

PHYSICS (PRE-STAGE LEVEL)

COURSE INTRODUCTION

Dr. NG, Yee Fai
phyfng@ust.hk

CDGT, HKUST

Physics (Pre-stage Level)

物理學 (預備階段)

2

□ **Course Aim:**

As a **bridging course** to Dual Program (DP) Level 1 Physics, providing students with **necessary mathematical foundation** for proceeding to Levels 1 and 2 Physics

□ **Medium of Instruction:**

English (lecture delivery; course materials)

□ **Assessments:**

Classwork, **assignments (30%)**,
mock assessment, **final assessment (70%)**

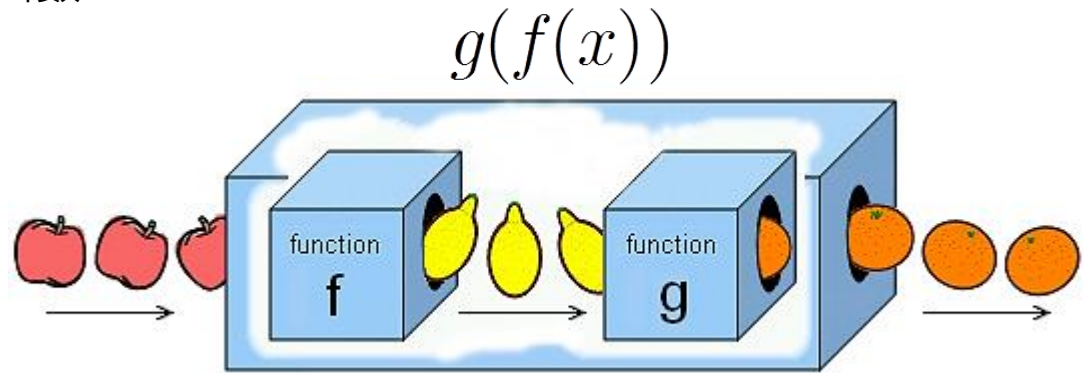
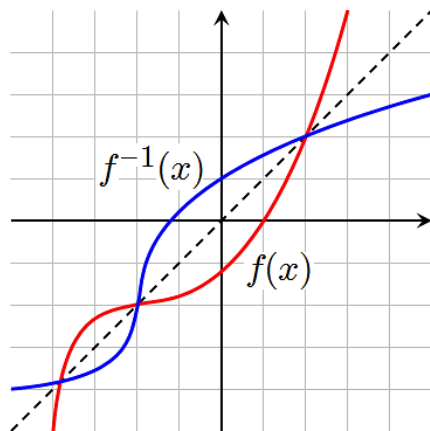
Outstanding students will be promoted to DP Level 1

Topics

3

□ 1. Functions, Inverse Functions & Composite Functions

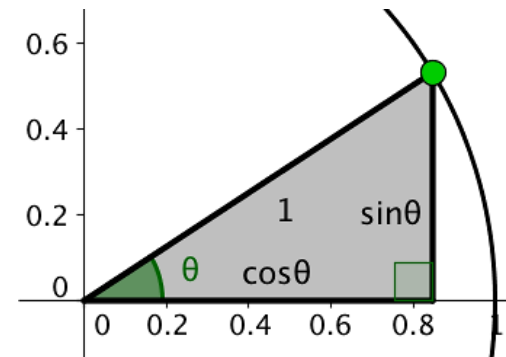
函數、反函數及複合函數



□ 2. Trigonometric Functions 三角函數

Applications to Physics:

Resolving a force; sinusoidal waves



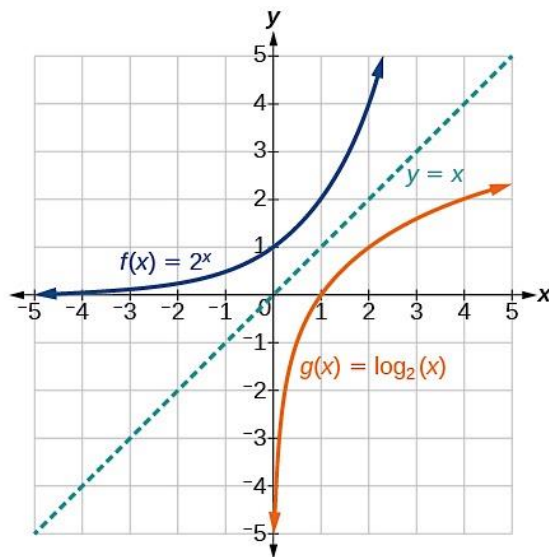
Topics

4

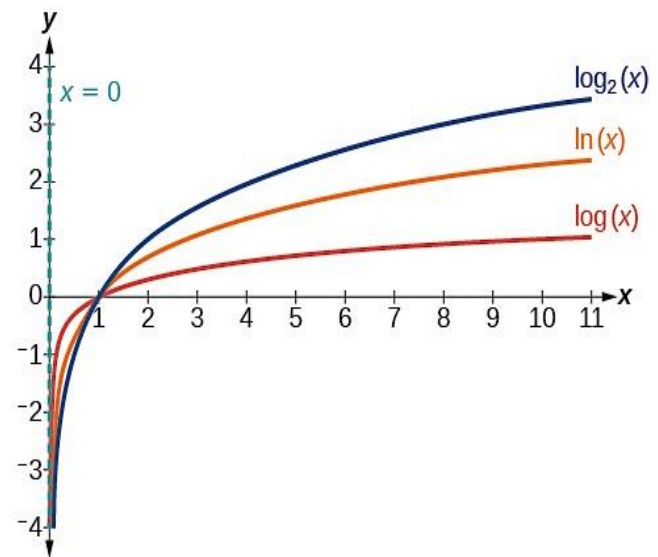
□ 3. Exponential and Logarithmic Functions

