PHYSICS 102 SYLLABUS

Syllabus **Dr. R.L. Herman** **Summer 2019**

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Course Content:

Required Text: *College Physics* by OpenStax College (2017). https://openstaxcollege.org/textbooks/college-physics

This is a continuation of Physics 101. We will cover Chapters 18 through 28 of the text. Previously, you have learned about linear and circular motion, gravitational and frictional forces, rotational motion, fluid, thermal physics and waves. In this second course we will study electrical and magnetic forces, electromagnetic waves, optics and the birth of modern physics.

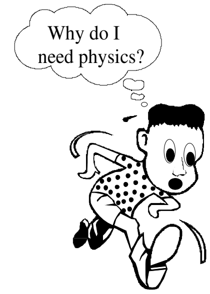
Learning Outcomes: www.uncw.edu/phy/about/slos.html.

After successfully completing this lecture and laboratory course you should at least be able to:

1. Demonstrate the ability to think critically and to use appropriate concepts to analyze qualitatively problems or situations involving the fundamental principles of physics. [SAN 1]
2. Demonstrate the ability to use appropriate mathematical techniques and concepts to obtain quantitative solutions to problems in physics. [SAN 2, QRE 1, QRE 2]
3. Demonstrate basic experimental skills by the practice of setting up and conducting an experiment with due regards to minimizing measurement error. [SAN 2, QRE 2, QRE 3]
4. Demonstrate basic communication skills by working in groups on laboratory experiments and the thoughtful discussion and interpretation of data. [SAN 3, QRE3]

Why Study Physics?

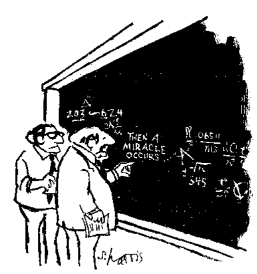
This is a question that students often ask. "Why do I need to take physics? I am a biology major!" (You can fill in your own major.) To many physics appears to be a difficult subject, which is too abstract, not relevant to everyday living, and uses too much mathematics. It is the ultimate cross to bear to get an undergraduate degree. No wonder many students try to put it off as long as possible. However, there must be a good reason for other disciplines to require students to take this course.



There are several possible reasons to take physics. One is to open students' eyes to the wonders of the physical world around them. Another is to train them to analyze what they see by developing simple models of that part of the world in which they are interested. This last reason is called problem solving, which is a key ingredient in learning physics. Finally, the experience in this course will help in making the student a more informed individual, which can come in handy when basic issues in science become political issues.

What is physics? Physics is the most basic science. It touches every part of your daily life at every moment. It governs the heaters and air conditioners, which allow us to live in comfortable surroundings. It is responsible for the light used to read this syllabus, or to make it possible for cars to bring you to class. Without physics energy could not be transported in DNA molecules to allow biological systems to develop, grow and reproduce.

The word physics has its roots in the Latin word *physica* and the Greek word *physis*, which mean nature. Physics is the study of the underlying principles that govern the behavior of the world around us. It is important that everyone have some understanding of the physical world in our technological society.



"I THINK YOU SHOULD BE MORE EXPLICIT HERE IN STEP TWO."

We are faced with the accumulation of 7000 years of scientific information and with the internet our access to information is growing exponentially. However, there is still much that is unknown or not understood. New physical principles are being discovered every year in an attempt to refine our understanding of nature. Typically these result from a series of observations and experiments, which are complemented by reflective reasoning. Theories are then developed and tested, leading to new principles. This was described in the 1963 lectures of the late Dr. Feynman:

"What do we mean by understanding something? We can imagine that this complicated array of moving things which constitutes the world is something like a great chess game being played by the gods, and we are observers of the game. We do not know what the rules of the game are; all we are allowed to do is watch the playing. Of course, if we watch long enough, we may eventually catch on to a few of the rules. The rules of the game are what we mean by fundamental physics. Even if we know every rule, however, we might not be able to understand why a particular move is made in the game, merely because it is too complicated and our minds are limited. If you play chess you must know that it is easy to learn all the rules, and yet it is often hard to select the best move or to understand why a player moves as he does. So it is in nature, only much more so; but we may be able to at least to find all the rules. Actually, we do not have all the rules now. (Every once in a while something like castling is going on that we still do not understand.) Aside from not knowing all of the rules, what we really can explain in terms of those rules is very limited, because almost all situations are so enormously complicated that we cannot follow the plays of the game using the rules, much less tell what is going to happen next. We must, therefore, limit ourselves to the more basic question of the rules of the game. If we know the rules, we consider that we understand the world."

