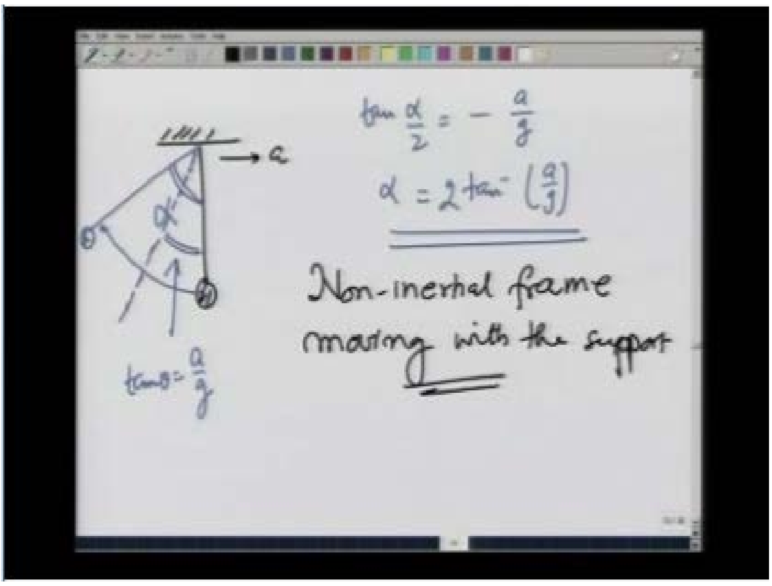

So, here was a support which suddenly moved towards this with acceleration a and the final position is such that at a point such that this angle is alpha, then tangent alpha by 2 is minus a upon g or alpha just in magnitude is equal to tan inverse a over g times two. This has a beautiful interpretation remember earlier this was the angle which has tangent theta equals a over g that angle where the new equilibrium point of the pendulum was. So, in a way the pendulum has swung across the equilibrium point by as much angle as it was away from it on 1 side and this is a solution that we gotten by solving an a an inertial frame. Let us see now, how would the solution look in a non-inertial frame, non-inertial frame moving with the support.

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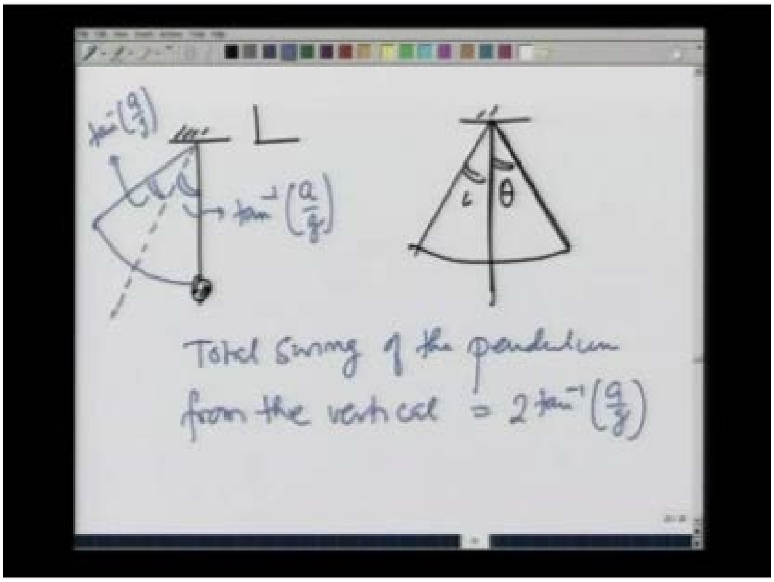

So, I look at this whole thing in a non-inertial frame moving with the support in that frame this is the equilibrium position of the pendulum such that this angle is tan inverse a over g. So, in this non-inertial frame this is the equilibrium position. So, I am looking at the pendulum as if it is moved to 1 side from the equilibrium position by an angle tan inverse a over g. Recall what happens, if I have a pendulum from the equilibrium position if it is left by if it is raised by an angle theta to 1 side what happens, when it swings back.

It swings exactly by the same angle to the other side. So, in this move the this frame accelerating frame the pendulum which swing across the equilibrium point exactly by the same angle as it was initially to the 1 side and that is going to tan inverse a over g. So, the total swing of the pendulum from the vertical is equal to 2 tan inverse a over g.

