Chapter 8

8.1	1.8
8.2	(a) From the given graph for a stress of 150×10^6 N m^{2} the strain is 0.002
	(b) Approximate yield strength of the material is $3\times 10^8\ \mbox{N}\ \mbox{m}^{-2}$
8.3	(a) Material A
	(b) Strength of a material is determined by the amount of stress required to cause fracture: material A is stronger than material B.
8.4	(a) False (b) True
8.5	1.5×10^{-4} m (steel); 1.3×10^{-4} m (brass)
8.6	Deflection = 4×10^{-6} m
8.7	$2.8 imes 10^{-6}$
8.8	0.127
8.9	$7.07 \times 10^4 \mathrm{N}$
8.10	$D_{copper}/D_{iron} = 1.25$
8.11	$1.539 \times 10^{-4} \mathrm{m}$
8.12	$2.026 \times 10^9 \text{Pa}$
8.13	$1.034 \times 10^3 \text{kg/m}^3$
8.14	0.0027
8.15	$0.058\mathrm{cm^3}$
8.16	$2.2 imes10^6\mathrm{N/m^2}$

Chapter 9

9.3 (a) decreases (b) η of gases increases, η of liquid decreases with temperature (c) shear strain, rate of shear strain (d) conservation of mass, Bernoulli's equation (e) greater.

- 9.5 $6.2 \times 10^6 \, \text{Pa}$
- **9.6** 10.5 m
- 19.7 Pressure at that depth in the sea is about 3×10^7 Pa. The structure is suitable since it can withstand far greater pressure or stress.
- 9.8 $6.92 \times 10^5 \,\mathrm{Pa}$
- 9.9 0.800
- **9.10** Mercury will rise in the arm containing spirit; the difference in levels of mercury will be 0.221 cm.
- **9.11** No, Bernoulli's principle applies to streamline flow only.
- **9.12** No, unless the atmospheric pressures at the two points where Bernoulli's equation is applied are significantly different.
- **9.13** 9.8×10^2 Pa (The Reynolds number is about 0.3 so the flow is laminar).
- **9.14** $1.5 \times 10^3 \, \text{N}$
- **9.15** Fig (a) is incorrect [Reason: at a constriction (i.e. where the area of cross-section of the tube is smaller), flow speed is larger due to mass conservation. Consequently pressure there is smaller according to Bernoulli's equation. We assume the fluid to be incompressible].
- 9.16 0.64 m s⁻¹
- **9.17** $2.5 \times 10^{-2} \text{ N m}^{-1}$
- **9.18** 4.5×10^{-2} N for (b) and (c), the same as in (a).
- **9.19** Excess pressure = 310 Pa, total pressure = $1.0131 \times 10^5 \text{ Pa}$. However, since data are correct to three significant figures, we should write total pressure inside the drop as $1.01 \times 10^5 \text{ Pa}$.
- 9.20 Excess pressure inside the soap bubble = 20.0 Pa; excess pressure inside the air bubble in soap solution = 10.0 Pa. Outside pressure for air bubble = $1.01 \times 10^5 + 0.4 \times 10^3 \times 9.8$ \times 1.2 = 1.06×10^5 Pa. The excess pressure is so small that up to three significant figures, total pressure inside the air bubble is 1.06×10^5 Pa.

Chapter 10

10.1 Neon:
$$-248.58 \,^{\circ}\text{C} = -415.44 \,^{\circ}\text{F};$$

 CO_2 : $-56.60 \,^{\circ}\text{C} = -69.88 \,^{\circ}\text{F}$

(use
$$t_{\rm F} = \frac{9}{5}t_{\rm c} + 32$$
)

- **10.2** $T_{\rm A} = (4/7) T_{\rm B}$
- **10.3** 384.8 K
- 10.4 (a) Triple-point has a *unique* temperature; fusion point and boiling point temperatures depend on pressure; (b) The other fixed point is the absolute zero itself; (c) Triple-point is 0.01°C, not 0 °C; (d) 491.69.
- 10.5 (a) T_A = 392.69 K, T_B = 391.98 K; (b) The discrepancy arises because the gases are not perfectly ideal. To reduce the discrepancy, readings should be taken for lower and lower pressures and the plot between temperature measured versus absolute pressure of the gas at triple point should be extrapolated to obtain temperature in the limit pressure tends to zero, when the gases approach ideal gas behaviour.
- 10.6 Actual length of the rod at $45.0\,^{\circ}\text{C} = (63.0 + 0.0136)\,\text{cm} = 63.0136\,\text{cm}$. (However, we should say that change in length up to three significant figures is $0.0136\,\text{cm}$, but the total length is $63.0\,\text{cm}$, up to three significant places. Length of the same rod at $27.0\,^{\circ}\text{C} = 63.0\,\text{cm}$.
- 10.7 When the shaft is cooled to temperature 69°C the wheel can slip on the shaft.
- **10.8** The diameter increases by an amount = 1.44×10^{-2} cm.
- **10.9** $3.8 \times 10^2 \,\mathrm{N}$
- **10.10** Since the ends of the combined rod are not clamped, each rod expands freely.

$$\Delta I_{\text{brass}} = 0.21 \text{ cm}, \Delta I_{\text{steel}} = 0.126 \text{ cm} = 0.13 \text{ cm}$$

Total change in length = 0.34 cm. No 'thermal stress' is developed at the junction since the rods freely expand.

- **10.11** $0.0147 = 1.5 \times 10^{-2}$
- **10.12** 103 °C
- **10.13** 1.5 kg
- **10.14** 0.43 J g ⁻¹ K⁻¹; smaller
- 10.15 The gases are diatomic, and have other degrees of freedom (i.e. have other modes of motion) possible besides the translational degrees of freedom. To raise the temperature of the gas by a certain amount, heat is to be supplied to increase the average energy of all the modes. Consequently, molar specific heat of diatomic gases is more than that of monatomic gases. It can be shown that if only rotational modes of motion are considered, the molar specific heat of diatomic gases is nearly (5/2) R which agrees with the observations for all the gases listed in the table, except chlorine. The higher value of molar specific heat of chlorine indicates that besides rotational modes, vibrational modes are also present in chlorine at room temperature.
- **10.16** 4.3 g/min
- **10.17** 3.7 kg
- 10.18 238 °C
- 10.20 9 min

Chapter 11

- **11.1** 16 g per min
- **11.2** 934 J
- **11.4** 2.64
- **11.5** 16.9 J
- 11.6 (a) 0.5 atm (b) zero (c) zero (assuming the gas to be ideal) (d) No, since the process (called free expansion) is rapid and cannot be controlled. The intermediate states are non-equilibrium states and do not satisfy the gas equation. In due course, the gas does return to an equilibrium state.
- **11.7** 25 W
- **11.8** 450 J

