Appendix A
Standards Pertaining to Viscosity

A.1 ISO Standards for Viscosity Measurement

ISO 2884	Paints and varnishes—Determination of viscosity using rotary viscometers Part 1 Cone and plate viscometers operated at high rate of shear Part 2 Disc or ball viscometers
ISO 3104	Petroleum products—Transparent or opaque liquid—Determination of Kinematic viscosity and calculation of dynamic viscosity
ISO 3105	Glass capillary kinematic viscometers—Specifications and operating instructions
ISO 3219	Plastics—Polymers resins in the liquid state or in emulsions or dispersions—Determination of viscosity using rotational viscometers with defining shear rates
ISO 12058	Plastics—Determination of viscosity using a falling ball viscometer
ISO 1652	Rubber latex—Determination of apparent viscosity by Brookfield test method
ISO 2431	Paints and varnishes—Determination of flow time by use of flow cups
ISO 2555	Plastics—Resins in the liquid state or in emulsions or dispersions—Determination of apparent viscosity by Brookfield method

A.2 ASTM Standards for Viscosity Measurement

ASTM D1200-10	Standard Test Method for Viscosity by Ford Viscosity Cup
ASTM ADJD2161	Viscosity Extrapolation Tables to Zero Degrees Fahrenheit (SSU)
ASTM D2161-10	Standard Practice for Conversion of Kinematic Viscosity to Saybolt Universal Viscosity or to Saybolt Furol Viscosity
ASTM D2162-06	Standard practice for basic calibration of Master viscometers and Viscosity oils
ASTM D2270	Practice for Calculating Viscosity Index from Kinematic Viscosity at 40 and 100 °C
ASTM D2983-09	Standard Test Method for Low-Temperature **Viscosity** of Lubricants Measured by Brookfield Viscometer1, 2
ASTM D3176	
ASTM D341-09	Standard Practice for Viscosity-Temperature Charts for Liquid Petroleum Products

(continued)

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(continued)

ASTM D3716	Standard test methods for use of emulsion Polymers in Floor Polishers 09-10-1999 (R 2006)
ASTM D4016	Standard test methods for viscosity of chemical grouts by Brookfield Viscometer (Laboratory method
ASTM D4212	Standard test methods for viscosity by dip-type viscosity cups
ASTM D4287-00(2010)	Standard Test Method for High-Shear Viscosity Using a Cone/Plate Viscometer
	1.1 This test method covers the determination of the viscosity of paints, varnishes, and related products at a rate of shear of 12,000 s^{-1}
	1.2 Paints and varnishes that dry very rapidly may not give reproducible results with this test method. Measurements made at elevated temperatures may also give poor precision due to loss of volatiles and to drying.
	1.3 The values stated in SI units
ASTM D445-12	Standard Test Method for Kinematic **Viscosity** of Transparent and Opaque Liquids (and Calculation of Dynamic **Viscosity**)
ASTM D446-07	Standard Specifications and operating instructions for glass Capillary Kinematic Viscometers
ASTM D4741-12	Standard Test Method for Measuring Viscosity at High Temperature and High Shear Rate by Tapered-Plug Viscometer
ASTM D5152	Standard test methods for viscosity of paints and related materials by ISO Flow cups
ASTM D5293	Standard test methods for apparent viscosity of engine oils between −5 and −35 °C
ASTM D5478	Standard test methods for viscosity of materials by falling needle method
ASTM D5481	Standard test methods for measuring apparent viscosity of at high temperature
ASTM D6606-00(2010)	Standard Test Method for Viscosity and Yield of Vehicles and Varnishes by the Duke Viscometer
	This test method covers the procedure for determining the viscosity of varnishes, ink vehicles, and similar liquids that are essentially non volatile and un-reactive under ordinary room conditions using the Duke Automated high-shear rod and collar viscometer
	2.1.2 The instrument in this test method is similar in principle to the falling-rod viscometer described in Test Method D4040
ASTM D7042-12a	Standard Test Method for Dynamic Viscosity and Density of Liquids by Stabinger Viscometer (and the Calculation of Kinematic **Viscosity**)
ASTM D88-07	Standard Test Method for Saybolt Viscosity

A.3 British Standards for Viscosity Measurement

BS 3900-A7.1:2000	Section A7-1: Cone and plate viscometer Methods of test for paints, Tests on liquid paints (excluding chemical tests) Determination of the viscosity of paint at a high rate of shear
BS 3900-A7-2:2003	Section A7-2: Disc or ball viscometer Methods of test for paints, Tests on liquid paints (excluding chemical tests), Determination of the viscosity of paint at a high rate of shear, Disc or ball viscometer operated at a specified speed
BS 188:1977	Methods for determination of the viscosity of liquids
BS EN ISO 1599:1999	Plastics, Cellulose acetate, Determination of viscosity loss on moulding
BS DD CEN/TS 15324:2008	Bitumen and bituminous binders. Determination of equi-viscous temperature based on low shear viscosity using a dynamic shear rheometer in low frequency oscillation mode
BS EN ISO 1599:1999	Plastics. Cellulose acetate. Determination of viscosity loss on moulding
BS ISO 10294-3:1999	Fire-resistance tests. Fire dampers for air distribution systems. Guidance on the test method
BS EN ISO 8619:2004	Plastics, Phenolic resin powder. Determination of flow distance on a heated glass plate