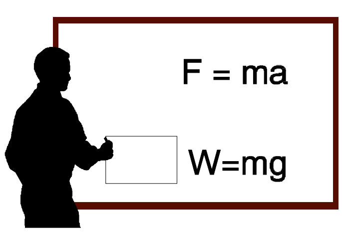
Study Tips:

To many students physics is difficult. Of course, this is true of any subject, which is not understood. The point is that physics can be understood through logic and objectivity. Physics is a subject, which builds on itself. Unfortunately, students must learn the basics, before they can venture to the more interesting applications. So, the subject may at first appear to be boring and not very relevant.

Another problem students face is that **the study of physics requires new terminology and a new way of thinking.** One cannot hope to learn physics the night before the exam. Therefore, in this course you will be expected to do homework assignments on a regular basis. In fact, you should spend several hours a day doing physics. **[You should spend at least six hours per week on physics outside of class.]**

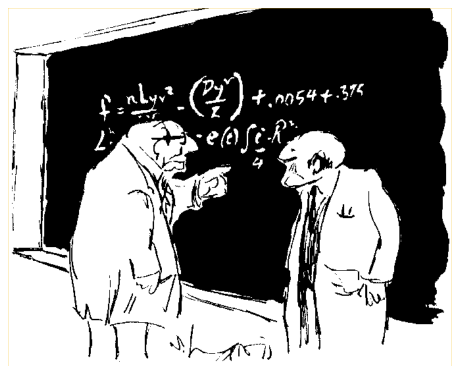
A final discouragement to studying physics is the use of mathematics. Mathematics is a tool for expressing the observed relationships between physical quantities. **Physics is not mathematics.** The principles of physics can be stated without mathematics, but the mathematical equations are more compact and can be used to predict the values of unknown quantities from known ones.

In a basic course, such as this one, we will practice using this tool by solving simple word problems. We will do this in the homework, in the lectures and in the exams. The key to doing word problems is the approach that one takes. In the following is a set of steps, which you should always follow to be successful:



SOLVING PROBLEMS

1. **Read the problem and determine the physical principle involved.**
2. **List the given and unknown information**
3. **Draw a picture, labeling it with the known and unknown information, when possible.**
4. **Write down any relationships between the given and the unknown variables.**
5. **Solve for the unknown quantities. Be careful to express everything in the appropriate units.**
6. **Express the answer with its units and the correct number of significant figures.**
7. **Final Check: Does the answer make sense?**



"Does this apply always, sometimes, or never?"

The goal of physics is to describe the maximum number of phenomena in our universe in terms of the minimum number of general principles. Also, these principles should be as simple as possible. Therefore, as you read the text and follow the lectures, you should get into the habit of identifying these principles. A suggested practice is as follows:

STUDYING PHYSICS

1. **Read the relevant text material before the lecture.**
2. **Go to class, takes notes, listen.**
3. **Reread the topic carefully. Identify the underlying principle of the section and/or chapter. Define all new terms. Understand the material, do not just memorize it.**
4. **Now, you are ready to start the problems and follow the problem solving strategy listed above.**

Bonus Work:

Unfortunately, at the conclusion of a two semester introductory physics course you will have seen only the physics known up to the early 1900s. However, in the past seventy years physics has changed considerably. The neutron was discovered in 1932, followed by the discovery of many other elementary particles. In 1945 the first atomic bomb was exploded. In the 60's and 70's pulsars and other distant objects were observed. Lasers have become commonplace and the movies are filled with new technology and even things that are physically impossible. Or are they? Teleportation was common in Star Trek. In 1997 a group of scientists carried out a form of teleportation.

In order to become familiar with these and other recent developments in physics, there will be periodic bonus questions handed out for extra credit. You will be required to answer these in essay form to receive credit. Only neat work will count! **Bonus points will be added to the total earned quiz points.**

Course Requirements:

Attendance: YOU ARE EXPECTED TO ATTEND ALL OF THE LECTURES! After three excused absences, there will be a penalty of 2% for each absence from your total grade.