Now, I would like you to appreciate the power of having solve this problem in a non-inertial frame while solving in the inertial frame I have to do work with many many equations 4 or 5 equations and had to manipulate a lot of them. On the other hand, when

I went to non-inertial frame the problem could be solved in 3 or 4 lines and that is the power of using non-inertial frames in certain problems having established that non-inertial frames do provide. Particularly in this case uniformly moving non-inertial frames do provide method of solving problems in an easier way. We will now solve a few examples; most of them will be from the book of Kleppner.

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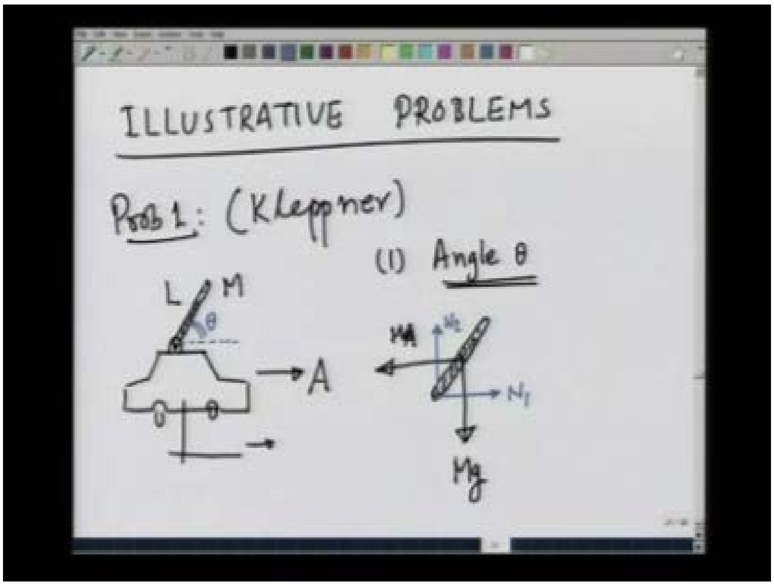

So, we are going to solve illustrative problems. Problem 1: this is taken from the book of Kleppner whose reference I have already given you. If I have a car moving with acceleration A to the right and it has a rod on the pivot of length L and mass M we want to find at what angle from the top of the car would it balance and what happens, when it is moved from that balance point slightly. So, let us first calculate angle theta at which the bar is balanced. We have already established that going to an uniformly moving frame makes problems easy.

So, we will be solving this problem in a uniformly moving frame which is attached to the car and therefore, accelerating to the right with acceleration A. When the rod is in equilibrium in this uniformly moving accelerating frame it is under equilibrium it is in equilibrium under the forces of Mg and has I have already argued. I can think of the fictitious force MA like an effective gravitational force which is working in the direction opposite to the direction of acceleration of the frame and it also acts on the centre of gravity. So, it is under the influence of the MA to the left and there are normal reactions at the pivot let us call this N 1 to the right and N 2 vertically up.

So, this rod is under equilibrium in equilibrium under these forces MA, N 1, N 2 and Mg. Let us go the next page and show this free body diagram of the rod again,

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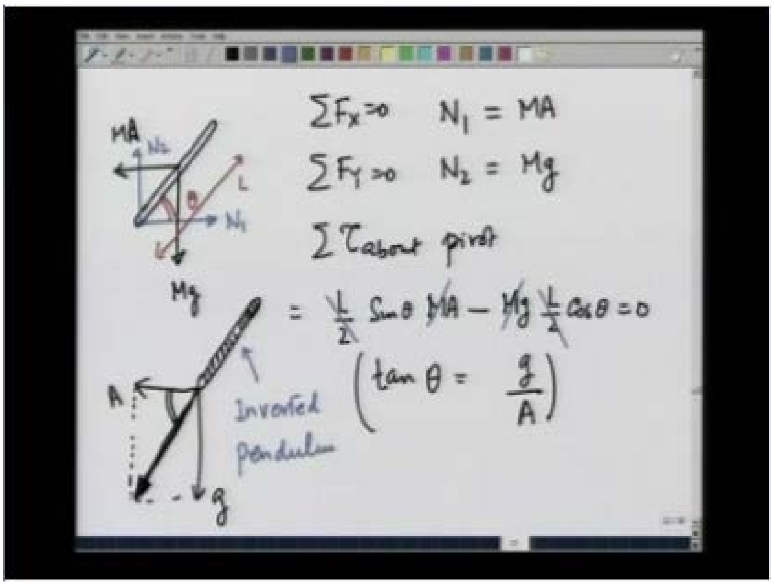

It has a force Mg acting downwards a force MA working to the left normal reaction N1 working the right normal reaction N2 working to the vertically up and summation Fx equals 0 gives me N1 equals MA. Summation Fy equal to 0 gives me N2 equals Mg and summation torque about pivot gives me if this angle is theta and the length of the rod is L it gives me L over 2 sin theta times MA minus Mg times L over 2 cosine of theta equal to zero. M drops out L by 2 drops out and that gives me tangent of theta equals g over A.

