Introduction to Launch Vehicle Analysis and Design

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Lecture - 32

Concluding Remarks

Hello and welcome to the concluding lecture of this course on introduction to launch vehicles analysis and design. In this final lecture, we will attempt to take an overview of the course that we have gone through and we will also look at possibilities of future reading in this very important area. So let us begin.

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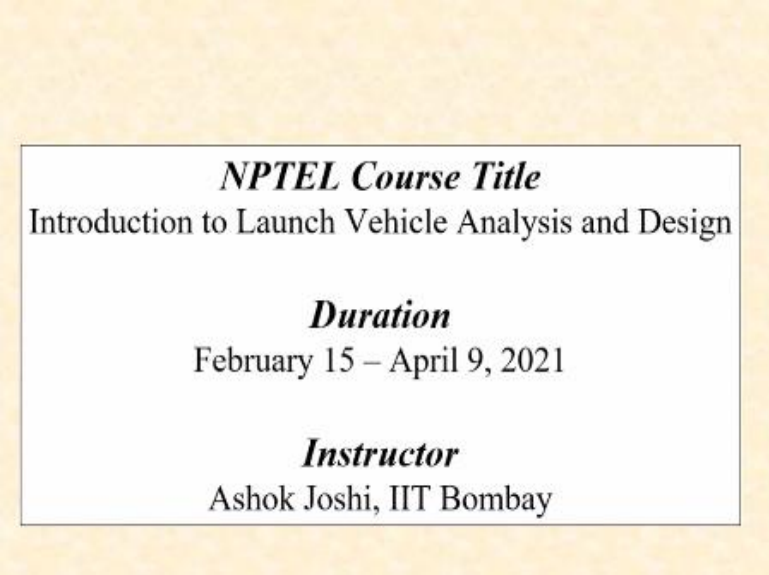

So, I am sure you would recall this slide, which I had put in my very first lecture as the introduction to the course when we started. We have now completed our journey of eight weeks starting February 15th. And during this period, we have looked at many aspects of launch vehicles, the analysis of the trajectory and the design aspects as well as the design of the configuration of multi-stage vehicles.

What I would like to do is to kind of take a look at what we actually had started off as our overall plan and to see if we have been able to reasonably adhere to it and provide the information that was intended.

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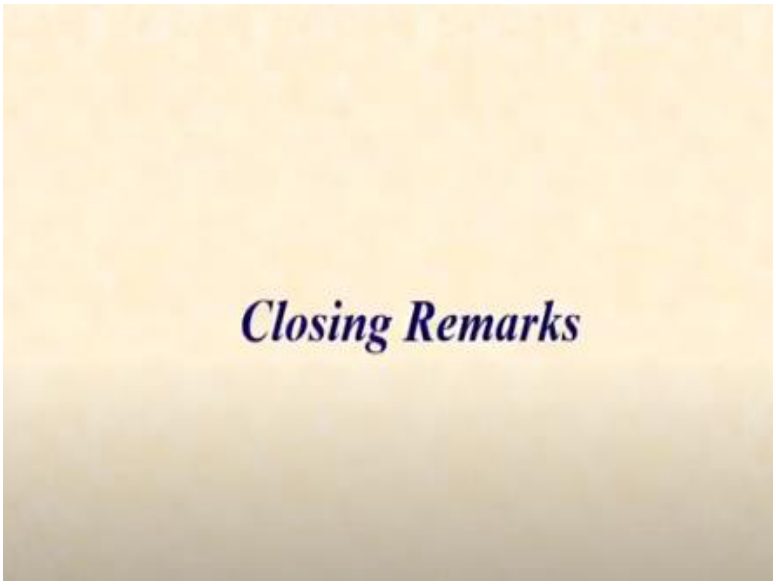

So let us begin our final journey of this course, through closing remarks.

