INDUSTRIES OF INDIA · THE ITEM STUDIES

The Ball Bearing

Source Companion

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How to read this companion

Every factual claim in *The Ball Bearing* carries an inline tag — [S1] to [S76] — that resolves to one entry below. Each entry names the source, its publisher and date, its URL where one was recorded, the claims it backs, and the chapters that cite it.

Read status is recorded honestly for each source, because the method requires it:

Fetched and read means the full text was retrieved and read during research on 1 November 2026. **Excerpts** means the source was identified through search results and snippets and its full text was not retrieved; claims resting on it are correspondingly lighter. **Bibliographic** means a primary scholarly work cited from the scholarly record itself (its text is behind archives or paywalls); such sources are named exactly so any reader can retrieve them.

One fetch failure was recorded during research: the standalone fluid-dynamic bearing article was unreachable, and that content was taken from the hard disk drive article instead, as noted at S58. Tags S11, S40 and S41 were reserved during drafting and are not cited in the final text. Market projections throughout are forecasts and are labelled as forecasts in the book.

Sources

S1 Ball bearing

Wikipedia, English edition · Continuously updated reference; consulted 1 Nov 2026 · Encyclopedia

https://en.wikipedia.org/wiki/Ball_bearing

Backs: Working principle, construction, cage function, types and designations of ball bearings.

Cited in: Four Parts and a Film, The Family of Designs, Grease, Shields and Seals, Names and Numbers

Full text fetched and read (1 Nov 2026)

S2 Philip Vaughan

Wikipedia, English edition · Consulted 1 Nov 2026 · Encyclopedia

https://en.wikipedia.org/wiki/Philip_Vaughan

Backs: The 1794 Carmarthen patent no. 2006 for iron ball bearings in carriage wheel axles; Vaughan's biography.

Cited in: A Patent in Carmarthen, Four Parts and a Film

Full text fetched and read (1 Nov 2026)

S3 Jules Suriray

Wikipedia, English edition · Consulted 1 Nov 2026 · Encyclopedia

https://en.wikipedia.org/wiki/Jules_Suriray

Backs: Suriray's 2 August 1869 ball bearing patent, the Paris-Rouen race win, and the bicycle application.

Cited in: Paris, 1869, The Bicycle, Again

Full text fetched and read (1 Nov 2026)

S4 Friedrich Fischer

Wikipedia, English edition · Consulted 1 Nov 2026 · Encyclopedia

https://en.wikipedia.org/wiki/Friedrich_Fischer

Backs: Fischer's 1883 ball grinding mill, FAG's founding and the Schweinfurt cluster.

Cited in: Fischer's Mill, Schweinfurt: The Town the Ball Built, The Business of Balls

Full text fetched and read (1 Nov 2026)

S5 Sven Gustaf Wingqvist

Wikipedia, English edition · Consulted 1 Nov 2026 · Encyclopedia

https://en.wikipedia.org/wiki/Sven_Wingquist

Backs: Wingquist's comparative study of ball and plain bearings, the self-aligning patent, SKF's founding.

Cited in: The Line Shaft's Demands, Stribeck Measures It, Wingquist and the Mud

Full text fetched and read (1 Nov 2026)

S6 Nemi ships

Wikipedia, English edition · Consulted 1 Nov 2026 · Encyclopedia

https://en.wikipedia.org/wiki/Nemi_ships

Backs: Caligula's barges, their fittings, and the discovery context of the Nemi finds.

Cited in: Caligula's Rotating Tables

Full text fetched and read (1 Nov 2026)

S7 History timeline

SKF Group (skf.com) · Consulted 1 Nov 2026 · Company publication

https://www.skf.com/us/organisation/about-skf/history-timeline

Backs: SKF's dated corporate timeline: founding 1907, early global plants, acquisitions (Atlas Ball, RecondOil 2019), and technical milestones.

Cited in: The Business of Balls, Wingquist and the Mud, SKF Runs the World, The Swedish Century, The Quality Revolution, The Quiet Globalisation, The First War and the Association, The Neutral Supplier, Friction, Energy and the Climate Ledger, The Long Game

Full text fetched and read (1 Nov 2026)

S8 Sven Wingquist - Spherical ball bearings

Tekniska museet (Swedish National Museum of Science and Technology) · Consulted 1 Nov 2026 · Museum publication

https://www.tekniskamuseet.se/en/learn-more/swedish-inventors/sven-wingquist-spherical-ball-bearings/

Backs: The Gamlestaden textile mill story: failing German bearings, misaligned shafts, and the invention of the self-aligning ball bearing.

Cited in: Wingquist and the Mud, SKF Runs the World, Japan's First Ball, The Quiet Globalisation

Full text fetched and read (1 Nov 2026)

S9 Second Schweinfurt raid

Wikipedia, English edition · Consulted 1 Nov 2026 · Encyclopedia

https://en.wikipedia.org/wiki/Second_Raid_on_Schweinfurt

Backs: Black Thursday, 14 October 1943: force sizes, timing, losses (60 B-17s lost of 291), bomb times, German production shares, dispersal and recovery.