So, the rod is at an angle theta such that tangent theta equals g over A from the horizontal. What direction is this? Recall earlier I had told you if there is an acceleration and there is g then the effective gravitational field is this one. The sum total of the 2 at this angle which is tangent theta equals g over two. So, it is not surprising that the rod is in equilibrium precisely aligned up with the direction of the effective gravitational field it is like an inverted pendulum right. It is the pendulum you can sort of put pointing up and that will also be in equilibrium; however, inverted pendulum is in unstable equilibrium if you just disturb it slightly from the equilibrium point it takes off. So, this rod should also be in an unstable equilibrium. Let us see, that in the next part of the problem.

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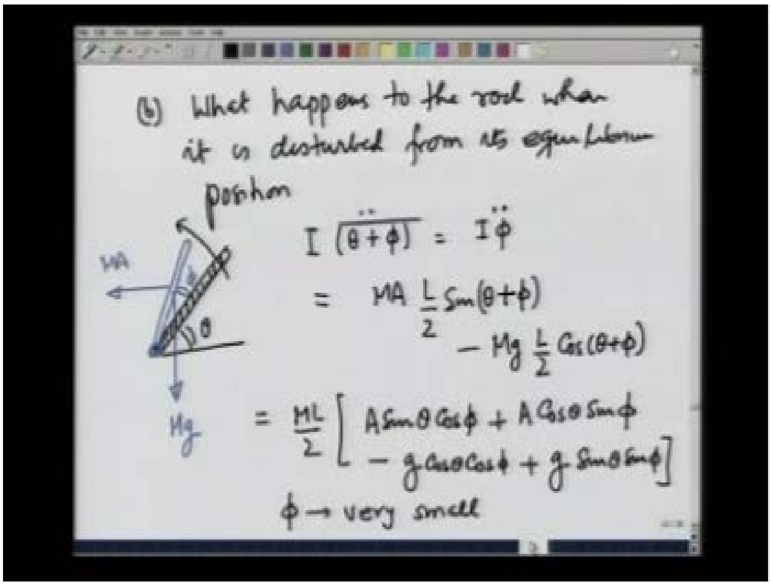

So, in part b we see what happens to the rod when it is disturbed from its equilibrium position. So, the rod is at angle theta from the horizontal or from the top of the car and what we do now, is disturb it slightly by an angle phi what happens, then naturally there is a force MA working to the left, Mg pulling it down and if I write the equation for theta plus phi about the pivot point. Here let us see, what that equation is looks like. So, that equation is going to look like. I where I is the moment of inertia of the rod about the pivot point theta plus phi double dot which is nothing but, I phi double dot theta is a given a fixed angle is equal to phi is going this way positive.

So, it is going to equal to MA L by 2 sin of theta plus phi minus Mg L by 2 cosine of theta plus phi. Let us expand this, when we expand this we are going to get ML by 2 can be taken out. A sin theta cosine phi plus A cosine theta sin phi minus g cosine theta cosine phi plus g sin theta sin phi. Let us take phi to be very small.

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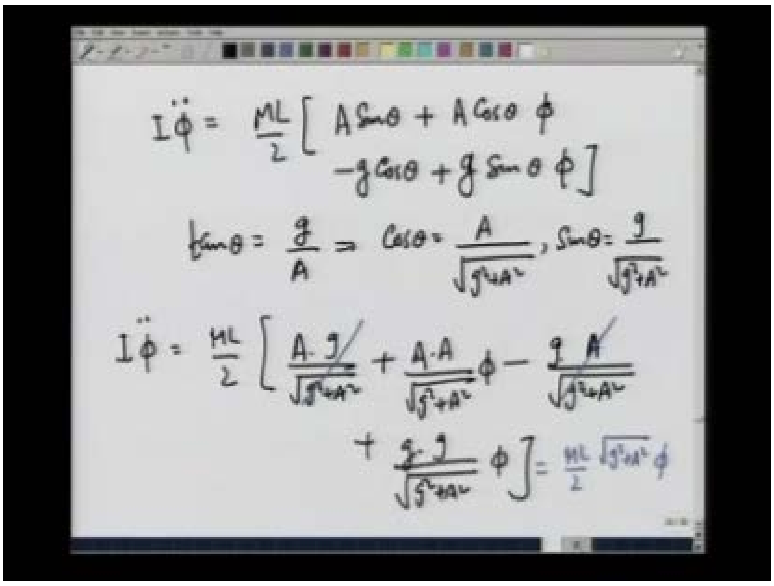

