Rocket Propulsion - Video course

COURSE OUTLINE

1. Motion in Space
2. Rocket Principle
3. Nozzles
4. Chemical Propellants
5. Solid propellant rockets
6. Liquid propellant rockets
7. Monopropellant rockets
8. Hybrid rockets
9. Combustion instability
10. Electrical rockets
11. Nuclear and advanced rockets; future goals.

COURSE DETAIL

Lecture. No	Topic
	I. Background and Requirements
1	Introduction, Motion of bodies in space, parameters describing motion of bodies, frame of reference
2	Impulse, force, universal law for gravitational force, motion in rotating frame of reference, pseudo-centrifugal force
3	Orbits, orbit velocities, orbital period, geosynchronous and geostationary orbits, eccentricity and inclination, polar, sun-synchronous and other orbits
4	Energy requirements for orbit, escape velocity, orbital and suborbital flight, state of weightlessness under free fall
	II. Rocket Principle
5	Means of achieving orbit, Motion of a sled initially at rest
6	Motion of giant squids, Rocket principle and Rocket equation

NP-TEL

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http://nptel.iitm.ac.in

Mechanical Engineering

Pre-requisites:

- Thermodynamics.
- Fluid Mechanics.

Additional Reading:

1. Timnat, Y. M., Advanced chemical rocket propulsion, London: Academic Press,,1987.
2. Shapiro, A. H., The dynamics and thermodynamics of compressible fluid flow, vol. 1, New York: John Wiley and Sons Inc., 1953.
3. E. Stulinger, Electric propulsion development, Progress in Astronautics and Aeronautics, vol. 9, Academic Press, New York, 1963.
4. M. Barrere, A. Jaumotte, B.J. Veubeke and J. Vanderkerckhove, Rocket Propulsion, Elsevier Publishing Company, Amsterdam, 1960.

Coordinators:

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7	Mass ratio of rocket, desirable parameters to achieve high velocities, propulsive efficiency
8	Performance parameters of a rocket, staging and clustering, classification of rockets
	III. Nozzles
9	Rocket nozzles: Expansion of gases from high pressure chamber, efflux velocity, shape of nozzle
10	Convergent divergent nozzle, choking, variation of parameters in nozzle
11	Expansion ratio of nozzles, Performance loss in nozzles
12	Under-expanded and over-expanded nozzles, flow separation,
13	Contour nozzles, adapted nozzles and unconventional nozzles,mass flow rates and characteristic velocities
14	Thrust developed by a rocket, thrust coefficient, vacuum and sea level specific impulse, efficiencies and thrust correction factor
	IV. Chemical Propellants
15	Chemical propellants: Choice from considerations of molecular mass, specific heats, specific heat ratios, temperature and pressure
16	Choice of chemical propellants: heats of formation, moles and mixture ratio; choice of mixture ratio
17	Calculation of heat of combustion, temperature, molecular mass and rocket performance parameters
18	Solid propellants: Double base, composite, composite modified double base and nitramine propellants
19	Liquid propellants; Energy content and classification, Earth storable and space storable propellants, hypergolic and other features, hybrid propellants
20	Influence of dissociation on propellant performance, frozen and equilibrium analysis
	V. Solid Propellant Rockets

21	Solid propellant rockets: burn rate of double base and composite propellants, parameters influencing burn rates
22	Choice of burn rates for stable operation
23	Propellant grain configurations: design of solid propellant rocket
24	Ignition of solid propellant rockets, ignition problems and solutions
25	Characteristic burn times and action times of solid propellant rockets, variation of burn rates with rocket size, erosive burning, components of solid propellant rocket
	VI. Liquid Propellant Rockets
26	Introduction to liquid propellant rockets, propellant feed systems, cycles of operation, gas generator, topping/staged combustion cycle, expander and other cycles, factors influencing choice of cycle
27	Thrust chamber, injector types, combustion chamber
28	Calculation of efficiency of liquid propellant rockets from non uniform distribution of propellants and incomplete vaporization, characteristic length of chamber
29	Cooling of thrust chamber and nozzle
30	Performance and choice of feed system cycle, Choice of parameters for liquid propellant rockets
31	Turbo-pumps for liquid propellant rockets
32	Expulsion of propellants using high pressure gas and mass requirements, draining of propellants under microgravity conditions
33	Complexity of liquid propellant rockets, determination of performance; current trends
	VII. Monopropellant and hybrid Rockets
34	Monopropellant rockets
35	Hybrid rockets

	VIII. Combustion Instability in Rockets
36	Combustion instability in rockets; illustration through examples, bulk and wave modes of instability
37	Modeling of bulk mode of instability in solid and liquid propellant rockets
38	Standing waves and characteristic frequencies in different wave modes
39	Modeling of wave mode instability in rockets
40	Other types of instabilities; Pogo, vortex shedding etc., Methods of overcoming instability problems
	IX. Electrical Rockets
41	Electrical rockets: electrical and magnetic fields, electro-thermal, arc-jet, electrostatic and electromagnetic thrusters
42	Gridded ion thrusters, neutralization and thrust limitations, Hall effect thrusters
43	Choice of parameters for electrical thrusters, specific mass and optimum efflux velocity, Current trends in electrical rockets.
	X. Nuclear and Advanced Propulsion
44	Nuclear, tri-propellant and advanced propulsion: Future trends.

References:

1. Hill, P. G. and Peterson, C.R., Mechanics and thermodynamics of propulsion, 2nd ed., Reading, Massachusetts: Addison Wesley Publishing Company,, 1992.
2. Sutton, G. P. and Biblarj, O. Rocket propulsion elements, 7th Ed., New York: Wiley Intescience Pulications, 2001.
3. Mukunda, H. S., Understanding aerospace propulsion, Bangalore: Interline Publishing, 2004.
4. Ramamurthi, K., Rocket Propulsion, Macmillan (in press) 2009