

INSTITUTE OF ARMAMENT TECHNOLOGY
FACULTY OF APPLIED MATHEMATICS
DEPARTMENT OF BALLISTICS

PROPOSAL FOR ESTABLISHING A CENTRE FOR ADVANCED
STUDIES IN BALLISTICS AND SPACE MECHANICS AT
THE INSTITUTE OF ARMAMENT TECHNOLOGY

The University Grants Commission has felt the need to promote advanced training and research in the university departments with the following aims and objects.

1. The scheme is intended to encourage the pursuit of excellence and team work in studies, training and research and to accelerate the realisation of international standard in different fields. It is proposed to give active support and substantial assistance to promising departments in a university selected on the basis of quality and extent of work already done in terms of their professional reputation and contributions in research and their potentiality for further developments.

2. The assistance is to be provided in terms of competent and promising personnel and essential equipments. The departments would have Professors, Readers and Research Associates/Fellows of outstanding ability and qualifications actively engaged in research and advanced studies. The substantial portion of faculty will be of floating type on deputation from other Universities/Institution in India or abroad.

3. Such a scheme will raise the standard of teaching/training and research in different fields. This will also make an appreciable impact to attract teachers and scholars; and thus will help in maintaining corporate intellectual life which in turn will demand team spirit and cooperation on the part of participants.

With these objectives in view the University Grants Commission has instituted many such centres in different subjects at various universities. For example advanced centres for Pure Mathematics have been instituted at Universities of Bombay and Punjab while advanced centre for Applied Mathematics has been established at Calcutta University. Two advanced centres viz; advanced centres in Statistics and in Sanskrit have been established at Pune University. While there are such centres in different subjects established by UGC at different universities but no such centre of excellence exists in the subject of Ballistics and Space Mechanics at any University/National Laboratory or elsewhere in the country. Keeping in view of the need for such a centre, it is proposed in this note to pursue a case for establishment of advanced centre in Ballistics and Theoretical Space Mechanics

It is highly desirable to have a Centre of advanced studies in ballistics and space mechanics. Dr. Sharma, whom I know very well, and his other colleagues have done very useful work in the field and can be entrusted with the formation of this centre. I have gone through the proposal details contained in the proposal enclosed with your letter & seen same and agree with the several points raised therein.

and to seek the approval of the Govt of India to start this centre at the Institute of Armament Technology Pune. Undoubtedly such a centre will meet the basic needs of defence research and development activities in diversified fields.

INTRODUCTION

It goes without saying that the subject of Ballistics and Space Mechanics with defence orientation is the root and basic field for armament science and technology. The subject of Ballistics has grown with the Institute since its inception. Prominent persons like Dr. BS Madhav Rao, FNA, FASC., Dr. VR Thiruvenkatachar FNA and Dr. SN Barua who have been on the roll of faculty of Applied Maths in general and this subject in particular, developed teaching and research in Ballistics, a subject underdeveloped in sixties. They concentrated their attention on original research aimed at reaching the advanced standards, and under their leadership graduate level teaching was established and some progress in research in external ballistics was made. Later original research work was however, continued in the field of external and internal ballistics (Research work and Ph.D. thesis completed and in progress till 1982 are listed as Appendices A & B). Besides this, considerable attention was concentrated on teaching, aimed at reaching the highest standard. In its chosen field of work viz. external ballistics, the Institute has developed professional reputation and contribution to original research. This prompted the department of Maths. (Poona University) to seek the help of the faculty members of this Institute to introduce ~~and to introduce~~ and to teach the subject of ballistics at MSc level to the regular students of the university. And now apart from imparting instructions to the students of various armament courses, the department of ballistics teaches the subject to MSc students of Poona University.

Further, it is emphasised that besides teaching activities at the Institute and Poona University, the subject has been recognised by Poona University for post-graduate studies and research. The Ph.D. programme in external ballistics is a regular feature of the department. The research advisers are guiding Ph.D. scholars in the field of external and internal ballistics. The department has since produced three doctorates in the subject and the other two are at advanced stage of completing their research work to be submitted to Poona University for Ph.D. degree (details of Ph.D. dissertations are given in Appendix B).

In addition to the above mentioned activities, the department has organised and conducted two all India level seminars in which the department has contributed and participated actively and has also published the proceedings.

A special course in 'Range Techniques & Technology' was conducted in 1981. Two research projects from defence R&D have since been sanctioned to the department. The project oriented research fellow scheme under the grants-in-aid of R&D has also made a beginning in the department. Based on the quality and extent of work already done in its chosen field of study the department has developed professional reputation and there is a scope for further development in different areas of the subjects. The research fields and postgraduate courses where there is enough scope for development at a level of excellence are listed as appendices C & D.

