

# Contents

## Part I. THE GENERAL THEORY OF BUNDLES

1. Introduction . . . . .	3
2. Coordinate bundles and fibre bundles . . . . .	6
3. Construction of a bundle from coordinate transformations . . . . .	14
4. The product bundle . . . . .	16
5. The Ehresmann-Feldbau definition of bundle. . . . .	18
6. Differentiable manifolds and tensor bundles . . . . .	20
7. Factor spaces of groups . . . . .	28
8. The principal bundle and the principal map . . . . .	35
9. Associated bundles and relative bundles . . . . .	43
10. The induced bundle . . . . .	47
11. Homotopies of maps of bundles. . . . .	49
12. Construction of cross-sections . . . . .	54
13. Bundles having a totally disconnected group. . . . .	59
14. Covering spaces . . . . .	67

## Part II. THE HOMOTOPY THEORY OF BUNDLES

15. Homotopy groups . . . . .	72
16. The operations of $\pi_1$ on $\pi_n$ . . . . .	83
17. The homotopy sequence of a bundle . . . . .	90
18. The classification of bundles over the $n$ -sphere . . . . .	96
19. Universal bundles and the classification theorem. . . . .	100
20. The fibering of spheres by spheres . . . . .	105
21. The homotopy groups of spheres . . . . .	110
22. Homotopy groups of the orthogonal groups . . . . .	114
23. A characteristic map for the bundle $R_{n+1}$ over $S^n$ . . . . .	118
24. A characteristic map for the bundle $U_n$ over $S^{2n-1}$ . . . . .	124
25. The homotopy groups of miscellaneous manifolds . . . . .	131
26. Sphere bundles over spheres. . . . .	134
27. The tangent bundle of $S^n$ . . . . .	140
28. On the non-existence of fiberings of spheres by spheres . . . . .	144

## Part III. THE COHOMOLOGY THEORY OF BUNDLES

29. The stepwise extension of a cross-section . . . . .	148
30. Bundles of coefficients . . . . .	151

31. Cohomology groups based on a bundle of coefficients . . .	155
32. The obstruction cocycle . . . . .	166
33. The difference cochain, . . . . .	169
34. Extension and deformation theorems . . . . .	174
35. The primary obstruction and the characteristic cohomology class. . . . .	177
36. The primary difference of two cross-sections . . . . .	181
37. Extensions of functions, and the homotopy classification of maps. . . . .	184
38. The Whitney characteristic classes of a sphere bundle . . . . .	190
39. The Stiefel characteristic classes of differentiable manifolds . . . . .	199
40. Quadratic forms on manifolds . . . . .	204
41. Complex analytic manifolds and exterior forms of degree 2. . . . .	209
Appendix . . . . .	2 18
Bibliography . . . . .	223
Index . . . . .	228