Chapter 1

Phys 130

1.1 Kinematics in One Dimension (Ch 1-2)

- motion diagrams - these represent an object's position as a function of time, kind of like the frames of a movie all superimposed on one image. You should know how to translate verbal description into a motion diagram; know how to translate motion diagram into a description of the object's position, velocity, and acceleration
- understand the difference between a vector and a scalar. For example, distance is a scalar and displacement is a vector.
- velocity - change in position over change in time, $v_s = \frac{ds}{dt}$; average vs. instantaneous velocity
- acceleration - change in velocity over change in time, $a_s = \frac{dv_s}{dt}$; average vs. instantaneous acceleration
- kinematic chain:$ds/dt = v$, $dv/dt = a$
- know how to estimate: velocity from position vs time graph, acceleration from velocity vs time graph (derivatives)
- Know how to use the kinematic equations.
- Free-fall is an example of a constant acceleration motion. Remember: the *magnitude* of the acceleration of gravity is 9.8 m/s^{s}; the *sign* of $\vec{g}$ depends on how you define your coordinate axes.

Uniform Acceleration

- You should be able to determine the instantaneous velocity of an object in two ways:
  1. determine the slope of the tangent to a position vs. time graph at a given point.
  2. use the mathematical model $v_2 = at + v_1$
- You should be able to determine the displacement of an object two ways:
  1. find the area under a velocity vs. time curve
  2. use the mathematical model $x_f = x_i + v_i t + 1/2at^2$
- You should be able to determine the acceleration of an object in five ways:

1. find the slope of a velocity vs. time graph
2. use the mathematical model $a = \Delta v/\Delta t$
3. rearrange the mathematical model $x_f = x_i + v_i t + 1/2at^2$
4. rearrange the mathematical model $v_f = v_i + at$
5. rearrange the mathematical model $v_f^2 = v_i^2 + 2a\Delta x$

- Given a position vs. time graph, you should be able to:
  1. describe the motion of the object (starting position, direction of motion, velocity)
  2. draw the corresponding velocity vs. time graph
  3. draw the corresponding acceleration vs. time graph
  4. determine the instantaneous velocity of the object at a given time
- Given a velocity vs. time graph, you should be able to:
  1. describe the motion of the object (direction of motion, acceleration)
  2. draw the corresponding position vs. time graph
  3. draw the corresponding acceleration vs. time graph
  4. write a mathematical model to describe the motion
  5. determine the acceleration
  6. determine the displacement for a given time interval

1.2 Motion in a Plane (Ch 3-4)

1.2.1 Vectors

A vector is a quantity that must be specified by two numbers; a scalar, in contrast, can be specified using just one number.

A common example of a vector is position. To specify where a point is located on an $x-y$ plane, we must specify both its x and y coordinates. We can also specify the location of this point using polar coordinates; the point is some distance r from the origin, and at some angle θ as measured counter-clockwise from the $+x$ axis. When using $x - y$ coordinates to specify a position, we say we are specifying the *components* of the position vector. We can also specify the vector using its magnitude (or length) and direction, and this is analogous to polar coordinates.

Examples of other vectors include: velocity, acceleration, force, and momentum.

Examples of scalars include: mass, speed, and energy.

You should be able to do the following:

1. Given the magnitude and direction of a vector, break the vector into its x and y components.
2. Given the x and y components of a vector, calculate the magnitude and direction.
3. Sum 2 or more vectors
   (a) using the tip-to-tail method
   (b) by breaking each vector into its components.