DEFICIENCIES AND NEED TO CHANGE THE PRESENT SET UP

The present set up conforms to the norms set up by the Sarkar Committee which however, rigidly restricts the strength of faculty members required for teaching at undergraduate level. And this in turn leaves no scope for further development in teaching and research at international excellence. At present, the research work is to a large extent concentrated to a particular aspect viz., external ballistics, which, however, comprise a very small area of research in the subject of ballistics and space mechanics. The remaining fields have not been developed and require considerable efforts to develop these in view of their growing importance to armament science and technology and other allied subjects.

It is emphasised that all advanced countries have their centres of excellence in this subject. And ballistics research laboratories are the basic information data bank sources for these countries, which form the prerequisite for any new or modification in armament design and development.

At present teaching is confined to as a supporting subject for various courses in armament. The specialised courses at postgraduate level are not being run for want of excellent teachers of outstanding ability and qualifications. Specially suited to the needs of the students at this Institute drawn from various disciplines and organisations such as defence R&D scientists and technologists, inspections, ordnance factories and other users from various organisations outside defence R&D. There is a requirement to establish a number of postgraduate level courses as listed in Appx C, at this Institute. The subject of Space Mechanics with defence orientation also requires considerable attention to be developed to a greater extent.

Such a centre will help to develop teaching and research in a number of fields as listed in Appendices C&D, which will broaden and coordinate work in their related disciplines. The coordination in various disciplines will be accelerated and this will in turn promote mutual relations of various research activities at the Institute. In short the centre will not only produce trained personnel of high calibre conferring international standard but also will produce research information useful in design and development in armament and other related fields.

ACADEMIC SET UP

The centre will be headed by a Director of the rank of Sc.'F'. There will be a number of groups, each being responsible for particular fields as shown in Appx E. Again each group will be headed by a Scientist A/D and will have at least three working Scientist C/B under him. There will be no provision for recruitment of SSA/JSA. Instead there will be provision for recruitment of Junior Research Fellows/Senior Research Fellows. Each scientist (recognised teacher of Poona University) will have a JRF/SRF working with him in a regular fashion each year; and the groups will work as research teams. Further to supplement theoretical research and advanced studies/training, there is a need to set up ballistics laboratory and ranges attached to the centre. Details of academic set up are given in Appx E and laboratory facilities in Appx F.

To report its research findings and other outstanding contributions in the concerned fields, the centre will publish with the help of the library staff its own research journal called 'Journal of Ballistics and Space Mechanics', which will be devoted to original research having significant contributions to the advancement of the subject. Besides this an 'Abstracting Journal' in the field of 'Armament' will also be required to promote research activities of the centre.

FINANCIAL AND ADMINISTRATIVE CONTROL

The financial and administrative control of the centre will rest with IAT. However, the centre will have its separate budget allocations in respect of expenditure incurred on TA, DA, grants for research fellows, seminars and other contingencies. Requirements of administrative support staff for the centre is appended as Appx G.

APPENDIX 'A'

The following research papers/reports have been published till 1982 by Faculty members of the Department of Ballistics and Space Mechanics :-

1. VR Thiruvengkatachar, Stress wave in a semi infinite elastic solid by an impulse over a circular area of the plane face. Paper presented at the Proc 1st Congress on Theoretical & Appl Mech. (1955).
2. VR Thiruvengkatachar, The internal ballistics of the H/L pressure gun. Paper presented at the Proc 1st Congress on Theoretical and Appl Mech (1955).
3. VR Thiruvengkatachar, Stress wave propagation induced in an infinite slab by an impulsive pressure over a circular area of one face. Proc National Inst of Sciences. (1960).
4. VR Thiruvengkatachar, Terminal Ballistics. INSL report.
5. VR Thiruvengkatachar, Cavitating motion of under water missiles, Jl of Sc & Engg Res. (1959).
6. VR Thiruvengkatachar, An approximate method for estimating rocket trajectory elements, Def Sc Jl, (1960).
7. SN Barua. The effects of liquid filling in the stability projectiles. Jr. Inst of Armt Studies, Vol III, No 1, Jan 1964.
8. SN Barua. Propulsion in space. Jl I.A.S.
9. SN Barua. On secondary flow in stationary curved pipes. Qrt. Jl. Mech. & Appl Maths. Vol XVI. Pt I, (1963).
10. PC Rath & KC Sharma. Note Sur la Representation Spuale on Movemnt Angulaire D'ur Projectile Tourant. Memo de L'artil Franc. Paris. 43, 757-761 (1969).
11. PC Rath & KC Sharma. Effect of bliques Magnus Sur la trajectoria helicoidale moyelle D'ur projectile tourant. Meo de L'artil Franc. Paris. 43, 729-755 (1969).
12. PC Rath & KC Sharma. On the secondary problem of exterior ballistics. Ind Jl of Pure & Appl Maths. Vol 2, 722-134 (1971).
13. PC Rath & AV Namboodiri, On the Lock-Fowler model of a spinning shell. Ind Jl of Pure & Appl Maths. Vol 5, 713-721, (1974).
14. PC Rath & AV Namboodiri, On the Lock-Fowler model of a spinning shell. Ind Jl of Pure & Appl Maths. Vol 5, 396-418, (1974).

