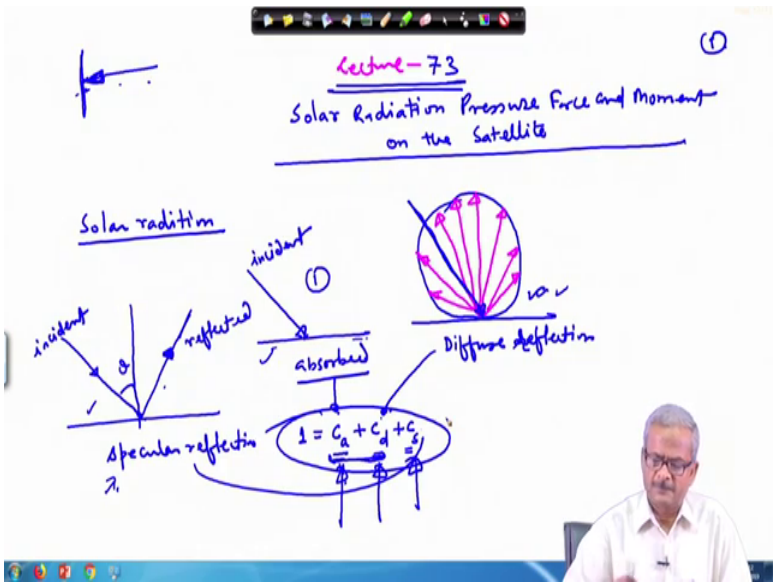
Satellite Attitude Dynamics and Control
Prof. Manoranjan Sinha
Department of Aerospace Engineering
Indian Institute of Technology, Kharagpur

Lecture - 73
Solar Radiation Force and Moment on the Satellite

Welcome to the lecture number 73. So, this will be a very brief lecture as the basic mathematical procedure will be the same as for the aerodynamic torque and the force we have calculated ok. So, I will just introduce you to various assumptions and what we need to do and the write up will appear I will upload the write up for this including the derivation and other things for the solar radiation pressure torque on the satellite and also the solar radiation force.

(Refer Slide Time: 00:54)



So, solar radiation falling on the surface of the satellite as in the case of the magnitude this aerodynamic torque and the force we have considered. So, your solar radiation one ray is coming here in the direction as shown here and then the diffuse reflection is taking place. Here, in this case this is the specular reflection, this is reflected and here in this place this ray is totally adsorbed.

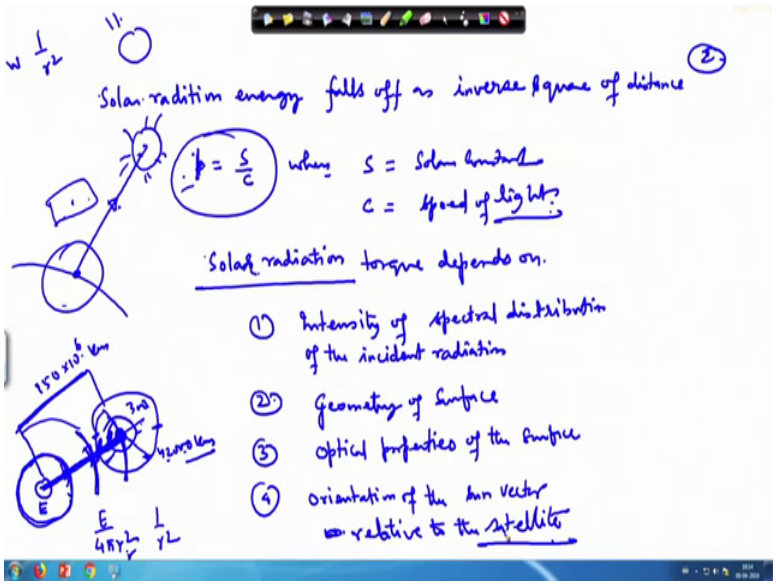
So, if we have considered that 1 unit of solar radiation is incident on the surface. So, this can be broken into three fractions; one fraction is for the observed one, another fraction for the diffused one and the third fraction for the reflected one. So, this is reflected or we

can put a notation for this I have use the notation here let us write it as c r only. So, this is the diffuse reflection, this is normal reflection, specular reflection or we can make it is to indicate this is specular reflection and this is absorbed. So this will total make 1 unit and then for each of them for if this is if we take this as the first case the radiation is incident it is totally absorbed. So, what will be the net force applied on the surface. So, this follows the same procedure ok, as been in the aerodynamic case.