Notes
(1) EN after BS stands for European standard
(2) ISO after BS stands for International Organisation for Standardisation

A.4 Bureau of Indian Standards (BIS) for Viscosity Measurement

IS 1448: Part 56	Methods of Test for Petroleum and its Products—Part 56: Viscosity Index by Calculation	2004
IS 13863	Cereals and milled cereal products—Determination of viscosity of flour—Method using an amylograph	1993
IS 1448: part 146	Methods of test for petroleum and its products—Part 146: Determination of yield stress and viscosity of engine oils at low temperature	1998
IS 1448: Part 25	Methods of Test for Petroleum and its Products—Part 25: Determination of Kinematic and Dynamic Viscosity	1976
IS 244	Method for determination of viscosity (or fluidity) of solutions of cotton and regenerated cellulosic man-made fibres in cuprammonium hydroxide	1984

(continued)

(continued)

IS 11720: Part 3	Methods of test for synthetic rubber—Part 3: Determination of Mooney Viscosity	1993
IS 12869: Part 1	Methods for Determination of Viscosity and Viscometric Fixed Points of Glass—Part 1: Determination of Viscosity by Fibre Elongation Method	1989
IS 12869: Part 2	Methods for determination of viscosity and viscometric fixed points of glass: Determination of softening point (IS 12869: Part 2)	1989
IS 12869	Methods for determination of viscosity and viscometric fixed points of glass—Part 3: Determination of annealing and strain point by beam bending method	1998
IS 13360: Part 11: Sec 10	Plastics—Methods of Testing—Part 11: Special Properties—Section 10: Resins in the Liquid State or as Emulsions or Dispersions—Determination of Apparent Viscosity by the Brookfield Test Method	1999
IS 13360: Part 11: Sec 15	Plastics—Methods of testing—Part 11: Special properties, Section 15 Determination of viscosity using a falling-ball viscometer—inclined-tube method	2006
IS 13360: Part 11: Sec 9	Plastics—Methods of testing—Part 11: Special propertiex, Section 9 Determination of the viscosity of polymers in dilute solution using capillary viscometers—General Principles	2004
IS 8543 : Part 1: Sec 1	Methods of testing plastics—Part 1: Characterization of polymer structure and size, Section 1: Determination of molecular mass from viscosity	1978
IS 4518: Part 1	Methods of test for styrene–butadiene rubbers (SBR)—Part I: Determination of volatile matter, total ash, organic acid, soap, antioxidants, bound styrene and mooney viscosity	1967
IS 6213 : Part 4	Methods of Test for Pulp—Part IV: Determination of Viscosity of Pulp	1971
IS 9466	Viscosity classification of industrial liquid lubricants	1980
IS 9316: Part 2	Methods of test for rubber latex—Part 2: Determination of viscosity (RL:2)	1987
IS 3660: Part 7	Methods of Test for Natural Rubber—Part 7: Determination of Mooney Viscosity 7)	1988

Appendix B
Standard Oils (An Example)

PSL stands for Poulten Selfe and Lee Ltd (PSL)
Russell House, Burnham Business Park
Burnham on Crouch, Essex
CM0 8TE
info@rheotek.com

PSL kinematic viscosity oil standards

PSL Ref	Marked	20 °C	25 °C	40 °C	50 °C	80 °C	100 °C
2700-V01*	N.4	0.47	0.45	0.40	–	–	–
2700-V02*	N.8	0.95	0.89	0.75	–	–	–
2700-V03*	N1.0	1.3	1.2	0.97	0.91	–	–
2700-V04	S3 #	4.6	4.0	2.9	2.4	1.6	1.2
2700-V05	S6	11	8.9	5.7	4.4	2.5	1.8
2700-V06	N10	21	17	10	7.3	4	2.7
2700-V07	S20	44	34	18	13	6	3.8
2700-V08	N35	87	66	32	21	9	5.3
2700-V09	S60	170	120	54	35	12	7.3
2700-V10	N100	330	230	97	60	20	11
2700-V11	S200	660	460	180	105	30	16
2700-V12	N350	1,300	850	310	170	45	23
2700-V13	S600	2,400	1,600	520	280	65	33
2700-V14	N1000	4,690	3,020	940	480	100	48
2700-V15	S2000	9,600	5,900	1,700	890	160	69
2700-V16	N4000	20,000	12,000	3,400	1,600	280	120
2700-V17	S8000	41,000	25,000	6,700	3,200	520	240
2700-V18	N15000	77,000	47,000	13,000	6,100	900	360
2700-V19	S30000	–	89,000	23,000	11,000	1,600	630