Chapter 12

- **12.1** 4×10^{-4}
- 12.3 (a) The dotted plot corresponds to 'ideal' gas behaviour; (b) $T_1 > T_2$; (c) 0.26 J K⁻¹; (d) No, 6.3×10^{-5} kg of H₂ would yield the same value
- **12.4** 0.14 kg
- **12.5** 5.3×10^{-6} m³
- **12.6** 6.10×10^{26}
- **12.7** (a) $6.2 \times 10^{-21} \,\mathrm{J}$
- (b) $1.24 \times 10^{-19} \,\mathrm{J}$
- (c) $2.1 \times 10^{-16} \,\mathrm{J}$
- 12.8 Yes, according to Avogadro's law. No, $v_{\rm rms}$ is largest for the lightest of the three gases; neon.
- **12.9** $2.52 \times 10^3 \,\mathrm{K}$
- **12.10** Use the formula for mean free path:

$$\bar{l} = \frac{1}{\sqrt{2}\pi nd^2}$$

where d is the diameter of a molecule. For the given pressure and temperature $N/V = 5.10 \times 10^{25} \, \mathrm{m}^{-3}$ and $= 1.0 \times 10^{-7} \, \mathrm{m}$. $v_{\mathrm{rms}} = 5.1 \times 10^{2} \, \mathrm{m \ s^{-1}}$.

collisional frequency =
$$\frac{v_{\rm rms}}{\bar{l}}$$
 = 5.1×10⁹ s⁻¹. Time taken for the collision = $d/v_{\rm rms}$ = 4×10⁻¹³ s.

Time taken between successive collisions = 1 / $v_{\rm rms}$ = 2 × 10⁻¹⁰ s. Thus the time taken between successive collisions is 500 times the time taken for a collision. Thus a molecule in a gas moves essentially free for most of the time.

Chapter 13

- **13.1** (b), (c)
- 13.2 (b) and (c): SHM; (a) and (d) represent periodic but not SHM [A polyatomic molecule has a number of natural frequencies; so in general, its vibration is a superposition of SHM's of a number of different frequencies. This superposition is periodic but not SHM].
- 13.3 (b) and (d) are periodic, each with a period of 2 s; (a) and (c) are not periodic. [Note in (c), repetition of merely one position is not enough for motion to be periodic; the entire motion during one period must be repeated successively].
- 13.4 (a) Simple harmonic, $T = (2\pi/\omega)$; (b) periodic, $T = (2\pi/\omega)$ but not simple harmonic; (c) simple harmonic, $T = (\pi/\omega)$; (d) periodic, $T = (2\pi/\omega)$ but not simple harmonic; (e) non-periodic; (f) non-periodic (physically not acceptable as the function $\to \infty$ as $t \to \infty$.
- **13.5** (a) 0, +, +; (b) 0, -, -; (c) -, 0, 0; (d) -, -, -; (e) +, +, +; (f) -, -, -
- **13.6** (c) represents a simple harmonic motion.
- **13.7** A = $\sqrt{2}$ cm, $\phi = 7\pi/4$; B = $\sqrt{2}$ cm, $a = \pi/4$.
- 13.8 219 N
- 13.9 Frequency $3.2 \, s^{-1}$; maximum acceleration of the mass $8.0 \, m \, s^{-2}$; maximum speed of the mass $0.4 \, m \, s^{-1}$.
- **13.10** (a) $x = 2 \sin 20t$
 - (b) $x = 2 \cos 20t$
 - (c) $x = -2 \cos 20t$

where x is in cm. These functions differ neither in amplitude nor frequency. They differ in initial phase.

- **13.11** (a) $x = -3 \sin \pi t$ where x is in cm.
 - (b) $x = -2 \cos \frac{\pi}{2}t$ where x is in cm.
- **13.13** (a) F/k for both (a) and (b).
 - (b) $T = 2\pi \sqrt{\frac{m}{k}}$ for (a) and $2\pi \sqrt{\frac{m}{2k}}$ for (b)

- **13.14** 100 m/min
- **13.15** 8.4 s
- 13.16 T = $2\pi \sqrt{\frac{l}{\sqrt{g^2 + v^4/R^2}}}$. Hint: Effective acceleration due to gravity will get reduced

due to radial acceleration v^2/R acting in the horizontal plane.

13.17 In equilibrium, weight of the cork equals the up thrust. When the cork is depressed by an amount x, the net upward force is $Ax\rho_{i}g$. Thus the force constant $k = A\rho_{i}g$.

Using $m = Ah\rho$, and $T = 2\pi \sqrt{\frac{m}{k}}$ one gets the given expression.

13.18 When both the ends are open to the atmosphere, and the difference in levels of the liquid in the two arms is h, the net force on the liquid column is $Ah\rho g$ where A is the area of cross-section of the tube and ρ is the density of the liquid. Since restoring force is proportional to h, motion is simple harmonic.

Chapter 14

- **14.1** 0.5 s
- **14.2** 8.7 s
- 14.3 $2.06 \times 10^4 \,\mathrm{N}$
- 14.4 Assume ideal gas law: $P = \frac{\rho RT}{M}$, where ρ is the density, M is the molecular mass, and

T is the temperature of the gas. This gives $v = \sqrt{\frac{\gamma RT}{M}}$. This shows that v is:

- (a) Independent of pressure.
- (b) Increases as \sqrt{T} .
- (c) The molecular mass of water (18) is less than that of N_2 (28) and O_2 (32).

 Therefore as humidity increases, the effective molecular mass of air decre

Therefore as humidity increases, the effective molecular mass of air decreases and hence v increases.

