



Todo en página 1 y 2 explica el movimiento del yoyo en forma lineal, es decir que descienda y ascienda en una misma dirección, sin cambios.

Urban Maths: Yo-yo

Alan Stevens CMATH FIMA



I was watching a couple of youngsters doing tricks with yo-yos. They had them moving continuously in all sorts of directions, not just up and down vertically; they were swinging them pendulum style, wrapping and unwrapping them around their arms, etc., all without getting tangled. I was full of admiration for their skill. The best I can do is a single vertical down and up – if I'm lucky! However, since I'm not much good at the real thing, I thought I would have a go at producing a mathematical model of the activity. Here is what I came up with.

Referring to Figure 1, and using **Newton's second law** (1) we have:

$$m \frac{dv}{dt} = T - mg \quad (1)$$

and

$$I \frac{d\omega}{dt} = Tr \quad (2)$$

where m is the mass, I is the moment of inertia, v is the velocity of the centre of mass (positive upwards), ω is the angular rotational speed, T is the tension in the string, r is the radius of the axle and g is gravitational acceleration.

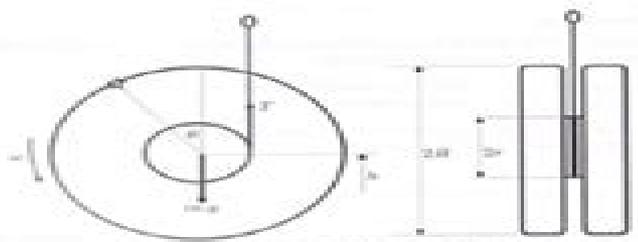


Figure 1: Two views of the yo-yo model.

We can also connect the rotational speed, ω , with the linear velocity of the centre of mass, v , through:

$$v = r\omega \quad (3)$$

(In one rotation, the centre of mass travels through a distance of $2\pi r$, because of the string travelling or unwrapping, in a time of $2\pi/\omega$.) Note that v is not the tangential velocity at the axle, though it has the same absolute magnitude. We also need to take into account that, as matter the direction of spins, the linear velocity will be negative during a descending phase and positive during an ascending phase (note that the yo-yo continues to spin in the same sense as it switches from descending to ascending).

We will simply take the **assumption of constant** $T = mR^2/2$ assuming the gap between the two main sections of the yo-yo is small enough that we need not bother to correct for it. We can

eliminate the string tension, T , between equations (1) and (2). Then, by differentiating equation (3) with respect to time (the noting that dv/dt will be positive during a descent and negative during an ascent, whereas $d\omega/dt$ will be negative throughout) and with a little algebraic manipulation, we get the following **expression for the rate of change of velocity at the centre of mass**:

$$\frac{dv}{dt} = \frac{g}{(1 + (R/r)^2/2)} \quad (4)$$

We can integrate equation (4) immediately for the **assumed motion**; so, with the assumption that there is zero initial velocity, i.e. we just let it unwind under the influence of gravity alone, we have:

$$v = \frac{gt}{(1 + (R/r)^2/2)} \quad (5)$$

(with a corresponding expression for rotational speed, ω , obtained by using equation (3)).

We can integrate this again to get the **height of the centre of mass as a function of time**:

$$h = h_0 - \frac{g^2 t^2}{2(1 + (R/r)^2/2)} \quad (6)$$

where h_0 is the initial height.

For the **inward motion**, we again integrate equation (4), this time getting:

$$v = h_0 - \frac{g(t - t_0)}{(1 + (R/r)^2/2)} \quad (7)$$

where t_0 is the time at which the yo-yo reaches its lowest height, h_0 , and h_0 is the magnitude of the linear velocity at that height (I am assuming the yo-yo changes direction instantly at its lowest height).

The corresponding **expression for height** is now:

$$h = h_0 - \frac{g^2(t - t_0)^2}{2(1 + (R/r)^2/2)} - v_0(t - t_0) \quad (8)$$

(Equation (8) is basically the **standard kinematics** $s = ut + at^2/2$ with suitably adjusted origins, t and u .) We set h_0 by specifying the **position of zero**, u , of the string that are on the yo-yo's axle (we will assume the string is thin enough that it does not significantly alter the effective radius of the axle). That is, we set $h_0 = h_0 - 2\pi r n$. Using this in equation (8), we find the **speed** to be:

$$v_0 = \sqrt{\frac{4\pi r n g}{g} \left(1 + \frac{1}{2} \left(\frac{R}{r}\right)^2\right)}$$

Using equation (7), the **minimum absolute velocity**, v_0 , is:

$$v_0 = \sqrt{\frac{4\pi r n g}{(1 + (R/r)^2/2)}}$$

Todo esto explica los cálculos del movimiento del yoyo al descender o bajar, considerando cero fuerza inicial y la gravedad como catalizador o fuerza que causa el movimiento (más todo lo demás a considerar, como la altura/distancia que alcanza el yoyo)

Todo explica los cálculos del yoyo al ascender de vuelta de su caída, considerando a la altura que el yoyo alcanza, su velocidad y la cantidad de vueltas (turns) que la cuerda del yoyo da alrededor del mismo.