指數函數及對數函數

$$f(x) = a^x$$



$$g(x) = \log_a x$$



$$X = B^Y \leftrightarrow Y = \log_B X$$

Topics

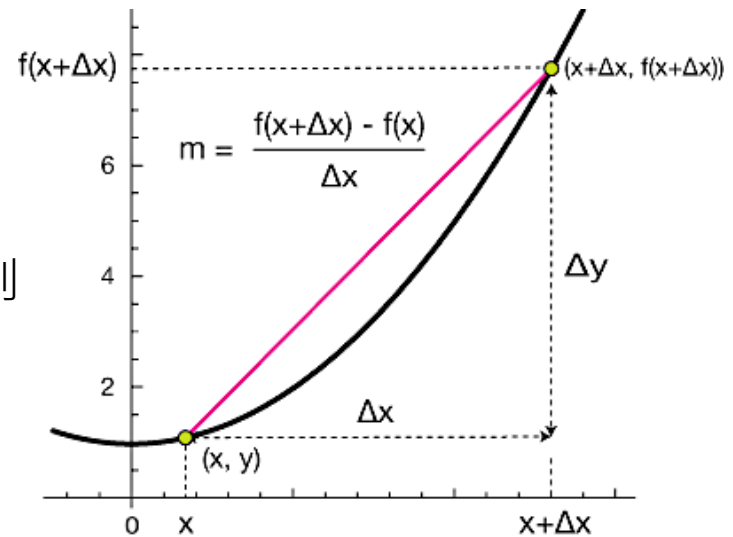
5

□ 4. Limits and Derivatives 極限和導數

$$\frac{dy}{dx} = \lim_{\Delta x \rightarrow 0} \frac{f(x + \Delta x) - f(x)}{\Delta x}$$

□ 5. Differentiation Rules 微分法則

$$\frac{d}{dx} uv = u \frac{dv}{dx} + v \frac{du}{dx}$$



Applications to Physics:

Variable mass of a rocket; error propagation

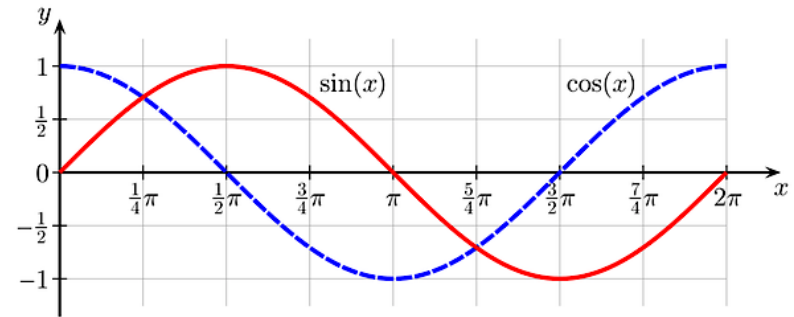
Topics

6

□ 6. Differentiation of Trigonometric Functions

三角函數求導

$$\frac{d}{d\vartheta} \cos \vartheta = -\sin \vartheta$$



□ 7. Differentiation of Exponential & Logarithmic Function

指數函數及對數函數求導

$$\frac{d}{dx} e^x = e^x$$

$$\frac{d}{dx} \ln x = \frac{1}{x}$$

Applications to Physics:

Radioactive decay; population growth

Topics

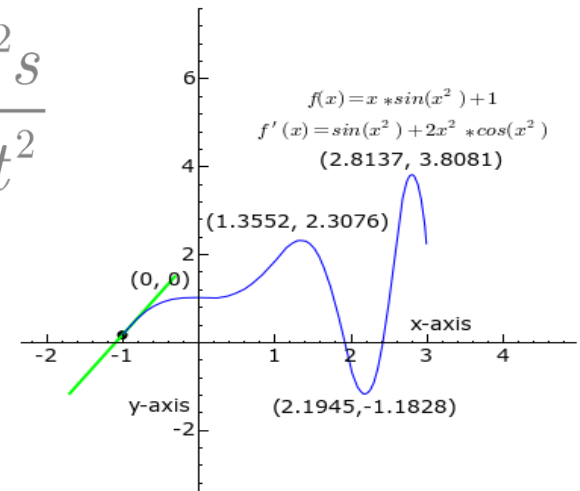
7

□ 8. Applications of Differentiation 微分之應用

Applications to Physics:

Instantaneous rate of change;
slope of a graph

$$a = \frac{dv}{dt} = \frac{d^2s}{dt^2}$$



□ 9. Indefinite Integration: Change of Variables & Integration by Parts 不定積分：換元積分法及分部積分法

$$\int f(x)dx = F(x) + \text{constant}$$

$$\int u dv = uv - \int v du$$

Topics

8

- 10. Definite Integration: Fundamental Theorems of Calculus 定積分：微積分基本定理

$$\int_a^b f(x) dx = F(x) \Big|_a^b = F(b) - F(a)$$

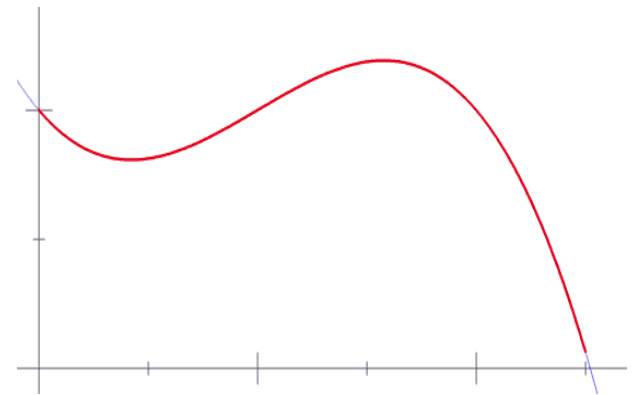
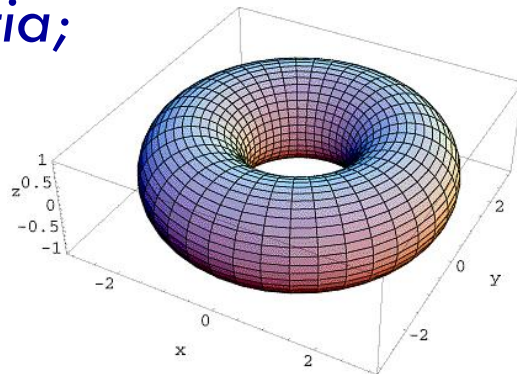
$$\frac{d}{dx} \int_a^x f(t) dt = f(x)$$

- 11. Applications of Definite Integration 定積分之應用

Applications to Physics:

Moment of inertia;

impulse



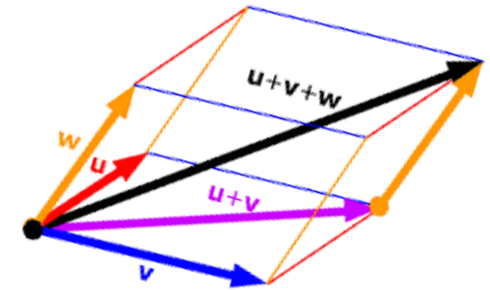
Topics

9

- 12. Vectors: Basic Vector Algebra 向量：基礎向量代數

Applications to Physics:

Relative velocities; resultant force



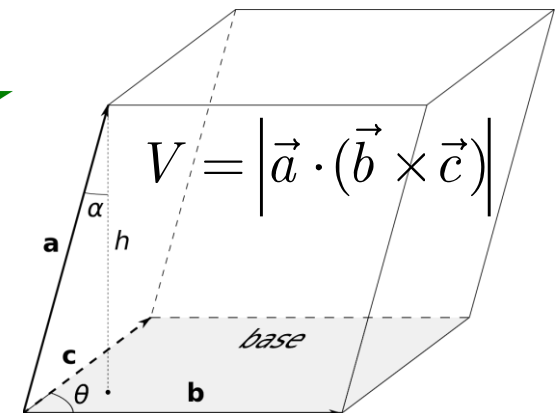
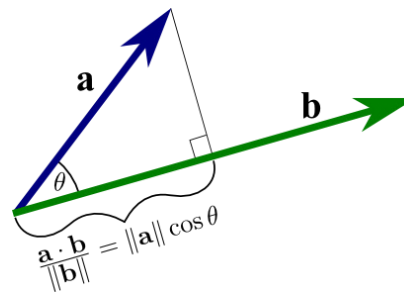
- 13. Vectors: Dot Product & Cross Product

向量：內積及向量積

Applications to Physics:

Work done; torque;