1.2.2 Projectile Motion

- Projectile motion describes all objects that are moving solely under the influence of gravity.
- The horizontal and vertical motions of a projectile are independent. Remember the demonstration that we did in class where one ball was launched horizontally while another ball was dropped straight down. The two hit the ground at the same time, demonstrating that the different horizontal motions do not affect the vertical motions. Both balls have identical vertical motions.
- The verticle motion of a projectile determines its time of flight (how *long* it is in the air).
- The horizontal motion of a project determines its range (how *far* it travels horizontally).
- When solving projectile motion problems, make a list of all the known quantities for both the horizontal and vertical (x and y) motions.
- For an object undergoing projectile motion, you should be able to draw position, velocity and acceleration vs. time for both dimensions.
- Draw a force diagram for an object undergoing projectile motion.
- Given information about the initial velocity and height of a projectile determine
  1. the time of flight,
  2. the point where the projectile lands
  3. magnitude and direction of velocity at impact
  4. time to reach maximum height
- Explain what effect the mass of a projectile has on its time of flight.
- If a projectile is launched at an angle θ above the horizontal, you need to break its initial velocity into horizontal (x) and vertical (y) components. Typically, $v_{ix} = v_i cos\theta$ and $v_{iy} = v_i sin\theta$, where θ is the angle the initial velocity makes with the horizontal.

1.3 Forces (Ch 5-8)

- What is a force?
- Know the different types of forces: gravity, spring, tension, normal, kinetic and static friction.
- Know how to identify the forces that are acting on an object - ask yourself:
  1. what is the object touching?
  2. what is the object interacting long-range with?
- Interaction diagram - shows the object and all the other objects it is interacting with. Conceptually, this is the first step in isolating the forces acting on an object and drawing the free-body diagram.
- Free-body diagram - this shows all the forces acting *on* the object
- Newton's First Law: be able to describe this and give examples. *An object at rest or moving at constant velocity continues its current motion unless acted upon by an outside agent (force).*

- Know how to apply Newton's Second Law to an object that is experiencing multiple forces.
  1. draw a force diagram for an object given a written description of the forces acting on it.
  2. resolve forces into x and y components as necessary, then sum the forces in each direction.
  3. analyze of the kinematic behavior of the object. If $\vec{a} = 0$, the object will be at rest or moving with a constant velocity. If $\vec{a} \neq 0$, you can describe its motion as explained below.
- Newton's Third Law: *All forces come in pairs; paired forces are equal in magnitude, opposite in direction and act on separate bodies.* $F_{AB} = -F_{BA}$.
- Newton's Third Law - know how to determine the acceleration of a *system* of objects, like two masses connected by a pulley; remember the acceleration of two joined objects must be the same. I recommend defining the direction of the acceleration ($\vec{a}$) as positive for all objects; forces that are in the direction of acceleration are then positive, and forces that are opposite the direction of acceleration are negative.
- linking forces and kinematics - by determing the net force on an object, you can calculate its acceleration. Once you know acceleration, you can use the kinematic equations to describe how the object moves with time.
- Distinguish mass versus weight.

1.3.1 Inclined Plane

Inclined planes are a common type of two-dimensional problem seen in general physics. They provide a means to practice breaking forces into components in a coordinate system that is not aligned with the horizontal and vertical directions.

- When you analyze the forces for an object on an inclined plane, you *almost always* want to rotate your coordinate system so that the x-direction is along the incline and the y-direction is perpendicular to the incline.
- You should know how to break the force of gravity into its components along the plane and perpendicular to the plane. Typically, $F_{g,x} = mgsin\theta$ and $F_{g,y} = mgcos\theta$, where θ is the angle between the bottom of the incline and the horizontal direction. You should be able to prove this to yourself using geometry.
- The sum of the forces in the y-direction is equal to zero (so long as the object is not accelerating up off the plane). This allows you to solve for the normal force. (The normal is **not** equal to mg!!!)
- If friction ($F_f = \mu F_N$) is involved, use the normal found from $\sum F_y = 0$.

1.4 Motion in a Circle (Ch 8)

- An object that is moving in a circle is accelerating, even if its speed is constant, because the direction of its velocity vector is changing.
- Remember the buggy activity. When the buggy was tied to the ringstand, it moved in a circle. When the string was cut, the buggy continued in a straight line that was tangent to the circle. The string was pulling the buggy toward the center of the circle.

