

CONTENTS

GENERAL PHYSICS

CHAP.

PAGE

1. MATHEMATICAL NOTES	1
Complex quantities, 1. Differential equations, 5. Vectors, 8. Partial differentiation, 13.	
2. HARMONIC MOTION	15
S.H.M., 15. Damped vibration, 20. Pendulum, 26. Torsional vibrations, 38. Combination of motions, 38. Forced vibration, 40.	
3. GRAVITATION	47
Determination of G , 52. Central orbits, 56.	
4. ELASTICITY	67
Principal moduli, 71. Energy, 74. Cantilever, 77. Loaded beam, 79. Poisson's ratio, 80. Torsion, 80. Spiral spring, 81.	
5. FRICTION—VISCOSITY	85
Friction, 85. Viscosity, 86. Poiseuille's method, 87. Gases, 92. Turbulence, 95. Bernoulli's Theorem, 97. Viscometers, 98. Stokes' method, 100. Temperature effects, 101. Thixotropy, 102.	
6. SURFACE TENSION	104
Angle of contact, 105. Pressure and curvature, 105. Capillary rise, 106. Drop methods, 109. Cylindrical films, 111. Energy, 115. Theory of surface tension, 116. Monolayers, 119. Adsorp- tion, 121.	

HEAT

7. THE MEASUREMENT AND CONTROL OF TEMPERATURE	122
Temperature scales, 122. Mercury thermometers, 123. Gases, 127. Vapour pressure thermometers, 131. Resistance thermo- meters, 132. Thermo-electric couples, 135. Other methods, 137. International scale, 137. Control, 139. Recording, 142.	
8. THERMAL EXPANSION	144
Anisotropic substances, 145. Measurement, linear coefficient, 146. X-rays, 149. Values and applications, 150. Bimetal, 151. Liquids, 154.	
9. CALORIMETRY	162
Definitions and units, 162. Mixtures, 163. Cooling correction, 164. Nernst, etc., 168. Cooling method, 169. Heat of reaction, 171. Fuels, 172. Continuous flow, 173. Latent heat of fusion, 176; of vaporisation, 179. Latent heat calorimetry, 180. Results: specific heats, 185; latent heats, 189. Heats of combustion and formation, 190.	

10. KINETIC THEORY

194

Pressure of gas, 196. Mixtures, 198. Gas laws, 199. Atmosphere, 200. Effusion, 203. Diffusion, 207. Transpiration, 209. Vapour pressure of metals, 210. Collisions, 211. Viscosity, 212. Thermal conductivity, 216. Diffusion coefficients, 217. Free path, 211, 219. Equipartition, 221. Brownian movement, 222.

11. ELEMENTARY THERMODYNAMICS

224

Mechanical equivalent, 224. First law, 226. Representations, 227. Reversibility, 229. Difference of specific heats, 231. Adiabatic change, 232. Ratio of specific heats, 233. Theory, 237.

12. PROPERTIES OF VAPOURS

239

Latent heat, 240. Vapour pressure, 242. Triple point, 246. Boiling, 248. Effect of curvature, 250. Vapour density, 253. Humidity, 255.

13. EQUATIONS OF STATE

264

High-pressure experiments, 264. Isothermals, 269. Critical phenomena, 271. Derivation of equation of state, 273. Van der Waals, 276. Tests, 281. Joule-Thomson porous plug, 283. Liquefaction of gases, 288. Rectification, 291.

14. SOLUTIONS

293

Colloids, 294. Osmosis, 296. Vapour pressure, 299. Boiling-point, 301. Freezing-point, 302. Molecular weights, 305.

15. CONDUCTION AND CONVECTION

308

Heat transfer, 308. Thermal conduction, 309. Bar, 312. Plates, 319. Sphere and cylinder, 321. Crystals, 323. Electrically heated rod, 323. Temperature waves, 325. Liquids, 329. Gases, 330. Theory and results, 332. Natural convection, 333. Forced, 334. Dimensional treatment, 335.

16. THERMAL RADIATION

339

Kirchhoff's law, 340. Black body, 341. Radiant energy, 342. Energy in spectrum, 346. Formulae, 353. Radiation pyrometry, 355. Pressure of radiation, 362.