Homework: Homework assignments will be handed out on a regular basis. They will not be collected, butyou are strongly encouraged to do assignments before the quizzes are given. **Doing the suggested problems is very important for learning the material in this course.**

Labs: Satisfactory lab performance is a required part of this course. For each missed lab, your final grade will be dropped by half a letter grade according to departmental policy. There will be an opportunity to made up one lab at the end of the semester. Labs will count 10% of your final grade.

Exams and Grades: There will be seven 30 minute quizzes and a final for this course. Quizzes will consist of a mixture of multiple choice, definitions or conceptual questions plus selected problems similar to those covered in class or in the Suggested Problems list. You will be tested on your grasp of the concepts and ability to use these concepts to solve problems.

All quizzes and the final exam will be closed book and no formulae will be included. There will be no makeup quizzes without prior permission. **Graphing calculators are not permitted for the exams.**

The final exam will be cumulative, covering all twelve chapters. It will be given 8 am- 11 am on August 1st.

Your grade will be based on the following information:

Quizzes	60%
Final	30%
Labs	10%
Final	20%

90-100	A
80-89.5	B
70-79.5	C
60-69.5	D

Plus-minus grading may be used in special cases.

Topics To Be Covered:

Electricity electric charges, Coulomb's Law, electric potential, Ohm's Law, Kirchoff's laws, resistance, capacitance, dielectrics.

Magnetism magnetic fields, moving coils, electromotive forces, Faraday's Law, inductance, moving charges, motors and generators, AC circuits, impedance, reactance.

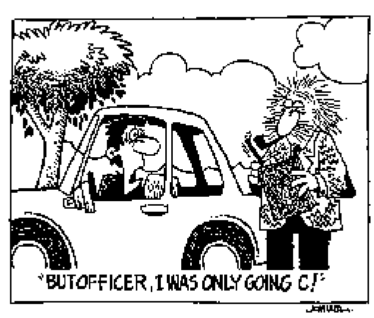
Electromagnetic Waves wavelength, frequency, speed, electromagnetic energy, reflection, refraction, Snell's Law, dispersion, polarization..

Geometric Optics plane mirrors, spherical mirrors, thin lenses, simple and compound systems, ray diagrams, optical instruments, resolving power, microscopes, telescopes.

Physical Optics Huygen's principle, interference, optical path length, diffraction, single and double slits, diffrection gratings.

Relativity fundamental principles, length contraction, time dilation, simultaneity, twin paradox, mass-energy relation.

Quantum Mechanics photoelectric effect, Compton effect, photons, deBroglie waves, wave-particle duality, Bohr's atomic model.



Homework Problems:

Doing and thinking about physics is important in learning the material. You should do all multiple choice and as many of the problems a possible. Suggested problems are on the assignment page.

THIS SCHEDULE IS SUBJECT TO CHANGE

Physics on the Web:

More information will be posted on the web related to the topics we are studying. Links can be found with summaries to the material, study suggestions and physics humor. Old quizzes will be made available, ideas for bonus topics and links to summaries of mathematical topics in algebra and trigonometry. These will be accesible through the instructor's homepage at

people.uncw.edu/hermanr/phy102

Advice for Success:

In order to learn the material in this course and earn a good grade, you need to put in some effort. Do not put off assignments or reading. If you do not understand something, ask the instructor. Come to office hours, use email, ask knowledgeble students, or go to the library/internet and find supplementary material. The instructor can only cover the basics in class. You are not expected to know the material by only listening to the lectures. You need to work problems and think about what you are doing.

Academic Honor Code: All members of UNCW's community are expected to follow the academic Honor Code. Please read the UNCW Honor Code carefully (as covered in the UNCW Student Handbook). Academic dishonesty in any form will not be tolerated in this class. Please be especially familiar with UNC-W's position on plagiarism as outlined in the UNCW Student Handbook. Plagiarism is a form of academic dishonesty in which you take someone else's ideas and represent them as your own.

Student Disabilities: UNCW Disability Services supplies information about disability law, documentation procedures and accommodations that can be found at www.uncw.edu/disability. To obtain accommodations the student should first contact Disability Services and present their documentation to the coordinator for review and verification.

Campus Respect Compact. UNCW has recently instituted a Respect Compact to affirm our commitment to a civil community, characterized by mutual respect. That Compact will soon be affixed to the wall of each classroom and can be accessed at: http://uncw.edu/diversity/documents/ApprovedSeahawkRespectCompact8x10.08.09.pdf .