So, the ray is coming here it impacts and it is totally absorbed it is not reflected back. So, due to this what will be the momentum transfer that we can calculate; similarly here in this case it is an incident ray here in this direction and then it is getting reflected here. So, what will be the total momentum transfer and here this case this is the diffuse one. So, for this also integration is required for this the whole thing the corresponding force transport will it can be all are the force applied can be computed.

So, this is various calculation for various surfaces; I will do it in the material to be uploaded there is no need of doing this because follows the same procedure as we have done for the aerodynamic force and the moment.

(Refer Slide Time: 05:06)



So, solar radiation energy falls off as inverse square of the distance or inverse square of the distance means 1 by r square energy it falls off. If the solar radiation is coming from the sun so this as you go from distance to distance.

So, whatever the power is there so, or says the energy falling over the per unit area if you go here in this direction. So, this will keep decreasing here you will get the per unit area very large quantity say the total energy emitted by the sun in unit time is e ok. So, here if you take the area and divide this E divided by 4 pi r square it gives you the energy per unit area. If you come here so, you can see that this will reduced because the area is increasing as r square. So, the energy per unit area it decreases in terms of 1 by r square.

So, as we keep going far away where it will keep decreasing. Now, if you look here into the say sun is here and the earth is here and around the earth there is a satellite. And this satellite let us say this in the 300 kilometres orbit and the other one is in the 42000 kilometre orbit which is the approximately geostationary altitude height. But distance from this place to this place it is approximately 15 crore kilometre means 150 into 10 to the power 6 kilometre; 150 million kilometres. So, this distance it is a quite small the distance from 300 kilometres to 42000 kilometre. So, sun has to travel a very little distance as compared to this.

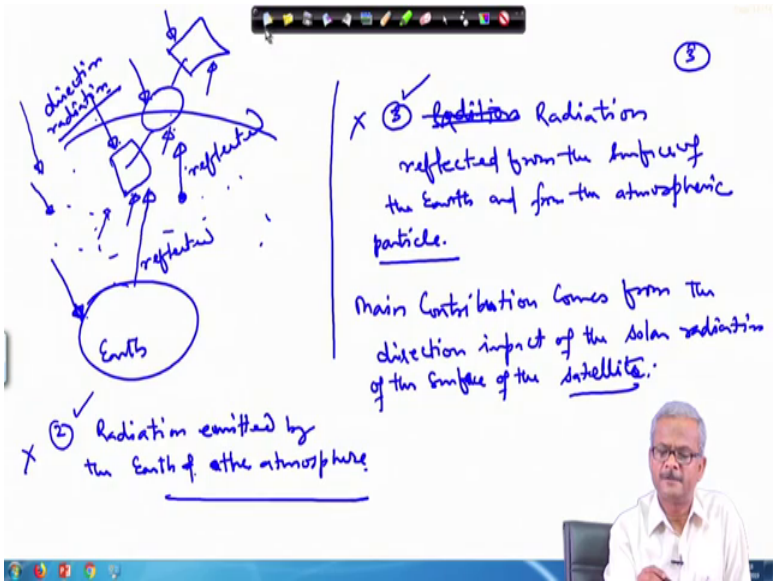
And therefore, the radiation pressure at this place and this place it will not be much different and radiation pressure equation it is written as p equal to S by C; where S is written as the solar constant and C is the speed of light. So, the solar radiation torque, so you can see that it is this is the pressure at any surface. So, if the pressure is known so immediately you can calculate the force acting on the surface also the torque acting on the surface can be computed. Only thing this gets complicated by the way that some are absorbed, some are the diffused and some are the specular one.