17. THE SECOND LAW OF THERMODYNAMICS

368

Efficiency, 369. Second law, 369. Carnot, 369. Kelvin scale, 371. Clausius' Theorem, 374. Entropy, 375. Latent heat equations, 379. Very low temperatures, 385. Refrigeration, 386. Heat engines, 389. Maxwell's relations, 391. Thermodynamic potentials, 393. Joule-Thomson effect, 395. Further applications, 399.

18. STATISTICAL MECHANICS AND QUANTUM THEORY

403

Statistical mechanics, 404. Energy distribution, 406. Maxwell's distribution law, 411. Equipartition, 416. Linear oscillator, 418. Planck, 420. Specific heats, 421, 424. Radiation, 422. Quantisation, 426. Specific heat of gas, 427.

LIGHT

CHAP.		PAGE
19.	THE NATURE AND SPEED OF LIGHT	429
	Waves and rays, 430. Divisions of subject, 431. Wave-trains, 431. Group velocity, 434. Huygens' principle, 437. Combination of indices, 441. Fermat's principle, 442. Speed of light, 446.	
20.	PHOTOMETRY	452
	Definitions, 452. Photometers, 457. Coloured sources, 463. Illumination, 464.	
21.	PLANE SURFACES AND PRISMS	470
	Field of view in mirror, 470. Striated medium, 472. Critical angle, 473. Reflected intensity, 475. Refraction, 478. Astigmatic refraction, 479. Prism, 481. Dispersion, 486. Achromatism, 488. Reflecting prisms, 489. Constant-deviation, 491. Rainbow, 492.	
22.	SPHERICAL MIRRORS AND THIN LENSES	496
	Mirror, 496. Sign-conventions and symbols, 500. Single refracting surface, 501. Lagrange, 502. Thin lens, 503. Fields of view, 511. Defects, aberrations, 512. Wave theory, 527.	
23.	LENS SYSTEMS AND THICK LENSES	531
	Two separated lenses, 531. Principal points, 532. Magnification, 539. Nodal points, 540. Thick lens, 542. Equivalent lens, 545. Sphere and other examples, 545. Chromatic aberration, 548. Helmholtz relation, 550.	
24.	THE EYE AND VISION	552
	Structure of eye, 552. Accommodation, 554. Defects and correction, 556. Acuity, 557. Binocular vision, 558. Perspective, 560. Colour, 563. Theories, 566.	
25.	GEOMETRICAL OPTICS OF OPTICAL INSTRUMENTS	568
	• Simple microscope, 569. Stereoscope, 571. Compound microscope, 572. Telescopes, 578. Periscope, 588. Range-finder, 589. Compound eyepieces, 592. Camera, 595. Brightness of image, 599. Projection systems, 602.	
26.	THE DETERMINATION OF REFRACTIVE INDICES	606
	Spectrometer, 606. Total reflection methods, 613. Miscellaneous methods, 620.	
27.	THE MEASUREMENT OF OPTICAL CONSTANTS	622
	Focal lengths, 622. Magnification methods, 625. Nodal slide, 627. Telescope, 628. Microscope, 629.	
28.	INTERFERENCE OF LIGHT	631
	Young's slits, 632. Coherence, 636. Fresnel's biprism, 637. Thin films, 640. Newton's rings, 643. Michelson interferometer, 646. Multiple reflections, 650. Fabry-Perot, 654. Refractometers, 655. Other applications, 659. Ether-drift, 660. Non-reflecting coatings, 661.	