PHY 101 College Physics Outline

Ch. 1. Introduction

1. Significant figures.
2. Units (MKS, CGS, British).
3. Dimensional Analysis.
4. Trigonometry: $\sin\theta = \frac{\text{opp}}{\text{hyp}}$, $\cos\theta = \frac{\text{adj}}{\text{hyp}}$, $\tan\theta = \frac{\text{opp}}{\text{adj}}$.
5. Vectors and Scalars.
6. Vector Addition.
7. Vector Components, $V_x = V\cos\theta$, $V_y = V\sin\theta$, $V = \sqrt{V_x^2 + V_y^2}$, $\tan\theta = \frac{V_x}{V_y}$.

Ch. 2. Kinematics-1D

1. Displacement, velocity, acceleration.
2. Average, Instantaneous values.
3. $\bar{v} = \frac{\Delta x}{\Delta t}$, $v = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t}$.
4. Uniform acceleration,
5. Kinematic Equations, $v = v_0 + at$, $x = \bar{v}t$, $\bar{v} = \frac{1}{2}(v_0 + v)$, $v^2 = v_0^2 + 2ax$, $x = v_0 t + \frac{1}{2}at^2$.
6. Free fall, $a = -g$.

Ch. 3. Kinematics-2D

1. Displacement, Velocity, Acceleration
2. Projectile Motion $(a_x = 0, a_y = -g)$

Ch. 4. Forces and Newton's Laws of Motion

1. Law of Inertia, Mass.
2. $F = ma$.
3. Action-Reaction.
4. Gravitational Force,
$$F = G\frac{m_1 m_2}{r^2}.$$
5. Weight, Normal force, $W = mg, N, g = \frac{GM}{R^2}$.
6. Apparent Weight, $W_{app} = m(g + a)$.
7. Vector Forces, Free Body Diagrams.
8. Friction $f = \mu_s N$.
9. Equilibrium and Non-equilibrium,
$$\sum \mathbf{F} = \mathbf{0}, \quad \sum \mathbf{F} = m\mathbf{a}$$

Ch. 5. Uniform Circular Motion

1. Circular Motion, $v = \frac{2\pi r}{T}$.
2. Centripetal Acceleration, $a_c = \frac{v^2}{r}$, $F_c = \frac{mv^2}{r}$.
3. Banked Curves, $\tan\theta = \frac{v^2}{rg}$.
4. Circular Orbits, $v = \sqrt{\frac{GM}{R}}$.
5. Weightlessness.

Ch. 6. Work and Energy

1. $W = \mathbf{F}\cdot\mathbf{d} = Fd\cos\theta$.
2. $W = \Delta KE$, $KE = \frac{1}{2}mv^2$.
3. $PE = mgh$, (gravitation).
4. Conservation of Energy,
$$E = \frac{1}{2}mv^2 + mgh = \text{const.}$$
5. Power, $\bar{P} = \frac{W}{t}$, $P = Fv$.

Ch. 7. Impulse and Momentum

1. Momentum, $\mathbf{p} = m\mathbf{v}$.
2. Impuulse, $\mathbf{I} = \mathbf{F}\Delta t = \Delta\mathbf{p}$.
3. Conservation of Linear Momentum.
4. Elastic/Inelastic Collisions.

Ch. 8. Rotational Kinematics

1. Arclength, $s = r\theta$.
2. Kinematics, $\omega = \omega_0 + \alpha t$, $\theta = \bar{\omega}t$, $\bar{\omega} = \frac{1}{2}(\omega_0 + \omega)$, $\omega^2 = \omega_0^2 + 2\alpha\theta$, $\theta = \omega_0 t + \frac{1}{2}\alpha t^2$.
3. Centripetal/Tangential Acceleration, $a + t = r\alpha$.
4. Rolling motion, $v = r\omega$.

Ch. 9. Rotational Dynamics

1. Torque, $\tau = F\ell = I\alpha$.
2. Moments of Inertia, $I = mr^2$ (particle), and rod, sphere, hoop, cylinder.
3. Parallel Axis Theorem.
4. Center of Gravity.
5. Angular Momentum, $L = I\omega$.
6. Kinetic Energy, $KE_{\text{rot}} = \frac{1}{2}I\omega^2$, $KE = KE_{\text{trans}} + KE_{\text{rot}}$. Rolling sphere,$KE = \frac{7}{10}mv^2$.
7. Equilibrium,
$$\sum \mathbf{F} = \mathbf{0}, \quad \sum \tau = \mathbf{0}.$$

Ch. 10. Elasticity and Simple Harmonic Motion

1. Stress $= \frac{F}{A}$, Strain $= \frac{\Delta L}{L_0}$.
2. Elastic Moduli
3. Springs, $F = -kx$, $\omega = \sqrt{\frac{k}{m}}$, $PE = \frac{1}{2}kx^2$.
4. Pendula, $\omega = \sqrt{\frac{g}{L}}$.