magnetic force on a moving charge



Topics

10

□ 14. Complex Numbers 複數

$$i = \sqrt{-1}$$

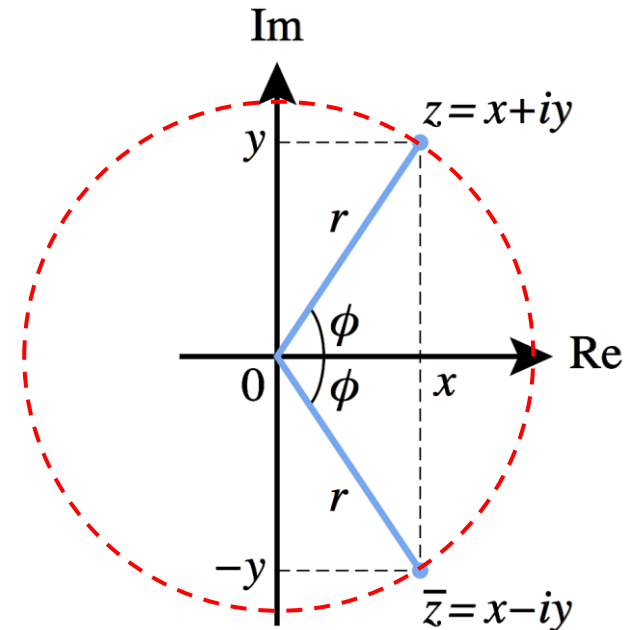
$$e^{i\phi} = \cos \phi + i \sin \phi$$

$$|z|^2 = z\bar{z} = x^2 + y^2$$

Applications to Physics:

Alternating-current (AC) circuits;

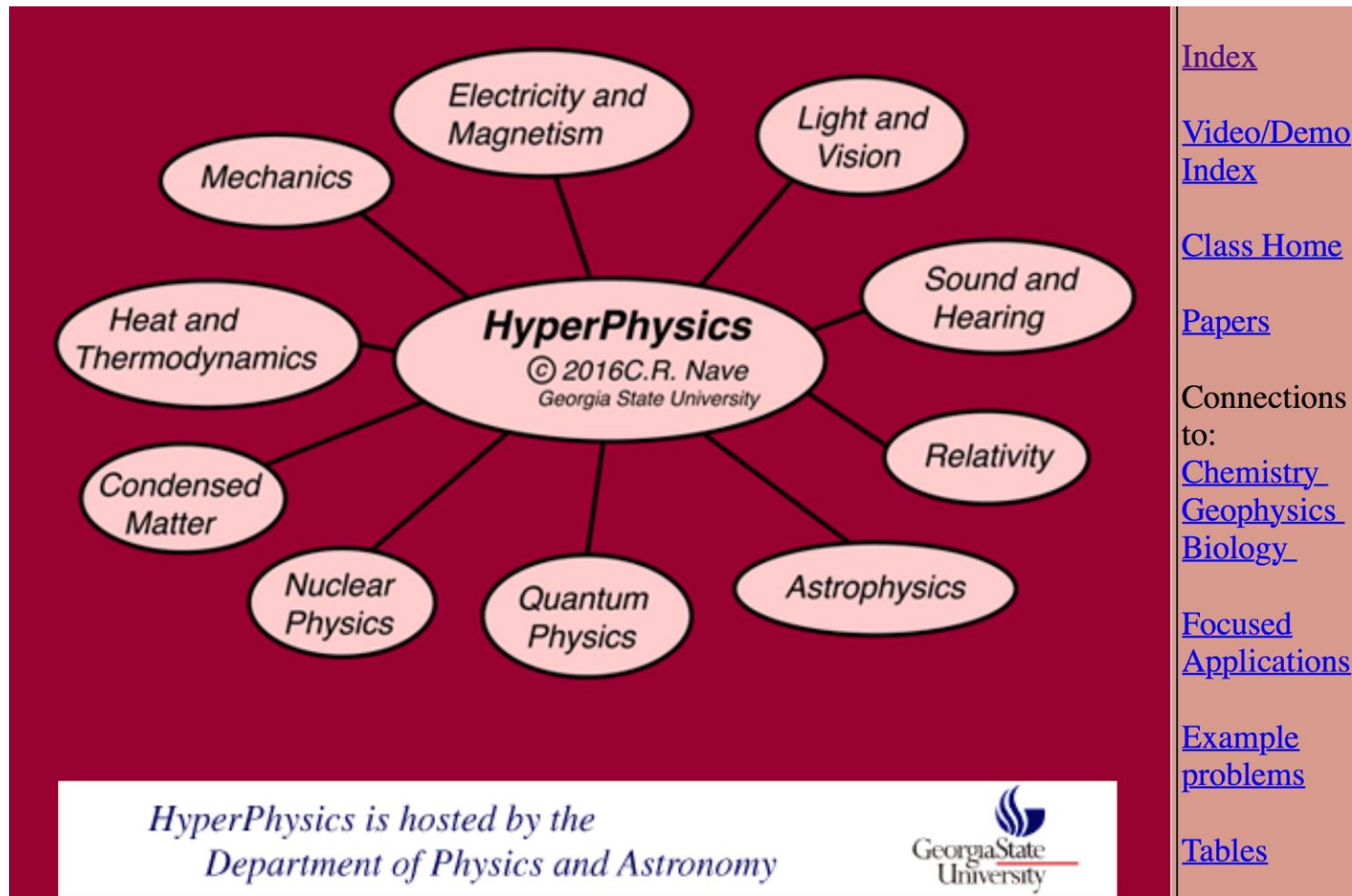
electromagnetic (EM) waves; quantum mechanics



Useful Websites (1)

11

HyperPhysics



The diagram shows a central oval labeled "HyperPhysics" with the copyright notice "© 2016 C.R. Nave Georgia State University". It is surrounded by ten other ovals, each representing a physics topic: Mechanics, Electricity and Magnetism, Light and Vision, Sound and Hearing, Relativity, Astrophysics, Quantum Physics, Nuclear Physics, Condensed Matter, and Heat and Thermodynamics. To the right of the diagram is a vertical list of navigation links: Index, Video/Demo Index, Class Home, Papers, Connections to: Chemistry, Geophysics, Biology, Focused Applications, Example problems, and Tables. At the bottom of the diagram area, there is a white box containing the text "HyperPhysics is hosted by the Department of Physics and Astronomy" and the Georgia State University logo.

