Experimental Physics I
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Lecture – 26
Experimental demonstration to calculate the moment of inertia of a given flywheel

So, now we will demonstrate how to measure the moment of inertia of a flywheel. So, as I have discussed in previous class that is, the working formula for this moment of inertia of a fly wheel.

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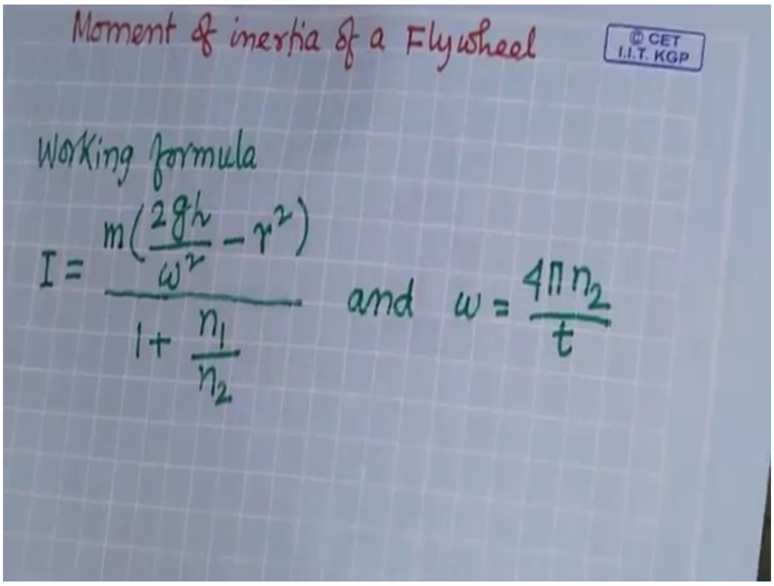

So, this the moment of inertia I equal to m 2 g h by omega square minus r square divided by 1 plus n 1 by n 2 and omega the relation of omega with the n 2 is 4 pi n 2 by t. So, this is the setup for this experiment to find out the moment of inertia of a flywheel.

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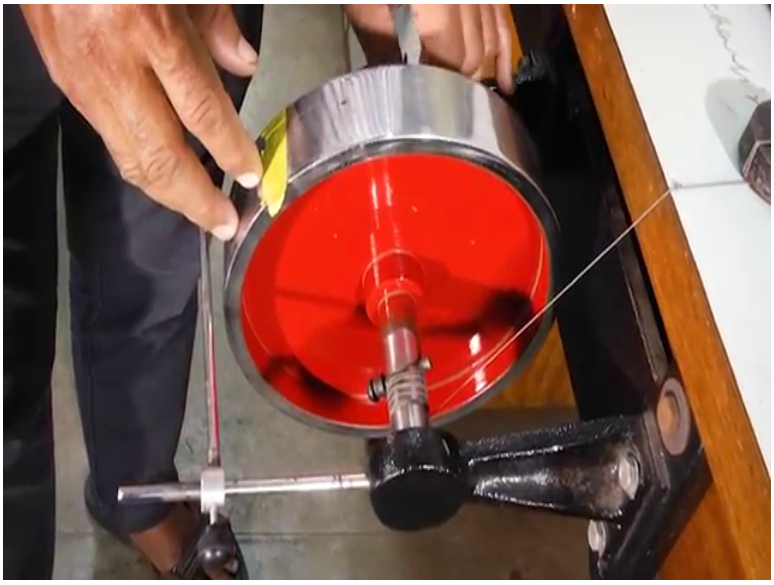

So, this is the basically this is the flywheel. So, I think yes this the flywheel. So, it has we can see this it has axis this flywheel, this it rotate about this axis right.

So, this r in the working formula whatever we have seen this r basically here this is the this radius of this of this one is r in our working formula. So, that we have to measure this radius r right. So, for measuring this radius r just first we can measure this radius of radius of this axis of the flywheel. So, why we are taking this radius of this axis of flywheel? So, that will understand because this place we are using for our experiment; so, using this thread with mass.

So, as you know this how to measure the diameters or radius.

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So, we will use as usual this slide calipers ok. So, slide calipers we will use to measure this diameters or radius. So, you know already I have discussed about this slide calipers, then how to use it, how to take reading right. So, slide calipers just we will use here this just yes first we have to take this whether is there any 0 error and then we will take this reading for this for this place.

So, here 2-3 reading you should take and then we will do averaging of these 2 3 readings and find out the diameter or radius of this axis of the wheel ok. So, why we are taking diameter or radius at this place that? I will explain you. So, one parameter we have measured that is diameters or radius. So, because it is this r is in working formula. Now we have to measure basically others, what are the parameter we have to measure here? So, g is fine g is basically this acceleration gravitational acceleration.

