Advanced Dynamics
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Lecture - 38
Gyroscopic Motion - I

With this lecture I am going to start discussions on gyroscopic motions. Gyroscopic motions are observed in axisymmetric bodies rotating about its axis of symmetry about a fixed point in inertial space. We will first calculate the gyroscopic forces in spinning axisymmetric bodies and look at precessional motion of these bodies with and without external moment.

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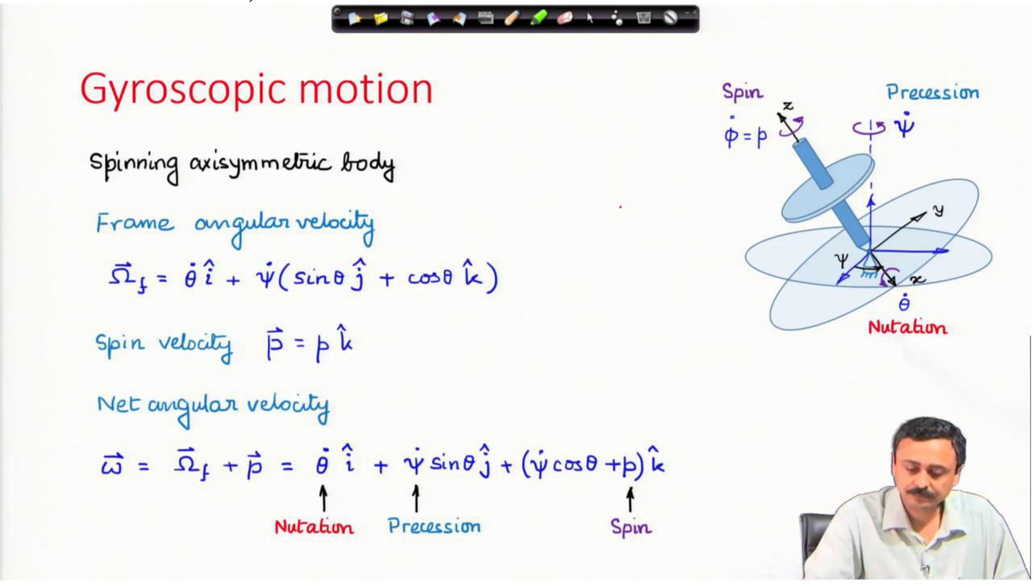

This is our prototype problem that we have discussed in the past lectures. We have discussed the setting up of the x-y-z frame which is not a body-fixed frame but ensures that the moment of inertia tensor is time invariant. The expression of the net angular velocity of the body represented in the x-y-z frame is presented in the above slide.

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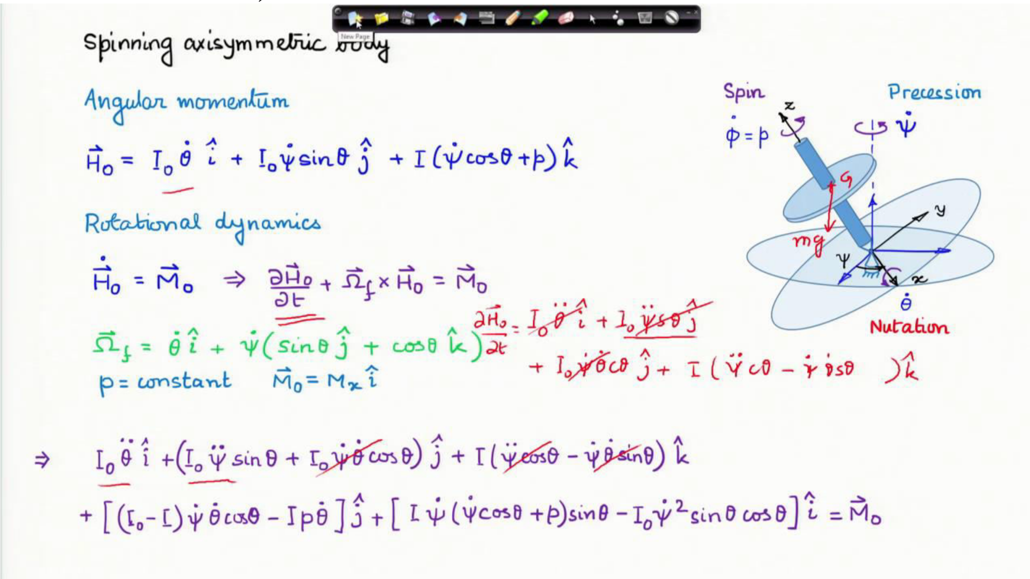

The calculation of the angular momentum about the fixed point O is shown in the above slide. Finally, using the rotational dynamics equation about O, we obtain the equation of motion.