- 14.5 The converse is not true. An obvious requirement for an acceptable function for a travelling wave is that it should be finite everywhere and at all times. Only function (c) satisfies this condition, the remaining functions cannot possibly represent a travelling wave.
- **14.6** (a) 3.4×10^{-4} m
- (b) 1.49×10^{-3} m

- **14.7** 4.1×10^{-4} m
- **14.8** (a) A travelling wave. It travels from right to left with a speed of 20 ms⁻¹.
 - (b) 3.0 cm, 5.7 Hz
 - (c) $\pi/4$
 - (d) 3.5 m
- 14.9 All the graphs are sinusoidal. They have same amplitude and frequency, but different initial phases.
- **14.10** (a) $6.4 \pi \text{ rad}$
 - (b) $0.8 \, \pi \, \text{rad}$
 - (c) π rad
 - (d) $(\pi/2)$ rad
- 14.11 (a) Stationary wave
 - (b) l = 3 m, n = 60 Hz, and $v = 180 \text{ m s}^{-1}$ for each wave
 - (c) 648 N
- **14.12** (a) All the points except the nodes on the string have the same frequency and phase, but not the same amplitude.
 - (b) 0.042 m
- **14.13** (a) Stationary wave.
 - (b) Unacceptable function for any wave.
 - (c) Travelling harmonic wave.
 - (d) Superposition of two stationary waves.
- **14.14** (a) 79 m s⁻¹
 - (b) 248 N
- **14.15** 347 m s⁻¹

Hint : $v_n = \frac{(2n-1)v}{4l}$; n = 1,2,3,... for a pipe with one end closed

- 14.16 5.06 km s⁻¹
- 14.17 First harmonic (fundamental); No.
- **14.18** 318 Hz

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INDEX

Α		Bulk modulus	242
Absolute scale temperature	280	Buoyant force	255
Absolute zero	280	0	
Acceleration (linear)	45	C	
Acceleration due to gravity	49,189	Calorimeter	285
Accuracy	22	Capillary rise	268
Action-reaction	97	Capillary waves	370
Addition of vectors	67	Carnot engine	316
Adiabatic process	311, 312	Central forces	186
Aerofoil	262	Centre of Gravity	161
Air resistance	79	Centre of mass	144
Amplitude	344, 372	Centripetal acceleration	81
Angle of contact	267, 268	Centripetal force	104
Angstrom	207, 200	Change of state	287
Angular Acceleration	154	Charle's law	326
Angular Acceleration Angular displacement	342	Chemical Energy Circular motion	126 104
Angular frequency	344, 373	Clausius statement	315
Angular mequency Angular momentum	155	Coefficient of area expansion	283
	153	Coefficient of linear expansion	281
Angular velocity	372	Coefficient of performance	314
Angular wave number Antinodes	381,382	Coefficient of static friction	101
	381,382 255	Coefficient of viscosity	262
Archimedes Principle		Coefficient of volume expansion	281
Area expansion	281	Cold reservoir	313
Atmospheric pressure	253	Collision	129
Average acceleration	45, 74	Collision in two dimensions	131
Average speed	42	Compressibility	242,243
Average velocity	42	Compressions 368	8, 369, 374
Avogardo's law	325	Compressive stress	236,243
-		Conduction	290
В		Conservation laws	12
Banked road	104	Conservation of angular momentum	157, 173
Barometer	254	Conservation of Mechanical Energy	121
Beat frequency	383	Conservation of momentum	98
Beats	382, 383	Conservative force	121
Bending of beam	244	Constant acceleration	46,75
Bernoulli's Principle	258	Contact force	100
Blood pressure	276	Convection	293
Boiling point	287	Couple	159
Boyle's law	326	Crest	371
Buckling	244	Cyclic process	312

D		Geostationary satellite Gravitational constant	196 189
Dalton's law of partial pressure	325	Gravitational Force	8, 192
Damped oscillations	355	Gravitational potential energy	191
Damped simple Harmonic motion	355	Gravity waves	370
Damping constant	355	dravity waves	010
Damping force	355	Н	
Derived units	16		000 001
Detergent action	269	Harmonic frequency	380, 381
Diastolic pressure	277	Harmonics	380, 381 284
Differential calculus	61	Heat capacity Heat engines	313
Dimensional analysis	32	Heat pumps	313
Dimensions	31	Heat	279
Displacement vector	66	Heliocentric model	183
Displacement	40	Hertz	343
Doppler effect	385, 386	Hooke's law	238
Doppler shift	387	Horizontal range	78
Driving frequency	358	Hot reservoir	313
Dynamics of rotational motion	169	Hydraulic brakes	255, 256
10		Hydraulic lift	255, 256
E		Hydraulic machines	255
Efficiency of heat engine	313	Hydraulic pressure	238
Elastic Collision	129	Hydraulic stress	238,243
Elastic deformation	236, 238	Hydrostatic paradox	253
Elastic limit	238	_ ' \ \ \ ' '	
Elastic moduli	239	I	
Elasticity	235	Ideal gas equation	280
Elastomers	239	Ideal gas	280, 325
Electromagnetic force	8	Impulse	96
Energy	117	Inelastic collision	129
Equality of vectors	66 257	Initial phase angle	372
Equation of continuity Equilibrium of a particle	99	Instantaneous acceleration	74
Equilibrium of Rigid body	158	Instantaneous speed	45
Equilibrium position	341, 342, 353	Instantaneous velocity	43
Errors in measurement	22	Interference	377
Escape speed	193	Internal energy	306, 330
Escape speed	130	Irreversible engine	315, 317
F		Irreversible processes	315
-	007	Isobaric process	311, 312
First law of Thermodynamics	307	Isochoric process	311, 312
Fluid pressure	251	Isotherm	310
Force	94	Isothermal process	311
Forced frequency	357 357, 358	K	
Forced oscillations	238		
Fracture point Free Fall		Kelvin-Planck statement	315
Free-body diagram	49 100	Kepler's laws of planetary motion	184
Frequency of periodic motion	342, 372	Kinematics of Rotational Motion	167
Friction	101	Kinematics Kinetic energy of rolling motion	39 174
Fundamental Forces	6	Kinetic energy of rolling motion Kinetic Energy	174 117
Fundamental mode	381	Kinetic Energy Kinetic interpretation of temperature	329
Fusion	287	Kinetic theory of gases	328
G		L	
Gauge pressure	253	Laminar flow	258, 264
Geocentric model	183	Laplace correction	376
		•	