Revisar la segunda ley de Newton

Todo lo que se lee aquí es fácil, nos dice que significa cada símbolo en las ecuaciones

Aquí nos relacionan la velocidad rotacional con la velocidad lineal del centro de la masa, easy peasy

Lo importante es la velocidad lineal del movimiento del yo-yo, negativa al bajar y positiva al subir

Yo Yo 1 Pb Intl

**Terence Favero, Barry Drust, Brian
Dawson**

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Shipbuilding & Marine Engineering International, 1923 **Axiomatic and Economic Approaches to International Comparisons** W. Erwin Diewert, 1996 The paper considers the problem of choosing a multilateral system of index numbers in order to make aggregate price and quantity comparisons between many countries and regions The problems involved in choosing functional forms in order to make these comparisons are both theoretically and empirically more difficult than the problems involved in choosing a bilateral index number formula The great variation in relative prices and quantities in the international context means that the choice of a multilateral method is empirically important different methods will give very different answers The paper reviews ten classes of multilateral methods both from the viewpoint of the axiomatic approach as well as the economic approach A new system of 11 desirable axioms or properties for multilateral systems is suggested With respect to the economic approach the concept of a superlative bilateral index number formula which can adequately model substitution effects is adapted to the multilateral context Each of the 10 classes of multilateral methods is evaluated from the axiomatic and economic perspectives Four classes of methods are identified as being best They are all superlative and satisfy slightly different sets of axioms *International Research in Science and Soccer II* Terence Favero, Barry Drust, Brian Dawson, 2015-10-23 *International Research in Science and Soccer II* showcases the very latest research into the world's most widely played sport With contributions from scientists researchers and practitioners working at every level of the game from grassroots to elite level the book covers every key aspect of preparation and performance including performance and match analysis training and testing physiotherapy and injury prevention biomechanics youth development women's soccer sport science and coaching sport psychology Sports scientists trainers coaches physiotherapists medical doctors psychologists educational officers and professionals working in soccer will find this in depth comprehensive volume an essential and up to date resource The chapters contained within this volume were first presented at The Fourth World Conference on Science and Soccer held in Portland Oregon in June 2014 under the auspices of the World Commission of Science and Sports **International Commerce**, 1965 *The International Confectioner*, 1922 Proceedings of the 1st International Conference on Fluid, Thermal and Energy Systems Sudev Das, Narasimha Mangadoddy, Jaap Hoffmann, 2024-01-17 This book comprises the proceedings of the 1st International Conference on Fluid Thermal and Energy Systems The contents of this book focus on phase change heat transfer advanced energy systems separated flows turbulence and multi phase modeling computational fluid flow and heat transfer thermal energy storage systems integrated energy systems nuclear thermal hydraulics heat transfer in nanofluids etc This book serves as a useful reference to researchers academicians and students interested in the broad field of thermo fluid science and engineering **Catalog of Copyright Entries** Library of Congress. Copyright Office, 1978 IEEE/ASME International Conference on Advanced Intelligent Mechatronics Proceedings, 2005 *Routledge Handbook of Strength and Conditioning* Anthony

Turner,2018-02-01 Drawing on the latest scientific research this handbook introduces the essentials of sport specific strength and conditioning programme design for over 30 different sports Enhanced by extensive illustrations and contributions from more than 70 world leading experts its chapters present evidence based best practice for sports including football rugby tennis hockey basketball rowing boxing golf swimming cycling and weightlifting as well as a variety of wheelchair sports Every chapter introduces the fundamental requirements of a particular sport such as the physiological and biomechanical demands on the athlete and describes a sport specific fitness testing battery and exercise programme Additional chapters cover the adaptation of programme design for special populations including female athletes young athletes and athletes with a disability Drawing on the experiences of Olympic and Paralympic coaches and trainers it offers original insights and practical advice from practitioners working at the highest level Innovative comprehensive and truly international in scope the Routledge Handbook of Strength and Conditioning is vital reading for all strength and conditioning students and an invaluable reference for strength and conditioning coaches and trainers

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1. Understanding the eBook Yo Yo 1 Pb Intl
 - The Rise of Digital Reading Yo Yo 1 Pb Intl
 - Advantages of eBooks Over Traditional Books
2. Identifying Yo Yo 1 Pb Intl
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Yo Yo 1 Pb Intl
 - User-Friendly Interface
4. Exploring eBook Recommendations from Yo Yo 1 Pb Intl
 - Personalized Recommendations
 - Yo Yo 1 Pb Intl User Reviews and Ratings
 - Yo Yo 1 Pb Intl and Bestseller Lists
5. Accessing Yo Yo 1 Pb Intl Free and Paid eBooks
 - Yo Yo 1 Pb Intl Public Domain eBooks
 - Yo Yo 1 Pb Intl eBook Subscription Services

- Yo Yo 1 Pb Intl Budget-Friendly Options
- 6. Navigating Yo Yo 1 Pb Intl eBook Formats
 - ePub, PDF, MOBI, and More
 - Yo Yo 1 Pb Intl Compatibility with Devices
 - Yo Yo 1 Pb Intl Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Yo Yo 1 Pb Intl
 - Highlighting and Note-Taking Yo Yo 1 Pb Intl
 - Interactive Elements Yo Yo 1 Pb Intl
- 8. Staying Engaged with Yo Yo 1 Pb Intl
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Yo Yo 1 Pb Intl
- 9. Balancing eBooks and Physical Books Yo Yo 1 Pb Intl
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Yo Yo 1 Pb Intl
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Yo Yo 1 Pb Intl
 - Setting Reading Goals Yo Yo 1 Pb Intl
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Yo Yo 1 Pb Intl
 - Fact-Checking eBook Content of Yo Yo 1 Pb Intl
 - Distinguishing Credible Sources
- 13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
- 14. Embracing eBook Trends

- Integration of Multimedia Elements
- Interactive and Gamified eBooks

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