

Contents

| | |
|---|-----------|
| PREFACE | 6 |
| 1 PRINCIPLES OF SURVEYING..... | 7 |
| 1.1 DEFINITIONS..... | 7 |
| 1.2 TYPES OF SURVEY | 9 |
| 1.3 UNITS OF MEASURE..... | 11 |
| 2 SURVEY OBSERVATIONS AND ADJUSTMENTS..... | 13 |
| 2.1 PLANNING AND DESIGN OF THE SURVEY | 13 |
| 2.2 PRE-ANALYSIS | 14 |
| 2.3 OBSERVATIONS AND ERRORS..... | 15 |
| 2.4 ACCURACY AND PRECISION..... | 17 |
| 2.5 VARIANCE, COVARIANCE AND CORRELATION | 17 |
| 2.6 ERROR ELLIPSES | 20 |
| 2.7 ERROR PROPAGATION | 21 |
| 3 DISTANCE MEASUREMENT..... | 23 |
| 3.1 ODOMETER, MILEAGE RECORDER, PACING, ETC. | 23 |
| 3.2 TAPING AND SYSTEMATIC CORRECTIONS..... | 25 |
| 3.3 ELECTRONIC DISTANCE MEASUREMENT | 28 |
| 3.3.1 <i>Basic principles.....</i> | <i>28</i> |
| 3.3.2 <i>Correction because of velocity of propagation.....</i> | <i>30</i> |
| 3.3.3 <i>Geometric reductions.....</i> | <i>31</i> |
| 4 ANGLE AND DIRECTION MEASUREMENT | 34 |
| 4.1 THE THEODOLITE (TRANSIT)..... | 34 |
| 4.2 MEASURING HORIZONTAL ANGLES..... | 36 |
| 4.3 BEARINGS AND AZIMUTHS..... | 38 |
| 4.4 TRAVERSE | 39 |
| 4.4.1 <i>Traverse in three dimensions.....</i> | <i>41</i> |
| 4.4.2 <i>Traverse computation</i> | <i>42</i> |
| 4.5 INTERSECTION AND RESECTION | 44 |
| 5 LEVELLING | 48 |
| 5.1 DEFINITIONS..... | 48 |
| 5.1.1 <i>Curvature and refraction</i> | <i>49</i> |
| 5.1.2 <i>Orthometric correction</i> | <i>51</i> |
| 5.2 METHODS OF LEVELLING..... | 52 |
| 5.2.1 <i>Spirit levelling</i> | <i>52</i> |
| 5.2.2 <i>Reciprocal levelling.....</i> | <i>54</i> |
| 5.2.3 <i>Trigonometric levelling.....</i> | <i>55</i> |
| 5.2.4 <i>Heights from GPS.....</i> | <i>56</i> |
| 5.3 LEVEL RODS | 57 |
| 5.4 KINDS OF LEVELS..... | 58 |
| 5.5 ELEVATION DETERMINATION BY SPIRIT LEVELLING | 60 |
| 5.5.1 <i>Simple Levelling</i> | <i>60</i> |
| 5.5.2 <i>Profiles and cross sections.....</i> | <i>61</i> |
| 5.5.2.1 <i>Profiles.....</i> | <i>61</i> |
| 5.5.2.2 <i>Cross sections.....</i> | <i>61</i> |
| 5.5.2.3 <i>Plotting of profiles and cross sections</i> | <i>63</i> |
| 5.5.3 <i>Area levelling</i> | <i>63</i> |
| 6 COORDINATES AND MAP PROJECTIONS..... | 66 |
| 6.1 INTRODUCTION | 66 |
| 6.2 TYPES OF MAP PROJECTION..... | 66 |
| 6.3 GEOMETRIC DISTORSIONS ON MAPS | 68 |