Cited in: Schweinfurt: The Town the Ball Built, The Business of Balls, The Strategic Component, Black Thursday, The Second Raid, The Bottleneck That Wasn't, The Neutral Supplier

Full text fetched and read (1 Nov 2026)

S10 Fighting Friction: Henry Timken and the Tapered Roller Bearing

German Historical Institute, Immigrant Entrepreneurship project · 2018; consulted 1 Nov 2026 · Scholarly essay

https://www.immigrantentrepreneurship.org/entries/fighting-friction-henry-timken-and-the-tapered-roller-bearing/

Backs: Timken's biography, the carriage trade, the tapered roller bearing, and the early industry's competitive landscape.

Cited in: The Boom That Made an Industry, The Axle Box Problem, The Business of Balls, The Cousin in St. Louis, Canton, Ohio, The Quiet Globalisation, The First War and the Association

Full text fetched and read (1 Nov 2026)

S12 NIHF Inductee: Henry Timken

National Inventors Hall of Fame (invent.org) · Consulted 1 Nov 2026 · Institutional publication

https://www.invent.org/inductees/henry-timken

Backs: US patent 606,636 (1898, with Reginald Heinzelman) for the tapered roller bearing.

Cited in: The Cousin in St. Louis

Full text fetched and read (1 Nov 2026)

S13 Revolving thrust bearings

Museo Leonardiano di Vinci · Consulted 1 Nov 2026 · Museum publication

https://museoleonardiano.it/en/opera/revolving-thrust-bearings/

Backs: The wooden model of Leonardo's revolving thrust bearing (Codex Madrid I), 17 cm tall, with balls in separated pools.

Cited in: The Idea That Kept Being Lost, The Thrust Question

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S14 Bearing Timeline

American Bearing Manufacturers Association (americanbearings.org) · Consulted 1 Nov 2026 · Industry association

https://www.americanbearings.org/general/custom.asp?page=bearing_timeline

Backs: Industry's own chronology: ancient lubrication, nineteenth-century patents, EHL theory (1960), association history.

Cited in: The Egyptian Question, The Clockmaker's Cage, The Oldest Enemy, The Idea That Kept Being Lost, The Patent Office Warms, Fischer's Mill, The Business of Balls, The Film That Saves Everything, Japan Enters the Race, The Quality Revolution, Four Parts and a Film, The Cage: The Part Nobody Notices, The Standards Book, The Strategic Component, The First War and the Association, The Long Tail of Makers, The Film of Oil

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S15 How are bearing balls made?

GlobalSpec (insights.globalspec.com), Ken Thayer · 31 July 2019; consulted 1 Nov 2026 · Trade press

https://insights.globalspec.com/article/12349/how-are-bearing-balls-made

Backs: The manufacturing route for bearing balls: heading, flashing, heat treatment, grinding, lapping; grades and tolerances.

Cited in: Why Round Is Hard, How a Ball Is Made Today, The Lapping Plate, The Business of Balls, The Long Supply Chain, The Bureaucracy of Precision, The First War and the Association

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S16 Ball Bearing Market Size, Share, Trends, Growth Analysis - 2035

Global Market Insights (gminsights.com), report GMI8015 · 2026 edition; consulted 1 Nov 2026 · Market research

https://www.gminsights.com/industry-analysis/ball-bearing-market

Backs: Market sizing ($17.5B in 2025; forecast $28.6B by 2035), segment and regional shares, EV sales context, cost structure, grinding-capacity constraints, qualification barriers, sensor integration. Forecast figures are used as labelled forecasts.

Cited in: The Line Shaft's Demands, The Materials Frontier, The Long Supply Chain, SKF Runs the World, Japan Enters the Race, Japan's First Ball, The Spinning Frame's Children, The Family of Designs, Making the Rings, The Home Appliance's Hum, The Motor and the Appliance, The Automobile, Wind, Water and Power, The Miniature World, Precision and Play, The Census of Dependence, The Pump's Steady Heart, The Fan Wall, How Big Is the Ball, The Six Houses, The Chinese Quarter, How the Market Works, The Aftermarket's Clock, The Trillion Spinning Shafts, The Steel Constraint, The Capacity and Skill Constraint, The Squeeze on the Middle, The Geography of Precision, The Qualification Wall, Friction, Energy and the Climate Ledger, The Grinder's Apprenticeship, The Clean Steel Queue, The Middle Squeeze, The Electric Problem, Ceramic Balls, Bearings That Talk, The Long Game, The Bearing as Data

Full text fetched and read (1 Nov 2026)

S17 SKF Annual Report 2024 published online; significant decarbonization milestone reached

SKF Group press release (skf.com) · 7 March 2025; consulted 1 Nov 2026 · Company publication

https://www.skf.com/group/news-and-events/news/2025/2025-Mar-07-skf-annual-report-2024-published-online-significant-decarbonization-milestone-reached

Backs: SKF 2024 figures: SEK 98,722M sales, 38,743 employees, ~130 countries, ~17,000 distributor locations, 59% scope 1-2 emissions cut vs 2019, 72% renewable electricity.