* S. Nos 13 & 14 are given at the end of this appendix

16. IC Rath & SM Sharma. On the stability of a dirigible body. Aero Jl (Roy Aero Soc. UK) Vol pp.179-181 (1975).
17. FC Rath, Delinerisation of the second ballistic problem Proc Nonlinear Ballistic Seminar (IAT) pp 286-293 (1975).
18. FC Rath & KC Sharma. On the Magnus instability of a spinning shell. Ind Jl of Pure & Appl Maths. Vol 17, 387-408 (1976).
19. FC Rath. On the sign of precession of a rolling missile. Jl of Armt Studies. Vol XII, No 1, 73-75 (1976).
20. FC Rath & AV Namboodir. On the apsidal limits of a rolling missile. Qutly of Appl Maths USA. 36, 1-17, (1978)
21. FC Rath & AV Namboodiri. Balancement D'un Irojectile de Lock Fowler (liberation of a Lock-Fowler Irojectile) Memo de D'art. Frac Vol 54, pp 313-350, (1980)
22. FC Rath & SM Sharma. On the nonlinear vibrations of a sprojectile. Aero Qutly Roy Aero Soc U.K. Vol 32, Pt 3. pp 228-242 (1981).
23. IC Rath & Jaipal . Precessional advances of a Lock-Fowler Missile. Qurt. Jl. of App. Maths. (Published, 1981).
24. FC Rath & SM Sharma. On the nonlinear stability theory of a missile rolleron system (in press).
25. IC Rath & Jaipal . Halphen Puisseux inequalities in the precessional motion of a rolling missile (in press).
26. KC Sharma. Eccentric rotation of a cylinder in viscous fluid. IAT Jl, IV, 1, Jan 1965.
27. KC Sharma. A note on the effect of Magnus moment of the tractability of a projectile. Memorial de L'artillerie Francaise.
28. KC Sharma. On the dynamic stability of a missile. Presented at Nonlinear Ballistic Seminar, IAT June, 1974 Def Sc Jrl, 27, 1, Jan 1977.
29. KC Sharma. Nonlinear ballistic equations and some solved models. Proc. of Nonlinear Ballistic Seminar IAT, June, 1974.
30. KC Sharma. Spin stability of nonlinear ballistic equations. Proc. of Nonlinear Ballistic Seminar, IAT, 1974.

31. KC Sharma. Scale factor in muzzle velocity computations. Jnl of Armt Studies, 13, 1, 1977.
 32. DK Narvilkar & KC Sharma. Density gradient solutions of internal ballistic systems. Accepted for publication in Memorial de L'Artillerie.
 33. DK Narvilkar & KC Sharma. Internal ballistics solutions for an exponential flow density coefficients. Accepted for publication in Memorial de L'Artillerie.
 34. KSB Rao & KC Sharma. Art in the internal ballistics. Accepted for publication in Def Sc Jnl. Apr 1982.
 35. KC Sharma. Definition of standard ballistics coefficient in SI & its derived units. Ballistics Report No 1. IAT, Pune, May 1977.
 36. KC Sharma. Motion analysis for yaw card measurements. Ballistic Report No 2, IAT Pune, Sep 1981.
 37. AV Namboodiri & YC Chawala. On the gyroscopic stability of Lock Fowler projectile. Proc of Nonlinear Ballistics Seminar. IAT. 1974.
 38. KN Katyal. Dynamics of blast waves with a shock surface. Proc of a Workshop on Terminal Ballistics. IAT, 1981.
 13. P.C. Rath and K.C. Sharma, On the limiting oscillations of a sounding rocket exiting the atmosphere. Indian Journal of pure and applied maths. Vol 2, 713-721, (1971)
 15. P.C. Rath & S.M. Sharma. Magnus effect on the initial oscillation of a projectile. Indian Journal of pure & applied maths. Vol 5, 311-320 (1975)
- Total No. of Papers 38

APPENDIX 'B'

The following Ph.D. thesis/projects under the guidance of Prof. P.C.RATH, Prof K.C. SHARMA and Prof R.H.DANI of the department of Ballistics and Space Mechanics have been approved/in progress for the award of Ph. D. Degree of Poona University.

