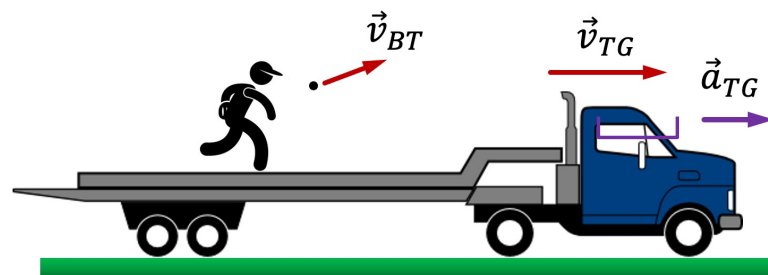
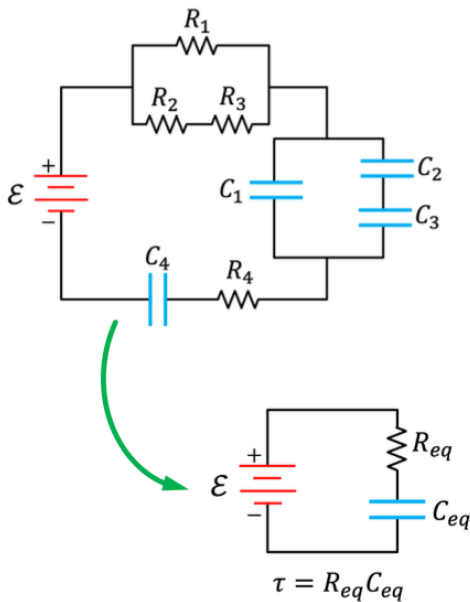




Introductory Physics at Rice University

Robert Beard

Associate Teaching Professor
Rice University
rpb5@rice.edu



Frame 1: **T**ruck

Frame 2: **G**round

Object: **B**all





RICE NATURAL SCIENCES

Physics and Astronomy

Introduction(s)



Dr. Robert Beaird

Associate Teaching Professor

My Roles and Responsibilities

- NTT Teaching Faculty
- Divisional Advisor – Natural Sciences
- RicePOP – Coordinator (1 of 4)
- Dept. Undergraduate Program Committee
- University Committee on Ex&S – Chair
- Baker College – Faculty Associate
- Rice Fencing Club – Faculty Sponsor



Dr. Melia Bonomo

Lecturer



Dr. Michael Cone

Assoc. Teaching Prof.



Dr. Julie Hoeink

Assist. Teaching Prof.



Dr. Jared Stenson

Assist. Teaching Prof.



Dr. Lam Yu

Assoc. Teaching Prof.



Pre-matriculation Credit

Q: Do I use my AP credit or retake the course?

A: It depends. What is your intended major?

Comfort level?

Competence?

AP Physics (C) Mechanics

PHYS 101- Mechanics with Lab (4 hrs)

AP Physics (C) E&M

PHYS 102- E&M with Lab (4 hrs)

AP Physics 1: Algebra Based

PHYS 141*- Concepts in Physics I (3hrs)

AP Physics 2: Algebra Based

PHYS 142*- Concepts in Physics II (3hrs)

Physics (HL)

PHYS 141*- Concepts in Physics I (3hrs)

PHYS 142*- Concepts in Physics II (3hrs)



RICE NATURAL SCIENCES

Physics and Astronomy

Intro Physics Sequences

Three Levels of Rigor



PHYS 125 & 126- *General Physics & General Physics II*

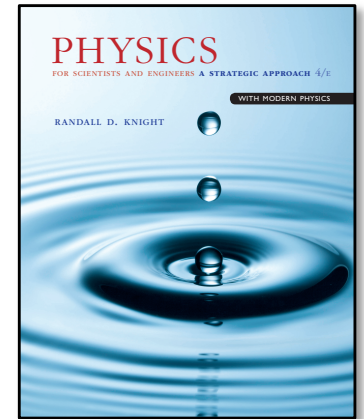


Course format: 2 plenary lectures, 1 discussion, 1 lab

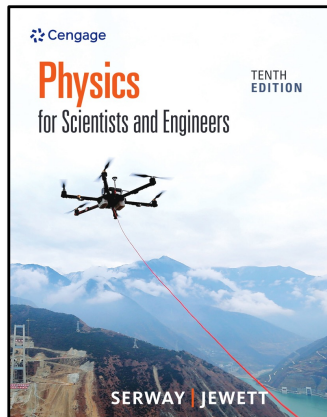
Audience: bioscience & premedical majors

Homework: “in house” problems on Canvas
& handwritten Pledge Problems

Calculus-based... but punches are pulled a bit.



R.D. Knight



Serway & Jewett

PHYS 101 & 102- *Mechanics & Electricity and Magnetism*

Course format: 2 plenary lectures, 1 discussion, 1 lab

Audience: physical science & engineering majors

Homework: textbook's problems on WebAssign

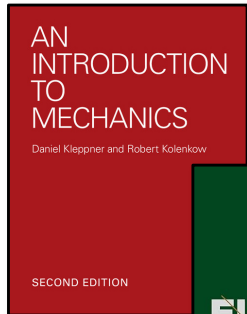
Calculus-based... does not shy away from math.