Cited in: SKF Runs the World, The Assembly Line's Rollers, The Six Houses, The Rebuild Trade, The Conveyor's Long Line, The Distribution Machine, How the Market Works, The Year of the Ledger, The Aftermarket's Clock, Friction, Energy and the Climate Ledger, The Long Game

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S18 Schaeffler with stable overall results in transition year 2024

Schaeffler Group press release (schaeffler.com) · 5 March 2025; consulted 1 Nov 2026 · Company publication

https://www.schaeffler.com/en/media/press-releases/press-releases-detail.jsp?id=88080770

Backs: Schaeffler 2024 figures: EUR 18.2B revenue, Bearings & Industrial Solutions EUR 6,570M, Vehicle Lifetime Solutions EUR 2,579M, 115,055 employees.

Cited in: The Business of Balls, The Six Houses, The Distribution Machine, How the Market Works, The Year of the Ledger

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S19 The bearing market (Markets)

SKF Group investor pages (skf.com) · Consulted 1 Nov 2026 · Company publication

https://www.skf.com/group/investors/skf-as-an-investment/the-bearing-market

Backs: SKF's market map: global bearing market ~SEK 500 billion, top six makers over half the market, China roughly one quarter, stable structure.

Cited in: The Quiet Globalisation, The Assembly Line's Rollers, The Census of Dependence, How Big Is the Ball, The Six Houses, The Chinese Quarter, The Rebuild Trade, The Conveyor's Long Line, How the Market Works, The Year of the Ledger, The Aftermarket's Clock, The Trillion Spinning Shafts, The Geography of Precision, The Middle Squeeze, Bearings That Talk

Full text fetched and read (1 Nov 2026)

S20 Timken Reports Fourth-Quarter and Full-Year 2024 Results

The Timken Company (news.timken.com) · 5 February 2025; consulted 1 Nov 2026 · Company publication

https://news.timken.com/2025-02-05-Timken-Reports-Fourth-Quarter-and-Full-Year-2024-Results

Backs: Timken Q4 2024 sales of $1.07 billion; full-year sales down 4.1% on 2023.

Cited in: The Cousin in St. Louis, The Six Houses, The Year of the Ledger

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S21 NSK Financial Results for FY2024 (Consolidated)

NSK Ltd. investor relations · May 2025 · Company publication

https://www.nsk.com/content/dam/nsk/common/company/investors/library/pdf/financial_announcement/2024/fy2024q4e.pdf

Backs: NSK fiscal 2024 sales and profit direction, led by industrial machinery bearings; NSK's position among the five largest ball bearing makers.

Cited in: Japan Enters the Race, The Six Houses, The Year of the Ledger

Identified through search results and excerpts; full text not retrieved (1 Nov 2026)

S22 Minebea's 1.5 mm bearing - Guinness World Records title

MinebeaMitsumi press release · 2015; consulted 1 Nov 2026 · Company publication

https://www.minebeamitsumi.com/english/news/press/2015/1189728_7564.html

Backs: The 1.5 mm outer-diameter steel ball bearing (0.5 mm bore, 0.65 mm width, six balls and cage); MinebeaMitsumi's founding in 1951 and its >60% share of miniature and small-sized ball bearings to 22 mm.

Cited in: Japan Enters the Race, The Miniature Empire, Names and Numbers, The Miniature World, The Office Machine, The Fishing Reel's Cast, The Six Houses

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S23 Hybrid ceramic bearings

SKF Group product pages (skf.com) · Consulted 1 Nov 2026 · Company publication

https://www.skf.com/group/products/rolling-bearings/engineered-products/hybrid-bearings/why-skf-hybrid-ceramic-bearings

Backs: SKF's hybrid claims: electrical-erosion shielding, up to 25% higher speed, up to 50% friction reduction, up to 8x grease life, tolerance of poor lubrication and refrigerants.

Cited in: The Film That Saves Everything, The Materials Frontier, Grease, Shields and Seals, Mounting and Care, The Compressor's Duty, The Fishing Reel's Cast, The Biggest Rings and the Fastest Balls, The Bicycle, Again, The Machine Tool's Spindle, Friction, Energy and the Climate Ledger, Ceramic Balls, The Ceramic Question

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S24 Stop Fake Bearings

World Bearing Association (stopfakebearings.com) · Consulted 1 Nov 2026 · Industry association

https://www.stopfakebearings.com/

Backs: The WBA anti-counterfeiting initiative, its member companies (JTEKT/Koyo, Nachi, NTN, NSK, Schaeffler, SKF, Timken), and the scale of bearing counterfeiting.

Cited in: The Spinning Frame's Children, The Mounted Bearing, The Power Tool's Scream, Fakes, The Distribution Machine, The Counterfeit Fight, The Squeeze on the Middle

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S25 The fidget-spinner boom

The Economist, Graphic Detail · 8 September 2017; consulted 1 Nov 2026 · News analysis

https://www.economist.com/graphic-detail/2017/09/08/the-fidget-spinner-boom

Backs: NPD sales estimates (at least 19 million spinners in twelve rich countries in H1 2017; other estimates above 50 million) and the speed of the fad's global spread.