So, that sin phi is almost phi and cosine phi is 1 and therefore, I get I phi double dot is equal to here, let us look here A sin theta ML by 2 A sin theta plus A cosine theta times phi minus g cosine theta plus g sin theta times phi. Recall tangent theta is g over A and therefore, cosine theta is equal to A over a square of g square plus A square and sin theta is g over cosine theta is A over g over square root of g square plus A square. Let us substitute that and then we get I phi double dot is equal to ML over 2 A sin theta is g over a square root g square plus A square plus A cosine theta is A over square root of g square plus A square phi minus g cosine theta is A over square root of a g square plus A square plus g sin theta is g over square root of g square plus A square phi.

This term cancels and you get this is equal to ML over 2 square root of g square plus A square times phi. And therefore, the equation when, the rod is disturbed from its equilibrium position is I phi double dot Is equal to ML by 2 square root of g square plus A square phi or I phi double dot minus ML over 2 I a square of g square plus A square phi equal to 0.

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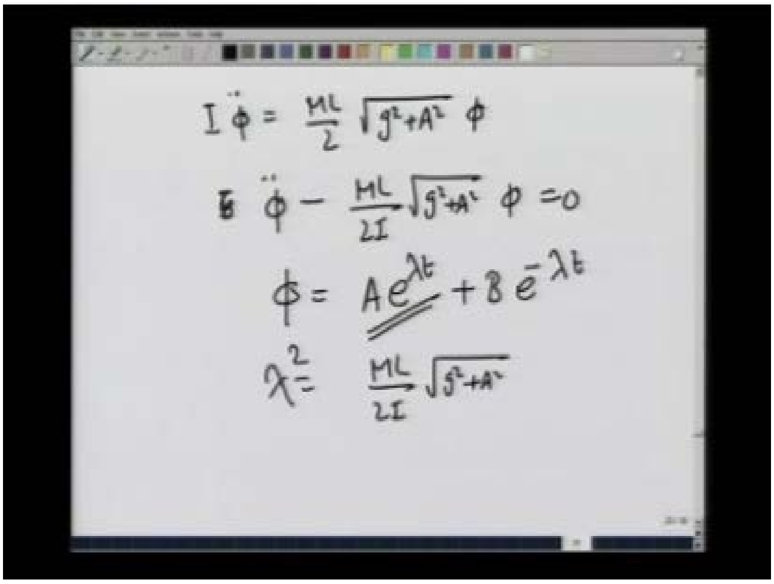

And the solution of this you have already seen in many many examples, of the form phi equals A e raise to the lambda t plus B e raise to minus lambda t, where lambda is lambda square is ML over 2 I square root of g square plus A square. So, we can see with time the solution is going grow phi is going to grow and therefore, the equilibrium is unstable problem number 2.

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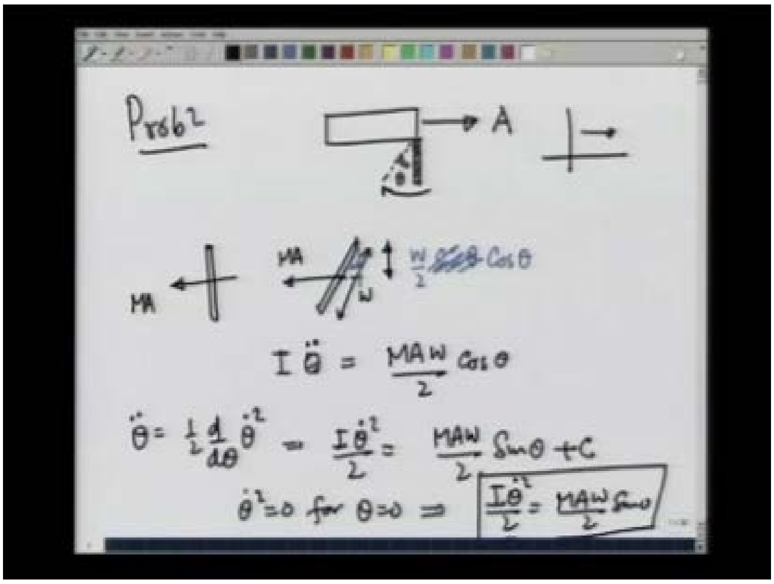