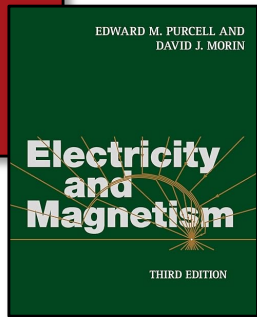


Intro Physics Sequences

Three Levels of Rigor



Kleppner &
Kolenkow



Percell & Morin

PHYS 111 & 112- *Honors Mechanics & Honors E&M*

Course format: 3 plenary lectures, 1 lab

Audience: physical science & engineering majors
... with strong background in physics and calculus

Homework: textbook's problems, handwritten submission

Calculus-based... seriously math heavy.

("Honors" means "advanced treatment of intro topics".)

Drop-Back Provision

Add date: Week 2 Drop-back: Week 7

Risk-averse students can take more challenging courses than they are feel prepared for.

Overconfident students have an escape plan if they bite a little too much to begin with.

Example: A student who has AP credit for Mechanics wishes to take PHYS 111 to better understand the material.

After week 2, the student discovers that PHYS 111's workload is a bit too challenging or time-consuming.

The student can "drop back" to PHYS 101 with no penalty... or judgement.



PHYS 125 Lecture

Orbital Dynamics



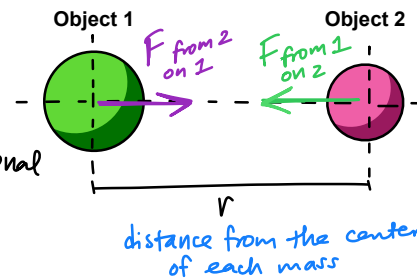
B. Law of Gravitation: Equation

- Two objects will exert a force of attraction on each other according to their masses and the distance between them
- These forces are a Newton's 3rd pair! $\vec{F}_{21} = -\vec{F}_{12}$

$$F_g = \frac{G m_1 m_2}{r^2}$$

where G is the universal gravitational constant, "Big G ":

$$G = 6.6743 \times 10^{-11} \frac{\text{Nm}^2}{\text{kg}^2}$$



PHYS 125 - Week 5 10

Semi old-school:

- iPad used as an "overhead"
- Notes provided after class
- Mostly lecture
- Some active learning

Covered:

- Newton's Law
- Near Earth
- Circular orbits

Not Covered:

- Elliptical orbits
- Kepler's Laws
- Orbital Energetics

B. Law of Gravitation: Where does "little g" come from?

What is the gravitational force on an object of mass m sitting on the Earth's surface?

$$F_g = \frac{G m_1 m_2}{r^2} = \frac{G M_E m}{R_E^2}$$

if we just calculate out this part of the equation we get:

$$\frac{G M_E}{R_E^2} = \frac{(6.6743 \times 10^{-11} \frac{\text{Nm}^2}{\text{kg}^2})(5.972 \times 10^{24} \text{ kg})}{(6.378 \times 10^6 \text{ m})^2}$$

$$= 9.798 \frac{\text{N}}{\text{kg}} \approx 9.8 \frac{\text{kg} \cdot \text{m}}{\text{kg} \cdot \text{s}^2} = 9.8 \frac{\text{m}}{\text{s}^2} = g$$

That's why we've been using $F_g = mg$ on the Earth's surface!



Mass of the earth:
 $M_E = 5.972 \times 10^{24} \text{ kg}$
radius of the earth:
 $R_E = 6.378 \times 10^6 \text{ m}$



Newton units
 $\text{N} = \frac{\text{kg} \cdot \text{m}}{\text{s}^2}$

PHYS 125 - Week 5 11

B. Orbits: An Extension of Centripetal Acceleration Concepts

An orbit can be modeled as circular motion with centripetal acceleration due to a net force (F_g) towards the center of the orbit.

FBD for satellite



$$F_g = \frac{G M_E m}{r^2}$$

from Earth on satellite

Newton's 2nd Law

$$\sum \vec{F}_r = m \vec{a}_r$$

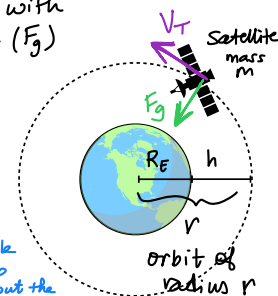
sum of radial forces on satellite

$$F_g = m a_r$$

$$\frac{G M_E m}{r^2} = m \frac{v_T^2}{r}$$

$$\frac{G M_E}{r} = v_T^2$$

Here, for example we're poised to answer Qs about the radius, height above earth, or tangential velocity



PHYS 125 - Week 5 19



PHYS 125 Discussion

Orbital Dynamics

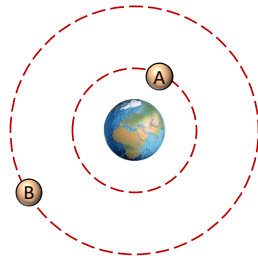


Discussion Question

Two satellites A and B of the same mass are going around Earth in concentric orbits. The distance of satellite B from Earth's center is twice that of satellite A .