HyperPhysics
© 2016 C.R. Nave
Georgia State University

Index
[Video/Demo Index](#)
[Class Home](#)
[Papers](#)
Connections to:
[Chemistry](#)
[Geophysics](#)
[Biology](#)
[Focused Applications](#)
[Example problems](#)
[Tables](#)

HyperPhysics is hosted by the
Department of Physics and Astronomy

Georgia State University

<http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html>

Useful Websites (2)

12

Nobel Prize > Educational Games

The screenshot shows the Nobel Prize website's educational section. The main heading is "Relativity", accompanied by a blue icon of a white arrow pointing right. Below the heading is a paragraph explaining the theory of special relativity, established in 1905 by Albert Einstein. To the left is a sidebar with a "Lists of Nobel Prizes and Laureates" dropdown menu and a list of "All Educational Productions" categorized by prize type (Physics, Chemistry, Medicine, Literature, Peace, Economic Sciences) and related topics. To the right is a vertical list of links to various educational resources, each with a small icon. The right sidebar contains promotional banners for the 2017 and 2016 Nobel Prize announcements, a Facebook link, and a "Nobel Year" photo gallery. At the bottom, it states the page was first published on May 15, 2001, and credits the production to Nobel Media and Tommy Ohlsson.

Nobelprize.org
The Official Web Site of the Nobel Prize

Home Nobel Prizes and Laureates Nomination Ceremonies Alfred Nobel Educational Events

Video Podcast About Us Search

Lists of Nobel Prizes and Laureates

Choose a list

All Educational Productions

Physics Prize Related

- Accelerators
- Energy from Matter
- Imaging Life
- Integrated Circuit
- Invar & Steel Alloys
- Laser Challenge
- Liquid Crystals
- Microscopes
- Observing the World of Particles
- Relativity**
- Semiconductors
- Star Stories
- Structure of Matter
- The Quantised World
- Transistors
- Vacuum Tubes
- X-rays

Chemistry Prize Related

Medicine Prize Related

Literature Prize Related

Peace Prize Related

Prize in Economic Sciences Related








Short about the Nobel Prize

Alfred Nobel's Life and Work

Teachers' Questionnaire

Relativity

The theory of special relativity (or special relativity for short) was established in 1905 by the famous physicist Albert Einstein at the age of 26. Special relativity is of importance in the realm of high relative velocities. It has been thoroughly verified on numerous occasions and has always stood up to the critical tests. Special relativity is now a tool at work, almost daily, in the scientists' calculations and laboratories.

-  → The Michelson-Morley Experiment
-  → The Postulates of Special Relativity
-  → Lorentz Transformations
-  → The Twin Paradox
-  → Energy is Equivalent to Mass
-  → Special Relativity as a Tool
-  → History of Special Relativity

2017 NOBEL PRIZE ANNOUNCEMENTS
Full schedule

2016 Nobel Laureates

Discover features and trivia about the Nobel Prize

Sign up for Nobelprize.org Monthly

Join us on Facebook

Nobel Year

First published: May 15, 2001
Credits: Produced by Nobel Media in collaboration with Tommy Ohlsson

<https://educationalgames.nobelprize.org/educational>

Apps (1)

GeoGebra

Download GeoGebra Apps

Free offline GeoGebra apps for iOS, Android, Windows, Mac, Chromebook and Linux



Graphing Calculator

Graph functions, investigate equations, and plot data with our free graphing app

DOWNLOAD

START



3D Calculator

Graph 3D functions, plot surfaces and do 3D geometry with our free 3D Grapher

DOWNLOAD

START



Geometry

Construct circles, angles, transformations and more with our free geometry tool

DOWNLOAD

START



GeoGebra Classic 6

Apps bundle including free tools for geometry, spreadsheet, probability, and CAS

DOWNLOAD

START



Augmented Reality

Put 3D math into the real world with GeoGebra Augmented Reality!

DOWNLOAD



GeoGebra Classic 5

Apps bundle including free tools for geometry, spreadsheet, probability, and CAS

DOWNLOAD

<https://www.geogebra.org/download>

Apps (2)

WolframAlpha > Physics Course Assistant

14

<http://products.wolframalpha.com/courseassistants/physicsII.html>

Wolfram PHYSICS I | COURSE ASSISTANT

Back **Ball Rolling on Incline**

Calculate the acceleration, distance, and final speed of a ball rolling down an inclined plane.

