## Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preface</td>
<td>xi</td>
</tr>
<tr>
<td>1 Light</td>
<td>1</td>
</tr>
<tr>
<td>1.1 The story</td>
<td>1</td>
</tr>
<tr>
<td>1.2 Models for the behavior of light</td>
<td>3</td>
</tr>
<tr>
<td>1.3 Measurements of light rays</td>
<td>9</td>
</tr>
<tr>
<td>1.4 Spectra</td>
<td>13</td>
</tr>
<tr>
<td>1.5 Magnitudes</td>
<td>22</td>
</tr>
<tr>
<td>Summary</td>
<td>28</td>
</tr>
<tr>
<td>Exercises</td>
<td>29</td>
</tr>
<tr>
<td>2 Uncertainty</td>
<td>32</td>
</tr>
<tr>
<td>2.1 Accuracy and precision</td>
<td>32</td>
</tr>
<tr>
<td>2.2 Describing populations</td>
<td>38</td>
</tr>
<tr>
<td>2.3 Probability distributions</td>
<td>43</td>
</tr>
<tr>
<td>2.4 Estimating uncertainty</td>
<td>48</td>
</tr>
<tr>
<td>2.5 Propagation of uncertainty</td>
<td>51</td>
</tr>
<tr>
<td>2.6 Additional topics</td>
<td>55</td>
</tr>
<tr>
<td>Summary</td>
<td>55</td>
</tr>
<tr>
<td>Exercises</td>
<td>56</td>
</tr>
<tr>
<td>3 Place, time, and motion</td>
<td>59</td>
</tr>
<tr>
<td>3.1 Astronomical coordinate systems</td>
<td>59</td>
</tr>
<tr>
<td>3.2 The third dimension</td>
<td>77</td>
</tr>
<tr>
<td>3.3 Time</td>
<td>82</td>
</tr>
<tr>
<td>3.4 Motion</td>
<td>87</td>
</tr>
<tr>
<td>Summary</td>
<td>92</td>
</tr>
<tr>
<td>Exercises</td>
<td>94</td>
</tr>
<tr>
<td>4 Names, catalogs, and databases</td>
<td>97</td>
</tr>
<tr>
<td>4.1 Star names</td>
<td>98</td>
</tr>
<tr>
<td>4.2 Non-stellar objects outside the Solar System</td>
<td>102</td>
</tr>
</tbody>
</table>
## Contents

4.3 Objects at non-optical wavelengths 105  
4.4 Atlases, finding charts, and sky surveys 105  
4.5 Solar System objects 108  
4.6 Websites and other computer resources 109  
Summary 110  
Exercises 111

5 **Optics for astronomy** 113  
5.1 Principles of geometrical optics 113  
5.2 Lenses, mirrors, and simple optical configurations 124  
5.3 Simple telescopes 130  
5.4 Image quality: telescopic resolution 133  
5.5 Aberrations 135  
Summary 146  
Exercises 147

6 **Astronomical telescopes** 150  
6.1 Telescope mounts and drives 150  
6.2 Reflecting telescope optics 153  
6.3 Telescopes in space 162  
6.4 The current revolution in ground-based observing 169  
6.5 Atmospheric blur 174  
6.6 Adaptive optics 177  
6.7 Extremely large telescopes 187  
Summary 189  
Exercises 190

7 **Matter and light** 193  
7.1 Isolated atoms 193  
7.2 Isolated molecules 200  
7.3 Solid-state crystals 202  
7.4 Photoconductors 214  
7.5 The MOS capacitor 216  
7.6 The p–n junction 218  
7.7 The vacuum photoelectric effect 222  
7.8 Superconductivity 224  
Summary 228  
Exercises 229

8 **Detectors** 232  
8.1 Detector characterization 232  
8.2 The CCD 239  
8.3 CMOS arrays 256
### Table of Contents

**8.4 Infrared arrays** 256  
**8.5 Photo-emissive devices** 261  
**8.6 Thermal detectors** 265  
**Summary** 267  
**Exercises** 268

**9 Digital images from arrays** 271  
**9.1 Arrays** 271  
**9.2 Digital image manipulation** 276  
**9.3 Preprocessing array data: bias, linearity, dark, flat, and fringe** 281  
**9.4 Combining images** 293  
**9.5 Digital aperture photometry** 304  
**Summary** 313  
**Exercises** 314

**10 Photometry** 316  
**10.1 Introduction: a short history** 317  
**10.2 The photometric response function** 319  
**10.3 The idea of a photometric system** 329  
**10.4 Common photometric systems** 330  
**10.5 Absorption by the atmosphere** 336  
**10.6 Transformation to a standard system** 348  
**10.7 Absorption outside the atmosphere** 349  
**10.8 Wavelength changes** 353  
**Summary** 357  
**Exercises** 358

**11 Spectroscopy** 362  
**11.1 Dispersive spectrometry** 363  
**11.2 Dispersing optical elements** 365  
**11.3 Spectrometers without slits** 374  
**11.4 Basic slit and fiber spectrometers** 375  
**11.5 Single-object spectrometer design for astronomy** 379  
**11.6 Multiplexed spectrometers** 382  
**11.7 Spectrometer stability and mounting** 388  
**11.8 Data acquisition and reduction** 389  
**11.9 Interpreting spectra** 395  
**Summary** 412  
**Exercises** 414

**Appendices** 417  
**References** 451  
**Index** 455