INDEX 311

Latent heat of fusion		290	0	
Latent heat of vaporisation		290		000
Latent heat		289	Odd harmonics	382 194
Law of cosine		72	Orbital velocity/speed Order of magnitude	28
Law of equipartition of energy		332	Oscillations	342
Law of Inertia		90	Oscillatory motion	342
Law of sine		72	osemucory metron	0.12
Linear expansion		281	P	
Linear harmonic oscillator	349,		Parallax method	18
Linear momentum		155	Parallelogram law of addition of vectors	_
Longitudinal strain	200	236	Pascal's law	252
Longitudinal strain	236,		Path length	40
Longitudinal stress	0.00	236	Path of projectile	78
Longitudinal Wave	369,	376	Periodic force	358
TA/F			Periodic motion	342
M			Periodic time	342
Magnus effect		261	Permanent set	238
Manometer		254	Phase angle	344
Mass Energy Equivalence		126	Phase constant	344
Maximum height of projectile		78	Pipe open at both ends	382
Maxwell Distribution		331	Pipe open at one end	381
Mean free path	324,		Pitch	384
Measurement of length		18	Plastic deformation	238
Measurement of mass		21	Plasticity	235
Measurement of temperature		279	Polar satellite	196
Measurement of time		22	Position vector and displacement	73
Melting point		286	Potential energy of a spring	123
Modeling of alasticity		380	Potential energy Power	120 128
Modulus of elasticity		238 242	Precession	143
Modulus of rigidity Molar specific heat capacity	284,		Pressure gauge	253
Molar specific heat capacity at constant pressure	204,	308	Pressure of an ideal gas	328
Molar specific heat capacity	284,	308	Pressure	250
at constant volume	204,	300	Principle of Conservation of Energy	128
Molar specific heat capacity		284	Principle of moments	160
Molecular nature of matter		323	Progressive wave	373
Moment of Inertia		163	Projectile motion	77
Momentum		93	Projectile	77
Motion in a plane		72	Propagation constant	371
Multiplication of vectors		67	Pulse	369
Musical instruments		384		
			g	
N			Quasi-static process	310, 311
Natural frequency		358	D	
Newton's first law of motion		91	R	
Newton's Law of cooling		295	Radiation	294
Newton's law of gravitation		185	Radius of Gyration	164
Newton's second law of motion		93	Raman effect	11
Newton's third law of motion		96	Rarefactions	369
Newtons' formula for speed of sound	1	377	Ratio of specific heat capacities	334 51
Nodes		381	Reaction time Real gases	326
Normal Modes 3	381, 382,		Rectilinear motion	39
Note	384,		Reductionism	2
Nuclear Energy	ŕ	126	Reflected wave	379
Null vector		68	Reflection of waves	378