So, we have h height, we have to measure height. Which height we have to measure? That I will explain and how to measure radius of what that I showed you; this radius of this axis axil that we are taking that we have already measured. I showed you how to measure that one, then in this formula omega is their angular velocity. So, that we have to measure angular velocity of this flywheel; we have to measure. So, this angular velocity omega is related like this so; that means, we have to measure basically n 2 and time t. So, what is n 2 and what is time t that I will explain. So, if I measure n 2 and time t, then we can find out the omega ok. So, we have to measure practically if we measures we have to measure n 1, what is n 1 I will explain. We have measure n 2 if I measure n 2 as well as how much time it is taking for this n 2 if we measure, then we can get omega. And then we have to also we have to load some mass either we have to measure or we have to take weight and find out the mass. So, mass of what? So, here is now I will explain. So, here in this experiment you know this basically working formula whatever we have we are using. So, that is derived based on the conservation of energy. So, basically potential energy is converted into the kinetic energy as well as frictional energy. So, basically what we have done?

So, we have taken a mass with thread. So, I think I will just take out it first and then I will show you from the beginning. So, we have taken a mass. So, now, if this mass is at different height. So, this mass will have.

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So, this mass will have it if it is at the ground, so its potential energy 0 because potential energy is m g h ok. m is the mass of this one whatever if this mass is hanging from with this thread. So, this mass of this weight ok.

So, now, when it is touching the floor, then h height we have taking that 1 is 0 height; so, potential energy 0. Now when I am taking up its height from the floor is increasing. So, its potential energy is increasing m g h; h is increasing potential energy is increasing. So, if I take at this height. So, if I find out what is the height of this mass now so, then I can tell what is the potential energy stored in this mass. So, now, from this place what will do?

So, starting from this place if I if we just release this mass and it is it will move towards the floor and when it is it will move towards the floor, then this wheel also will rotate. So, we have to do arrangement for that. So, basically the mass is moving towards the floor and simultaneously, this wheel is moving. So, from where this wheel is getting energy to move? That is basically if we if we just do the arrangement in such a way that this potential energy decreasing and that energy is basically is spent for this for this movement that is rotation of this wheel.

So, basically this energy spent for this for the rotation of the wheel means, for the kinetic energy of the wheel angular kinetic energy of the wheel ok. As well as this mass initially it was at static position now also mass is moving right. So, it has some velocity say v, then also this mass will have this kinetic energy. So, that kinetic energy also it is coming from the potential energy whatever potential energy decreasing due to the mass movement towards the floor. So, basically the conversion this is a another nice experiment for showing that how this one energy is converted into the other energy.

Here basically potential energy how it is spent, how it is spent or how it is converted to the kinetic energy. So, from this experiment also 1 can understand. So, this omega is basically omega what in the formula whatever instead of this what is the angular velocity of this rotation that we have to find out. And what is then n 1 and n 2? So, n 1 is basically you see. So, this mass is hang from a thread. So, now, this thread is at a particular if I show just; if we keep this way. Here there is a hole and if I put just to this pin kind of things. In this position if I keep ok so, this it will just thrown down know if I just leave it, but that means, this h of this weight when it will just touch the floor, then it will be detach with the from this from this wheel. So, basically this way we have do the we have made arrangement. So, at this position this kinetic potential energy of this mass is 0.

So, now what we are doing? Here just you see at this position this is a marker this is the indicator marker. So, position of this wheel at this under this condition position of the wheel is see we have marked with this yellow tape ok. So, this the position of this wheel ok. Now I am taking up the upwards and I will crown this we are taking how many turns to take the mass of at a particular height. So, this is see this is one turn.

So, then I will continue this is 2 turn ok, then this 3 turn, 4 turn, 5 turn, 6 turn 7 turn, 8 turn then 9 turn, then 10 turn. So, 10 turns. So, I have taken this height of the mass up and when we are taking up, then I have taken here 10 turns; that means, ok. So, now, let me tell you. So, now, mass is at this height. So, if this height is h so, its potential energy is m g h right. So, now, what is the height that I have to measure?

So, we will use this scale, it is the basically millimetre scale here 900 millimetre; so, 90 centimetre ok. So, here I think this the another 10. So, it is the metre scale. So, its reading is take I think it is levelled with the millimetre reading. So, this other end is probably is 0 other end is probably its yes 10, its a 0. So, initial position of the of the mass was is it was just touching the it was just touching the floor. So, that is our zero reading. So, that is there.