What is the orbital speed of B , in terms of the orbital speed of A ?

1. $v_B = v_A / 2$
2. $v_B = v_A / \sqrt{2}$
3. $v_B = v_A$
4. $v_B = \sqrt{2} v_A$
5. $v_B = 2 v_A$



Pi



Earth is not really flat. Fast enough projectiles can 'see' the curvature of Earth's surface.

A fast enough projectile will miss the ground!

- (a) How fast would a cannonball have to be in order to orbit the Earth at sea level?
- (b) How long would it take the cannonball to orbit the Earth at sea level?

Possibly Useful Numbers

$$M_E = 5.98 \times 10^{24} \text{ kg} \quad R_E = 6.37 \times 10^6 \text{ m}$$

$$G = 6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$$

(a) Orbits: F_G is the centripetal force F_c .

$$F_G = \frac{GmM_E}{r^2} \quad F_c = ma_c = \frac{mv^2}{r}$$

Use these to find the orbital speed v .

(b) Circular orbit is uniform circular motion.

$$v = r\omega \quad \omega = \frac{2\pi}{T}$$

Use these to find the orbital period T .

Orbital speed and period depend only on mass of the planet and orbital radius!

$$v = \sqrt{\frac{GM_E}{r}} \quad T = 2\pi \sqrt{\frac{r^3}{GM_E}}$$

Discussion Questions

- Multiple choice
- "Think, pair, share"
- Student "volunteer" at the board

Free Response Problems

- Posed & scaffolded
- Think, pair, share
- Volunteer at the board
- Solution provided online



Earth is not really flat. Fast enough projectiles can 'see' the curvature of Earth's surface.

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$$M_E = 5.98 \times 10^{24} \text{ kg} \quad R_E = 6.37 \times 10^6 \text{ m}$$

$$G = 6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$$

(a) Orbital motion, F_G is centripetal: $F_G = F_c$

So: $\frac{mv^2}{R_E} = mg \Rightarrow v = \sqrt{R_E g}$

$$v = \sqrt{6.37 \times 10^6 \text{ m} \times 9.8 \text{ m/s}^2} = 7901 \frac{\text{m}}{\text{s}} = 474 \frac{\text{km}}{\text{min}}$$

Alternate: $\frac{mv^2}{R_E} = G \frac{mM_E}{R_E^2} \Rightarrow v = \sqrt{\frac{GM_E}{R_E}}$

(b) Uniform circular motion:

$$v = \frac{2\pi R_E}{T} \Rightarrow T = \frac{2\pi R_E}{v}$$

$$T = \frac{2\pi R_E}{v} = 5066 \text{ s} = 84.4 \text{ min} = 1.4 \text{ hr}$$

Orbital speed depends only on mass of the planet and orbital radius!



PHYS 125 Discussion

Orbital Dynamics

Supplemental!

In-class and homework is not enough!

- Some bog-standard problems. 
- Some challenging problems. 
- Premeds are surprisingly proactive about working the supplemental material!

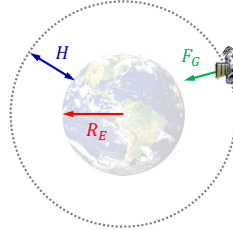


An Earth satellite moves in a circular orbit $H = 640$ km above the earth's surface with a period $T = 98.0$ min.

What is a_c the centripetal acceleration of the satellite?

$M_E = 5.98 \times 10^{24}$ kg $R_E = 6.37 \times 10^6$ m

$G = 6.67 \times 10^{-11}$ Nm²/kg²



Orbits: F_G is the centripetal force F_c .

$$F_G = \frac{GmM_E}{r^2} \quad F_c = ma_c$$

Circular orbit is uniform circular motion.

$$v = r\omega \quad \omega = \frac{2\pi}{T} \quad a_c = \frac{v^2}{r}$$

Use these to find an expression for altitude a_c in terms of G , M_E and T .

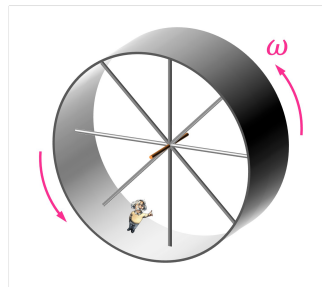
Then run the numbers and calculate!

Altitude: $H = ?!$
 Orbital radius: $r = R_E + H$
 Period: $T = 24$ hr

Discussion Question

Einstein is standing on the "floor" of a rotating space station that is spinning counter clockwise with angular speed ω , as shown below. If Einstein drops a ball from rest (relative to himself) from a height h above the floor, where will the ball land?

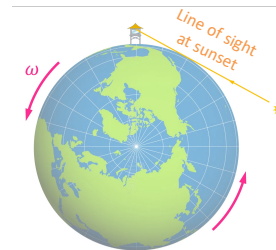
1. At his feet.
2. Behind him.
3. Ahead of him.
4. Depends on the value of ω .



Note: this is a challenging question, and a bit beyond the scope of the course.

You are sitting at the base of a lifeguard tower at the equator. Your friend, is sitting at the top of the tower ($h = 6.0$ m). At sundown, your friend sees the sun disappear behind the horizon 19 s after you do. You decide to use this information to estimate the earth's radius.