Refracted wave 379 Surface tension 285 Regelation 287 Symmetry 146 Regelation 287 System of units 16 Relative velocity 51 Tensolution of vectors 29 Resonance 358 Temperature 279 Restoring force 236, 350, 369 7 Tensile strength 238 Reversible engine 316, 317 Tensile strength 238 Reversible processes 315 Tenminal velocity 264 Reglation of vectors 316 Tensile strength 238 Reversible engine 316, 317 Tensile strength 238 Reversible processes 315 Tenminal velocity 241 Regelation 242 Theorem of perpendicular axes 166 Rolling motion 173 Thermal expansion 281 Rotation 144 Thermal expansion 281 S.H.M. (Simple Harmonic Motion) 343 Thermal expansion 281 Scealars poduct 141 <				20=
Regelation Relative velocity in two dimensions 287 System of unitits 16 Relative velocity in two dimensions 76 System of unitits 277 Relative velocity in two dimensions 69 Tensile stream 77 Resonance 358 78 278 Restoring force 236, 350, 369 29 Tensile strength 238 Reversible engine 316, 317 Tensile strength 238 Reversible engine 316, 317 Tensile strength 238 Reversible processes 315 Tensile strength 238 Reversible processes 315 Tensile strength 238 Restoring force 236, 350, 369 72 Tensile strength 238 Restoring forcesses 316 Theorem of paralle axes 166 Rolling motion 132 Thermal expansion 291 Rotation 142 Thermal expansion 291 Retaring 114 Thermodynamic state variables 166 Secalars 257 17 Tremsile expansion <td>Refracted wave</td> <td></td> <td></td> <td></td>	Refracted wave			
Relative velocity in two dimensions 76 Systolic pressure 277 Relative velocity 69 T 7 Resonance 69 T 279 Restoring force 236, 350, 369 Tensile strength 238 Reversible engine 316, 317 Tensile strength 238 Reversible processes 315 Terminal velocity 264 Reynolds number 264 Theorem of parallel axes 167 Rolling motion 173 Thermal expansion 261 Rolling motion 123 Thermal expansion 281 Rotation 142 Thermal expansion 281 Rotation 142 Thermal expansion 281 S. Thermal expansion 281 S. Thermal expansion 281 S. Thermal expansion 281 Thermal expansion 281 Thermodynamic state variables 300 Scalars produlum 14 Trade wind 294 Shearing stress 237, 243 Trave	Refrigerator			
Relative velocity				
Resolution of vectors 69 T Resonance 358 Temperature 279 Restoring force 236, 350, 369 Temple attree of the strength 238 Reversible engine 316, 317 Tensile stress 236 Reversible processes 315 Terminal velocity 264 Rigid body 141 Theorem of perpendicular axes 165 Rolling motion 173 Thermal conductivity 291 Rotation 142 Thermal conductivity 291 Rotation 142 Thermal conductivity 291 S.H.M. (Simple Harmonic Motion) 343 Thermodynamic processes 310 S.H.M. (Simple Harmonic Motion) 111 Thermodynamic processes 310			Systolic pressure	277
Resonance 358 Temperature 279 Restoring force 236, 350, 369 Temperature 236 Reversible engine 316, 317 Tensile strength 238 Reversible processes 315 Terminal velocity 264 Reynolds number 249 Theorem of perpendicular axes 167 Rigid body 141 Theorem of perpendicular axes 166 Rolling motion 173 Thermal conductivity 291 Rotation 142 Thermal expansion 281 Thermal expansion 281 Thermal expansion 281 S Thermal expansion 281 S. Thermal expansion 281 Thermodynamic state variables 309 Thermal expansion 281 Thermodynamic state variables 30 Scalars 16 Trensile strength Scalars	·	_	A	
Restoring force 236, 350, 369 Tensile strength 238 Reversible engine 316, 317 Tensile strength 288 Reversible processes 315 Tensile strength 264 Reynolds number 264 Theorem of parallel axes 165 Rigid body 141 Theorem of perpendicular axes 165 Rolling motion 173 Thermal equilbirium 304 Rot are square speed 329 Thermal conductivity 291 Rotation 142 Thermal expansion 281 Thermal expansion 281 Thermodynamic state variables 309 Scalar-product 114 Thermodynamic state variables 309 Scalars 65 Thermodynamic state variables 309 Scalar product 114 Thermodynamic state variables 309 Scentific Method 1 Torque 154 Scelatific Method 1 Torque 154 Shearing strain 227 Torque 174 Shearing strain 232			T	
Restoring force 236, 350, 369 Tensile strength 238 Reversible engine 316, 317 Tensile stress 236 Reversible processes 316, 317 Tensile stress 236 Reversible processes 315 Tennial velocity 264 Reynolds number 264 Theorem of perpendicular axes 165 Rolling motion 137 Thermal equilibrium 304 Rot atotion 142 Thermal equilibrium 304 S S Thermal equilibrium 304 SH.M. (Simple Harmonic Motion) 343 Thermal expansion 281 Secondary 114 Thermodynamic state variables 309 Scialar-product 114 Thermodynamic state variables 309 Scialars 65 Thermodynamic state variables 309 Sceondaw of Thermodynamics 314 Thermodynamic state variables 309 Shearing strain 232 Traveling use 259 Shearing strain 237 243 Traveling use 370			Temperature	279
Reversible processes 315 Terminal velocity 264 Reynolds number 264 Theorem of parallel axes 165 Rigid body 141 Theorem of perpendicular axes 165 Rolling motion 173 Thermal conductivity 291 Rotation 142 Thermal equilibrium 304 Rotation 142 Thermal equilibrium 304 S.H.M. (Simple Harmonic Motion) 343 Thermal expansion 281 S.H.M. (Simple Harmonic Motion) 343 Thermodynamic state variables 309 Scalar- product 114 Thermodynamics state variables 309 Scalars 65 Time of flight 78 Scalars 65 Time of flight 78 Scentific Method 1 Torricell's Law 259, 260 Shearing strain 227 Torricell's Law 259, 260 Shearing strain 237 Travelling wave 379 Simple pendulum 343, 353 Truple point 288 Simple pendulum 343				238
Reynolds number 264 Theorem of parallel axes 167 Rigid body 141 Theorem of parallel axes 165 Rolling motion 173 Thermal conductivity 291 Rot mean square speed 329 Thermal equilibrium 304 Rotation 142 Thermal expansion 281 S Thermal stress 284 Thermodynamic state variables 309 Scalars 65 Thermodynamics state variables 309 Scalars 65 Time of light 78 Scelatific Method 1 Torricell's Law 259, 260 Sceoal aw of Thermodynamics 314 Torque 154 Shear modulus 242 Travelling wave 259, 260 Stearing strain 237 Travelling wave 379 Significant figures 27 Travelling wave 380 Significant figures 27 Traveling wave 380 Specific heat capacity of Solids 308, 335 True 258, 259 Specific heat capac			Tensile stress	236
Rigid body 141 Theorem of perpendicular axes 165 Rolling motion 173 Thermal conductivity 291 Rot ation 142 Thermal equilibrium 304 Rotation 142 Thermal equilibrium 304 S.H.M. (Simple Harmonic Motion) 343 Thermodynamic stress 281 S.H.M. (Simple Harmonic Motion) 343 Thermodynamic state variables 309 Scalar-product 114 Thermodynamic state variables 309 Scientific Method 1 Torque 154 Sceond law of Thermodynamics 314 Torricell's Law 259, 260 Shear modulus 242 Trade wind 294 Shearing strain 237 Transmitted wave 379 Stearing strain 237 Transmitted wave 380 Significant figures 27 Triple point 288 Simple pendulum 343, 353 True 384 Specific heat capacity of Solids 308, 355 Turbulent flow 258, 259 Specific heat capacity			Terminal velocity	264