(Nominal kinematic viscosity values, stated in mm^2/s, cSt)

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PSL dynamic viscosity oil standards

PSL Ref	Marked	20 °C	25 °C	40 °C	50 °C	80 °C	100 °C
2700-V01*	N.4		0.29	0.26	–	–	–
2700-V02*	N.8	0.73	0.68	0.56	–	–	–
2700-V03*	N1.0	1.0	0.93	0.76	0.71	–	–
2700-V04	S3	3.9	3.3	2.4	1.9	1.2	0.9
2700-V05	S6	9.1	7.6	4.8	3.7	2	1.4
2700-V06	N10	18	15	8.8	6.2	3	2.2
2700-V07	S20	39	31	16	11	5	3.2
2700-V08	N35	76	57	27	18	7	4.3
2700-V09	S60	140	100	46	30	10	6.0
2700-V10	N100	290	210	84	50	17	9.0
2700-V11	S200	580	400	150	90	25	13
2700-V12	N350	1,100	750	270	150	37	19
2700-V13	S600	2,100	1,400	450	240	54	28
2700-V14	N1000	4,080	2,630	810	415	85	39
2700-V15	S2000	7,600	4,900	1,500	770	135	62
2700-V16	N4000	17,000	11,000	2,900	1,400	238	100
2700-V17	S8000	33,000	20,000	5,900	2,800	490	200
2700-V18	N15000	68,000	41,000	11,000	5,400	770	300
2700-V19	S30000	–	80,000	21,000	9,500	1,387	540

(Nominal dynamic viscosity values, stated in mPa·s, cP)

PSL measurement capability

Range	Relative uncertainty Kinematic (mm^2/s)	Relative uncertainty Dynamic (mPa·s)
Up to 6	0.18 %	0.18 %
6–19	0.18 %	0.18 %
19–100	0.22 %	0.22 %
19–100	0.22 %	0.22 %
100–450	0.27 %	0.27 %
450–1,750	0.40 %	0.40 %
1,750 and above	0.66 %	0.66 %

Expanded uncertainty at $k = 2$

Appendix C
Viscosity and Density of Standard Oils

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Viscosity of some standard oils at different temperature, mm^2/s

Designation	20 °C 68 °F	25 °C 77 °F	37.78 °C 100 °F	40 °C 104 °F	50 °C 122 °F	60 °C 140 °F	80 °C 176 °F	98.89 °C 210 °F	100 °C 212 °F	SUS 100 °F	SUS 210 °F
N.4(b)	0.47	0.45	0.41	0.40	–	–	–	–	–	–	–
N.8(b)	0.74	0.70	0.61	0.60	–	–	–	–	–	–	–
N1.0(b)	1.3	1.2	1.0	0.97	0.91	–	–	–	–	–	–
N2	2.9	2.6	2.1	2.0	1.7	–	1.2	0.95	0.94	–	–
S3(a)	4.6	4.0	3.0	2.9	2.4	–	1.5	1.2	1.2	–	–
N4	6.7	5.8	4.2	4.0	3.2	–	1.9	1.5	1.5	–	–
S6	11	8.9	6.0	5.7	4.4	–	2.4	1.8	1.8	–	–
N7.5	14	12	8.0	7.5	5.8	–	3.1	2.3	2.3	–	–
N10	21	17	11	10	7.3	–	3.5	2.7	2.7	–	–
N14	30	25	15	14	10	–	5.0	3.5	3.4	–	–
S20	44	34	20	18	13	–	5.6	3.9	3.8	100	–
N26	57	46	27	25	18	–	7.9	5.3	5.2	130	–
N35	87	66	35	32	21	–	8.5	5.4	5.3	170	–
N44	110	86	48	44	30	–	12	7.7	7.5	220	–
S60	160	120	60	54	35	–	12	7.7	7.5	280	–
N75	200	150	82	75	50	–	19	12	12	380	–
N100	330	230	110	97	60	–	19	11	11	500	–
N140	400	300	160	140	90	–	31	19	18	720	–
S200	550	400	200	180	110	–	35	22	20	925	105
N250	770	570	280	250	160	–	51	30	29	1,300	140
N350	1,000	720	340	310	190	–	55	34	32	1,570	160
N415	1,400	990	470	415	250	–	77	43	41	2,180	200
S600(c)	1,700	1,300	590	520	310	–	93	51	50	–	240
N750	2,600	1,900	850	750	440	–	130	68	66	–	–
N1000	3,400	2,400	–	940	550	350	150	–	80	–	–

(continued)

(continued)