We do suppose I have a car whose door is opened at the right angle to the car and suddenly the car accelerates to the right with an acceleration A. I want to find as the door swings back when, it has swung by an angle theta what is its angular speed. As I said earlier is best to go to an accelerating frame in this yes and you will see that the door hinge here a sort of moving in a gravitational field with a force MA being applied as its centre of gravity.

At an angle theta the force acts as a centre of gravity on this side MA. If the width of the door is W then the distance from the hinge to the force if it has moved by an angle theta here is W by 2 cosine of theta. Therefore, the equation of motion of the door in the accelerating frame is going to be I where I is the moment of inertia of the door theta double dot is equal to MAW over 2 cosine of theta. Again writing theta double dot as 1 half d over d theta theta dot square we get I theta dot square divided by 2 as equal to MAW over 2 sin theta plus a constant, but theta dot square is equal to 0 for theta equal to 0 and therefore, I theta dot square over 2 is equal to MAW over 2 sin of theta and that gives you the angular velocity of the door at an angle theta when, the car starts accelerating towards the right.

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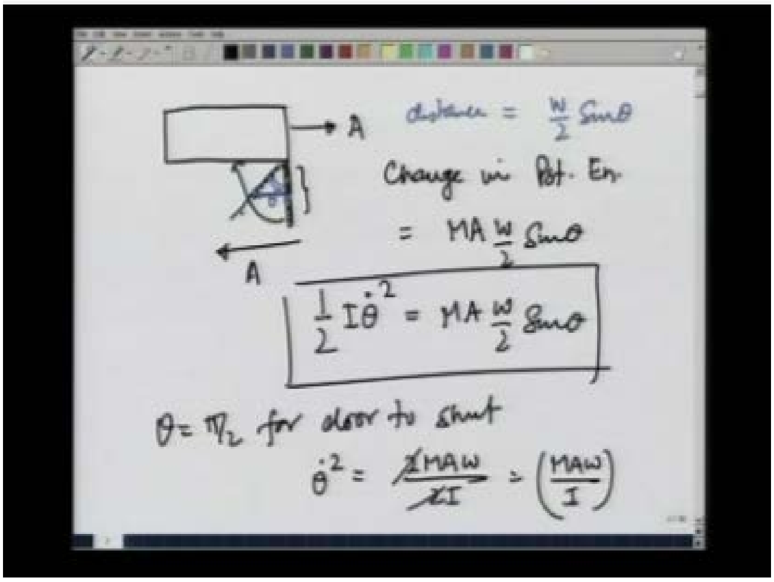

This is a nice interpretation of this and you will see that really the interpreting of this force fictitious force MA like a gravitational field makes sense, When this is moving towards the right with acceleration A we can consider this door to be in a gravitational field with gravitational acceleration A by the time the door has swung by an angle theta a centre of mass has come down by this much distance here. And that distance that it has travelled along the direction of minus A is nothing but, the W over 2 sin of theta and therefore, change in its potential energy is equal to MA which is a force times W over 2 sin of theta. It is by that much that its potential energy has decreased and therefore, the increase in the kinetic energy should precisely that MAW over 2 sin of theta and that is your answer.

By the time door shuts that is it comes all the way by then theta equals pi by 2 for door to shut. So, its shuts at an speed theta dot square which is equal to 2 MAW over 2 I 2 cancels, equals MAW over I that gives you the angular speed with which the door shuts. There is another example of solving the problem using accelerating frames as a as a 3 problem.