Rolling motion 173 Thermal conductivity 291 Root mean square speed 329 Thermal equilibrium 304 Kotation 142 Thermal expansion 281 S Thermodynamic spocesses 310 S.H.M. (Simple Harmonic Motion) 343 Thermodynamic processes 310 Scalars 65 Thermodynamic state variables 309 Scalars 65 Time of flight 78 Scalars (scalars) 65 Time of flight 78 Scalar (modulus) 242 Trammitted ware 259, 260 Shear modulus 242 Trade wind 294 Shearing strain 237 Trade wind 294 Shearing strain 237 Travelling wave 380 Significant figures 27 Trapmitted wave 379 Significant figures 27 Triple point 288 Significant figures 27 Truple point 288 Specific heat capacity of Solids 308, 35 Tume 39 <t< td=""><td></td><td>_</td><td>Theorem of parallel axes</td><td>167</td></t<>		_	Theorem of parallel axes	167
Rotation 329 Thermal equilibrium 304 Rotation 142 Thermal expansion 281 S Thermodynamic processes 310 S.H.M. (Simple Harmonic Motion) 343 Thermodynamic processes 310 Scalar-product 1114 Thermodynamics state variables 309 Scalar-product 1114 Thermodynamics state variables 309 Scalar-product 1114 Thermodynamics state variables 309 Scientific Method 1 Torne flight 78 Scientific Method 1 Torricell's Law 259, 260 Scend law of Thermodynamics 314 Torricell's Law 259, 260 Shearing strain 237 Travelling wave 379 Shearing strain 237 Traveling wave 389 Significant figures 27 Triple point 288 Significant figures 26 Triple point 288 Significant figures 26 Triple point 288 Significant figures 26 Turbulant			Theorem of perpendicular axes	165
Rotation				
S			Thermal equilibrium	304
Shamman Thermodynamic processes 310 S.H.M. (Simple Harmonic Motion) 343 Thermodynamic state variables 309 Scalar-product 114 Thermodynamics 3, 303 Scalars 65 Time of flight 78 Sceond law of Thermodynamics 314 Torque 154 Second law of Thermodynamics 314 Torque 154 Shear modulus 242 Transmitted wave 379 Shearing strain 237 Transmitted wave 379 Shearing stress 237, 243 Transmitted wave 380 Slumits 16 Transmitted wave 380 Slumits 16 Transmitted wave 380 Significant figures 27 Triple point 288 Significant figures 27 Triple point 288 Significant figures 268 Triangle law of addition of vectors 66 Significant figures 27 Triple point 288 Trough 33 37 Trough 37	Rotation	142	Thermal expansion	281
S.H.M. (Simple Harmonic Motion) 343			Thermal stress	284
Scalar-product 114 Thermodynamics 3, 303 Scalars 65 Time of flight 78 Scientific Method 1 Torque 154 Second law of Thermodynamics 314 Torque 154 Shear modulus 242 Transmitted wave 379 Shearing streas 237, 243 Transmitted wave 380 Shearing stress 237, 243 Transmitted wave 380 Slumits 16 Time of flight 289 Shearing stress 237, 243 Transmitted wave 379 Shearing stress 237, 243 Transmitted wave 380 Slumificant figures 27 Travelling wave daddition of vectors 66 Significant figures 27 Trangle law of addition of vectors 66 Significant figures 27 Trangle law of addition of vectors 66 Significant figures 27 Trubulent flow 258 Simple pendulum 343, 353 Tune 334 Specific heat capacity of Gases 333, 334 </td <td>S</td> <td></td> <td></td> <td></td>	S			
Scalar product 114 Thermodynamics 3,303 Scalars 65 Time of flight 78 Scientific Method 1 Torque 154 Second law of Thermodynamics 314 Torricell's Law 259,260 Shear modulus 242 Trade wind 294 Shearing strain 237 Trade wind 294 Shearing stress 237, 243 Transmitted wave 379 Shearing stress 237, 243 Transmitted wave 380 SI units 16 Triangle law of addition of vectors 66 Significant figures 27 Tripole point 288 Significant figures 27 Trough 371 Sopongraphy 387 Turbulent flow 258	S.H.M. (Simple Harmonic Motion)	343		
Scalars 65 Time of tlight 78 Scientific Method 1 Torque 154 Second law of Thermodynamics 314 Torricelli's Law 259, 260 Shear modulus 242 Trace wind 294 Shearing strain 237 Transmitted wave 379 Shearing stress 237, 243 Travelling wave 380 SI units 16 Triangle law of addition of vectors 66 Significant figures 27 Triple point 288 Simple pendulum 343, 353 Trough 371 Soap bubbles 268 Trune 384 Sonography 387 Torcell'is Law 258, 259 Specific heat capacity 363 Torule Junifor 288 Specific heat capacity of Solids 308, 335 Ultrasonic waves 387 Specific heat capacity of Water 335 Ultrasonic waves 387 Specific heat capacity of Water 335 Ultrasonic waves 387 Specific heat capacity of Water 35, 376				
Second law of Thermodynamics 314 Shear modulus 242 Trade wind 294 Trade win	-	65		
Second law of Thermodynamies 314 Torricelli's Law 294 Shear modulus 242 Trade wind 294 Shearing strain 237 Travel wind 294 Shearing stress 237, 243 Travelling wave 380 Significant figures 27 Triangle law of addition of vectors 66 Significant figures 27 Triple point 288 Simple pendulum 343, 353 Trough 371 Sonography 387 Tune 384 Sonography 387 Tune 384 Sound 375 Turbulent flow 258, 259 Sound 375 Uttrasonic waves 387 Specific heat capacity of Water 335 Uttrasonic waves 387 Specific heat capacity of Water 350 Unification of Forces 10 Speed of Gefflux 259 Uniform dication of Forces 10 Speed of Transverse wave 375, 376 Uniform dication of Forces 10 Strading waves 380 Vuniform dica	Scientific Method	1		
Shear modulus 242 Irade wind 2949 Shearing strain 237 Transmitted wave 379 Shearing stress 237, 243 Transmitted wave 380 SI units 16 Triangle law of addition of vectors 66 Significant figures 27 Triple point 288 Simple pendulum 343, 353 Trough 371 Soap bubbles 268 Tune 384 Sonography 387 Tune 384 Sound 375 Tune 384 Specific heat capacity of Gases 333, 334 Ultrasonic waves 387 Specific heat capacity of Water 335 Ultrasonic waves 387 Specific heat capacity of Water 350 Ultrasonic waves 387 Specific heat capacity of Water 350 Ultrasonic waves 387 Specific heat capacity of Water 353 Ultrasonic waves 387 Specific heat capacity of Water 353 Unificed Atomic Mass Unit 21 Specific heat capacity of Water <		314		
Shearing stress 237, 243 Travelling wave 380 Shearing stress 237, 243 Travelling wave 380 Sl units 16 Triple point 288 Significant figures 27 Triple point 288 Simple pendulum 343, 353 Trough 371 Soap bubbles 268 Tune 384 Sonography 387 Tune 384 Sound 375 Tune 384 Specific heat capacity of Gases 333, 334 Ultimate strength 238 Specific heat capacity of Water 335 Ultimate strength 238 Specific heat capacity of Water 335 Ultimate strength 238 Specific heat capacity of Water 355 Ultimate strength 238 Specific heat capacity of Water 355 Ultimate strength 238 Specific heat capacity of Water 355 Ultimate strength 238 Specific heat capacity of Water 353 Uniform to water 360 Specific heat capacity of Water		242		
Shearing stress 237, 243	Shearing strain	237		
Significant figures 17 Triple point 288 Significant figures 27 Trough 371 Simple pendulum 343, 353 Trough 371 Soap bubbles 268 Turbulent flow 258, 259 Sound 375 U Turbulent flow 258, 259 Specific heat capacity of Solids 308, 335 U U 238 Specific heat capacity of Water 335 Ultrasonic waves 387 387 238 Uniform circular motion 238 387 387 10 384 Uniform circular motion 10 384 10 384 Uniform dotion 41 384 48		237, 243		