Designation	20 °C 68 °F	25 °C 77 °F	37.78 °C 100 °F	40 °C 104 °F	50 °C 122 °F	60 °C 140 °F	80 °C 176 °F	98.89 °C 210 °F	100 °C 212 °F	SUS 100 °F	SUS 210 °F
N1400	5,100	3,600	–	1,400	820	510	220	–	120	–	–
S2000	8,300	5,300	1,900	1,600	800	–	160	75	72	–	360
N2500	8,400	6,000	–	2,500	1,500	950	430	–	230	–	–
N4000	20,000	12,000	–	3,400	1,600	850	290	–	120	–	–
N5100	28,000	18,000	–	5,100	2,500	1,300	420	–	170	–	–
S8000	41,000	25,000	8,000	6,700	3,200	–	530	–	240	–	–
N10200	58,000	36,000	–	10,200	4,900	2,500	775	–	300	–	–
N15000	77,000	47,000	–	13,000	6,100	3,000	980	–	360	–	–
N18000	103,000	64,000	–	18,000	8,500	4,300	1,320	–	500	–	–

Density of some standard oils at different temperature, g/cm³

Designation	20 °C 68 °F	25 °C 77 °F	37.78 °C 100 °F	40 °C 104 °F	50 °C 122 °F	60 °C 140 °F	80 °C 176 °F	98.89 °C 210 °F	100 °C 212 °F
N.4(b)	0.669	0.664	0.652	0.650	–	–	–	–	–
N.8(b)	0.867	0.862	0.851	0.849	–	–	–	–	–
N1.0(b)	0.928	0.861	0.720	0.699	0.616	–	–	–	–
N2	0.762	0.758	0.749	0.748	0.741	–	0.719	0.706	0.705
S3(a)	0.868	0.864	0.855	0.854	0.847	–	0.826	0.812	0.811
N4	0.787	0.783	0.775	0.773	0.767	–	0.746	0.734	0.733
S6	0.878	0.874	0.866	0.864	0.858	–	0.837	0.824	0.823
N7.5	0.801	0.798	0.789	0.788	0.781	–	0.761	0.749	0.748
N10	0.884	0.881	0.872	0.871	0.864	–	0.844	0.832	0.831
N14	0.812	0.809	0.801	0.800	0.793	–	0.774	0.762	0.761
S20	0.863	0.860	0.852	0.850	0.844	–	0.824	0.812	0.811
N26	0.820	0.817	0.809	0.808	0.801	–	0.783	0.771	0.770
N35	0.868	0.864	0.856	0.854	0.849	–	0.830	0.818	0.817
N44	0.828	0.825	0.817	0.816	0.809	–	0.791	0.779	0.778
S60	0.876	0.873	0.865	0.863	0.857	–	0.838	0.826	0.825
N75	0.833	0.830	0.822	0.820	0.814	–	0.796	0.785	0.784
N100	0.882	0.879	0.871	0.870	0.863	–	0.845	0.833	0.832
N140	0.838	0.835	0.827	0.826	0.819	–	0.801	0.790	0.789
S200	0.840	0.837	0.829	0.827	0.821	–	0.803	0.792	0.791
N250	0.842	0.839	0.831	0.830	0.824	–	0.806	0.795	0.794
N350	0.843	0.840	0.833	0.831	0.825	–	0.808	0.797	0.796
N415	0.846	0.843	0.835	0.834	0.828	–	0.810	0.799	0.798
S600(c)	0.847	0.844	0.836	0.835	0.829	–	0.811	0.800	0.799
N750	0.849	0.846	0.838	0.837	0.831	–	0.813	0.802	0.801
N1000	0.850	0.847	–	0.838	0.832	0.826	0.814	–	0.802
N1400	0.851	0.848	–	0.839	0.833	0.827	0.815	–	0.804
S2000	0.877	0.874	0.867	0.865	0.860	–	0.842	0.832	0.831
N2500	0.849	0.846	–	0.837	0.832	0.826	0.814	–	0.802
N4000	0.883	0.880	–	0.872	0.866	0.860	0.850	–	0.838
N5100	0.886	0.883	–	0.875	0.870	0.864	0.853	–	0.842
S8000	0.890	0.888	0.881	0.879	0.874	–	0.858	–	0.847
N10200	0.891	0.888	–	0.880	0.874	0.869	0.858	–	0.847
N15000	0.894	0.891	–	0.823	0.877	0.872	0.861	–	0.850
N18000	0.895	0.892	–	0.884	0.879	0.873	0.863	–	0.852
S30000	–	0.894	0.887	0.886	0.881	–	0.865	–	0.854