Cited in: Precision and Play, The Skateboard's Eight, The Spinning Toy, The Yo-yo's Sleep

Full text fetched and read (1 Nov 2026)

S26 Understanding and Mitigating Electric Discharge Damage in Electric Vehicle Motor Bearings

SKF Group (skf.com) · 10 April 2024; consulted 1 Nov 2026 · Company research publication

https://www.skf.com/group/newsroom/news-and-stories/understanding-and-mitigating-electric-discharge-damage-in-electric-vehicle-motor-bearings

Backs: SKF's 2024 study of electrical erosion in EV motor bearings under EHL conditions; frosting, pitting and fluting mechanisms.

Cited in: The Film That Saves Everything, What Kills a Bearing, The Failure Gallery, The Fan Wall, The Electric Problem, The Lubricant Is the Bearing

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S27 NTN Starts Mass-Production of Resin Mold Insulated Bearing for e-Axle

NTN Corporation new product release · 2025 · Company publication

https://www.ntnglobal.com/en/news/new_products/news202500030.html

Backs: NTN's 2025 mass production of resin-mould insulated bearings for EV e-axles (insulation countermeasure).

Cited in: The Osaka Rival, The Electric Problem

Full text fetched and read (1 Nov 2026)

S28 **SKF overcomes current leakage challenges in advanced electric vehicle powertrains**

SKF Group press release · 4 April 2024 · Company publication

https://www.skf.com/group/news-and-events/news/2024/2024-04-04-skf-overcomes-current-leakage-challenges-in-advanced-electric-vehicle-powertrains

Backs: Conduction countermeasures for shaft currents: grounding arrangements and conductive approaches.

Cited in: The Electric Problem

Full text fetched and read (1 Nov 2026)

S29 **H. Hertz, 'Ueber die Beruehrung fester elastischer Koerper'**

Journal fuer die reine und angewandte Mathematik (Crelle's Journal), vol. 92, pp. 156-171 · 1882 · Journal article

(no live URL recorded; standard archival citation, widely held in digital archives)

Backs: Hertz's contact theory: the elastic foundation of all bearing load and life analysis.

Cited in: Hertz Touches the Problem

Cited bibliographically from the scholarly record; text not retrieved

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S30 **Men of Tribology: Heinrich Hertz and Richard Stribeck**

ASME Journal of Tribology 101(2):115 (D. Dowson) · 1979 · Journal article

https://doi.org/10.1115/1.3453287

Backs: The Hertz-Stribeck pairing: contact theory carried into the bearing laboratory; the Stribeck curve and lubrication regimes.

Cited in: Hertz Touches the Problem, Stribeck Measures It, The Curve and the Regimes, Mounting and Care

Identified through search results and excerpts; full text not retrieved (1 Nov 2026)

S31 **A. Palmgren, 'Die Lebensdauer von Kugellagern' (1924); G. Lundberg & A. Palmgren, 'Dynamic Capacity of Rolling Bearings' (1947/1952)**

Palmgren: VDI-Zeitschrift 68(14), 1924; Lundberg-Palmgren: Acta Polytechnica, Mech. Eng. Series · 1924; 1947/1952 · Journal articles

https://ntrl.ntis.gov/NTRL/dashboard/searchResults/titleDetail/N7119009.xhtml

Backs: Weibull statistics applied to the stressed volume under the raceway; the L10 rating-life convention.

Cited in: The Life Equation, The Statistics of Survival, The Quality Revolution

Cited bibliographically from the scholarly record; text not retrieved

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S32 **A. Palmgren Revisited: A Basis for Bearing Life Prediction (E. Zaretsky)**

NASA Technical Reports Server (NASA Lewis Research Center) · 1997 · Agency technical report

https://ntrs.nasa.gov/citations/19970025228

Backs: NASA's confirmation that Lundberg-Palmgren statistics remain the basis of rolling-bearing life prediction, including its own methods.

Cited in: The Life Equation, Bearings off Earth, The Space Agency's Bearing Laboratory

Identified through search results and excerpts; full text not retrieved (1 Nov 2026)

S33 **From Innovation to Standardization - A Century of Rolling Bearing Life Formula**

Machines (MDPI) 12(7):444 · 2024 · Journal article

https://doi.org/10.3390/machines12070444

Backs: The 2024 centenary review of the life formula: Lundberg-Palmgren as the skeleton under ISO 281 and modern selection software.

Cited in: The Life Equation, The Statistics of Survival, The Quality Revolution, The Standards Book, The Grinder's Apprenticeship, The Film of Oil

Identified through search results and excerpts; full text not retrieved (1 Nov 2026)

S34 **Rolling bearing steels - a technical and historical perspective**

Materials Science and Technology / ASTM bearing-steel technology literature · Consulted via search excerpts, 1 Nov 2026 · Journal/technical literature

https://doi.org/10.1179/1743284711y.0000000043

Backs: How 52100-type high-carbon chromium steel became the default bearing material; M50 and case-carburising grades for temperature and shock.