Time: s

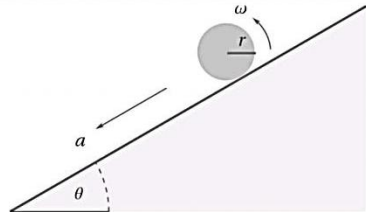
Slope angle: rad

Initial speed: m per s

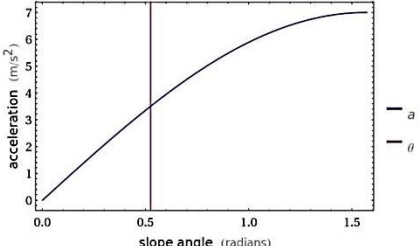
Radius: m

Compute

Schematic



Acceleration vs. slope angle



Equation

$$a = \frac{g \sin(\theta)}{1 + \sigma_{\text{shape}}} \quad d = v_i t + \frac{1}{2} a t^2$$

Powered by WolframAlpha

Wolfram PHYSICS II | COURSE ASSISTANT

Back **Single Slit Diffraction**


Calculate the Rayleigh criterion angle.

Wavelength: nm

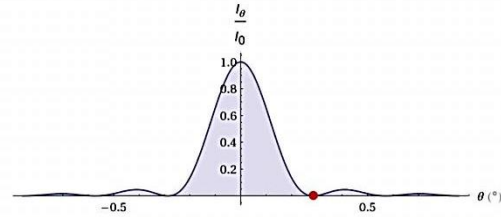
Slit width: mm

Compute

Diffraction pattern



Normalized transmitted intensity vs. diffraction angle



Zeros of transmitted intensity as a function of diffraction angle

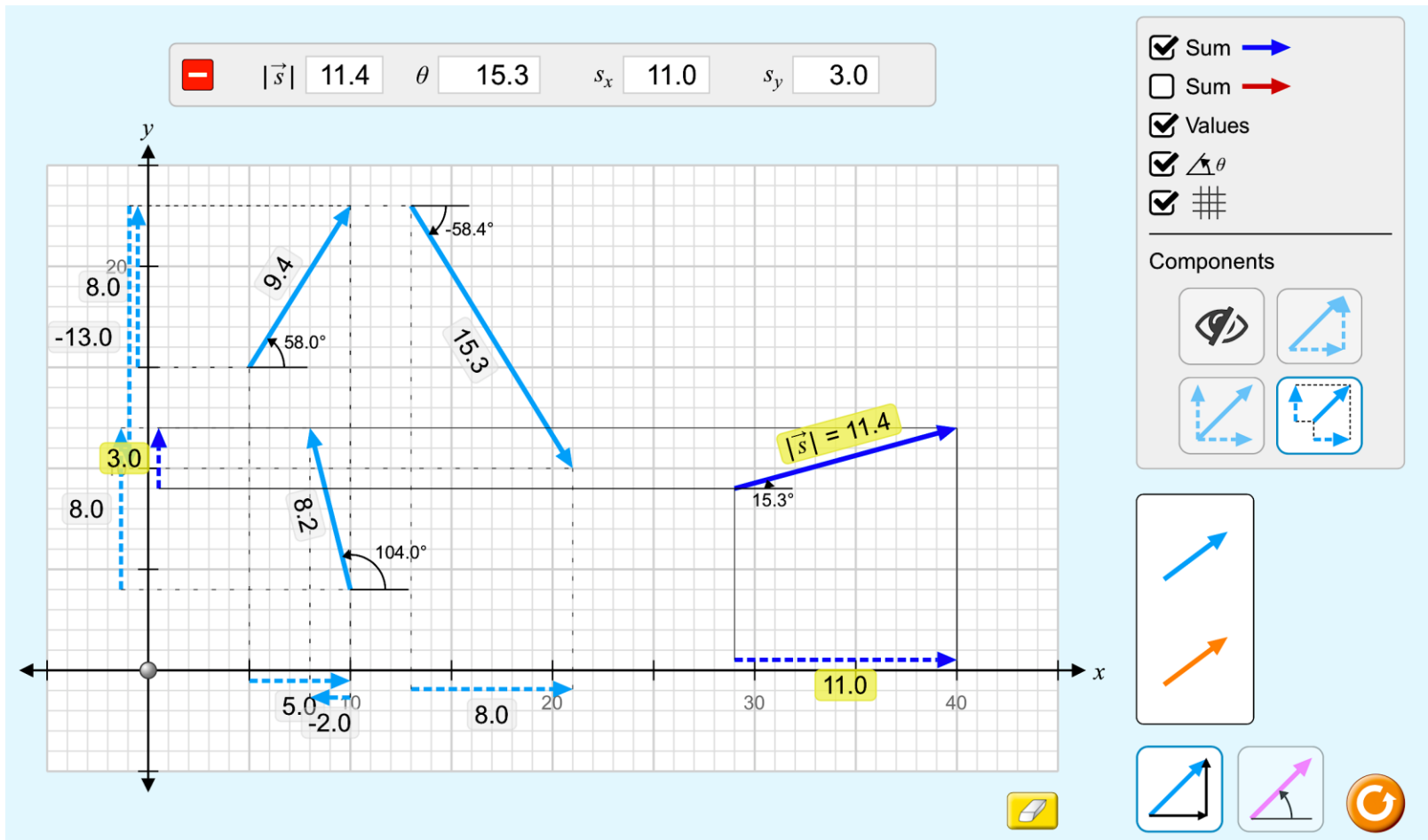
order of zero | diffraction angle | enclosed intensity