Appendix D
Buoyancy Correction

Data for buoyancy and temperature corrections

Viscosity standards	Kinematic viscosity mm^2/s		Density g/ml		$\rho_{n-1} - \rho_n$ at 40 °C
	37.78 °C	40 °C	20 °C	40 °C	
S3(a)	3.0	2.9	0.868	0.748	–
N10	11	10	0.884	0.788	0.040
N35	35	32	0.868	0.808	0.020
N100	110	97	0.882	0.820	0.012
N350	340	310	0.843	0.830	0.008
N1000	550**	940	0.850	0.837	0.007
N2500	1,500**	2,500	0.849	0.865	0.028
S8000	8,000	6,700	0.890	0.875	0.010
N10200	4,900**	10,200	0.891	0.879	0.004
S30000	28,000	23,000	–	0.884	0.005

D.1 Buoyancy Correction Water at 20 °C to Oil at 40 °C

Buoyancy correction to be applied to the viscometer constant of the first viscometer which was calibrated taking water as primary standard at 20 °C but is used to determine the viscosity of the oil at 40 °C is calculated as follows:

Density of water at 20 °C = 998.4081 at 40 °C = 992.2166 kg/m^3
Density of air at 20 °C = 1.199217 at 40 °C = 1.111770 kg/m^3

Relative Buoyancy correction c_b to viscometer constant for the viscometer calibrated by water at 20 °C but is used to determine the viscosity of oil at 40 °C

$$c_b = \frac{\sigma_{20}}{\rho_{20}} - \frac{\sigma_{40}}{\rho_{o40}}$$

Here ρ_{o40} is the density of first oil to be used with this viscometer

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$$\begin{aligned} c_b &= 1.199217/998.4081 - 1.111770/748 \\ &= 0.00120\,113\ - 0.00148632 \\ &= -0.000\,285 \\ &\cong -0.03\,\%. \end{aligned}$$

D.1 Maximum Buoyancy Correction Oil to Oil at 40 °C

Relative buoyancy corrections defined applicable to consecutive viscometers

$$c_b = \sigma_{40}(\rho_{n-1} - \rho_n)/\rho_n \rho_{n-1}$$

We see that maximum difference between the densities of any two consequent oils is 0.044 kg/m^3. Hence maximum relative buoyancy correction for a viscometer used at 40 °C with any oil

$$c_b = 1.111770(1/748 - 1/788)\ = 0.0013368 - 0.00126903\ = 0.000065$$

or 0.0065 % which is negligible in comparison to the target uncertainty of 0.1 %.

Appendix E
Coefficients of Viscosity of Some Standard Oils

Kinematic viscosity of oils is temperature dependent. Coefficient of increase in kinematic viscosity is defined as

$$\alpha_\nu = (\nu_{40} - \nu_{38.78})/\nu_{40}$$

Viscosity of some oils at 38.78 °C (100 °F) and at 40 °C

Viscosity standard	Kinematic viscosity		Coeff. of viscosity
	38.78 °C	40 °C	
S3(a)	3.0	2.9	0.0155
N10	11	10	0.045
N35	35	32	0.0422
N100	110	97	0.0604
N350	340	310	0.0436
N1000	550**	940	0.0415
N2500	1,500**	2,500	0.0400
S8000	8,000	6,700	0.0873
N10200	4,900**	10,200	0.1082
S30000	28,000	23,000	0.0979

Coefficients of expansion of standard oils are given in column 4 of the table.

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Appendix F
Equivalent Viscosities at 100 °F

F.1 Lower Range

Approximates values of kinematic viscosity on different scales corresponding to the values in mm^2/s, a sub-multiple SI unit of kinematic viscosity

Kinematic viscosity (mm^2/s)	Saybolt universal seconds (SUS)	ASTM viscosity grade +10 % SUS*	Saybolt Furol seconds	Engler degrees	Redwood No. 1 seconds	Redwood admiralty No. 2 seconds
2	32.62	32	–	1.1195	–	–
4	39.14	–	–	1.3075	36.5	–
6	45.56	40	–	1.4805	41.9	–
8	52.09	–	–	1.6535	47.6	–
10	58.91	60	–	1.834	53.5	–
12	66.04	–	–	2.023	59.6	–
14	73.57	75	–	2.222	66.1	–
16	81.30	–	–	2.435	72.7	–
18	89.44	–	–	2.646	79.6	–
20	97.77	–	–	2.876	86.6	–
22	106.4	105	–	3.11	93.9	–
24	115.0	–	–	3.35	101.3	–
26	123.7	–	–	3.59	108.8	–
28	132.7	–	–	3.83	116.4	–
30	141.3	–	–	4.08	124.0	–
32	150.2	150	–	4.33	1319	13.9
34	159.2	–	–	4.58	1.39.9	–
36	168.2	–	–	4.84	147.6	(16.2)
38	177.3	–	–	5.09	153.6	(16.9)
40	186.3	–	–	5.35	163.5	–