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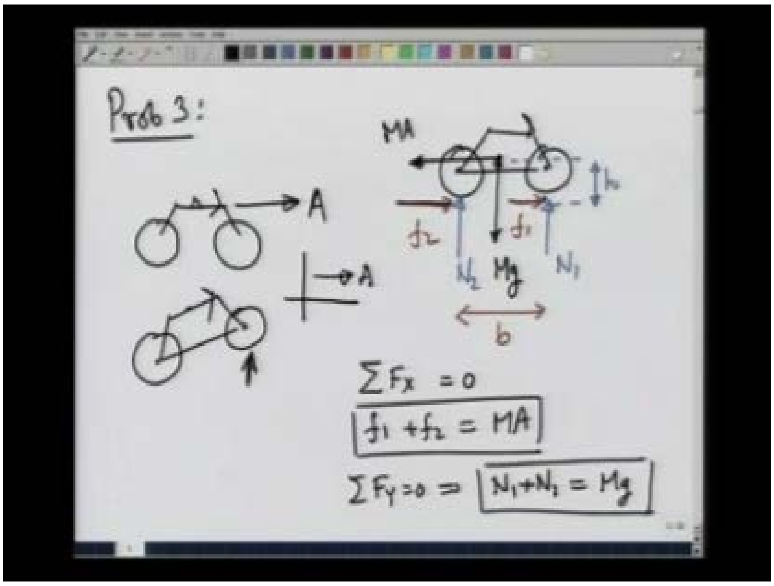

I take a problem that you must have seen sometime, that if you have a motor cycle and the rider accelerates it suddenly at a very high acceleration, then you see it tends to topple the upper the front wheel sort of lifts off the ground. And we want to calculate as to at what acceleration does it start lifting of the ground. I am again going to look at this problem from a frame which is accelerating with the motor cycle towards right with A.

If it does that, then the motor cycle is in equilibrium it is not moving in the that frame and if I look at motor cycle, it is in equilibrium under the following forces; that, the force N2 on the back wheel normal reaction N1 on the front wheel there is a frictional force f1 in the front wheel. There is a frictional force f2 on the back wheel there is the fictitious force working on the centre of gravity towards the left MA and at the centre of gravity there is a force gravitational force Mg.

Let us, take the height of the centre of gravity from the ground to be h and let us take the distance between the 2 wheels to be b. We wish to calculate as to at what acceleration does the front wheel start getting off the ground. So, in this accelerating frame the motor cycle is in equilibrium under these forces. Let us, write the equilibrium conditions. You get summation Fx is equal to 0 which gives me f1 plus f 2 equal MA. Summation Fy equals 0 gives me N 1 plus N 2 equals Mg and the torque about any point should be 0 let us take for convenience the torque about the centre of gravity. Let we make the picture again for you in the next page;

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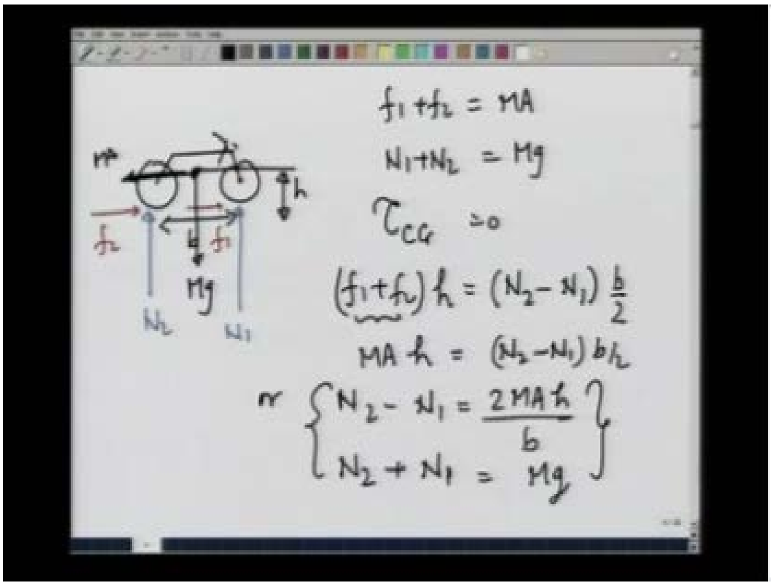

Here is the motor cycle with distance b here, centre of gravity being at height h from the ground there is normal reaction N2, N1 there is friction f2, f1 and there is a force at the centre of gravity MA and Mg and we have already found that f1 plus f2 equals MA and N1 plus N2 equals Mg and balancing the torque about CG equal to 0 gives me, f1 plus f2 which is a counter clockwise torque times h equals N2 which gives you clockwise torque minus N 1 minus. Because, N 1 gives you a counter clockwise torque times b by 2. If I assume that the centre of gravity lies right in the middle of the 2 wheels and therefore, substituting f1 plus f2 equals MA h equals N2 minus N1 b by 2 or N 2 minus N 1 equals

MA h times 2 divided by b and I already know that, N2 plus N1 equals Mg. I have got these 2 equations to solve for N2 and N1 let me show again.