- 29. DIFFRACTION** 664
 Slit, 665. Double slit, 671. Gratings, 672. Concave grating, 681. Fresnel's zones, 682. Circular aperture, 685. Zone plate, 689. Circular obstacle, 691. Cornu's spiral, 693. Straight edge, 694. Scattering, 696.
- 30. RESOLVING POWER** 699
 Definitions, 699. Telescope, 700. Star diameters, 703. Microscope, 705. Spectroscopes, 706.
- 31. POLARISATION AND DOUBLE REFRACTION** 711
 Polarisation by reflection, 714; by scattering, 717. Crystals, 718. Double refraction, 719. Wave surfaces, 722. Nicol prism, 728. Other prisms, 729. Elliptic and circular polarisation, 730. Rotatory polarisation, 737. Polarimeters, 740. Saccharimetry, 743. Faraday effect, 746. Photo-elasticity, 747. Interference with crystals, 748.
- 32. SPECTROSCOPY** 755
 Instruments, 755. Types of spectra, 758. Line spectra, 761. Band spectra, 765. Ultra-violet and infra-red, 766. Absorption spectra, 768. Fraunhofer lines, 769. Luminiscence, 770. Dispersion, 772. Zeeman and Stark effects, 774. Applications, 779.
- 33. THE ELECTROMAGNETIC THEORY OF LIGHT** 781
 Theories, 781. Maxwell's equations, 781. Plane waves, 783. Fresnel's formulae, 787. Dispersion, 789. Total reflection, 795. Metals, 796. Photons and quanta, 799.
- SOUND**
- 34. THE NATURE AND SPEED OF SOUND** 800
 Maintained vibrations, 801. Quality, etc., 803. Echo, 806. Sound in air, 807. Gases, 810. Water, 811. Applications, 812.
- 35. WAVE MOTION** 814
 Waves on cord, 814, 823. Plane waves, 815. Fourier analysis, 817. Wave equation, 821. Longitudinal waves, 825. Gas (theory), 827. Transverse waves (rods, etc.), 830. Torsional waves, 832. Liquids, 832. Ripples, 836. Reflection, 838. Beats, 843. Group-velocity, 845. Modes of vibration, 845. Interference, 848. Doppler effect, 850. Shock waves, 854. Wave-equations (more general), 854.
- 36. FREE AND FORCED VIBRATIONS** 857
 Natural vibrations, 857. Maintained vibrations, 860. Resonance, 862. Tuning, 865. Coupled systems, 868. Heat and cold, 872. Sonometer, 874. Melde, 876. Kundt's tube, 876.
- 37. MUSICAL SCALES AND INSTRUMENTS** 880
 Notation, 880. Harmony, 881. Scales, 882. Temperament, 883. Standard pitch, 885. Instruments, 885. Jets, 888. Reeds, 889. Air columns, 890. Percussion, 893. Human voice, 893.

CHAP.		
38.	EXPERIMENTAL AND APPLIED ACOUSTICS	
	Techniques, 895. Chladni's plate, 901. Ear, 902. Hearing, 903. Sound intensity, 907. Binaural hearing, 908. Combination tones, 909. Applications, 910.	
39.	THE COMPARISON AND MEASUREMENT OF FREQUENCIES	914
	Apparatus, 914. Lissajous figures, 919. Oscillograph, 924. Frequency standards, 925.	

ELECTRICITY

40.	ELECTROSTATICS	927
	Definitions, 927. Doublet, 931. Energy, 934. General equations, coefficients of potential, etc., 935. Capacity, 937. Proof of inverse square, 939. Gauss' Theorem, 941; applications, 944. Energy in field, 946. Dielectrics, 946. Displacement, 950. Electrometers, 955. Electroscopes, 960. Comparison of capacities, 962.	
41.	MAGNETOSTATICS	965
	Definitions, 965. Magnetometers, 968. Gauss: proof, 971; theorem, 973. Magnetic media, 973.	
42.	ELECTRIC CURRENT	976
	Magnetic fields due to currents, 977. Helmholtz coils, 979. Magnetic shells, 982. Circuital law, 983. Force on current, 984. E.m.f., p.d., 987. Resistance, 988. Ohm's law, 989. Practical units, 989. Resistivity, 989, 991. Kirchhoff's rules, 991. Wheatstone bridge, 992. Potentiometer, 993. Ballistic galvanometer, 993. Special galvanometers, 998.	
43.	ELECTROLYSIS	1000
	Faraday's laws, 1000. Theory, 1001. Mobilities, 1005. Reversible cells, 1006. Solution pressure, 1010. Theory (Debye-Hückel), 1012.	
44.	THERMOELECTRICITY	1018
	Laws of circuit, 1020. Thermodynamic treatment, 1021. Thermo-electric diagram, 1023. Experimental measurements, 1027. Applications, 1027.	
45.	ELECTROMAGNETIC INDUCTION	1030
	Laws of Faraday, 1030; Lenz, 1031. Magnetic flux, 1032. Earth inductor, 1034. Flux meter, 1035. Mutual inductance, 1037. Self inductance, 1038. Growth of current, 1040. Condenser charge and discharge, 1042. General circuit, oscillatory discharge, 1044.	
46.	MAGNETISATION OF MATERIALS	1048
	Types of magnetisation, 1048. Magnetometer method, 1048. Cycle, 1050. Demagnetising field, 1050. Energy, 1052. Ballistic method, 1053. Bar and yoke, 1055. Methods for low susceptibility, 1059. Theories, 1062. Curie's law, 1067. Magnetostriction, 1071.	