Notes (1) () Figures in parentheses means approximate
(2) Tentative nominal viscosity grade at 1,000 °F. Each grade permits a maximum range of ± 10% of the nominal viscosity
(3) Centipoise are obtained by multiplying kinematic viscosity in centistokes by specific gravity
(4) 1 centipoise symbol (cP) = 1 millipascal·second symbol (mPa·s)
(5) 1 centistoke symbol (cSt) = 1 millimetre square per second symbol (mm^2 /s)

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F.2 Higher Range

Kinematic viscosity (mm^2/s)	Saybolt universal seconds (SUS)	Viscosity grade ±10 % SUS*	Saybolt Furol seconds	Engler degrees	Redwood standard No. 1 seconds	Redwood admiralty No. 2 seconds
42	195.3	–	–	5.61	171.6	–
44	204.4	–	–	5.87	179.7	–
46	213.7	215	–	6.12	187.7	(20.2)
48	222.9	–	–	6,38	195.7	(20.7)
50	232.1	–	26.3	6,64	203.8	(21.4)
55	255.2	–	28.72	7.30	224.1	(23.4)
60	278.3	–	30.9	7.95	244.5	(25.6)
65	301.4	315	32.9	8.61	264.7	(27.8)
70	324.4	–	35.0	9.26	286.1	(30.0)
75	347.6	–	37.5	9.92	306	31.8
80	370.8	–	40.0	10.57	326	33.8
85	393.9	–	42.0	11.23	346	35.8
90	417.1	–	44.3	11.89	367	37.7
95	440.3	–	46.5	12.54	387	39.7
100	463.5	465	48.5	13.20	408	41.7
110	509.8	–	54	14.52	449	45.7
120	556.2	–	58	15.84	490	49.6
130	602.5	–	63	17.16	530	53.7
140	648.9	–	67	18.48	571	57.7
150	695.2	700	72	19.80	612	61.7
160	741.6	–	77	21.12	653	65.7
170	787.9	–	82	22.44	707	69.8
180	834.2	–	86	23.76	734	73.8
190	880.6	–	90	25.08	775	77.9
200	926.9	–	95	26.40	816	81.9
220	1019.6	1,000	104	29.04	898	90.0
240	1112.3	–	114	31.68	979	98.1
260	1205.0	–	123	34.32	1,061	106.2
280	1297.7	–	1333	36.96	1,142	114.4
300	1390.4	–	143	39.60	1,224	122.5
320	1483.1	1,500	153	42.24	1,306	130.7
370	1714.8	–	175	48.84	1,510	–
464	2155.1	2,150	220	61.25	1,893	–
500	2317.4	–	238	66.00	2,040	204.3
580	3150.0	3,150	(325)	89.76	2,774	(280)
(1,000)	4,650	4,650	(465)	(133)	(4,050)	–
1,510	7,000	7,000	(700)	199.3	616	–

Appendix G
Moment of Inertia

Assumptions:

(1) Every solid body is made of materials of uniform density and has a mass denoted by m.
(2) A particle of mass m has no dimensions (length, breadth or height).

G.1 Particle

The moment of inertia I of a particle of mass m and at a distance r from the axis of rotation is given as

$$I = mr^2.$$

G.2 Rod of Length L of Circular Section of Radius r

G2.1 The moment of inertia I about the axis passing through its mid point Fig. G.1 is given as

$$I = \frac{mL^2}{12}$$

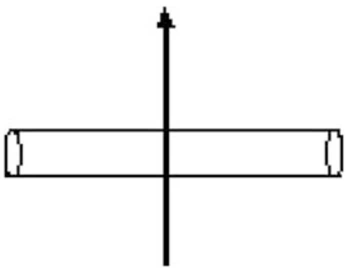

Fig. G.1 *Rod* of *circular* section

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G2.2 The moment of inertia I about the axis passing through its either end Fig. G.2 is given as

$$I = \frac{mL^2}{3}$$

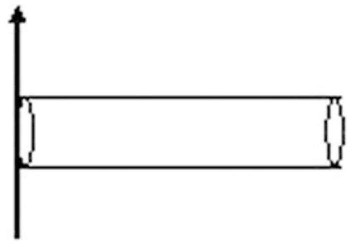

Fig. G.2 *Rod* of *circular* section

G.3 Circular Plate of Radius r

G3.1 The moment of inertia I_z about z axis (axis normal to the plate and passing through its centre Fig. G.3 is given as

$$I_z = \frac{mr^2}{2}$$

G3.2 The moment of inertia I about x or y axis (any diameter of the plate) is given as

$$I = \frac{mr^2}{4}$$

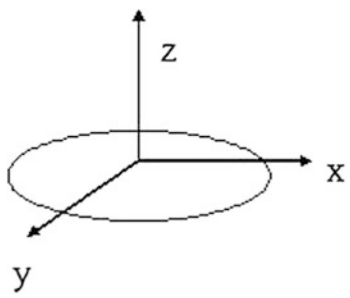

Fig. G.3 *Circular disc*

G.4 A Rectangular Plate of Uniform Thickness, Length a and Breadth b

G4.1 The moment of inertia I about the axis passing through its centre Fig. G.4 is given as