Cited in: The Steel Underneath, The Materials Frontier, The Long Supply Chain, The Quality Revolution, Precision and Play, Bearings off Earth, The Steel Constraint, The Clean Steel Queue

Identified through search results and excerpts; full text not retrieved (1 Nov 2026)

S35 **Formation and Evolution of Inclusions in High Chromium Steel (ISIJ International 61(9)); 'Low-oxygen rare earth steels' (Nature Materials, 2022)**

ISIJ International (jstage.jst.go.jp); Nature Materials · 2021; 2022 · Journal articles

https://www.nature.com/articles/s41563-022-01352-9

Backs: Inclusion control in high-carbon chromium bearing steel; the 2022 low-oxygen rare-earth steel frontier.

Cited in: The Steel Underneath, The Long Supply Chain, The Quality Revolution, The Steel Constraint, The Clean Steel Queue

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S36 **The ball grinding machine from Friedrich Fischer was patented 125 years ago**

Schaeffler Technologies press release (via pressebox.com) · 2008 · Company publication

https://www.pressebox.com/pressrelease/schaeffler-technologies-ag-co-kg/the-ball-grinding-machine-from-friedrich-fischer-was-patented-125-years-ago/boxid/760392

Backs: Schaeffler's marking of the 1883 grinding-mill patent as a foundation date.

Cited in: Fischer's Mill

Identified through search results and excerpts; full text not retrieved (1 Nov 2026)

S37 History (Pioneering Spirit)

Schaeffler Group (schaeffler.com) · Consulted 1 Nov 2026 · Company publication

https://www.schaeffler.com/en/group/history/

Backs: Schaeffler's account of how Fischer's process revolutionised ball bearing manufacture and centred it on Schweinfurt.

Cited in: Schweinfurt: The Town the Ball Built

Identified through search results and excerpts; full text not retrieved (1 Nov 2026)

S38 Ball Bearings

Scientific American · 1 September 2009; consulted 1 Nov 2026 · Magazine

https://www.scientificamerican.com/article/ball-bearings/

Backs: Bessemer steel plus the bicycle as the fixing combination; Vaughan's cast-iron balls cracking; Suriray's steel-ball patent; Gravity Probe B's near-perfect quartz spheres.

Cited in: Bessemer's Gift, The Patent Office Warms, The Most Perfect Spheres Ever Made, The One That Got Away: The Hard Drive

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S39 D. Dowson & B. Hamrock, 'History of Ball Bearings' (NASA TM-81689)

NASA Technical Reports Server · 1981; consulted 1 Nov 2026 · Agency technical memorandum

https://ntrs.nasa.gov/api/citations/19810009866/downloads/19810009866.pdf

Backs: The standard scholarly history: Diades (c. 330 BCE), the Nemi bearings (AD 44-54, sixteen bronze balls in the Museo Nazionale Romano), Leonardo's bearing studies, Galileo's cage, early friction laws.

Cited in: The Classical Rolling Engineers, Diades and the Ram, Leonardo in Madrid, Bearings off Earth, The Space Agency's Bearing Laboratory

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S42 As fidget spinner craze goes global, its inventor struggles to make ends meet

The Guardian · 3 May 2017 · News

https://www.theguardian.com/lifeandstyle/2017/may/03/fidget-spinner-inventor-patent-catherine-hettinger

Backs: Catherine Hettinger's precursor spinning-toy patent (US5591062A), lapsed in 2005.

Cited in: Precision and Play

Full text fetched and read (1 Nov 2026)

S43 Worldwide Ball and Roller Bearings Market to Reach 4.5M Tons and $70.5B by 2030

IndexBox market intelligence · 2024 edition · Market research

https://www.indexbox.io/blog/bearing-world-market-overview-2024/

Backs: Global ball and roller bearing market projection to ~$70.5B and 4.5M tonnes by 2030. Used as a labelled forecast.

Cited in: How Big Is the Ball

Full text fetched and read (1 Nov 2026)

S44 Ball Bearings from Roman Imperial Ships of Nemi Lake

Advances in Historical Studies 8(3), doi:10.4236/ahs.2019.83009 · 2019 · Journal article

https://doi.org/10.4236/ahs.2019.83009

Backs: The modern scholarly case that the Nemi platforms were true thrust ball bearings, likely for rotating display statues; the alternative deck-crane reading.

Cited in: Caligula's Rotating Tables, The Thrust Question, The Escalator's Steps

Full text fetched and read (1 Nov 2026)

S45 Analysis and Reconstruction of a Platform with Ball Bearings in Roman Ships of Nemi Lake

Springer, History of Mechanism and Machine Science, doi:10.1007/978-3-030-03538-9_16 · 2019 · Book chapter

https://doi.org/10.1007/978-3-030-03538-9_16

Backs: Engineering reconstruction of the Nemi ball bearing platform.

Cited in: Caligula's Rotating Tables

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S46 Leonardo da Vinci: Pressure-resistant ball bearing

Leonardo and the Engineers of the Renaissance, IMSS Florence (brunelleschi.imss.fi.it) · Consulted 1 Nov 2026 · Museum publication

https://brunelleschi.imss.fi.it/genscheda.asp?appl=LIR&chiave=100873&lingua=ENG&xsl=paginamanoscritto

Backs: The Codex Madrid I sketch of a pressure-resistant ball bearing for loaded vertical shafts.

