

# AN INTRODUCTION TO TENSOR CALCULUS

JACQUES L. MERCIER

*professor of engineering sciences*

*pontificia universidade católica, rio de janeiro*



WOLTERS-NOORDHOFF PUBLISHING GRONINGEN  
THE NETHERLANDS

## CONTENTS

PREFACE . . . . .	VII
-------------------	-----

### I. INVARIANT FORMULATION

1. Space, coordinate systems . . . . .	2
2. Transformation of coordinates . . . . .	4
3. Indicical notation . . . . .	7
4. Invariants, scalars, vectors . . . . .	11
5. Laws of transformation. . . . .	17
6. Dot product, Riemannian space . . . . .	24
7. Reciprocal contravariant base vectors in $R_N$ . . . . .	31
8. Riemannian tensors . . . . .	39
9. Algebra of Riemannian tensors . . . . .	44
10. Cartesian components . . . . .	51
11. Vectors cross product in $E_3$ . . . . .	56
12. Triple vector product in $E_3$ . . . . .	64
13. Physical components and vector projections in $E_3$ . . . . .	67
14. Tensor equations . . . . .	73

### II. COVARIANT DIFFERENTIATION

15. Derivatives of base vectors . . . . .	75
16. Derivatives of Riemannian tensors . . . . .	81
17. Covariant differentiation in mechanics . . . . .	85
18. Covariant differentiation in $E_N$ . . . . .	97
19. Local coordinate systems in $R_N$ . . . . .	100

20. Intrinsic derivatives . . . . .	104
21. The vector operator Del . . . . .	109
22. Applications of the operator Del. . . . .	119
23. Riemann-Christoffel tensor . . . . .	124
24. Surface geometry . . . . .	127
SUMMARY . . . . .	135
APPENDIX, ANSWERS . . . . .	143
BIBLIOGRAPHY . . . . .	149
INDEX . . . . .	150