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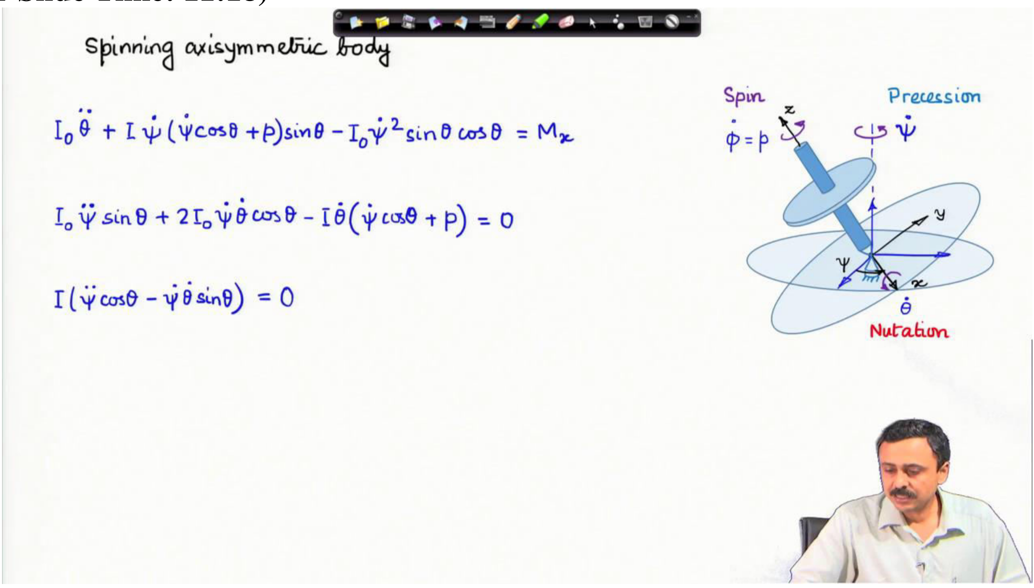
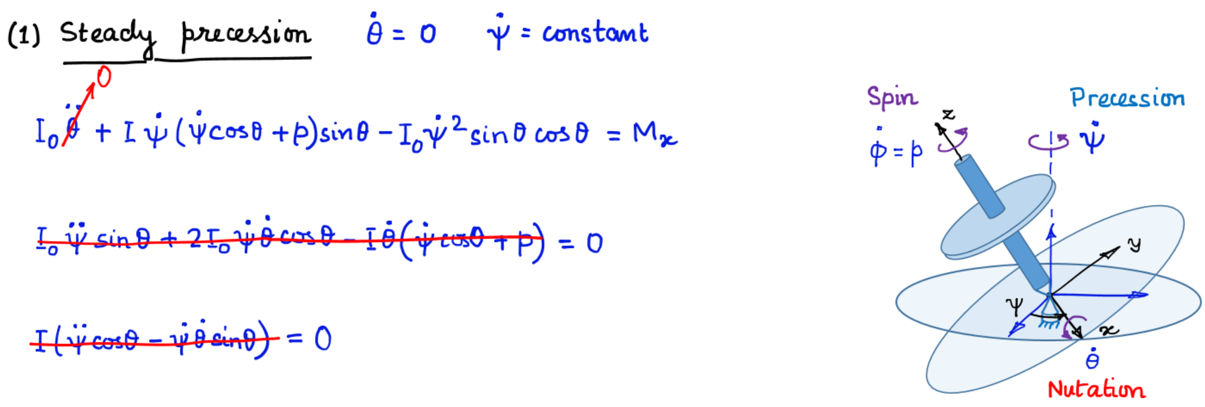


The components of the equation of motion is presented in the slide above.



For steady precession, we have simplifications as indicated in the slide above.