In the case of the aerodynamic one only the diffuse one was present and specular one was very minor which is shown here in this case. So, basically this part we are written together in the this is absorbed in the contamination layer on the surface and thereafter it is emitted. And for that reason what will be the torque acting on the torque and the force acting on the system. So, we have to follow the same procedure as done for the aerodynamic one.

So, solar radiation torque depends on intensity of the spectral distribution of the incident radiation geometry of the surface also optical properties of the surface of the satellite and orientation of the sun vector or vector from the satellite to the sun if this is your satellite. So, in the orbit from here and sun is somewhere here ok. So, this is a vector from the

satellite to the sun. So, orientation of the sun vector related to the satellite its relative to the satellite.

(Refer Slide Time: 11:27)



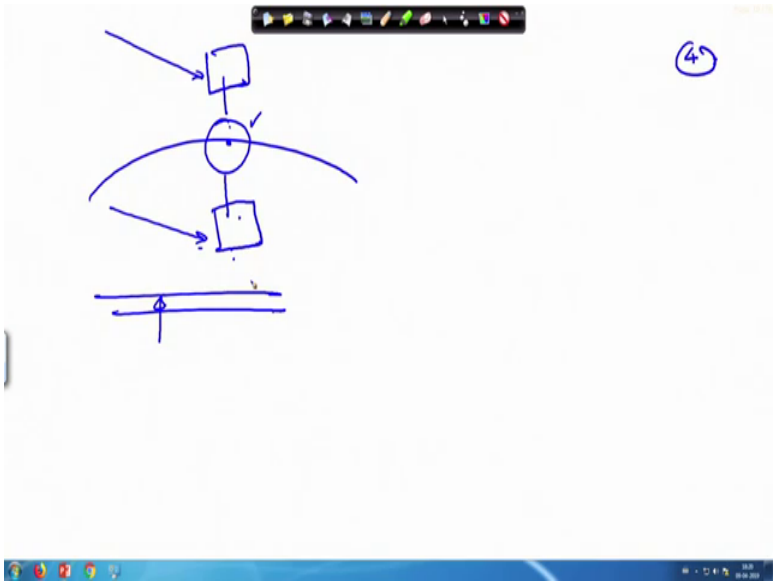
Now, if the satellite is in the orbit. So, direct radiation of the sun is falling on the surface of the satellite. So, this is the direct radiation the other one is that absorbed by the atmosphere. So, here is the earth. So, earth will the radiation is falling over the earth and also the atmospheric particles are there distributed throughout ok. So, they are also getting the radiation energy and there after they release the energy. So, they will give absorb one wavelength and emit it on another wavelength ok. So, this will also go and impact the solar panel and the satellite main body. So, the second one is radiation emitted by the earth and the atmosphere earth and the atmosphere and third one is directly from the reflection.

So, sun radiation is coming here it is falling on the earth and then some of them is getting reflected. So, this is reflected similarly from the atmosphere some of them will be reflected. So, this will also go and impact. So, the radiation reflected; radiation reflected from the surface of the earth and from the atmospheric particles.

So, all this three will be contributing. However, this two are dropped out the main contribution is taken from; main contribution comes from the direct impact of the solar radiation on the surface of the satellite ok. So, once you neglect them then the procedure

becomes easy and it is then it is of the same nature as the aerodynamic force and torque acting on the satellite with little bit of difference.

(Refer Slide Time: 15:24)



So we will conclude here. Now, so what we have done that I have in the orbit one satellite is there, on the satellite there is solar panel once you do the research. So, you can take it to any complication whatever you want to do because you will need to provide time accordingly. So solar radiation is coming and directly impinging on this, then depending on the orientation of the panel, shape of the panel optical properties of the panel of optical properties of the satellite it is a shape.

So, this force and the torque will depend. So, the material I am going to upload. So, it will include all these quantities how to calculate them and what are their significance. So, we will discuss all this in the material to be uploaded. Thank you very much for listening we will conclude this lecture here.

And so, thank you for being with me for this course and I hope that you enjoyed the course and it is useful to you and supplementary material I will be uploading there are many things to be uploaded which I have not included in the lecture because of the shortage of the time ok. So, hopefully they will benefit you and I wish you all the best for the exam.

Thank you very much.