CRAP.

	PAGE
47. ALTERNATING CURRENTS	1073
<p><i>L, R</i> circuit, 1073. Impedance-phase, reactance, 1076. Vector diagram, 1077. Use of imaginary quantities, 1078. <i>R, C</i> circuit, 1080. <i>L, C, R</i> circuit, 1081. Parallel circuits, 1082. General Wheatstone bridge, 1083. A.C. bridges, 1084. Star-delta meshes, 1090. Kelvin double bridge, 1092. Bridges with mutual inductance, 1093. Instruments, 1094. Power, 1096. Large inductances, 1101. Wattmeters, 1102. A.C. galvanometers, 1104. Transformers, 1104. Skin effect, 1107.</p>	
48. ELECTRICAL UNITS	1110
<p>E.S. and E.M. systems, 1110. Ratio of units, 1113. Table of units and dimensions, 1116. M.K.S. Ω system, 1116. Practical standards and absolute measurements, 1116.</p>	
49. ELECTROMAGNETIC WAVES	1123
<p>Circuital relations, 1123. Wave equation, 1125. Plane waves, 1127. Energy, 1129. Pressure, 1129. Poynting's theorem and vector, 1130. Radiation, 1131. Hertz's experiments, 1133.</p>	
50. GASES, ELECTRONS, ETC.	1135
<p>Current in gas, 1135. Cathode rays, 1136. Electrons, 1136. Ionisation by X-rays, 1142. Saturation current, 1143. Wilson chamber, 1144. Positive rays, 1145. Mass spectrograph, 1147. Isotopes, 1148. Cathode ray oscillograph, 1149. Radar, 1154.</p>	
51. X-RAYS	1156
<p>Production, 1156. Intensity measurement, 1157. Absorption, 1158. Scattering, 1159. Characteristic X-rays, 1160. Crystal structure, 1161. Spectrometer, 1162. Gratings, 1166. Refractive index, 1167. Moseley's law, atomic number, 1169. Absorption limits, 1172.</p>	
52. RADIOACTIVITY	1174
<p>Discovery, 1174. α, β, γ radiation, 1175. Radioactive changes, 1180. Radioactive equilibrium, 1183. Tables, 1185, 1186. Geiger-Nuttall relation, 1185. Isotopes, 1186. Artificial radioactivity, 1187. Cyclotron, 1188.</p>	
53. ATOMS AND RADIATION	1190
<p>Planck's constant, 1190. Bohr atom, 1190. Hydrogen spectra, 1192. Ionisation potential, 1194. Photoelectricity, 1195. Thermionics, 1197. Triode, 1199; rectification, 1201; oscillations, 1202. Modulation, 1204. Relativity, 1204. Larmor-Lorentz transformation, 1206. Mass and energy, 1208. Experimental evidence, 1211. Compton effect, 1212. Neutrons, 1215. Cosmic rays, 1216. Positron, 1216. Mesons, 1219. Extension of Bohr theory, 1220. Zeeman effect, 1222. Gyromagnetic effect, 1224. Spinning electron, 1225. Gerlach-Stern experiment, 1225. Electronic structure of atoms, 1226. Nuclear fission, 1230. Trans-uranic elements, 1232. Isotopic tracers, 1233.</p>	

CONTENTS

JV

TABLES

TABLE	PAGE
1. The Greek Alphabet	1235
2. Metric Prefixes	1235
3. Weights and Measures	1236
4. The Elements	1236
5. Elements in Order of Atomic Number	1238
6. Miscellaneous Data	1238
7. Fundamental Physical Constants	1239
8. Masses of Fundamental Particles	1239
9. Densities	1240
10. Moments of Inertia	1240
11. Moduli of Elasticity	1241
12. Saturation Vapour Pressure	1241
13. Logarithms	1242
14. Natural Sines	1244
15. Natural Tangents	1246
16. Reciprocals	1248
17. Radians and Degrees	1250
18. Numerical Constants	1250
19. Wavelength Standards	1251
20. Standard Wire Gauge	1251
21. Natural Logarithms and The Exponential Function	1252
Exercises	1253
Index	1281
Index of Symbols	1299