Topics of Ph.D. thesis/research Project	author/supervisor of the research project	University/ Defence R&D Organisation	Year
1) Studies on Magnus instability and some related problems in exterior ballistics (Ph.D. thesis).	K. C. SHARMA	Poona University	1972
2) Studies on non-linear vibrations of a projectile (Ph.D. thesis).	S. M. SHARMA	Poona University	1981
3) On the dynamic response of a rolling missile due to a non-linear aerodynamic movement of the Lock-Fowler Type. (Ph. D. thesis).	A. V. NAMBOODIRI	Poona University	1982
4) Studies in hydrodynamical flows behind a shell in internal ballistics (Ph. D. thesis).	D. K. NARVILKAR	Poona University	In progress
5) Studies in differential variations and some other methods in internal ballistics. (Ph. D. thesis).	K.S.B. RAO	Poona University	In progress
6) Development of miss distance indicator using PCC systems (research project).	R. H. DANI	Defence R&D Orgn.	In progress
7) Stability of a spinning projectile (research project).	K. C. SHARMA	Defence R&D Orgn.	In progress

APPENDIX 'C'

Post-graduate and need based courses need to be developed in Ballistics and Space Mechanics are as follows :-

- 1) Dynamics of propulsion system viz., seat ejection, internal ballistics of guns and rockets.
- 2) Flight Dynamics viz., external ballistics of guns, shells, rockets, bombs, missile kinematics etc.
- 3) Underwater motion (Hydrodynamics of torpedoes and other naval weapons systems fired from air to water and vice versa).
- 4) Hyper velocity and jet impact phenomena.
- 5) Dynamics of air borne stores (towed targets, missile target, aircraft, pilotless targets etc).
- 6) Shock propagation through solids and liquids,
- 7) Fragmentation and lethality.
- 8) Range techniques and computing methods.
- 9) **Statistical Methods.**
- 10) The following areas in ballistics instrumentation and experimental ballistics methods are also needed to be strengthened in relation to the above mentioned fields :-
 - (a) High speed photography
 - (b) Microwave techniques in ranges
 - (c) Schlieren techniques
 - (d) Velocity and pressure measurement instruments.

APPENDIX 'D'

Research Fields to be developed at a level of excellence.

1. Hyper velocity and jet impact phenomena.
2. Shock propagation through solids and liquids.
3. Fragmentation and lethality.
4. Underwater motion (various topics in Hydroballistics).
5. Flight Mechanics (re-entry problems, many bodies, problems, ballistics of rockets).
6. Internal ballistics of guns and rockets.
7. Experimental ballistics methods.

APPENDIX 'E'

ACADEMIC GROUPS OF THE CENTRE

Director (Sc. 'F')

Group 1

One Scientist E/D
Three Scientist C/B
Four Research Fellows

Areas of Activities :

Dynamics of propulsion systems viz. seat ejection, internal ballistics of guns and rockets. Fragmentation and lethality, shock propagation in solids damage to structures, statistical methods, light gas gun.

Group 2

One Scientist E/D
Three Scientist C/B
Four Research fellows.

Areas of Activities :

Flight dynamics (external ballistics of guns, shells, rockets, bombs) range techniques and computing methods. Space mechanics, dynamics of air borne stores, re-entry problems, many body problems, missile kinematics.

Group 3

One Scientist E/D
Three Scientist C/B
Four Research fellows.

Areas of Activities :

Hyper velocity and impact phenomena damage to armour plates, under water motion shock propagation through liquids, damage to naval equipments.

Group 4

One Scientist E/D
Three Scientist C/B
Four Research Fellows.

Areas of Activities :

Ballistics experimentation and instrumentation.

APPENDIX 'F'

BALLISTICS LABORATORY FACILITIES

Group I

Area of Activities : Design and Development.

Group II

Maintenance of Ballistics Laboratory equipments.
This also includes equipments for outside users also.

Technical/other staff required for Ballistics
Laboratory :-

- a) Four Lab.Assts for each group.
- b) Eight technical assistants.
- c) Six Laskars
- d) One Storekeeper

APPENDIX 'G'

SUPPORT OFFICE LAY OUT

