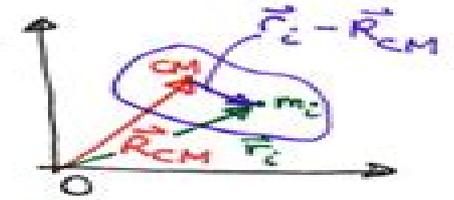## 3.8 Classical spin – angular momentum about the CM

For a system of masses (discrete or continuous) we can define total angular momentum w.r.t. O as

$$\vec{L}_O = \sum_i \vec{r}_i \times \vec{p}_i = \sum_i m_i (\vec{r}_i \times \vec{v}_i).$$

$\vec{L}_O$ changes with O!

$$\vec{R}_{CM} := \frac{1}{M} \sum_i m_i \vec{r}_i \quad, \text{where} \quad M = \sum_i m_i$$

now add to $\vec{L}_O$ a zero $\quad \emptyset = \sum_i m_i (\vec{R}_{CM} \times \vec{v}_i) - \sum_i m_i (\vec{R}_{CM} \times \vec{v}_i)$

$$\vec{L}_O = \underbrace{\sum_i (\vec{r}_i - \vec{R}_{CM}) \times \vec{p}_i}_{\vec{L}_{tot} \text{ w.r.t. } \vec{R}_{CM}} + \underbrace{\sum_i \vec{R}_{CM} \times \vec{p}_i}_{= \vec{R}_{CM} \times \sum_i \vec{p}_i = \vec{R}_{CM} \times \vec{P}} = \underline{\vec{L}_{CM} + \vec{R}_{CM} \times \vec{P}}$$

Angular momentum about O = angular momentum about CM + angular momentum of CM about O.

$$\vec{L}_{CM} := \sum_i (\vec{r}_i - \vec{R}_{CM}) \times \vec{p}_i \quad \text{is the intrinsic angular momentum or classical spin of the body.}$$

No external torques on CM $\Rightarrow \frac{d}{dt} \vec{L}_{CM} = 0$

or: $\frac{d}{dt} \vec{L}_{CM} = \vec{N}^{ext}_{CM}$

The CM provides a natural reference system for calculating angular momentum and torque in an N-body object.

Application: Earth's rotation axis points currently towards the North Star (polar star). This axis, however, sweeps out a cone with 23.5° opening angle, and period 25,800 years. Implication: External forces generate a precession.

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Y Pai

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Introduction To Classical Mechanics: Solutions To Problems John Dirk Walecka,2020-08-24 The textbook Introduction to Classical Mechanics aims to provide a clear and concise set of lectures that take one from the introduction and application of Newton s laws up to Hamilton s principle of stationary action and the lagrangian mechanics of continuous systems An extensive set of accessible problems enhances and extends the coverage It serves as a prequel to the author s recently published book entitled Introduction to Electricity and Magnetism based on an introductory course taught some time ago at Stanford with over 400 students enrolled Both lectures assume a good concurrent course in calculus and familiarity with basic concepts in physics the development is otherwise self contained As an aid for teaching and learning and as was previously done with the publication of Introduction to Electricity and Magnetism Solutions to Problems this additional book provides the solutions to the problems in the text Introduction to Classical Mechanics **Solved Problems in Classical Mechanics** O. L. de Lange,J. Pierrus,2010-05-06 Apart from an introductory chapter giving a brief summary of Newtonian and Lagrangian mechanics this book consists entirely of questions and solutions on topics in classical mechanics that will be encountered in undergraduate and graduate courses These include one two and three dimensional motion linear and nonlinear oscillations energy potentials momentum and angular momentum spherically symmetric potentials multi particle systems rigid bodies translation and rotation of the reference frame the relativity principle and some of its consequences The solutions are followed by a set of comments intended to stimulate inductive reasoning and provide additional information of interest Both analytical and numerical computer techniques are used to obtain and analyze solutions The computer calculations use Mathematica version 7 and the relevant code is given in the text It includes use of the interactive Manipulate function which enables one to observe simulated motion on a computer screen and to study the effects of changing parameters The book will be useful to students and lecturers in undergraduate and graduate courses on classical mechanics and students and lecturers in courses in computational physics **Theory of Sum Frequency Generation Spectroscopy** Akihiro Morita,2018-08-02 This book describes fundamental theory and recent advances of sum frequency generation SFG spectroscopy SFG spectroscopy is widely used as a powerful tool of surface characterization although theoretical interpretation of the obtained spectra has been a major bottleneck for most users Recent advances in SFG theory have brought about a breakthrough in the analysis methods beyond conventional empirical ones and molecular dynamics MD simulation of SFG spectroscopy allows for simultaneous understanding of observed spectra and interface structure in unprecedented detail This book explains these recently understood theoretical aspects of SFG spectroscopy by the major developer of the theory The theoretical topics are treated at basic levels for undergraduate students and are described in

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   Encyclopaedia of Mathematics Michiel Hazewinkel,2012-12-06 This is the first Supplementary volume to Kluwer s highly acclaimed Encyclopaedia of Mathematics This additional volume contains nearly 600 new entries written by experts and covers developments and topics not included in the already published 10 volume set These entries have been arranged alphabetically throughout A detailed index is included in the book This Supplementary volume enhances the existing 10 volume set Together these eleven volumes represent the most authoritative comprehensive up to date Encyclopaedia of Mathematics available   **Introduction to Classical Mechanics** David Morin,2008-01-10 This textbook covers all the standard introductory topics in classical mechanics including Newton s laws oscillations energy momentum angular momentum planetary motion and special relativity It also explores more advanced topics such as normal modes the Lagrangian method gyroscopic motion fictitious forces 4 vectors and general relativity It contains more than 250 problems with detailed solutions so students can easily check their understanding of the topic There are also over 350 unworked exercises which are ideal for homework assignments Password protected solutions are available to instructors at www cambridge org 9780521876223 The vast number of problems alone makes it an ideal supplementary text for all levels of undergraduate physics courses in classical mechanics Remarks are scattered throughout the text discussing issues that are often glossed over in other textbooks and it is thoroughly illustrated with more than 600 figures to help demonstrate key concepts   **Proceedings of the Physical Society** Institute of Physics and the Physical Society,1927   The Logical Analysis of Quantum Mechanics Erhard Scheibe,1973   *Proceedings of the Physical Society* Physical Society of London,1927   **Classical Mechanics** Carolina C. Ilie,Zachariah S. Schrecengost,Elina M. van Kempen,2022-12-29 This book of problems and solutions in classical mechanics is dedicated to junior or senior undergraduate students in physics engineering applied mathematics astronomy or chemistry who may want to improve their problems solving skills or to freshman graduate students who may be seeking a refresh of the material The book is structured in ten chapters starting with Newton s laws motion with air resistance conservation laws oscillations and the Lagrangian and Hamiltonian Formalisms The last two chapters introduce some ideas in nonlinear dynamics chaos and special relativity Each chapter starts with a brief theoretical outline and continues with problems and detailed solutions A concise presentation of

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