Powered by WolframAlpha ©2013

<http://products.wolframalpha.com/courseassistants/physicsI.html>

Simulations (1)

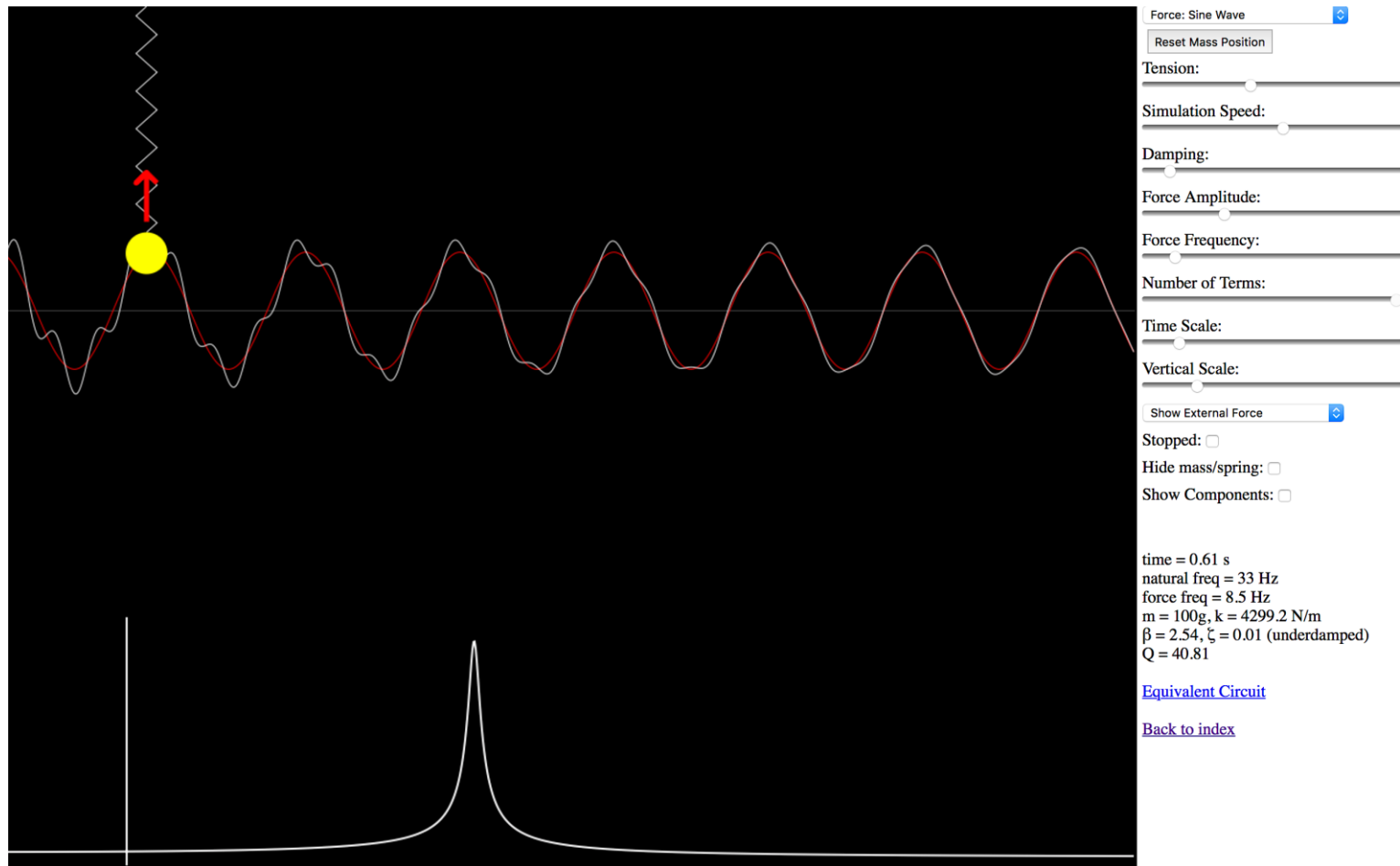
PhET > Vector Addition



Simulations (2)

16

Falstad's Applets > Harmonic Oscillator



<http://www.falstad.com/harmonicosc>

Animations (1)

17

Science ABC > Time Dilation



<https://www.youtube.com/watch?v=yuD34tEpRFw>

Animations (2)

18

OpenLearn > Achilles and the Tortoise



<https://www.youtube.com/watch?v=skM37PcZmWE>

Videos (1)