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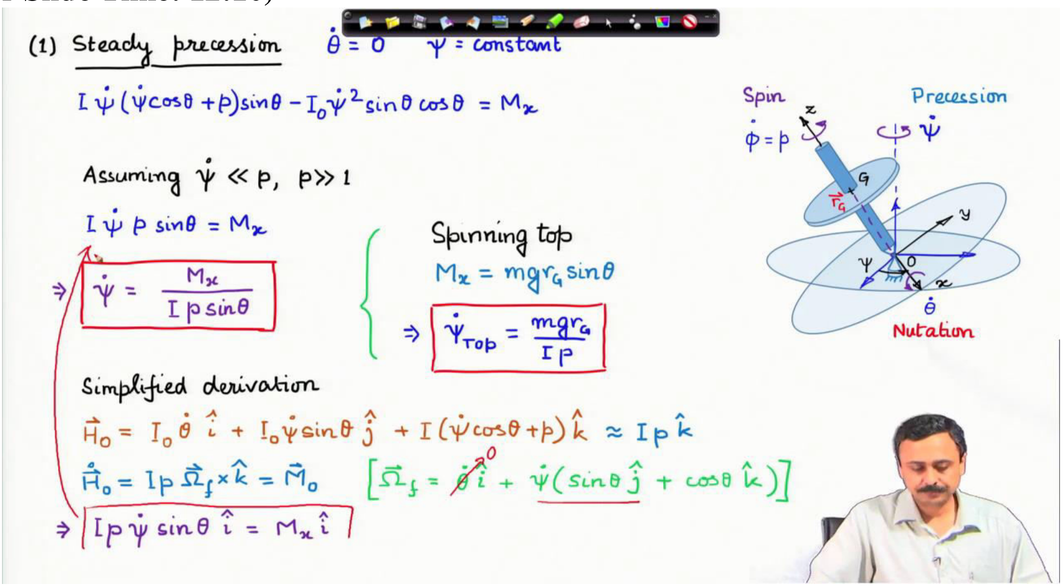

Assuming steady precession and spin speed to be much higher compared to the precession angular speed, we obtain a simple expression of the precession angular speed as shown in the slide above.

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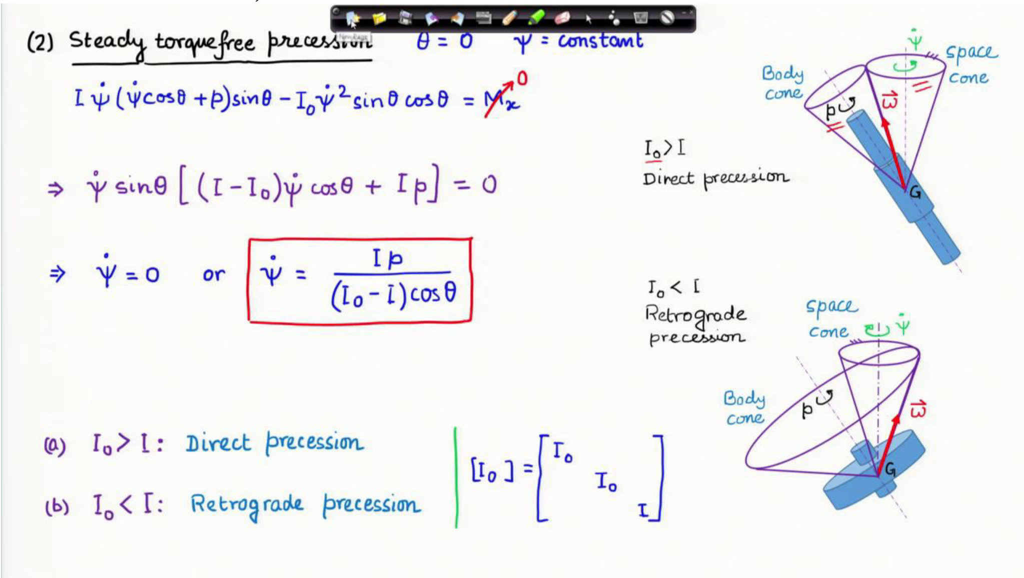

Next we look at the second simplification which is the steady torque-free precession as shown above. This leads us to two cases (a) direct/prograde precession (when I_o<I), and (b) retrograde precession (when I<I_o). In the former case, the precessional angular velocity appears in the same direction as the spin angular velocity. These can also be understood kinematically as rolling of the body cone on the fixed space cone as show in the figures.

We consider the following problem.