Significant figures 27 Triple point 288 Simple pendulum 343,353 Trough 371 Soap bubbles 268 Tume 384 Sonography 387 Turbulent flow 258,259 Sound 375 Turbulent flow 258,259 Specific heat capacity of Gases 333,334 Ultimate strength 238 Specific heat capacity of Water 335 Ultrasonic waves 387 Specific heat capacity of Water 335 Ultrasonic waves 387 Specific heat capacity of Water 335 Ultrasonic waves 387 Specific heat capacity of Water 335 Ultrasonic waves 387 Specific heat capacity of Water 335 Ultrasonic waves 387 Specific heat capacity of Water 335 Ultrasonic waves 387 Specific heat capacity 285,308 Uniform dotion 10 Speed of Flux 250 Uniform dotion 41 On a stretched string 352,355 Vunit vectors 70 Straining	\sim			
Simple pendulum 343, 353 Irough 371 Soap bubbles 268 Tune 384 Sonography 387 Turbulent flow 258, 259 Specific heat capacity of Solids 308, 335 U Specific heat capacity of Gases 333, 334 Ultimate strength 238 Specific heat capacity of Water 335 Ultrasonic waves 387 Specific heat capacity 285, 308 Uniform circular motion 10 Speed of efflux 259 Uniform dation 79 Speed of Sound 375, 376 Uniform Motion 41 on a stretched string Uniform Motion 41 Sphygmomanometer 277 Unif vectors 70 Spring constant 352, 355 Vane 356 Stading waves 382 Vane 356 Stethoscope 281 Vector-product 151 Stokes' law 263 Vectors 66 Stopping distance 50 Velocity amplitude 349 Streamline flow </td <td>Significant figures</td> <td>27</td> <td></td> <td></td>	Significant figures	27		
Songraphy Sound Songraphy Sound Specific heat capacity of Solids Specific heat capacity of Gases Specific heat capacity of Gases Specific heat capacity of Water Specific heat capacity of Water Specific heat capacity Specific heat		343, 353		
Sound 375		268		
Specific heat capacity of Solids 308, 335 U Specific heat capacity of Gases 333, 334 Ultimate strength 238 Specific heat capacity of Water 335 Ultrasonic waves 387 Specific heat capacity 285, 308 Unification of Forces 10 Speed of efflux 259 Unified Atomic Mass Unit 21 Speed of Sound 375, 376 Uniform circular motion 79 Speed of Transverse wave 375, 376 Uniform Motion 41 on a stretched string 277 Uniform Motion 47 Sphygmomanometer 277 Unit vectors 70 Spring constant 352, 355 Standing waves 380 Stationary waves 382 Vane 356 Steady flow 257 Vaporisation 288 Stethoscope 281 Vector-product 151 Stokes' law 263 Vectors 66 Stopping distance 50 Velocity amplitude 349 Streamline flow 257, 258 Viscosity<	Sonography	387	Turbulent flow	258, 259
Specific heat capacity of Gases Specific heat capacity of Gases Specific heat capacity of Water Specific heat capacity Specific heat capa		375	TT	
Specific heat capacity of Water 335 Ultrasonic waves 387 Specific heat capacity 285, 308 Unification of Forces 10 Speed of efflux 259 Unified Atomic Mass Unit 21 Speed of Sound 375, 376 Uniform circular motion 79 Speed of Transverse wave 375, 376 Uniform Motion 41 on a stretched string Uniformly accelerated motion 47 Sphygmomanometer 277 Unit vectors 70 Spring constant 352, 355 V Standing waves 380 V Stationary waves 382 Vane Steady flow 257 Vaporisation 288 Stethoscope 281 Vector-product 151 Stokes' law 263 Vectors 66 Stopping distance 50 Velocity amplitude 349 Strain 236 Venturi meter 260 Streamline flow 257, 258 Viscosity 262 Stress 236 Volume expansion<	Specific heat capacity of Solids	308, 335	U	
Specific heat capacity 285, 308 Unification of Forces 10 Speed of efflux 259 Unified Atomic Mass Unit 21 Speed of Sound 375, 376 Uniform circular motion 79 Speed of Transverse wave 375, 376 Uniform Motion 41 on a stretched string Uniform Motion 47 Splygmomanometer 277 Uniformly accelerated motion 47 Spring constant 352, 355 V Standing waves 380 V Stationary waves 382 Vane Stethoscope 281 Vector-product 151 Stokes' law 263 Vectors 66 Stopping distance 50 Velocity amplitude 349 Strain 236 Venturi meter 260 Streamline flow 257, 258 Vibration 341 Stress 236 Volume expansion 281 Stress-strain curve 238 Volume Strain 238 Surface energy 265 Wavelength	Specific heat capacity of Gases	333, 334	Ultimate strength	238
Speed of efflux 259 Unified Atomic Mass Unit 21 Speed of Sound 375, 376 Uniform circular motion 79 Speed of Transverse wave 375, 376 Uniform Motion 41 on a stretched string 277 Unit vectors 70 Spring constant 352, 355 Standing waves 380 Standing waves 382 Vane 356 Steady flow 257 Vaporisation 288 Stethoscope 281 Vector-product 151 Stokes' law 263 Vectors 66 Stopping distance 50 Velocity amplitude 349 Streamline flow 257, 258 Vibration 341 Streamline flow 257, 258 Vibration 341 Stress 236 Volume expansion 281 Stress-strain curve 238 Volume Strain 238 Stretched string 374 Sublimation 294 W Superposition principle 378 Surfos	Specific heat capacity of Water	335	Ultrasonic waves	387
Speed of Sound 375, 376 Uniform circular motion 79 Speed of Transverse wave 375, 376 Uniform Motion 41 on a stretched string Uniformly accelerated motion 47 Sphygmomanometer 277 Unit vectors 70 Spring constant 352, 355 Standing waves 380 V Stationary waves 382 Vane 356 Steady flow 257 Vaporisation 288 Stethoscope 281 Vector-product 151 Stokes' law 263 Vectors 66 Stopping distance 50 Velocity amplitude 349 Strain 236 Venturi meter 260 Streamline flow 257, 258 Vibration 341 Streamline 257, 258 Viscosity 262 Stress 236 Volume expansion 281 Stretched string 374 Sublimation 294 W Subtraction principle 378 Superposition principle 378 Superposition principle 378 Superposition principle 378 Superposition principle 378 Suverementary 372	Specific heat capacity	285, 308	Unification of Forces	10
Speed of Transverse wave on a stretched string Uniform Motion 47 Sphygmomanometer 277 Unit vectors 70 Spring constant 352, 355 Standing waves 380 V Stationary waves 382 Vane 356 Steady flow 257 Vaporisation 288 Stethoscope 281 Vector-product 151 Stokes' law 263 Vectors 66 Stopping distance 50 Velocity amplitude 349 Strain 236 Venturi meter 260 Streamline flow 257, 258 Vibration 341 Streamline 257, 258 Viscosity 262 Stress 236 Volume expansion 281 Stretched string 374 Sublimation 294 W Subtraction of vectors 67 Superposition principle 378 Superposition principle 378 Superposition principle 378 Surface energy 365	Speed of efflux	259	Unified Atomic Mass Unit	21
on a stretched string Uniformly accelerated motion 47 Sphygmomanometer 277 Unit vectors 70 Spring constant 352, 355 Standing waves 380 V Stationary waves 382 Vane 356 Steady flow 257 Vaporisation 288 Stethoscope 281 Vector-product 151 Stokes' law 263 Vectors 66 Stopping distance 50 Velocity amplitude 349 Strain 236 Venturi meter 260 Streamline flow 257, 258 Vibration 341 Streamline 257, 258 Viscosity 262 Stress 236 Volume expansion 281 Stress-strain curve 238 Stretched string 374 Sublimation 294 Subtraction of vectors 67 Superposition principle 378 Superposition principle 378 Suvelength 372	Speed of Sound	375, 376	Uniform circular motion	79