19

3Blue1Brown > Feynman's Lost Lecture

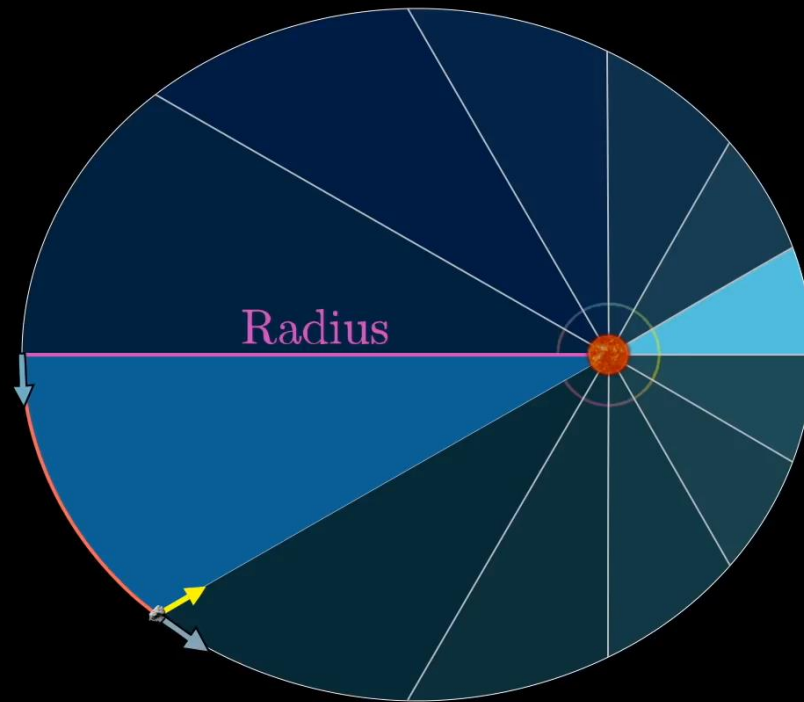
$$ma = \text{Force} \propto \frac{1}{(\text{Radius})^2}$$

$$\text{Time} \propto \text{Area} \propto (\text{Radius})^2$$

(proportional to)

$$a = \frac{\Delta v}{\Delta t} \propto \frac{1}{(\text{Radius})^2}$$

$$\Delta v \propto \frac{(\text{Radius})^2}{(\text{Radius})^2}$$



<https://www.youtube.com/watch?v=xdljYBtnvZU>

Videos (2)

李永乐老师 > 如何把“天问一号”探测器发射到火星？

霍乱转移轨道 1925年 德国

① A点: 点火加速 1 → 3
 ② AB: 自然减速
 ③ B点: 点火加速 3 → 2

∴ 小轨 → 大轨: 加速 2 次
 大轨 → 小轨: 减速 2 次

2. 地球-火星轨道

① 地球 $r_1 = 1.5 \times 10^{11} \text{m}$ $T_1 = 365 \text{天}$
 ② 火星 $r_2 = 2.3 \times 10^{11} \text{m}$ $T_2 = 687 \text{天}$

③ 转移轨道 相同半长轴 $a = \frac{r_1 + r_2}{2} = 1.9 \times 10^{11} \text{m}$

3. 开普勒第三定律: 半长轴³ = 周期² = Const.

$$\frac{r_1^3}{T_1^2} = \frac{a^3}{T_3^2} \Rightarrow T_3 = 1.4 T_1 = 520 \text{天}$$

$t_{\text{orb}} = \frac{1}{2} T_3 = 260 \text{天}$

$\theta_k = \frac{260 \text{天}}{687 \text{天}} \times 360^\circ = 136^\circ$

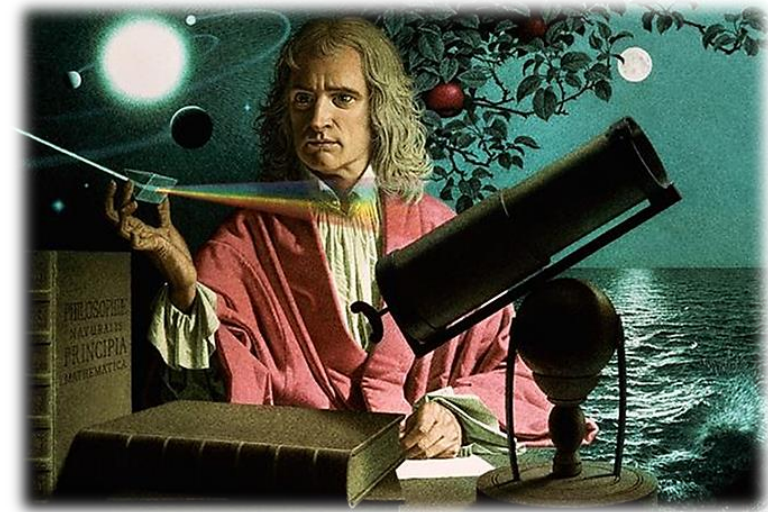
4. 天问一号: 侦、落、巡

Mathematicians & Physicists

21

Sir Isaac Newton (1642–1727)

English physicist and mathematician. Isaac Newton was a contentious genius who made extraordinary strides in mathematics, optics, mechanics, and gravitational attraction. He invented calculus, explained the colors of the rainbow, and realized that the same gravitational force giving us weight also controls the movements of the Moon and planets.



“If I have seen further it is by standing on ye shoulders of Giants.”

Isaac Newton