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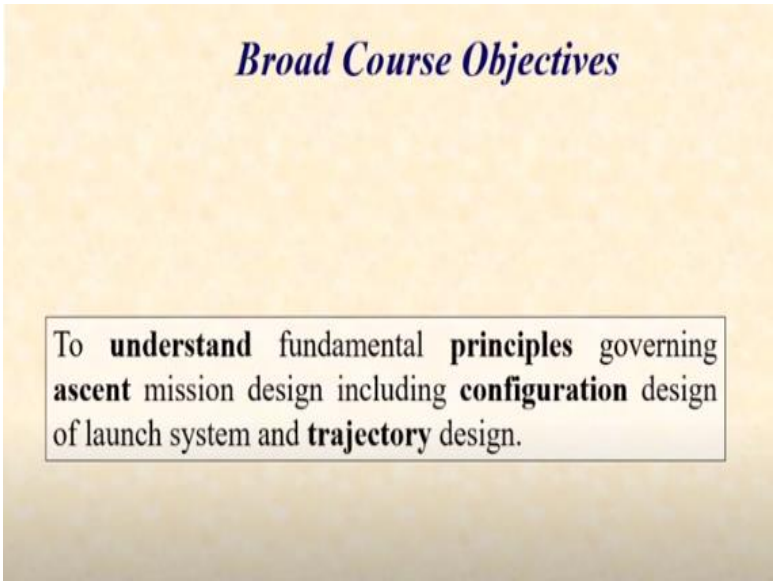

If you recall, the broad course objectives with which we started was to understand fundamental principles governing ascent mission design, including configuration design of launch system and the trajectory design.

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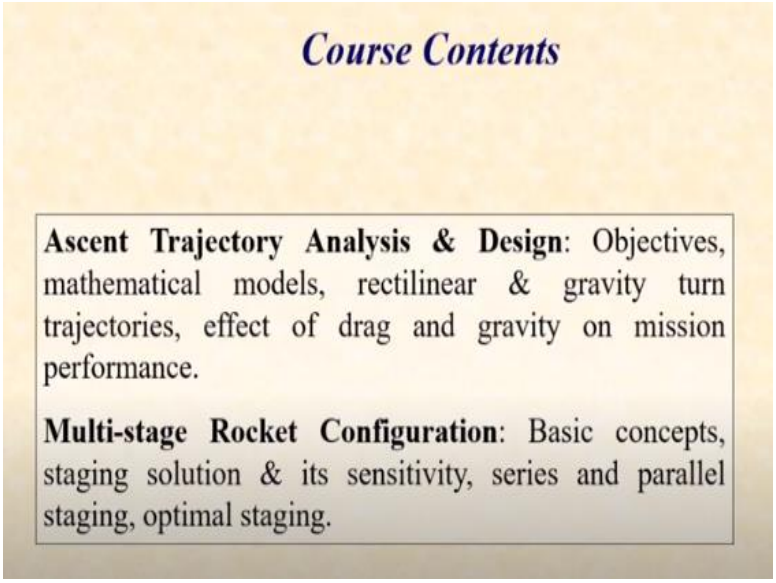

With this objective in mind, we had put the following contents in front of us which we intended to cover during these eight weeks. That is ascent trajectory analysis and design containing mathematical models, various trajectories via system effects such as drag, gravity, etc.

Then, in the context of multi-stage rocket configuration, our intention was to look at the staging solution and sensitivity, series and parallel staging, optimal staging. This is all what we had intended to cover. The point is, how did we do? Did we fare well? Let us look at it.

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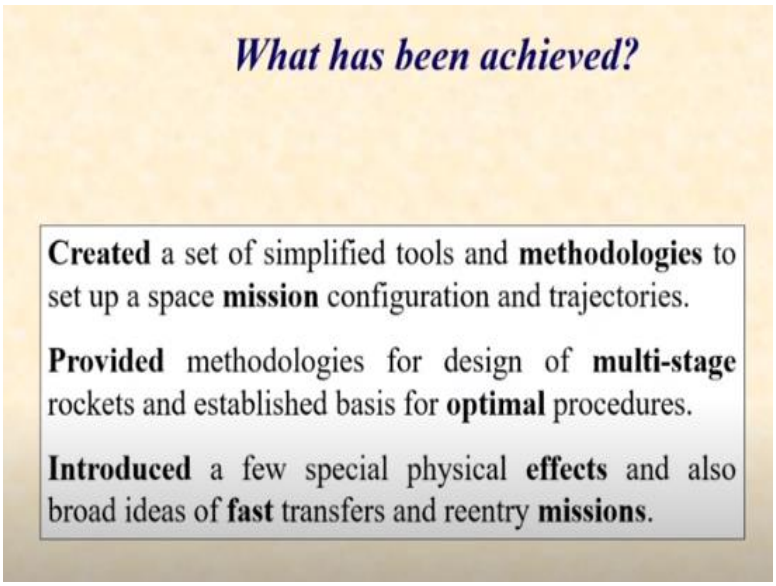

So, what has been achieved? If you just recall the material that we have covered, we have created a set of simplified tools and methodologies to set up a space mission

configuration and trajectories. So, the first objective has been reasonably served. We have also provided methodologies for design of multi-stage rockets and established basis for optimal procedures.