on a stretched string Sphygmomanometer Spring constant Spring constant Standing waves Stationary waves Stationary waves Steady flow Steady flow Stethoscope Stephing distance Stopping distance Streamline Streamline Streamline Streamline Streamline Stress Stress Stress Stress Stress Stress Stress Stretched string Sublimation Subtraction of vectors Spring constant Stream Sase Stream Unit vectors To Unit vectors To Unit vectors To Unit vectors To Vaporisation Vaporisation Vaporisation Streamline Stretched string Sublimation Subtraction of vectors Superposition principle Stress Superposition principle Surface energy Superposition principle Superposition	Speed of Transverse wave	375, 376	Uniform Motion	41
Spring constant Standing waves Stationary waves Stationary waves Steady flow Stethoscope Stethoscope Stokes' law Stopping distance Storeamline flow Streamline Streamline Streamline Stress Stress Stress Stress Stress Stress Stress Stress Stretched string Sublimation Subtraction of vectors Station Streamline Streamline Subtraction of vectors Superposition principle Surface energy Stress Stress Stress Stress Stress Stress Stress Superposition principle Surface energy Stress Stress Stress Stress Stress Stress Superposition principle Surface energy Sublimation Subtraction of vectors Superposition principle Surface energy Superposition principle Surface energy Sublimation Subtraction of vectors Superposition principle Surface energy Sublimation Subtraction of vectors Superposition principle Surface energy Superposition principle Sup	on a stretched string		Uniformly accelerated motion	47
Standing waves380VStationary waves382Vane356Steady flow257Vaporisation288Stethoscope281Vector-product151Stokes' law263Vectors66Stopping distance50Velocity amplitude349Strain236Venturi meter260Streamline flow257, 258Vibration341Streamline257, 258Viscosity262Stress236Volume expansion281Stress-strain curve238Volume Strain238Stretched string374Sublimation294WSubtraction of vectors67Wave equation374Superposition principle378Wavelength372	_	277	Unit vectors	70
Standing waves380VStationary waves382Vane356Steady flow257Vaporisation288Stethoscope281Vector-product151Stokes' law263Vectors66Stopping distance50Velocity amplitude349Strain236Venturi meter260Streamline flow257, 258Vibration341Streamline257, 258Viscosity262Stress236Volume expansion281Stress-strain curve238Volume Strain238Stretched string374Sublimation294WSubtraction of vectors67Wave equation374Superposition principle378Wavelength372	Spring constant	352, 355		
Steady flow257VancStethoscope281Vector-product151Stokes' law263Vectors66Stopping distance50Velocity amplitude349Strain236Venturi meter260Streamline flow257, 258Vibration341Streamline257, 258Viscosity262Stress236Volume expansion281Stress-strain curve238Volume Strain238Stretched string374Sublimation294WSubtraction of vectors67Wave equation374Superposition principle378Wavelength372		380	V	
Steady flow257Vaporisation288Stethoscope281Vector-product151Stokes' law263Vectors66Stopping distance50Velocity amplitude349Strain236Venturi meter260Streamline flow257, 258Vibration341Streamline257, 258Viscosity262Stress236Volume expansion281Stress-strain curve238Volume Strain238Stretched string374WSublimation294WSubtraction of vectors67Wave equation374Superposition principle378Wavelength372	Stationary waves	382	Vane	356
Stethoscope281Vector-product151Stokes' law263Vectors66Stopping distance50Velocity amplitude349Strain236Venturi meter260Streamline flow257, 258Vibration341Streamline257, 258Viscosity262Stress236Volume expansion281Stress-strain curve238Volume Strain238Stretched string374Sublimation294WSubtraction of vectors67Wave equation374Superposition principle378Wave length372	Steady flow	257		
Stokes' law 263 Vectors 66 Stopping distance 50 Velocity amplitude 349 Strain 236 Venturi meter 260 Streamline flow 257, 258 Vibration 341 Streamline 257, 258 Viscosity 262 Stress 236 Volume expansion 281 Stress-strain curve 238 Volume Strain 238 Stretched string 374 Sublimation 294 W Subtraction of vectors 67 Superposition principle 378 Surface energy 265 Stress 360 Wave equation 374 Surface energy 372	Stethoscope	281		
Stopping distance50Velocity amplitude349Strain236Venturi meter260Streamline flow257, 258Vibration341Streamline257, 258Viscosity262Stress236Volume expansion281Stress-strain curve238Volume Strain238Stretched string374Sublimation294WSubtraction of vectors67Wave equation374Superposition principle378Wavelength372	Stokes' law	263		
Strain 236 Venturi meter 260 Streamline flow 257, 258 Vibration 341 Streamline 257, 258 Vibration 262 Stress 236 Volume expansion 281 Stress-strain curve 238 Volume Strain 238 Stretched string 374 Sublimation 294 W Subtraction of vectors 67 Superposition principle 378 Surface energy 265 Surface energy 265 Streamline 257, 258 Vibration 241 Viscosity 262 Volume expansion 281 Wave equation 374 Wave equation 374 Wave equation 374 Surface energy 375	Stopping distance	50		
Streamline flow 257, 258 Vibration 341 Streamline 257, 258 Viscosity 262 Stress 236 Volume expansion 281 Stress-strain curve 238 Volume Strain 238 Stretched string 374 Sublimation 294 W Subtraction of vectors 67 Superposition principle 378 Surface energy 265 Surface energy 265		236		
Streamline257, 258Viscosity262Stress236Volume expansion281Stress-strain curve238Volume Strain238Stretched string374Sublimation294WSubtraction of vectors67Wave equation374Superposition principle378Wavelength372	Streamline flow	257, 258		
Stress 236 Volume expansion 281 Stress-strain curve 238 Volume Strain 238 Stretched string 374 Sublimation 294 W Subtraction of vectors 67 Superposition principle 378 Surface energy 265 Surface energy 265	Streamline			
Stress-strain curve 238 Volume Strain 238 Stretched string 374 Sublimation 294 W Subtraction of vectors 67 Superposition principle 378 Surface energy 265 Surface energy 288 Volume Strain 238 W Wave equation 374 Wave equation 374 Wavelength 372	Stress			
Stretched string 374 Sublimation 294 W Subtraction of vectors 67 Superposition principle 378 Surface energy 265 Surface energy 374 Surface energy 374 Surface energy 374 Surface energy 375 Surface energy 375 Surface energy 376 Surface energy 376 Surface energy 376 Surface energy 377 Surface energy	Stress-strain curve			_
Sublimation 294 W Subtraction of vectors 67 Superposition principle 378 Surface energy 265 Wave equation 374 Wavelength 372	Stretched string			
Subtraction of vectors 67 Superposition principle 378 Surface energy 265 Wave equation 374 Wavelength 372			W	
Surface energy 378 Surface energy 378 Wavelength 372	Subtraction of vectors			274
Surface energy 965 Wavelength 372	Superposition principle	378		
wave speed 374				
	<u></u>		wave specu	3/4

INDEX 313

Waves	368	Y	
Waxing and waning of sound	385	Yield Point	238
Weak nuclear force	9		
Weightlessness	197	Yield strength	238
Work done by variable force	118	Young's modulus	239
Work	116	7	
Work-Energy Theorem	116	Z	
Working substance	313	Zeroth law of Thermodynamics	305

Notes