- Through what angle θ has the earth rotated during the 19 s?
- What is the approximate radius of the earth?



(a) Uniform circular motion means constant ω :

$$\omega = \frac{\Delta\theta}{\Delta t} \quad \text{Your time: } \Delta t_{\text{you}} = 19 \text{ s} \quad \text{One day: } \Delta t_{\text{day}} = 24 \text{ hr}$$

(b) The sun sets when the sun drops below the horizon... and is no longer in your field of view.

Use the figure to construct a right triangle that will relate Earth's radius R_E , the tower height H , and the angle θ you found in (a).

Solve for R_E in terms of H and θ ... and then sub in the numbers and calculate!



Comparison of Depth

Orbital Dynamics

PHYS 125 (and PHYS 101)

- Newton's 2nd and Gravitation
- Circular orbits

13.3 Newton's Law of Gravity

Newton proposed that *every* object in the universe attracts *every other* object with a force that is

1. Inversely proportional to the square of the distance between the objects.
2. Directly proportional to the product of the masses of the two objects.

To make these ideas more specific, **FIGURE 13.4** shows masses m_1 and m_2 separated by distance r . Each mass exerts an attractive force on the other, a force that we call the **gravitational force**. These two forces form an action/reaction pair, so $\vec{F}_{1\text{ on }2}$ is equal and opposite to $\vec{F}_{2\text{ on }1}$. The magnitude of the forces is given by Newton's law of gravity.

Newton's law of gravity If two objects with masses m_1 and m_2 are a distance r apart, the objects exert attractive forces on each other of magnitude

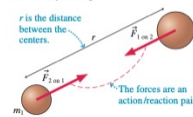
$$F_{1\text{ on }2} = F_{2\text{ on }1} = \frac{Gm_1m_2}{r^2} \quad (13.2)$$

The forces are directed along the straight line joining the two objects.

The constant G , called the **gravitational constant**, is a proportionality constant necessary to relate the masses, measured in kilograms, to the force, measured in newtons. In the SI system of units, G has the value

$$G = 6.67 \times 10^{-11} \text{ N}\cdot\text{m}^2/\text{kg}^2$$

FIGURE 13.4 The gravitational forces on masses m_1 and m_2 .



13.6 Satellite Orbits and Energies

Solving Newton's second law to find the trajectory of a mass moving under the influence of gravity is mathematically beyond this textbook. It turns out that the solution is a set of elliptical orbits, which is Kepler's first law. Kepler had no *reason* why orbits should be ellipses rather than some other shape. Newton was able to show that ellipses are a *consequence* of his theory of gravity.

The mathematics of ellipses is rather difficult, so we will restrict most of our analysis to the limiting case in which an ellipse becomes a circle. Most planetary orbits differ only very slightly from being circular. The earth's orbit, for example has a (semiminor axis/semimajor axis) ratio of 0.99986—very close to a true circle!

FIGURE 13.16 shows a massive body M , such as the earth or the sun, with a lighter body m orbiting it. The lighter body is called a **satellite**, even though it may be a planet orbiting the sun. For circular motion, where the gravitational force provides the centripetal acceleration v^2/r , Newton's second law for the satellite is

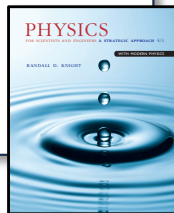
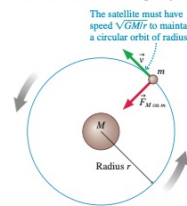
$$F_{M\text{ on }m} = \frac{GMm}{r^2} = ma_c = \frac{mv^2}{r} \quad (13.21)$$

Thus the speed of a satellite in a circular orbit is

$$v = \sqrt{\frac{GM}{r}} \quad (13.22)$$

A satellite must have this specific speed in order to have a circular orbit of radius r about the larger mass M . If the velocity differs from this value, the orbit will become elliptical rather than circular. Notice that the orbital speed does *not* depend on the satellite's mass m . This is consistent with our previous discovery, for motion on a flat earth, that motion due to gravity is independent of the mass.

FIGURE 13.16 The orbital motion of a satellite due to the force of gravity.



PHYS 111

- Newtonian Gravity (Ch. 3)
- Central force motion (Ch. 10)

3.3 Gravity

Gravity, the most familiar of the fundamental forces, played an honored role in the development of mechanics; Newton discovered the law of universal gravitation in 1666, the same year that he formulated his laws of

respectively, separated by distance r . Let $\vec{F}_{b,a}$ be the force exerted on particle b by particle a . Our verbal description of the magnitude of the gravitational force can be expressed mathematically as

$$|\vec{F}_{b,a}| = \frac{GM_aM_b}{r^2}$$

AN
INTRODUCTION
TO
MECHANICS
Daniel Kleppner and Robert Kolenkow
SECOND EDITION

10.5 Planetary Motion

In this section we solve the chapter's main problem: finding the orbit for a planet of mass m moving about a star of mass M under the gravitational interaction