So, we have done that as well which was also the second objective. Now in addition, we did something more than what we had intended or what we had planned for in terms of introducing a few special physical effects such as jet damping. We also looked at some special current concepts in the form of air-breathing rockets, photonic rockets. And we also introduced ideas of fast transfers, launch window and the reentry missions.

So, this was something which we did not explicitly intended. But as many of these in some ways were related to the basic launcher configuration, I thought it appropriate to include this as part of our course.

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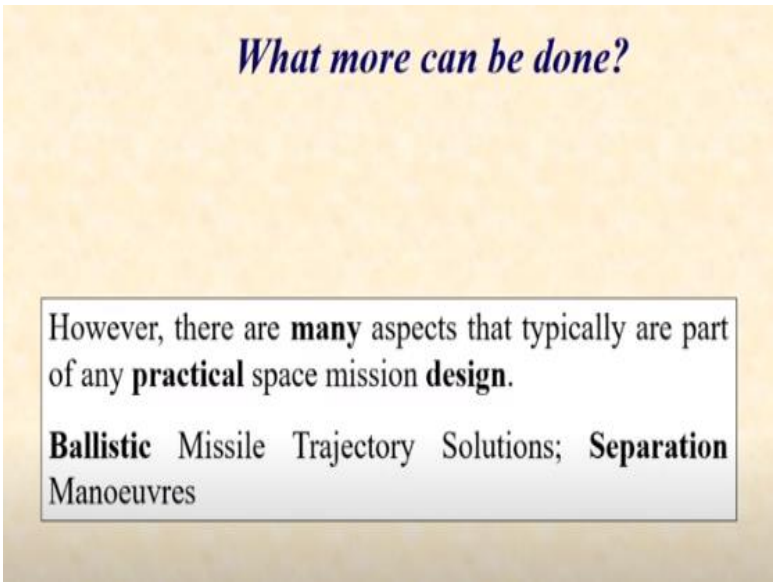

Question is, is that all? Is there anything more that we can do? And here I would like to say that yes, in a course which spans only eight weeks, we can only touch upon some aspects and we have chosen the ideas that we have presented in this course. There are many aspects that are typically part of any particular space mission design. I will only list couple of them, but there are many more that you can think of.

So ballistic missile trajectory solutions. If you recall, I did introduce the basic idea of ballistic missile concept, but left it at the conceptual level in terms of what it intends, but did not give a detailed trajectory solution. So, one could look at those detailed

trajectory solutions and to some extent relate to the ballistic reentry trajectory solutions that we have seen as part of this course.

Another aspect that we have not touched upon and is an extremely important and critical aspect is the separation maneuver. The separation maneuver is the backbone of all space missions that use multi-stage rockets. And hence needs a separate study of the separation dynamics, the various mechanisms and the associated solutions as well as safety measures, which are part of such design procedures.

Another aspect that we have not looked at explicitly are the attitude dynamics and control of launch vehicles, which is again an essential ingredient of the ascent mission trajectory design. Because during atmosphere motion, there will be disturbances and in order to hold the trajectory as per requirement, you need to provide some amount of control.

You would also have realized that we made an assumption of zero angle of attack during the ascent mission. One of the ways in which that would be ensured would be through a closed loop attitude control. And then of course, there are other aspects of launch pad dynamics, the liftoff mechanisms, the other issues of modeling the atmosphere, the recovery of payloads through different reusable technologies.

Greater emphasis is on development of propulsions for future, the propellants for future. So, there is a whole lot of material that can be looked at. So, I hope that this short course of eight weeks has given you sufficient background material.

But more importantly, I hope it has also given you a lasting interest in this area of launch vehicle analysis and design and that you would be able to sustain this interest with additional material reading and be able to practice some of the things and contribute to this important discipline that all of us feel is going to be the future of the mankind. So, with this let me wish you all the best for the exams and bye for now. Thank you.