Now, here I will take for this position what is the reading of the lower end of this mass. So, from here you can see its I think 70 yeah. So, 1 centimetre 2 centimetre 3. So, it is the 67 centimetres; it is the 67 centimetre ok. So, this height is now 67 centimetre. So, that is basically h ok; so, it is potential m g h. So, height is 70 67 centimetre. So, one can note down so, for this height at this height so, here turn is turn is 10. So, now these 10 turns basically we are telling n 1 because what is the n 1? N 1 is if I release it so, this height will this mass will go down towards floor.

It will now its velocity 0. So, it will move down its velocity will increase and this one also will rotate you know because of this rotate ok. So, that is are we are telling this potential is decreasing and that energy is spent for the kinetic energy of the wheel rotation as well as the for the motion of this mass as well as the friction as well as the friction this dissipation of energy due to friction.

So, that is because of this you see here when it is it turns ball bearing this arrangement is there. So, this because of the friction at this place inside ball bearing is there. So, there is a friction it cannot be frictionless ok. So, due to the friction, it will there will be energy spent. So, if this friction that force or energy is f for each for each turn energy spent for each turn is f. So, here during this when it will touch the floor, then it will turn 10 times right.

It will just rotate 10 times. So, for each turn it is f then for n 1 turn that is what we are telling n 1 turn ok. So, for each turn this energy distribution will be there. So, that is n 1 f basically. In theory I told you. So, this is the meaning of n 1. So, my position was 10 turn it was there. So, this 10 n 1 we are taking this the reading of this reading is 10. So, if I take 8 turn if I take say 2 turn less 1 and then another 8 turn; obviously, now see this height is different right height is different.

Now, what is the height? Height will be that we can measure this height we can measure. So, this height will be it is I think this is 1 2 3 4 5 6 it is around 54 its around 54 centimetre right. So, earlier for 10 turn it was it was 67 now for 8 turn it is 54 ok. So, in our working formula there is a variable 1 is h, another is another is r. So, r you cannot change and other variable is n. So, r cannot change.

We can change now these 2 parameter in our hand one is we can repeat the experiment we can repeat the experiment just varying the height ok. So, we will do this experiment for 3 height. So, one for 10 turn and this height is 67 and another is 8 turn and height is 54 ok. So, then you can take another height just take turn 6 and then what is the height you measure for 3 height 1 can repeat the experiment and we do one can take the average of the result, also we can vary the mass also. So, these are this 200 gram mass we have taken. So, this experiment can be done using the different mass using the different mass.

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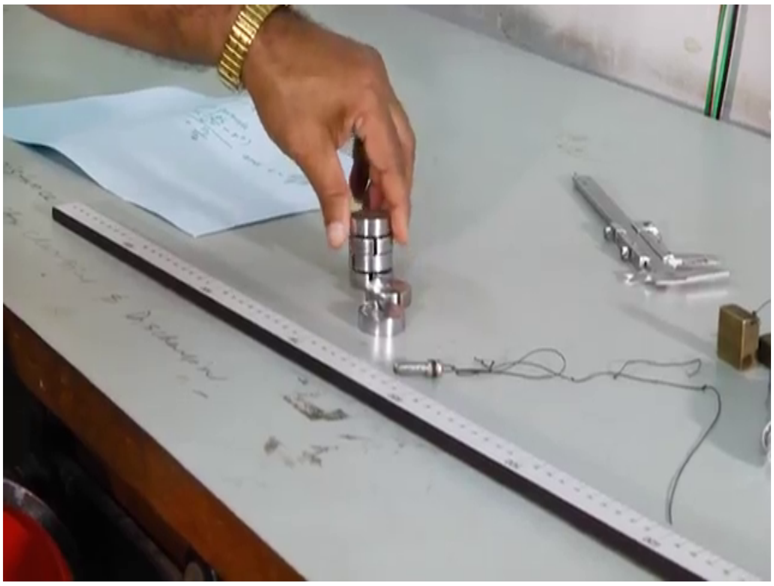

So, we have this mass of 50, it is a 50 gram. So, we have 50 gram mass. So, you put 2 3 4 mass together hang with this thread and for different mass also. So, one can do this experiment repeat the experiment for 2-3 mass also. So, for 2-3 height and or 2 3 mass one can do this experiment repeat the experiment. So, repetition of the experiment is all always better ok.

So, here just basically I will show this just show how to do for a particular mass and particular height. So, let me take this height. So, that means, I have n 1 equal to 8 turn, n 1 equal to 8 turn ok. Now I have to just I have to find out the n 2 mass I know this the 200 gram and radius already we have measured, height also h height also 54 we have measured n 1 also I know this the 8. Now I have to find out n 2 as per working formula I have to find out n 2 and time t ok. So, what is n 2 and time t?