Ch. 11. Fluids

1. $m = \rho V$, $P = \frac{F}{A}$.
2. $P = P_0 + \rho gh$.
3. Pascal's Principle, $P_o = P_i$.
4. Archimede's Principle, $B = \rho_f gh$.
5. Flow Rate,$Q = Av$.
6. Bernoulli's Equation,
$$P + \frac{1}{2}\rho v^2 + \rho gh = \text{const.}$$

Ch. 12. Temperature, Thermal Expansion, and Heat energy

1. Temperature Scales.
2. Thermal Expansion, $\Delta L = \alpha L_0 \Delta T$.
3. $Q = mc\Delta T$, $Q = mL$.

Ch. 13. The Transfer of Heat

1. Conduction, $Q = \frac{kA\Delta Tt}{L}$.
2. Convection.
3. Radiation, $Q = e\sigma AT^4$.

Ch. 14. Ideal Gas Law and Kinetic Theory

1. $PV = nRT = NkT$.
2. $\frac{1}{2}\left(mv^2\right)_{\text{ave}} = \frac{3}{2}kT \Rightarrow v_{\text{rms}} = \sqrt{\frac{3kT}{m}}$.
3. $U = \frac{3}{2}nRT = \frac{3}{2}NkT$.

Ch. 15. Thermodynamics

1. $W = P\Delta V$, $W = nRT\ln\frac{V_2}{V_1}$
2. 1st Law, $\Delta U = Q - W$.
3. $Q = nC\Delta T$.
4. $C_p - C_v = R$, $\gamma = C_p/C_v$.
5. Isothermal, isobaric, isochoric, adiabatic.
6. PV^γ =const (adiabatic).
7. 2nd Law, $\Delta S \geq 0$.
8. $e = \frac{W}{Q_H} = 1 - \frac{Q_C}{Q_H}$, $e_{\text{max}} = 1 - \frac{T_C}{T_H}$.
9. Carnot Engines (reversible).
10. Entropy: $S = \frac{\Delta Q}{T}$.

Ch. 16. Waves and Sound

1. $v = f\lambda$.
2. $v = \sqrt{\frac{F}{\mu}}$ (string).
3. $v = \sqrt{\frac{B}{\rho}}$, $v \approx 331 + 0.60T$.
4. Loudness, pitch, audible range.
5. Intensity, $I = \frac{\bar{P}}{A} \propto A^2, \frac{1}{r^2}$.
6. $\beta(\text{dB}) = 10\log\frac{I}{I_0}$.
7. $y = A\sin(kx \pm \omega t)$, $k = \frac{2\pi}{\lambda}, \omega = \frac{2\pi}{T} = 2\pi f$.
8. Doppler Effect, $f' = \frac{v+v_0}{v-v_0}f$ (towards).

Ch. 17. Superposition and Interference

1. Superposition, reflection, refraction, diffraction.
2. Diffraction, $\lambda = D\sin\theta$.
3. Standing Waves, string, $f = n\frac{v}{2L}$, $n = 1, 2, \ldots$.
4. Standing Waves, open/closed tubes.

Constants

1. $g = 9.8$ m/s^2
2. $G = 6.67 \times 10^{-11}$ Nm^2/kg^2
3. $N_A = 6.02 \times 10^{23}$ mol^{-1}
4. $R = 8.315$ J/(mol-K)
5. $k = 1.38 \times 10^{-23}$ J/K
6. $\sigma = 5.67 \times 10^{-8}$ W/(m^2–K^4)
7. 1 cal = 4.184 J.
8. 1 atm = 1.013×10^5 N/m^2
9. $L_f = 80$ kcal/kg, $L_v = 540$ kcal/kg.

PHY 102 College Physics Outline

Ch. 18. Electric Forces and Fields

1. Charge, Conductors.
2. Coulomb's Law: $F = k\dfrac{q_1 q_2}{r^2}$, $k = \frac{1}{4\pi\epsilon_0}$
3. Electric Field: $\mathbf{E} = \dfrac{\mathbf{F}}{q}$,
4. $E = k\dfrac{q}{r^2}$, (pt charge)
5. Field lines.