$$U(r) = -G \frac{Mm}{r} \equiv -\frac{C}{r} \quad (10.16)$$

Our results would also apply to a satellite of mass m orbiting a planet of

Inserting the potential $U(r)$ from Eq. (10.16) into the orbit equation, Eq. (10.14), we obtain

$$\theta - \theta_0 = L \int \frac{dr}{r \sqrt{(2\mu E r^2 + 2\mu C r - L^2)}}$$

Physically, r_0 is the radius of the circular orbit corresponding to the given values of L , μ , and C . The dimensionless parameter ϵ , called the **eccentricity**, characterizes the shape of the orbit, as we shall see. With these replacements, Eq. (10.18) becomes

$$r = \frac{r_0}{1 - \epsilon \cos \theta} \quad (10.21)$$



Online Homework

Gravitation

PHYS 125/126

- Prof-designed problems
- Submitted via Canvas
- Multiple submissions per answer box- no penalty

In 1956, Frank Lloyd Wright proposed the construction of a mile-high building in Chicago. Suppose the building had been constructed. Ignoring Earth's rotation, find the change in your weight, in N, if you were to ride an elevator from street level, where you weight 600 N, to the top of the building. The Earth's radius is 6371 km.

A spaceship is on a straight-line path between Earth and the Moon. At what distance from the Earth is the net gravitational force on the spaceship zero? The Earth's mass is 5.972×10^{24} kg, the mass of the Moon is 7.348×10^{22} kg, and the separation between their centers is 3.844×10^8 m. Give you answer in m from the *center* of the Earth.

PHYS 101/102

- Textbook problems & some prof-designed
- Submitted via WebAssign.
- Multiple subs per answer box- no penalty

A satellite of mass 220 kg is placed into Earth orbit at a height of 400 km above the surface.

(a) Assuming a circular orbit, how long does the satellite take to complete one orbit?

 h

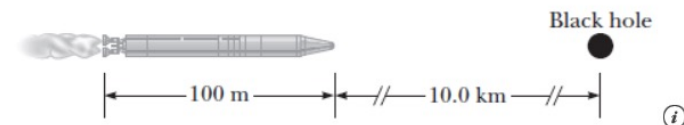
(b) What is the satellite's speed?

 m/s

(c) Starting from the satellite on the Earth's surface at the equator, what is the minimum energy input necessary to place this satellite in orbit? Ignore air resistance but include the effect of the planet's daily rotation.

 J

A spacecraft in the shape of a long cylinder has a length of 100 m, and its mass with occupants is 1 980 kg. It has strayed too close to a black hole having a mass 90 times that of the Sun. The nose of the spacecraft points toward the black hole, and the distance between the nose and the center of the black hole is 10.0 km.



(a) Determine the total force on the spacecraft.

 N

(b) What is the difference in the gravitational fields acting on the occupants in the nose of the ship and on those in the rear of the ship, farthest from the black hole? (This difference in acceleration grows rapidly as the ship approaches the black hole. It puts the body of the ship under extreme tension and eventually tears it apart.)

 N/kg



Some Issues

Math Literacy

Abuse of equals signs:

$$\begin{array}{l} \Delta V = 12 \text{ V} \\ R = 6.0 \, \Omega \end{array} \quad 12 \text{ V} = \frac{I \cancel{R}}{\cancel{R}} = 2.0 \text{ A}$$

Adding fractions:

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{2R} + \frac{1}{3R} = \frac{1}{5R}$$

Algorithm vs. understanding:

Can do: $\frac{d}{dx}(ax^2 + bx + c)$

Can't do: $\frac{d}{dt}\left(\theta_0 + \omega t + \frac{\alpha}{2}t^2\right)$

Discomfort with symbolic quantities.

Algebra line by line:

$$\begin{array}{r} x_f = x_i + \frac{1}{2} a_x t^2 \\ -x_i \quad \quad -x_i \end{array}$$

$$\begin{array}{r} x_f - x_i = \frac{1}{2} a_x t^2 \\ \times 2 \quad \quad \times 2 \end{array}$$

$$2(x_f - x_i) = a_x t^2$$

$$\begin{array}{r} \swarrow \quad \searrow \\ \frac{\cancel{a_x} t^2}{\cancel{a_x}} = \frac{2(x_f - x_i)}{a_x} \end{array}$$

$$t = \sqrt{\frac{2(x_f - x_i)}{a_x}}$$



Some Issues

Definitions vs. Special Cases

E.g., kinematics:

Given $x(t) = A + Bt + Ct^2 + Dt^3$, what is the object's acceleration?

Too common: $a_x = 2C$ ❌

Because $x(t) = x_i + v_i t + \frac{1}{2} a_x t^2$

$$x(t) = A + Bt + Ct^2 + Dt^3$$

Not common enough:

$$v_x = \frac{dx}{dt} = B + 2Ct + 3Dt^2$$

$$a_x = \frac{dv_x}{dt} = 2C + 6Dt$$
 ✓

E.g.:

Discussion Question

Magnesium fluoride MgF_2 ($n_1 = 1.4$) is used to make an anti-reflection coating on the upper surface of a glass ($n_2 = 1.5$) microscope slide. The coated surface is illuminated with light of wavelength λ .