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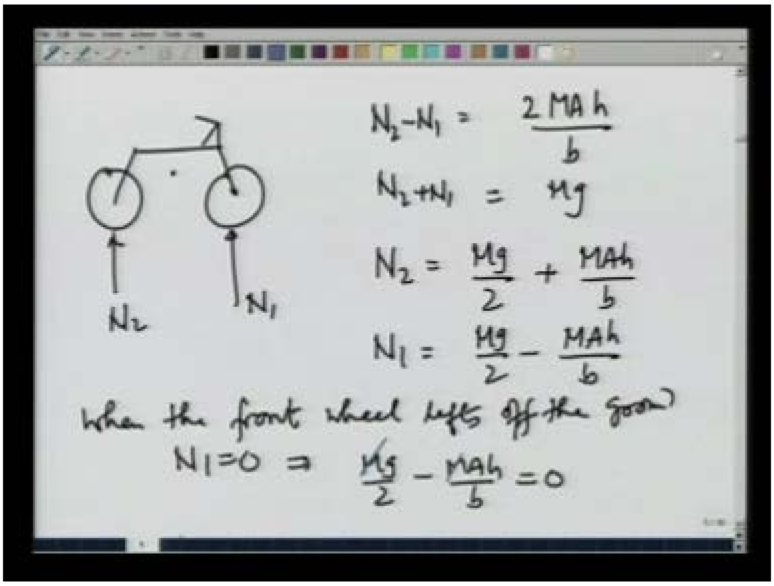

As a motor cycle is a centre of gravity here is reaction N1, here is reaction N2 and we have found that N2 minus N1 is equal to 2 MA h over b and N2 plus N1 is equal to Mg and that gives you N2 equals Mg over 2 plus MA h divided by b and N1 equals Mg over 2 minus MA h divided by b. When, the front wheel lifts off the ground N1 equals 0 and that gives you Mg over 2 minus MA h over b equals 0. M drops out and therefore, A equals we go to the next page,

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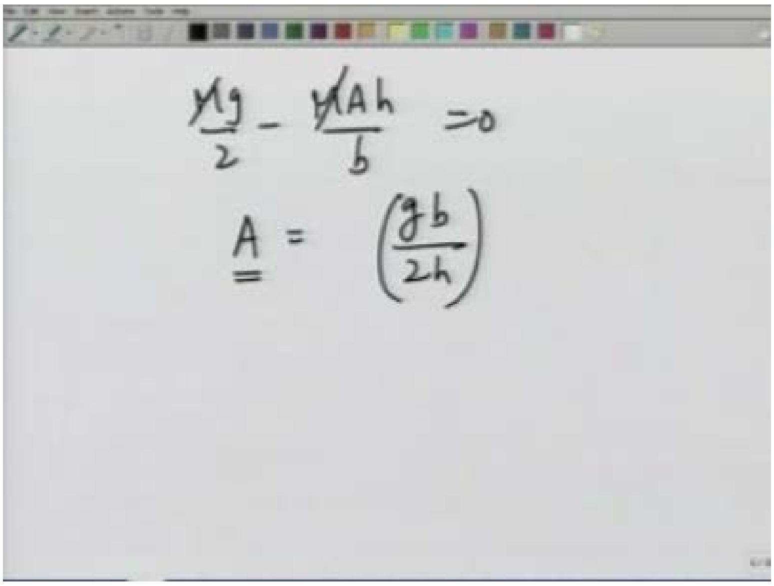

You have Mg over 2 minus MA h over b equal to 0 M has dropped out. So, A equals gb over 2 h. If the acceleration is gb over 2h the front wheel would start lifting off the ground. So, if you keep acceleration below this the front wheel doest go up. Similarly, if you decelerate exactly opposite what happen, the real wheel would start coming of the ground that I will leave for you as a problem. To conclude this lecture what we have done today is looked at solving the problem in an uniformly accelerating frame.

In the coming lectures we will go to an another kind of rotating, another kind of non-inertial frame which is a rotating frame our earth is one example, of that and see the consequences of that.