Ch. 19. Electric Potential Energy and Electric Potential

1. Work to move charge: $W = -qV$
2. Potential: $V = -k\dfrac{q}{r}$ (pt charge)
3. Parallel Plates: $E = \dfrac{\sigma}{\epsilon_0}$, $\sigma = \dfrac{Q}{A}$
4. $V = Ed$ (Uniform Field)
5. Capacitance: $Q = CV$
6. Parallel plates: $C = \dfrac{\kappa\epsilon_0 A}{d}$
7. Stored Energy: $U = \frac{1}{2}CV^2$.
8. Dielectrics: $\kappa = \dfrac{E_0}{E}$

Ch. 20. Current and Resistance

1. Current: $I = \dfrac{\Delta q}{\Delta t}$
2. Ohm's Law: $V = IR$
3. Resistance (Wire): $R = \rho\dfrac{L}{A}$
4. Temperature Dependence:
   $\rho = \rho_0(1 + \alpha\Delta T)$, $R = R_0(1 + \alpha\Delta T)$
5. Electric Power: $P = IV$, $P = I^2R$
6. AC circuits, $V = V_0\sin(2\pi f t)$
7. Peak and RMS: $V_{\text{rms}} = \dfrac{V_0}{\sqrt{2}}$
8. Average Power: $P_{\text{ave}} = I_{\text{rms}}V_{\text{rms}}$

Ch. 21. Electric Circuits

1. Series Resistance: $R = R_1 + R_2$
2. Parallel Resistance: $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$
3. Terminal Voltage: $V = \mathcal{E} - Ir$
4. Kirchoff's Rules: Point and Loop
5. Capacitors: $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$
6. Parallel Capacitors: $C = C_1 + C_2$
7. RC - Charging Capacitor: $\tau = RC$.

Ch. 22. Magnetism

1. Magnetic Force for
   (a) a moving charge: $F = qvB\sin\theta$
   (b) Current in Wire: $F = ILB\sin\theta$
2. Cyclotron radius: $r = \dfrac{mv}{qB}$
3. Torque on loop: $\tau_{\max} = NIAB$,
4. Fields from currents
   (a) Straight wire: $B = \dfrac{\mu_0 I}{2\pi r}$
   (b) Current Loop: $B = \dfrac{\mu_0 I}{2R}$
   (c) Solenoid: $B = \mu_0 nI$, $n = N/\ell$
   (d) Crossed fields: $v = E/B$

Ch. 23. Electromagnetic Induction

1. Magnetic flux: $\Phi = BA\cos\theta$
2. Faraday's Law: $\mathcal{E} = -N\dfrac{\Delta\Phi}{\Delta t}$
3. Lenz's Law, Induced emf
4. Motional Emf: $\mathcal{E} = B\ell v$
5. Generators: $\mathcal{E} = NAB\omega\sin\omega t$
6. Transformers: $\dfrac{V_s}{V_p} = \dfrac{N_s}{N_p} = \dfrac{I_p}{I_s}$
7. Mutual Inductance: $\mathcal{E} = -M\dfrac{\Delta I_p}{\Delta t}$
8. Self Inductance: $\mathcal{E} = -L\dfrac{\Delta I}{\Delta t}$
9. Solenoid: $L = \mu_0 n^2 A\ell$
10. Stored energy: $U = \frac{1}{2}LI^2$
11. AC circuits
    (a) $\mathcal{E} = I_0\sin\omega t$, $\omega = 2\pi f$, $f = \frac{1}{t}$
    (b) $I = I_0\sin\omega t$,
    (c) $V_{\text{rms}} = I_{\text{rms}}Z$, Impedance Z: $Z = \sqrt{R^2 + (X_L - X_C)^2}$
    (d) Inductive and Capacitive Reactances: $X_L = 2\pi fL$, $X_C = \dfrac{1}{2\pi fC}$
    (e) $\tan\phi = \dfrac{X_L - X_C}{R}$
    (f) Power loss $= VI\cos\phi$
    (g) Resonance: $X_L = X_C \Rightarrow f_0 = \dfrac{1}{2\pi\sqrt{LC}}$