Cited in: Leonardo in Madrid, The Idea That Kept Being Lost, The Thrust Question

Full text fetched and read (1 Nov 2026)

S47 Leonardo interactivo (Codex Madrid I)

Biblioteca Nacional de Espana (bne.es) · Consulted 1 Nov 2026 · Library publication

https://www.bne.es/es/publicaciones/leonardo-interactivo

Backs: The Codex Madrid I itself: the notebook rediscovered in 1967 holding Leonardo's most developed mechanical thinking.

Cited in: The Idea That Kept Being Lost

Full text fetched and read (1 Nov 2026)

S48 Experimental Study: Bearing Degradation Caused by Electrical Currents and Voltages at Low Speeds

Lubricants (MDPI) 13(4):175 · 2025 · Journal article

https://doi.org/10.3390/lubricants13040175

Backs: Electrical erosion dependence on film thickness, lubricant dielectric strength and breakdown voltage, tested under EHL conditions.

Cited in: The Electric Problem

Full text fetched and read (1 Nov 2026)

S49 Defect tolerance assessment of silicon nitride in rolling contact (A.W. Awan, PhD thesis, Bournemouth University)

Bournemouth University ePrints · 2015 · Thesis

http://eprints.bournemouth.ac.uk/25044/

Backs: Defect control during grinding and lapping as the decisive variable in silicon nitride rolling-contact fatigue reliability.

Cited in: The Materials Frontier, Ceramic Balls, The Ceramic Question

Identified through search results and excerpts; full text not retrieved (1 Nov 2026)

S50 The 1,000th main bearing

thyssenkrupp rothe erde newsroom · Consulted 1 Nov 2026 · Company publication

https://www.thyssenkrupp-rotheerde.com/en/newsroom/stories/1000th-main-bearing-for-multi-megawatt-wind-turbines

Backs: thyssenkrupp rothe erde's 1,000th main bearing for multi-megawatt wind turbines.

Cited in: Wind, Water and Power, The Crane's Circle

Full text fetched and read (1 Nov 2026)

S51 Sinomach bearings power completion of world's largest 17-MW direct-drive floating wind turbine generator

Sinomach news · July 2025 · Company publication

https://www.sinomach.com.cn/en/MediaCenter/News/202507/t20250724_561938.html

Backs: Sinomach bearings in the 17 MW direct-drive floating wind turbine generator (2025).

Cited in: Wind, Water and Power, The Crane's Circle, The Chinese Quarter

Full text fetched and read (1 Nov 2026)

S52 Main bearings for wind turbines

Liebherr Components (liebherr.com) · Consulted 1 Nov 2026 · Company publication

https://www.liebherr.com/en-int/components/solutions/slewing-bearings-and-slew-drives/main-bearings-for-wind-turbines-5373827

Backs: Liebherr's large-diameter main bearings for wind turbines; the specialist slewing-bearing trade.

Cited in: Wind, Water and Power, The Crane's Circle

Identified through search results and excerpts; full text not retrieved (1 Nov 2026)

S53 Rolling through the ages

Schaeffler tomorrow magazine (schaeffler-tomorrow.com) · September 2017; consulted 1 Nov 2026 · Company magazine

https://schaeffler-tomorrow.com/en/article/rolling-through-the-ages

Backs: Schaeffler's historical essay: ancient lubrication and the log-roller question, the Celtic chariot bearing (~2,700 years), Leonardo's friction laws, the safety bicycle sequence, the 1949 INA cage, Istanbul Metro FAG units past 2.7 million km, London Eye bearings (2.6 m, 11 t), dental turbines at 100,000 rpm, >100 bearings per car.

Cited in: The Egyptian Question, The Boom That Made an Industry, The Safety Machine, The Needle and the Cage, The Cage: The Part Nobody Notices, The Escalator's Steps, The Automobile, Wheels of Steel: The Railway, The Biggest Rings and the Fastest Balls, The Dentist's Chair, The Distribution Machine, The Trillion Spinning Shafts, The Bearing as Data

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S54 Magnetic bearing

Wikipedia, English edition · Consulted 1 Nov 2026 · Encyclopedia

https://en.wikipedia.org/wiki/Magnetic_bearing

Backs: Magnetic levitation bearings: Jesse Beams, S2M (1976), Groningen 23 MW motor-compressors, backup bearings, flywheels and blood pumps; SKF's Revolve/S2M lineage.

Cited in: The One That Got Away: The Hard Drive, Bearings Without Contact, The Beams Sensation

Full text fetched and read (1 Nov 2026)

S55 Bearing (mechanical)

Wikipedia, English edition · Consulted 1 Nov 2026 · Encyclopedia

https://en.wikipedia.org/wiki/Bearing_(mechanical)

Backs: The wide bearing story: the Djehutihotep sledge drawings (wetted sand, no evidence of log rollers), Ramelli's published roller and thrust bearings, Harrison's caged roller bearing for H3, Franke wire-race bearings, Mars Rover bearings.