Basically when I release it so, after 10 8 turn after 8 turn. So, this mass will be detached from the system ok. So, no potential energies or this mass will not supply any energy to the system now system. So, when mass just will detached from this wheel. So, it will have highest angular velocity, it will have highest angular velocity. So, when mass will detach so, these system will have the maximum kinetic energy now. So, because of this kinetic energy so, this wheel will continue to rotate and for his for the frictional force because for each turn this frictional force is f as I told ok or for this frictional energy spent that is f ok.

So, so this wheel starting from the highest angular velocity. So, after sometime it will just come to the rest ok. So, it is coming to the rest it means that this kinetic energy whatever this wheel was having. So, that is spent that is spent to for the for the fiction. So, to come to the rest to come to the restso, it will turn how many times it will turn? It will rotate and how much time it will take? So, that is why n 2 and t ok. So, we will use stop watch ok.

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Yes this stopwatch we have start and stop button.

I can. So, now, 0 reset now I can start and it is you can see this. Its resolution or least count is 0.01 second 0.01 second ok. So, what I have to do? When just mass will detach immediately I have to start the stopwatch and when this wheel will come to the rest and before coming to the rest how many how many rotations that I have to count. So, that is n 2, then immediately I have to stop the watch and then I have to take the reading from this watch that will be the t ok.

So, let us do this one. So, yes ok. So, my watch is ready, I reset it I reset it to 0; so, this aero reading. So, when it will just my this mass will detach from the wheel, I just start it and when it will come to the rest I will stop it. So, this one has to do very efficiently. So, I am so, this the we will count from here you know because when it will be detached. So, this position; this marker it can come at this position. So, that way we have placed it.

So, yes ok. So, it start stop since a ready I will start, then stop then reset ok. So, I have to be familiar with this. So, this basically this is the so, this think start button; this the start button, then this the stop start button stop button and this the which one is reset button that I have to see can you see please which 1 is start and stop button.

Student: (Refer Time: 26:23).

Start stop reset. So, basically I just known this mechanism; so, stop reset start stop reset ok. So, one has to be familiar with the instrument you know of the time. So, this my starting point let us be ready let us be ready ok. So, marker I kept here. So, I just now just release it. So, it started you see rotation is started rotation is started. So, is a then yI am ready to start stopwatch yes. So, I did mistake, but I have not yeah. So, one has to be efficient really ok. So, we have to start and now we see its stop ok. So, start and stop one has to really do very efficiently.

So, but I was not able to do in very accurately. So, this the way one has to practice and do the experiment ok. So, let me just repeat once more because it is not taking much time. So, all the time is an. So, this again just for another height you can do another height we can do; so, for 10. So, this way starting will be this. So, again I will take turn I will take turn ok. So, this the starting point what is it opposite way have to take; so, this 1 2 3 4 5 6 7 8 9. So, for 10 turn I will take this time for 10 turn, I will take this time for 10 turn ok.

So, for height I already had measured for 10 turn that is 67 centimetre. So, again let me try with this case. So, this hopefully I will do measurement with efficient to this time. So, I will yes. So, just I will release it now, I release it now yes. So, mass is going down mass is going down mass is going down mass is going down my stop is ready stop. So, start. So, I have started 3 4 5 6 7 8 9 10 11 12 13 14 15 16 stop.

So, time is 25 time one can take reading this time is 25.72 ok. So, t is 25.72 and this what is the how many number of turns?

Student: 16 and half.

That is sixteen and slightly moved on that that moved on is you can see this the it is the just.

Student: (Refer Time: 30:26).

Fractional thing. So, this will be half. So, how to find out this half that.

I think.

Student: (Refer Time: 30:39).

One has to just take the circumference and then what is this circumference this part of the; this arc basically ok. So, this length divide by this length of the circumference. So, that will be the fraction. So, it is 16 point whatever the fraction. So, that will be the reading ok. So, n 2 will be sixteen point let the more or less you can take this half. So, you have t t25.72, and n 2 is 16.5 and n 1 is 10 height is 56 centimetre.

So, all parameters are now known whatever in working formula you need mass is 200 gram. So, one can calculate. So, now, one can repeat this experiment for another height. So, 3 states of reading you will get or if you want this for each height you can vary the mass 200 gram is there. So, you take another mass say 300 gram and repeat again the experiment for this mass. So, that why you can you take few states of data and then in next class I will discuss how to analyse the data find out this moment of inertia of this flywheel as well as the some aspect also we will discuss; so, error calculation etcetera. So, I think this I will stop today.

Thank you very much.