| | | |
|-----------|---|------------|
| 6.4 | PRESERVING SOME OF THE GEOMETRIC PROPERTIES..... | 72 |
| 6.5 | MINIMIZING GEOMETRIC DISTORTIONS FOR A PROJECT AREA | 74 |
| 6.6 | NAMING OF MAP PROJECTIONS..... | 77 |
| 6.7 | RECTANGULAR GRID SYSTEM | 77 |
| 6.8 | THE UTM PROJECTION..... | 78 |
| 6.9 | THE UTM GRID | 81 |
| 6.10 | INTEGRATING MAPS OF DIFFERENT PROJECTIONS | 84 |
| 6.11 | MAP PROJECTION AND DIGITAL MAPS..... | 85 |
| 7 | THE GLOBAL POSITIONING SYSTEM..... | 87 |
| 7.1 | BACKGROUND | 87 |
| 7.2 | GPS SEGMENTS | 87 |
| 7.3 | GPS REFERENCE SYSTEMS..... | 88 |
| 7.4 | GPS SIGNALS..... | 89 |
| 7.5 | GPS OBSERVABLES..... | 90 |
| 7.6 | GPS RECEIVERS..... | 93 |
| 7.7 | GPS OBSERVATION TECHNIQUES | 94 |
| 7.8 | MISSION PLANNING..... | 97 |
| 7.9 | SOURCES OF ERROR..... | 97 |
| 7.10 | SATELLITE GEOMETRY | 99 |
| 7.11 | DILUTION OF PRECISION | 99 |
| 7.12 | POST PROCESSING GPS DATA | 100 |
| 7.12.1 | Baseline resolution..... | 102 |
| 7.12.2 | Network adjustment..... | 102 |
| 7.13 | VERTICAL SURVEYING WITH GPS | 103 |
| 8 | ROUTE SURVEYING..... | 105 |
| 8.1 | ROUTE CURVES FOR HORIZONTAL AND VERTICAL ALIGNMENT | 105 |
| 8.1.1 | Horizontal curves | 105 |
| 8.1.2 | Vertical Curves..... | 110 |
| 8.2 | TERRAIN DATA..... | 111 |
| 9 | TOPOGRAPHIC SURVEYS..... | 113 |
| 9.1 | VERTICAL AND HORIZONTAL CONTROL..... | 113 |
| 9.2 | LOCATION OF DETAILS | 115 |
| 9.3 | DETAILS BY THE CONTROLLING POINT METHOD..... | 115 |
| 9.3.1 | Radial surveys by the total station..... | 116 |
| 9.3.2 | GPS kinematic surveys for topographic details..... | 116 |
| 9.3.3 | Theodolite stadia..... | 118 |
| 9.3.4 | Terrain elevations..... | 119 |
| 9.4 | DRAINAGE..... | 120 |
| 10 | PHOTOGRAMMETRIC CONTROL SURVEYING..... | 121 |
| 10.1 | CAMERA SYSTEMS | 121 |
| 10.2 | PHOTOGRAPHIC SCALE..... | 122 |
| 10.3 | FLYING HEIGHTS AND ALTITUDES | 123 |
| 10.4 | RELIEF DISPLACEMENT..... | 124 |
| 10.5 | FLYING LINES AND PHOTOGRAPHIC OVERLAP | 125 |
| 10.6 | STEREOSCOPIC VIEWING AND PARALLAX | 126 |
| 10.7 | PHOTOGRAMMETRIC MAPPING..... | 128 |
| 10.7.1 | Orthophotos | 133 |
| 10.8 | GROUND CONTROL..... | 137 |
| 11 | REMOTE SENSING..... | 140 |
| 11.1 | REMOTELY SENSED DATA..... | 141 |
| 11.2 | THE DIGITAL IMAGE..... | 141 |
| 11.3 | PASSIVE SYSTEMS: EXAMPLE, LANDSAT..... | 142 |
| 11.4 | ACTIVE SENSING SYSTEMS: EXAMPLE, SLAR | 143 |
| 11.5 | SOURCES OF IMAGERY | 144 |
| 11.6 | IMAGE PROCESSING | 144 |
| 11.7 | INTERPRETATION, CLASSIFICATION AND "GROUND TRUTHING" OF IMAGERY | 145 |

| | | |
|-----------|---|------------|
| 12 | FUNDAMENTALS OF GIS | 148 |
| 12.1 | DEFINING GIS | 148 |
| 12.2 | MAPPING CONCEPTS, FEATURES & PROPERTIES | 149 |
| 12.3 | SCALE | 150 |
| 12.4 | SCALE IN DIGITAL MAPS | 151 |
| 12.5 | MAPS AND MAP ANALYSIS | 157 |
| 13 | REFERENCES..... | 158 |
| 14 | FIGURES..... | 159 |
| 15 | TABLES..... | 160 |