Cited in: The Egyptian Question, The Clockmaker's Cage, The Bookseller's Pivot, Leonardo in Madrid, The Thrust Question, The Cage: The Part Nobody Notices, The Cousins: Rolling's Extended Family, The Mounted Bearing, The Assembly Line's Rollers, The Power Tool's Scream, The Home Appliance's Hum, The Compressor's Duty, The Escalator's Steps, The Pump's Steady Heart, The Office Machine, The Steel Mill's Own Bearings, The Crusher's Shock, The Fan Wall, The Railway's Second Century, The Harvester's Season, Bearings off Earth, The Trillion Spinning Shafts

Full text fetched and read (1 Nov 2026)

S56 Rolling-element bearing

Wikipedia, English edition · Consulted 1 Nov 2026 · Encyclopedia

https://en.wikipedia.org/wiki/Rolling-element_bearing

Backs: Types, geometries, failure modes (spalling, brinelling, false brinelling), life statistics, mounting practice, and rolling-element bearing families.

Cited in: The Clockmaker's Cage, The Curve and the Regimes, The Statistics of Survival, The Vocabulary of Rolling, Making the Rings, What Kills a Bearing, The Contact Patch, The Cage: The Part Nobody Notices, The Cousins: Rolling's Extended Family, The Failure Gallery, Mounting and Care, The Grease Cartridge, The Sealed Decision, The Escalator's Steps, The Gearbox's Pairs, The Crusher's Shock, The Machine Tool's Spindle, The Lubricant Is the Bearing, The Bearing as Data

Full text fetched and read (1 Nov 2026)

S57 ABEC scale

Wikipedia, English edition · Consulted 1 Nov 2026 · Encyclopedia

https://en.wikipedia.org/wiki/ABEC_scale

Backs: ABEC tolerance classes 1/3/5/7/9 with inner-race runouts of 10/7/4/2.5/1.5 micrometres; ISO 492, DIN 620, JIS B1514 mirrors.

Cited in: Grades of Truth, The Standards Book, The Skateboard's Eight, The Machine Tool's Spindle

Full text fetched and read (1 Nov 2026)

S58 Hard disk drive

Wikipedia, English edition · Consulted 1 Nov 2026 · Encyclopedia

https://en.wikipedia.org/wiki/Hard_disk_drive

Backs: HDD spindle motors and the fluid dynamic bearing's displacement of ball bearings in drives; the direct fluid-bearing page was unreachable, content taken from the HDD article (fetch failure recorded 1 Nov 2026).

Cited in: The One That Got Away: The Hard Drive

Full text fetched and read (1 Nov 2026)

S59 Line shaft

Wikipedia, English edition · Consulted 1 Nov 2026 · Encyclopedia

https://en.wikipedia.org/wiki/Line_shaft

Backs: Factory line-shaft power distribution; the 500 hp engine driving 600 looms; shafting, countershafts and the bearing demands of the factory system.

Cited in: The Line Shaft's Demands

Full text fetched and read (1 Nov 2026)

S60 Joseph Whitworth

Wikipedia, English edition · Consulted 1 Nov 2026 · Encyclopedia

https://en.wikipedia.org/wiki/Joseph_Whitworth

Backs: Whitworth's millionth-of-an-inch measuring machine demonstrated at the Great Exhibition of 1851; practical accuracy limits (~500 nm) from thermal effects.

Cited in: Whitworth's Millionth

Full text fetched and read (1 Nov 2026)

S61 Journal bearing

Wikipedia, English edition · Consulted 1 Nov 2026 · Encyclopedia

https://en.wikipedia.org/wiki/Journal_bearing

Backs: The plain/journal bearing: simplest bearing type, no rolling elements; railway 'friction bearings'; hydrodynamic lubrication and the oil-film wedge.

Cited in: The Watermill's Bearings, The Journal's Long Reign, The Axle Box Problem, The Turbine's Spin, The Steel Mill's Own Bearings, The Railway's Second Century

Full text fetched and read (1 Nov 2026)

S62 Hertzian contact stress (Contact mechanics)

Wikipedia, English edition · Consulted 1 Nov 2026 · Encyclopedia

https://en.wikipedia.org/wiki/Hertzian_contact_stress

Backs: Hertz's 1882 solution for two elastic bodies with curved surfaces in contact; the classical foundation of contact mechanics.

Cited in: Hertz Touches the Problem

Full text fetched and read (1 Nov 2026)

S63 Watermill

Wikipedia, English edition · Consulted 1 Nov 2026 · Encyclopedia

https://en.wikipedia.org/wiki/Watermill

Backs: Watermill history and distribution; Domesday Book mill counts; the medieval mill's power economy and bearing arrangements.

Cited in: The Watermill's Bearings

Full text fetched and read (1 Nov 2026)

S64 NSK Ltd.

Wikipedia, English edition · Consulted 1 Nov 2026 · Encyclopedia

https://en.wikipedia.org/wiki/NSK_Ltd.

Backs: NSK's 1916 first Japanese bearing plant; company scale and product range.