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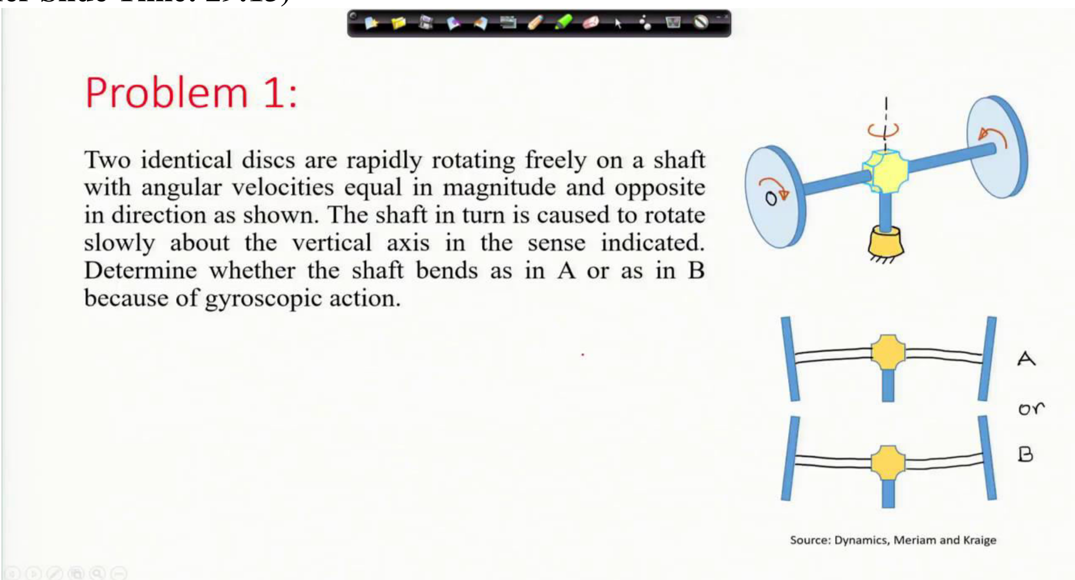

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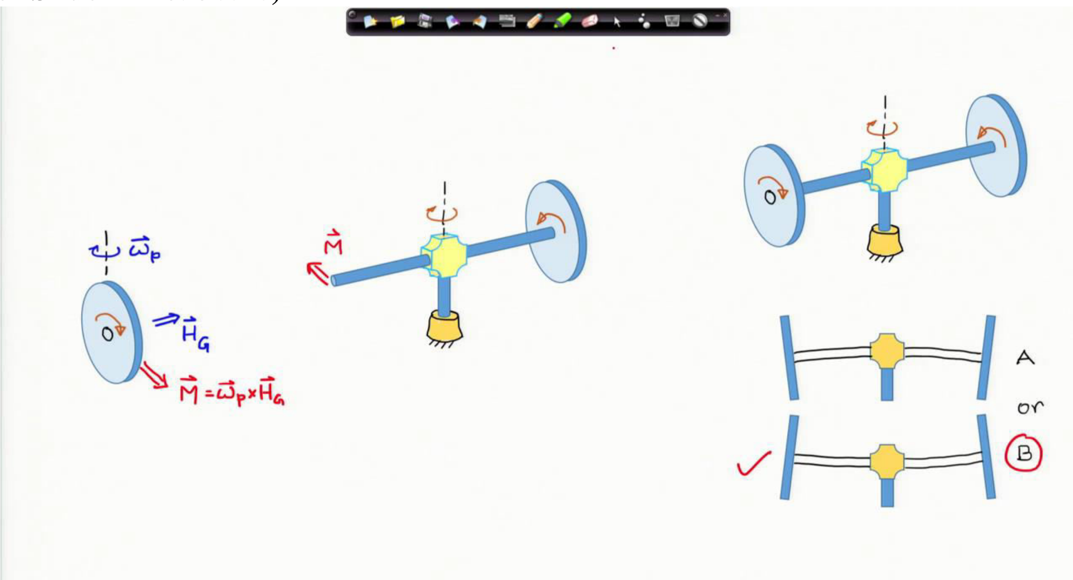

The solution is discussed in the above slide.

Consider the next problem as shown below.