Assuming that the film has thickness t , what is the phase difference for reflected light?

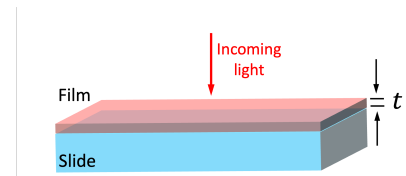
1) $\frac{\Delta\phi}{2\pi} = \frac{2nt}{\lambda} + \frac{1}{2}$

2) $\frac{\Delta\phi}{2\pi} = \frac{2nt}{\lambda}$

3) $\frac{\Delta\phi}{2\pi} = \frac{2t}{n\lambda} - \frac{1}{2}$

4) $\frac{\Delta\phi}{2\pi} = \frac{2t}{n\lambda}$

5) None of these.



Too common: Memorize by cases. ❌ ✓

Not common enough:

$$\frac{\Delta\phi}{2\pi} = \frac{2t}{\lambda_{film}} + \frac{\Delta\phi_{refl}}{2\pi} = \dots$$
 ✓ ✓



Some Issues

An informal poll

“Normalize the idea that physics is hard. Thinking is hard. This doesn’t mean you are at bad it.”

“The AP experience is not the same thing as a university course. The pacing of the course is very different. Depth of coverage varies.”

“Time management is multi-faceted. Not just for HW, but on exams too.”

“Physics sits right between the pure abstraction of math and the tangible reality of everyday life.

“Make things as simple as possible, but not simpler.”

Students want to do physics the same way they do biology or chem... or how they did in HS.”

Communication
& written work.

“It’s in my calculator.”
(silent scream)

Complete sentences!

“Use your nouns.”

Avoid 3PPP.



Checking for self-consistency

Check for physical consistency.

Number sense.

Order of magnitude.

Dimensional consistency.

*Write the **expletive** units!!!*

Other Observations

“I got my HW answer, but I don’t really understand it.”

Current problem vs. larger context.

“How should I study for the exam?”

Cumulative... exam to exam
and course to course.



RICE NATURAL SCIENCES

Physics and Astronomy

PHYS 100- “Exploring Physics”

Bite Size Physics



Provides small-group learning support for less-well-prepared students taking PHYS 101/102. Students are invited based on demonstrated need* early in the fall semester at the beginning of the semester. (**E.g.*, math diagnostic, RESP participants, *etc.*)

Racial & Gender Equity in Physics



Explores the underrepresentation of women and racial/ethnic minorities in mainstream physics history and the field at large today. Students from all disciplines are invited and encouraged to take this discussion-based course.

Exploring Physics with a Computer



Explores classic physics problems that are tricky/near impossible to solve with a pencil and paper alone. *I.e.*, the ones that are “beyond the scope” of a typical intro physics course.

Uses VPython, Trinket, and Mathematica.

Now FWIS: “Science vs. Pseudoscience” and “Foundations of Quantum Physics for Regular People”



RICE NATURAL SCIENCES

Physics and Astronomy

FWIS- Physics Topics

First-Year Writing Intensive Seminars:

- Required for all degrees.
- Strategies for analyzing, synthesizing, and responding to college-level readings.
- Improve their ability to communicate effectively in writing and in speech
- Learn appropriate use and citation.
- Learn to articulate oral arguments and responses in-class and in presentations.

Storytelling in the Sciences

Scientists communicate through articles, press releases, podcasts, and books. Students explore how scientific ideas transform across formats for different audiences.



The Meaning and Impact of Quantum Mechanics



Focuses on the debates over the content and meaning of quantum theory. Students learn how theories are formed, how science is done, how these impact day-to-day culture, and the role that humans play in objective science.

Science, Pseudoscience, & Skepticism: How to tell good science from junk science



Focuses on scientific skepticism and critical thinking. Core topics include the fallibility of perception; mechanisms of self-deception; as well as metacognition, cognitive biases and logical fallacies.



Hidden Curriculum

Internal Resources

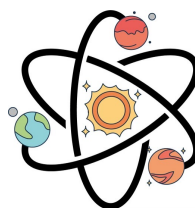


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Academic Fellows/Mentors

- Course-Specific Academic Assistance
 - Office Hours
 - Group study sessions
 - Paper editing
 - Exam review sessions
 - One-on-one tutoring
- Academic Enrichment Events/Workshops
 - Research, fellowship, and internship opportunities

What students can and/or should do...
but isn't officially part of any one course.



Society of
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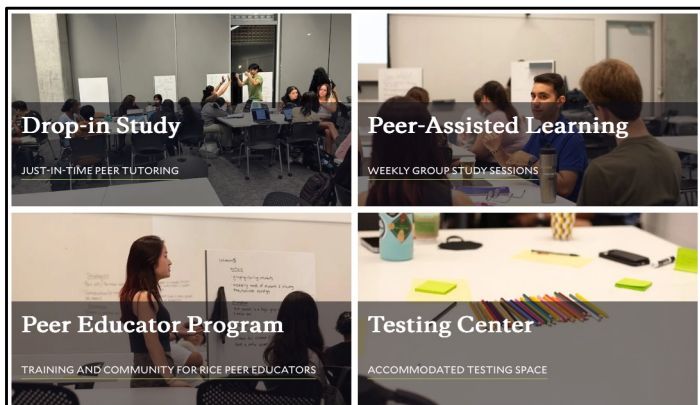


RICE ECLIPSE

Rice University's Student Rocketry Team



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RICE UNIVERSITY
Wiess School of Natural Sciences

PATHWAYS TO DISCOVERY

Scholarship · Community · Research · Careers · Engagement

The [Pathways to Discovery](#) program in the School of Natural Sciences aims to give all Natural Sciences undergraduate and graduate students the opportunity to develop the skills they need to become the scientific leaders and decision makers of tomorrow.