Cited in: Japan's First Ball, The Spinning Frame's Children, The British Houses

Full text fetched and read (1 Nov 2026)

S65 JTEKT

Wikipedia, English edition · Consulted 1 Nov 2026 · Encyclopedia

https://en.wikipedia.org/wiki/JTEKT

Backs: JTEKT's creation in January 2006 by the Koyo Seiko - Toyoda Machine Works merger; Toyota Group parentage; ~40,700 employees.

Cited in: The Spinning Frame's Children, The Koyo Merger

Full text fetched and read (1 Nov 2026)

S66 NTN Corporation

Wikipedia, English edition · Consulted 1 Nov 2026 · Encyclopedia

https://en.wikipedia.org/wiki/NTN_Corporation

Backs: NTN's 1918 founding; NTN USA (1990) and its subsidiaries; hub units and constant-velocity joints.

Cited in: The Spinning Frame's Children, The Osaka Rival

Full text fetched and read (1 Nov 2026)

S67 Nachi-Fujikoshi

Wikipedia, English edition · Consulted 1 Nov 2026 · Encyclopedia

https://en.wikipedia.org/wiki/Nachi-Fujikoshi

Backs: Nachi's 1928 Toyama founding; integrated bearings, cutting tools, machine tools, specialty steels, robots and hydraulics.

Cited in: The Spinning Frame's Children, The Toyama Arsenal

Full text fetched and read (1 Nov 2026)

S68 Torrington Company

Wikipedia, English edition · Consulted 1 Nov 2026 · Encyclopedia

https://en.wikipedia.org/wiki/Torrington_Company

Backs: Torrington's origin as the Excelsior Needle Company (1866); the needle bearing lineage.

Cited in: The Vocabulary of Rolling, The Needle Makers of Connecticut

Full text fetched and read (1 Nov 2026)

S69 Strain wave gearing (Harmonic drive)

Wikipedia, English edition · Consulted 1 Nov 2026 · Encyclopedia

https://en.wikipedia.org/wiki/Harmonic_drive

Backs: Musser's 1957 strain wave gearing patent at United Shoe Machinery; first successful use 1960; robotics and aerospace applications.

Cited in: The Robot's Wrist

Full text fetched and read (1 Nov 2026)

S70 Dry lubricant

Wikipedia, English edition · Consulted 1 Nov 2026 · Encyclopedia

https://en.wikipedia.org/wiki/Dry_lubricant

Backs: Graphite and molybdenum disulfide as the two main dry lubricants; MoS2 lubricating in vacuum (space vehicles, CV joints); hexagonal boron nitride ('white graphite').

Cited in: The Solid Slip

Full text fetched and read (1 Nov 2026)

S71 Ransome & Marles

Wikipedia, English edition · Consulted 1 Nov 2026 · Encyclopedia

https://en.wikipedia.org/wiki/Ransome_%26_Marles

Backs: The Ransome & Marles bearing company: British bearing manufacture in Newark-on-Trent.

Cited in: The British Houses

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S72 Turbocharger

Wikipedia, English edition · Consulted 1 Nov 2026 · Encyclopedia

https://en.wikipedia.org/wiki/Turbocharger

Backs: Turbocharger turbine speeds up to 250,000 rpm; free-floating turbochargers; the shaft bearing environment.

Cited in: The Boost Business

Full text fetched and read (1 Nov 2026)

S73 Stuxnet

Wikipedia, English edition · Consulted 1 Nov 2026 · Encyclopedia

https://en.wikipedia.org/wiki/Stuxnet

Backs: Stuxnet at Natanz from 2009; IR-1 centrifuge speed manipulation from 1,064 Hz to 1,410 Hz for 15 minutes and down to 2 Hz; rootkit behaviour.

Cited in: The Centrifuge's Wound

Full text fetched and read (1 Nov 2026)

S74 Yo-yo

Wikipedia, English edition · Consulted 1 Nov 2026 · Encyclopedia

https://en.wikipedia.org/wiki/Yo-yo

Backs: Yo-yos in Ancient Greek vase painting; surviving bronze and terracotta examples; sleeping and transaxle mechanics.

Cited in: The Fishing Reel's Cast, The Yo-yo's Sleep

Full text fetched and read (1 Nov 2026)

S75 CT scan

Wikipedia, English edition · Consulted 1 Nov 2026 · Encyclopedia

https://en.wikipedia.org/wiki/CT_scan

Backs: CT scanner construction: rotating X-ray tube and detector row in a gantry; Hounsfield and Cormack's 1979 Nobel Prize.

Cited in: The Gantry's Revolution

Full text fetched and read (1 Nov 2026)

S76 Condition monitoring

Wikipedia, English edition · Consulted 1 Nov 2026 · Encyclopedia

https://en.wikipedia.org/wiki/Condition_monitoring

Backs: Condition monitoring techniques: vibration analysis, lubricant analysis, acoustic emission, infrared thermography, ultrasound.

Cited in: The Pump's Steady Heart, The Conveyor's Long Line, Listening to the Races

Full text fetched and read (1 Nov 2026)