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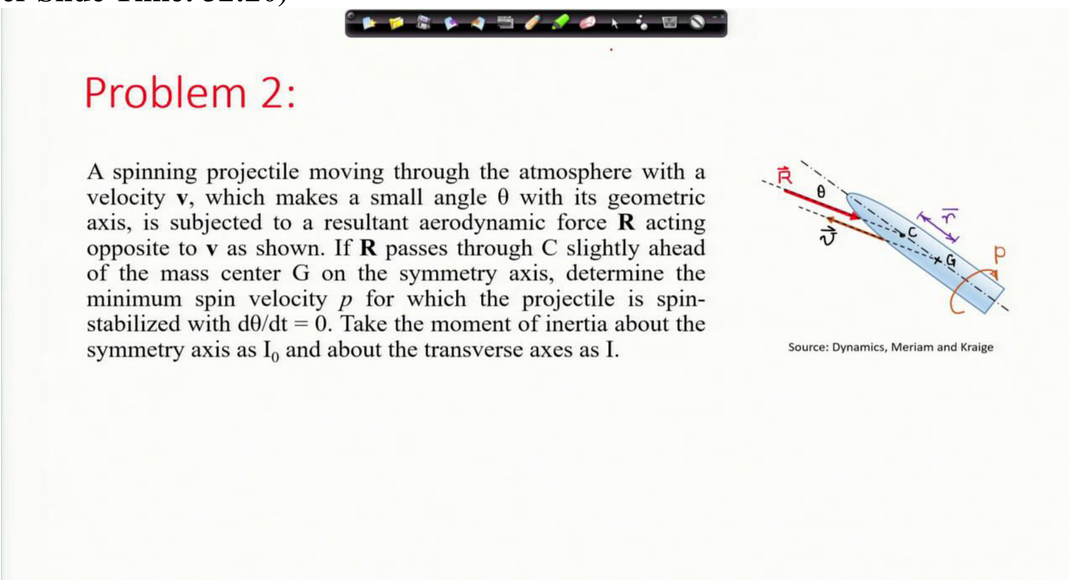

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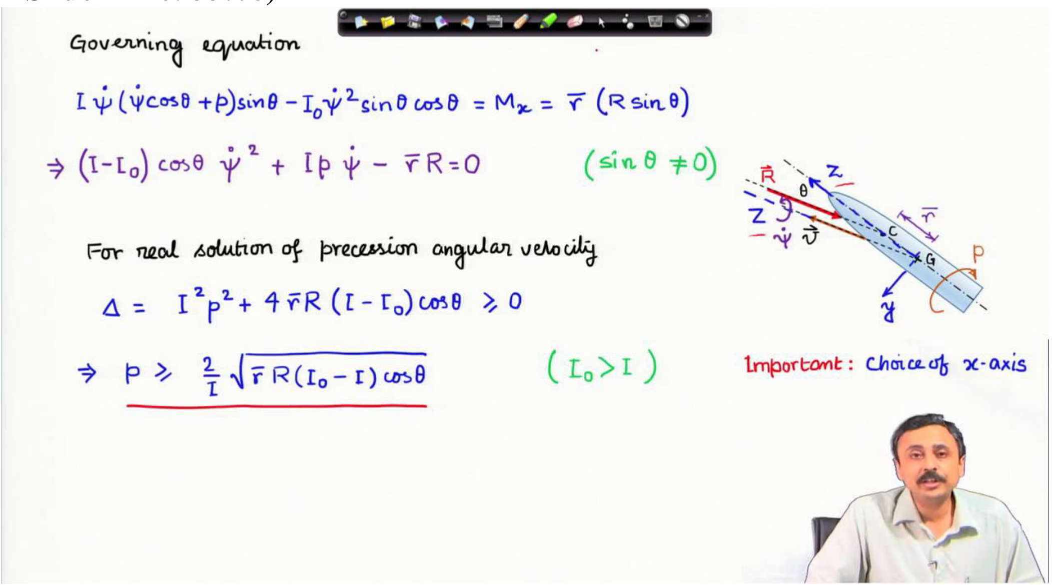

First thing we fix up is the coordinate frame based on our previous discussions. This should be noted carefully. The solution steps are detailed in the slide above.

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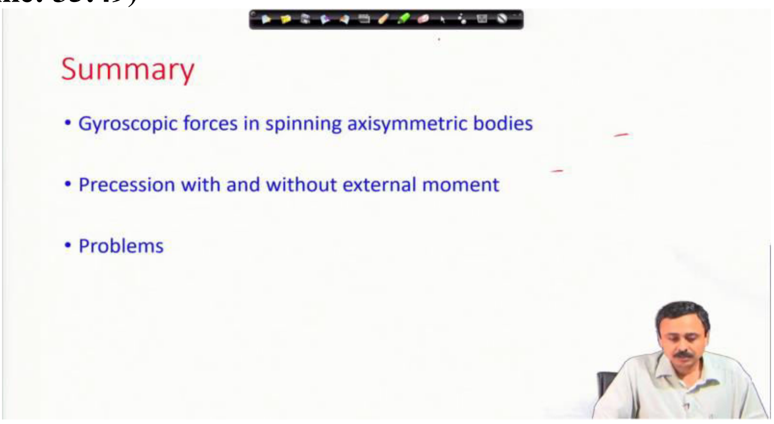

The discussions are summarized as shown above.