$$I = m\frac{a^2 + b^2}{12}$$

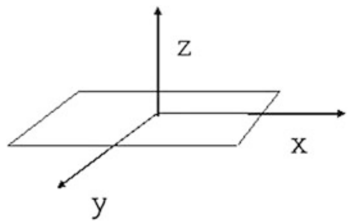

Fig. G.4 *Rectangular* plate

G4.2 The moment of inertia I about the axis passing through its corner Fig. G.5 is given as

$$I = m\frac{a^2 + b^2}{3}$$

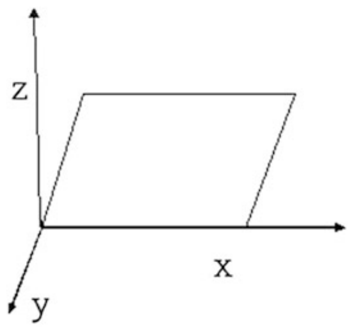

Fig. G.5 *Rectangular* plate

G.5 Thin Cylindrical Shell of Uniform Thickness

The moment of inertia I about the axis of a cylindrical shell Fig. G.6 is given as

$$I = mr^2$$

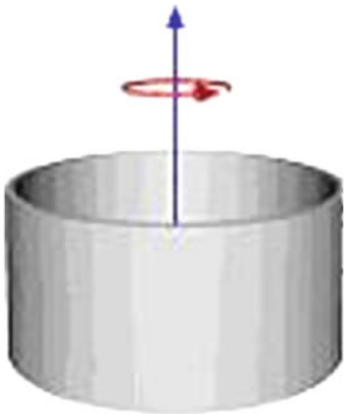

Fig. G.6 *Cylindrical* shell

G.6 Solid Cylinder of Radius r and Height h

G6.1 The moment of inertia I of a solid cylinder about its axis (z axis) Fig. G.7 is given as

$$I = \frac{mr^2}{2}$$

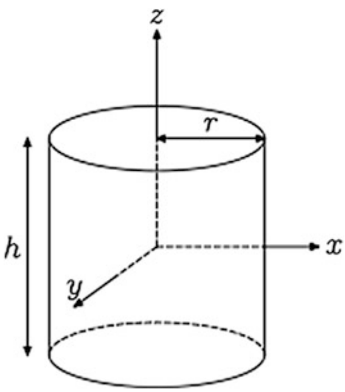

Fig. G.7 *Solid cylinder*

G6.2 The moment of inertia I of the solid cylinder about x or y axis Fig. G.7 is given as

$$I = \frac{1}{12}\left(3r^2 + h^2\right)$$

G.7 Solid Hollow Cylinder of Inner Radius r_1 and Outer Radius r_2

G7.1 The moment of inertia I_z of a hollow cylinder Fig. G.8 about its axis (z axis) is given as

$$I_z = \frac{1}{2}m\left(r_2^2 + r_1^2\right)$$

G7.2 The moment of inertia of hollow cylinder about x or y axis is given as

$$I_x = I_y = \frac{1}{12}\left\{3\left(r_1^2 + r_2^2\right) + h^2\right\}$$

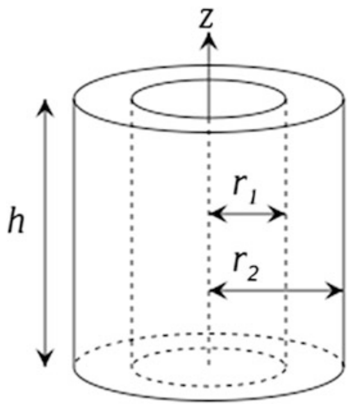

Fig. G.8 *Hollow cylinder*

G.8 Solid Sphere or Radius r

The moment of inertia I of a solid sphere about any of its diameter as axis Fig. G.9 is given as

$$I = \frac{2mr^2}{5}$$

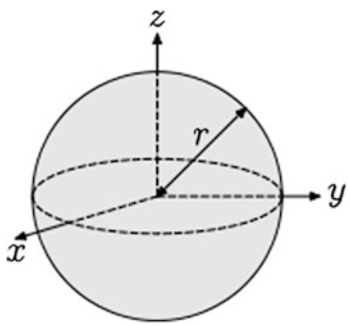

Fig. G.9 *Solid sphere*

G.9 Spherical Shell of Radius r

The moment of inertia *I* of a spherical shell about any of its diameter Fig. G.10 is given as