Ch. 24. Electromagnetic Waves

1. Wavespeed: $v = f\lambda$
2. Speed of light in vacuum: $c = \dfrac{1}{\sqrt{\epsilon_0\mu_0}} = 3.0 \times 10^8$ m/s
3. Ranges in spectrum - visible, microwave, infrared, ultraviolet, radio, x-rays
4. $E = cB$
5. Energy $u = \frac{\epsilon_0}{2}E^2 + \frac{1}{2\mu_0}B^2$
6. Intensity $S = cu = c\epsilon_0 E^2$

Ch. 25. Geometric Optics

1. Plane mirrors: $i = r$
2. Spherical mirrors: $R = 2f$, $\dfrac{1}{f} = \dfrac{1}{d_o} + \dfrac{1}{d_i}$, $M = \dfrac{h_i}{h_o} = -\dfrac{d_i}{d_o}$
3. Index of Refraction: $n = \dfrac{c}{v}$
4. Snell's Law: $n_1\sin\theta_1 = n_2\sin\theta_2$
5. Total Internal Reflection: $\sin\theta_c = \dfrac{n_2}{n_1}$
6. Apparent depth $d' = \dfrac{n_2}{n_1}d$
7. Thin Lenses: converging $f > 0$, diverging $f < 0$: $\dfrac{1}{f} = \dfrac{1}{d_o} + \dfrac{1}{d_i}$, $M = \frac{h_i}{h_o} = -\frac{d_i}{d_o}$
8. Dispersion - Prisms and rainbows

Ch. 26. Optical Devices

1. Lens Power (Diopters): $P = 1/f$
2. Near point (25 cm) and far point (∞)
3. Vision correction
4. Magnifying glass
5. Telescopes, $M = \frac{\theta'}{\theta} \approx -\frac{f_o}{f_e}$, and Microscopes, $m = m_e m_0$

Ch. 27. Wave Optics

1. Linear superposition
2. Interference (m integer below)
   (a) Constructive: $\Delta L = m\lambda$
   (b) Destructive: $\Delta L = \left(m + \frac{1}{2}\right)\lambda$
   (c) Thin films: $\lambda_n = \lambda/n$, $2t + \text{shift}_1 + \text{shift}_2 = A\lambda_n$ for $A = m$ (max), $A = m + \frac{1}{2}$ (min)
   Shift $= \begin{cases} \frac{1}{2}\lambda_n, & n_2 > n_1, \\ 0, & n_1 > n_2 \end{cases}$
3. Wavelength in medium: $\lambda_n = \lambda/n$
4. Double slit (m integer): $d\sin\theta = \begin{cases} m\lambda, & \text{max}, \\ \left(m + \frac{1}{2}\right)\lambda, & \text{min} \end{cases}$
5. Single slit: $W\sin\theta = m\lambda$ (min), $m \neq 0$
6. Diffraction: $d\sin\theta = m\lambda$ (max),
7. Rayleigh Criterion: $\theta_{\text{min}} = 1.22\dfrac{\lambda}{D}$
8. Polarization,
   Malus' Law: $S = S_0\cos^2\theta$
   Brewster's angle: $\tan\theta_B = \dfrac{n_2}{n_1}$

Ch. 28. Special Relativity

1. Einstein's Postulates
2. Time dilation $\Delta t = \gamma\Delta t_o$
   $\gamma = \dfrac{1}{\sqrt{1 - v^2/c^2}}$
3. Length contraction $L = \dfrac{L_0}{\gamma}$
4. Relativistic Momentum $p = \gamma m_0 u$
5. Relativistic Energy $E = \gamma mc^2$, $E_0 = mc^2$.
6. Velocity Addition $u = \dfrac{v + u'}{1 + vu'/c^2}$

Ch. 29. Quantum Physics

1. Energy quantization: $E = nhf$
2. Photoelectric effect:
   $hf = KE_{\max} + BE$
3. Photons: $E = hf$, $p = \dfrac{E}{c} = \dfrac{h}{\lambda}$
4. Compton Effect
5. deBroglie Wavelength: $\lambda = \dfrac{h}{mv}$
6. Uncertainty Principle

Constants

1. $g = 9.8$ m/s^2
2. $k = 9.0 \times 10^9$ Nm^2/C^2
3. $e = 1.602 \times 10^{-19}$ C
4. $c = 3.0 \times 10^8$ m/s
5. 1eV $= 1.602 \times 10^{-19}$ J
6. $\epsilon_0 = 8.85 \times 10^{-12}$ C^2/Nm^2
7. $h = 6.626 \times 10^{-34}$ Js