University

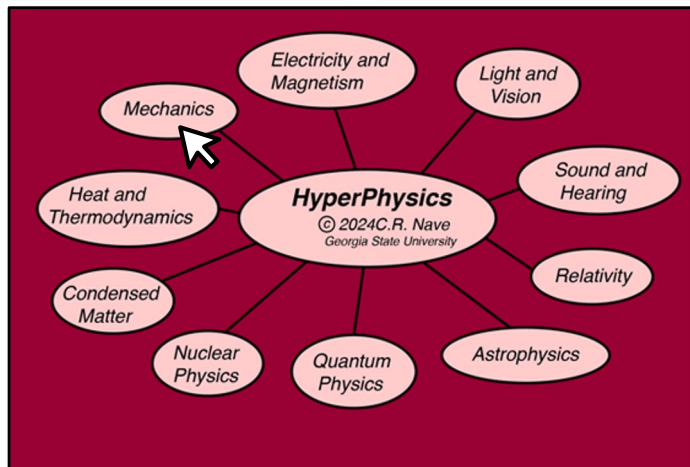
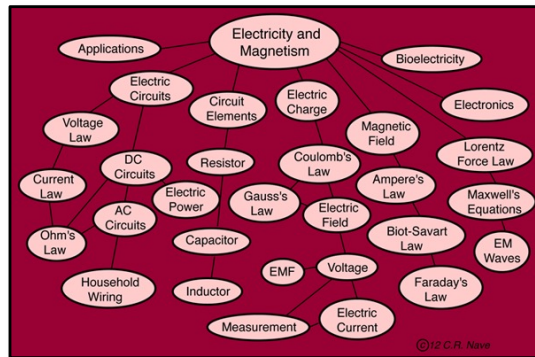
Physics

Volume 1

```

graph TD
    Mechanics((Mechanics))
    Examples((Examples))
    PhysicalUnits((Physical Units))
    Solids((Solids))
    CircularMotion((Circular Motion))
    Orbits((Orbits))
    ConservationLaws((Conservation Laws))
    Fluids((Fluids))
    PeriodicMotion((Periodic Motion))
    NewtonsLaws((Newton's Laws))
    Forces((Forces))
    Mass((Mass))
    Gravity((Gravity))
    WorkEnergyPrinciple((Work-Energy Principle))
    WorkEnergyPower((Work, Energy and Power))
    ConservationEnergy((Conservation of Energy))
    ConservationMomentum((Conservation of Momentum))
    ConservationAngularMomentum((Conservation of Angular Momentum))
    Rotation((Rotation))
    Torques((Torques))
    Equilibrium((Equilibrium))

    Mechanics -- "describes motion with" --- Examples
    Mechanics -- "develops" --- PhysicalUnits
    Mechanics -- "develops" --- Solids
    Mechanics -- "develops" --- CircularMotion
    Mechanics -- "develops" --- Orbits
    Mechanics -- "is founded upon" --- ConservationLaws
    ConservationLaws -- "describes" --- Fluids
    ConservationLaws -- "includes" --- PeriodicMotion
    ConservationLaws -- "includes" --- NewtonsLaws
    ConservationLaws -- "like" --- ConservationEnergy
    ConservationLaws -- "like" --- ConservationMomentum
    ConservationLaws -- "like" --- ConservationAngularMomentum
    ConservationEnergy -- "uses" --- Forces
    Forces -- "forces in action involve" --- Mass
    Forces -- "such as" --- Gravity
    ConservationEnergy -- "and" --- WorkEnergyPrinciple
    ConservationAngularMomentum -- "and" --- ConservationMomentum
    ConservationAngularMomentum -- "and its causes" --- Rotation
    Rotation -- "and its causes" --- Torques
    Torques -- "and the conditions for" --- Equilibrium
    WorkEnergyPrinciple -- "and" --- WorkEnergyPower
  
```

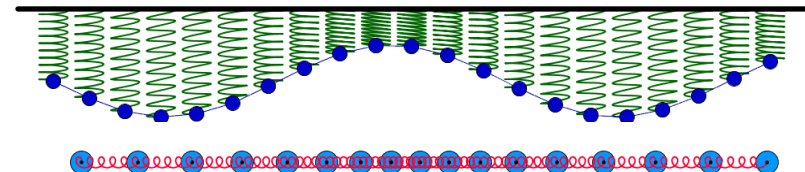




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<https://ophysics.com/>



RicePOP



Rice Physics Outreach Program:

- Demos for in-class use and outreach
- Student designed and made (if possible)
- Students from all majors.
- PHYS 461/462- 1 hour research credit
- Brown Teaching Grants (2017 & 2024)
Teaching Innovation Grant (2018)
Departmental Funds (~\$5K annually)

ECLIPSING BINARY STAR MODEL

This demonstration shows how the brightness (flux) of an eclipsing binary system changes over time and varies based on the size and brightness of both stars.