$$I = \frac{2mr^2}{3}$$

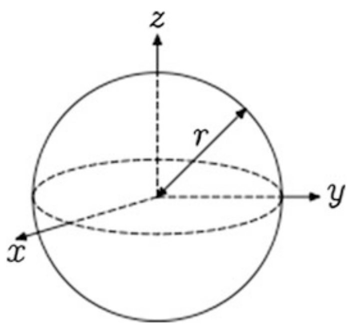

Fig. G.10 *Spherical* shell

G.10 Hollow Sphere Inner Radius r_1 and Outer Radius r_2

The moment of inertia *I* of a hollow sphere of about its any diameter Fig. G.11 is given as

$$I = \frac{2m\left(r_2^5 - r_1^5\right)}{5\left(r_2^3 - r_1^3\right)}$$

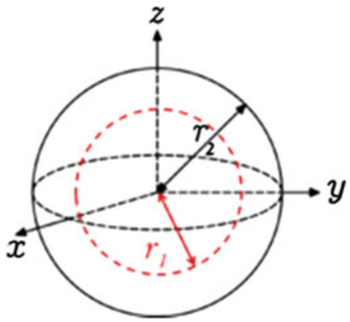

Fig. G.11 *Hollow sphere*

G.11 Solid Vertical Cone of Radius r and Height h

G11.1 The moment of inertia I_z of right circular solid cone Fig. G.12, about z axis is given as

$$I_z = \frac{3}{10} m r^2$$

G11.2 The moment of inertia of right circular solid cone about x or y axis Fig. G.10 is given as

$$I = \frac{3}{4} m \left(\frac{r^2}{2} + h^2 \right)$$

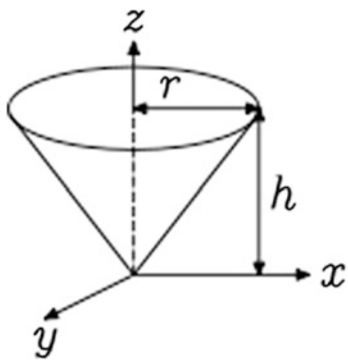

Fig. G.12 *Solid circular cone*

G.12 Rectangular Plate of Breadth b and Length a

The moment inertia of a rectangular plate about axis normal to its plane at the edge of its middle point, Fig. G.13, is given as

$$I = \frac{ma^2}{3} + \frac{mb^2}{12}$$

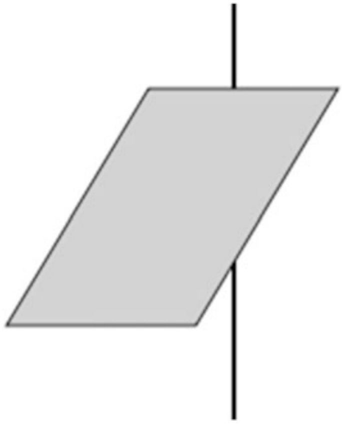

Fig. G.13 *Rectangular* plate

G.13 Rectangular Block of Length a, Breadth b and Height c

G13.1 Moment of inertia I_c of a solid rectangular block about the axis passing through it centre of gravity along its height c, Fig. G.12, is given as

$$I_c = \frac{m(a^2 + b^2)}{12}$$

G13.2 Moment of inertia I_a of a solid rectangular block about the axis passing through it centre of gravity along its length a is

$$I_a = \frac{m(b^2 + c^2)}{12}$$

G13.3 Moment of inertia I_b of a solid rectangular block about the axis passing through it centre of gravity along its breadth b is (Fig. G.14)

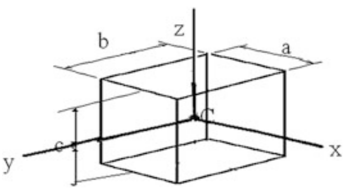

Fig. G.14 *Rectangular* block

$$I_b = \frac{m(c^2 + a^2)}{12}$$

G13.4 Moment of inertia I of a solid rectangular block about its longest diagonal, Fig. G.15, is given as

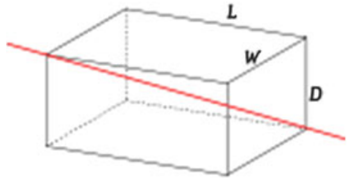

Fig. G.15 *Solid rectangular* block

$$I = \frac{m(a^2b^2 + b^2c^2 + c^2a^2)}{6(a^2 + b^2 + c^2)}$$

References

1. Serway RA (1986) Physics for scientists and engineers, 2nd edn. Saunders College Publishing, p 202, ISBN 0-03-004534-7
2. Classical Mechanics—Moment of inertia of a uniform hollow cylinder. www.LivePhysics.com. Accessed 31 Jan 2008
3. Beer FP, Russell Johnston E Jr (1984) Vector mechanics for engineers, 4th edn. McGraw-Hill, New York, p 911, ISBN 0-07-004389-2
4. Weisstein EW (2010) Moment of inertia—ring. Wolfram Research. Accessed 25 March 2010

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