What are eclipsing binary stars?

A pair of stars that orbit each other in a way that causes one star to periodically block the light from the other as seen from Earth

For stars of the same brightness, the dips in brightness are roughly the same size since the amount of light being blocked when one orbits the other is the same!

For stars of the same size, the dips in brightness have a sharp minimum (vs the flat minimum of the different sizes) since the time it takes for one to cover the other is the same for both stars!

Same size same brightness

Same size different brightness

different size same brightness

different size different brightness

Department of Physics and Astronomy, Rice University

Laminar Flow (high laminarity)

Turbulent Flow (low laminarity)

Laminar Flow Nozzle

Have you ever noticed how sometimes clean water is easier to see through? Compare the pictures to the right. The difference between these two flows is **laminarity**, which measures water's tendency to travel in the same direction, without lateral mixing.

The laminar flow nozzle changes a garden hoses' turbulent flow into a stream of laminar flow. Dynamic viscosity (η) is constant for this demo, so the water's **speed** (v) and the container's **hydraulic diameter** (D_h) most significantly determine the water's laminarity. Because laminar flow is associated with a smaller **Reynold's number** (Re), v and D_h should be small.

$$Re = \frac{v D_h}{\eta}$$

Mesh held in place by a ring of PVC forces the water to travel parallel with the length of the nozzle.

Two more mesh layers ensure the flow doesn't become turbulent before leaving the nozzle.

The water exits through a hole in a thin sheet of metal, which has a smooth edge.

Scouring pads minimize the water's turbulence before entering the straws.

The straws force the water to flow parallel with each other, towards the end of the nozzle. Each straw has a small **hydraulic diameter** (D_h), but the water's **speed** (v) remains low.

Laminar Flow (high laminarity)

Turbulent Flow (low laminarity)

RICE POP! Department of Physics and Astronomy, Rice University

Double Pendulum

Physics 461 - Cristiana De Sousa

A single pendulum only has one arm to rotate. As a result, it has much simpler motion.

A double pendulum has two arms that rotate instead of one. As a result, it has a more complicated motion.

Double Pendulum

Have you ever heard of the butterfly effect? It is the theory that something small can have a larger effect.

The double pendulum is a model of the butterfly effect! It cares a lot about how and where it starts more than a single pendulum.

While it seems that the pendulum moves randomly, we can use equations to predict how the pendulum will move based on its initial conditions.

Starting at 500.0/2 Starting at 500.1/2

Beginning Positions:

Ending Positions:

While the pendulums move very similarly, their paths diverge over time.

This project was made possible by the help of Rob Funn, the Materials and support from VP Undergraduate Group.

Citation: This project was inspired by this video: https://www.youtube.com/watch?v=2C9F_uu8d8

The simulation used is from these codes linked below: <https://github.com/andrewmiller1994/doublePendulum>
https://www.youtube.com/watch?v=2C9F_uu8d8

Department of Physics and Astronomy, Rice University

Laser Audio Transmission

By Ryan MacLerray for Physics 461- RicePOP

Principles:

Many types of audio cables carry sound in different ways. One technique that is used in certain types of audio cables is to carry sound by turning the audio signal into electricity and sending it through a wire, then converting it into an audio signal again at the other end. Although this method of audio transfer has its flaws it has existed for a long time and is very simple.

This demonstration is very similar to such types of audio cables, although instead of using a physical wire to transfer the energy, it is transferred through a laser. Instead of differences in strength of the electric current, information is transferred through differences in the amount of light particles called photons sent by the laser.

How It Works:

The demo is made up of two parts, the transmitter, and the receiver, both being fairly simple.

The transmitter is composed of a battery, an audio input with an AUX cable, a transistor, a laser diode, and a few resistors and capacitors. It works by the transistor taking the audio signal and altering it so that the change in audio signal is turned into a change in the intensity of the laser diode. The light from the laser diode is then sent across the room, where it hits the solar panel of the receiver.

The receiver then takes the energy generated by the solar panel and directs it into the audio amplifier. The capacitors and resistors in the circuit change the volume of the sound and the frequencies that are transmitted, and the signal that exits the amplifier is played by the speaker. Ideally, the sound playing from the speaker will sound close to the sound which initially went into the circuit through the audio cable.

Acknowledgements:

The images included omit resistors, capacitors, and some specific branches of circuits for simplicity. Much of this project was based off of circuit diagrams from the website linked below, and the circuit diagrams for the transmitter and receiver circuits are shown below.

The Transmitter:

The Receiver:

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RICE NATURAL SCIENCES
Physics and Astronomy

RicePOP



Children's Museum Houston
Free Family Night



Houston Science Festival
Casa to College



Reach for the Stars
Rice STEM Festival