- The direction of the acceleration (and thus the net force) is toward the center of the circle.
- The magnitude of the acceleration for an object moving in a circle with constant speed is $a_c = v^2/r$.
- You should use an r-z coordinate system for circular motion problems, where r points to the center of the circle and z is perpendicular to r. (Technically, this coordinate system is attached to the object that is rotating.)
- Vertical circular motion - we looked at a roller coaster and pilot in an airplane as examples; make sure you understand how the normal force changes in these situations. The net force in the radial direction must be mv^2/r, and the normal force will adjust accordingly. At the bottom of a vertical circle, the normal force will have to be greater than F_g so that the net force is toward the center of the circle. At the top of a vertical circle, the normal force will work with F_g to provide the centripetal force; the normal force will go to zero as the speed of the object is descreased (see Exam 2 problem).

1.5 Momentum (Ch 9)

- momentum - *momentum* $=$ *mass* $\times$ *velocity*. The units are $kg\ m/s$, and momentum is a vector.
- Impulse is defined as the change in momentum. Impulse can be calculated from the area under Force vs. time graph.
- Conservation of momentum - momentum is conserved for an isolated system. Because momentum is a vector, you have a conservation of momentum equation for both the x and y directions, and the two directions must be treated separately. In class, we focused mainly on collisions in one dimension, but in lab we did a two-dimensional problem (the accident reconstruction).
- Understand how to express Newton's Second Law in terms of momentum: $\vec{F} = \frac{\Delta \vec{p}}{\Delta t}$.
- Be able to distinguish between elastic vs. inelastic collision. Know what is conserved in each type of collision. Conservation of momentum governs all collisions. If a collision is elastic, meaning that the two objects bounce and don't stick together, then kinetic energy is also conserved. **Kinetic energy is not conserved in an inelastic collision.**
- Draw before and after pictures when trying to conceptualize collisions or explosions.

1.6 Energy (Ch 10)

- Know the different forms of energy - kinetic, potential, thermal, source
- Potential energy - potential energy must be able to be converted back to kinetic energy. Examples include gravitational potential energy and the potential energy stored in a spring.
- Source energy - this is usually some type of chemical energy (muscles, gasoline) or solar energy that can be transformed into mechanical energy.
- Conservation of energy - applies to an isolated system

- Remember that energy is a scalar. This means that *direction* does not enter into the energy equations.
- Know how to use energy bar charts to conceptualize conservation of energy problems.
- The zeropoint for gravitational potential energy is arbitrary, so you can set it to be a convenient location. We can only measure a change in potential energy.
- Springs - Hooke's law, spring constant, potential energy stored in a spring ($U_{Spring} = 1/2k\Delta x^2$).
- ballistic pendulum - this is a great problem to review because it requires you to apply conservation of momentum (collision) and conservation of energy (pendulum swinging up to its max height).
- Dissipative (irreversible) vs. non-dissipative (reversible) interactions. Understand that once energy is converted to thermal energy, it can not go back to mechanical energy. (Mechanical energy is the sum of potential and kinetic energy.)

1.7 Work (Ch 11)

- Work is energy transferred into or out of a system
- if the system's energy increases, $W > 0$; if the system's energy decreases, $W < 0$.
- Work kinetic energy theorem: $\Delta K = W_{net}$
- Work is the area under a Force vs position graph. You should be able to calculate work given a graph of $F\ vs.\ x$.
- The work done by a force is the component of the force that is in the direction of motion times the displacement. This can be expressed as a dot product

  $$W = \vec{F}_{\parallel}\ \Delta\vec{r} = \vec{F} \cdot \Delta\vec{r} = F\ \Delta r\ cos\alpha$$

  where α is the angle between the force and the displacement.
- A *conservative force* is a force for which the work done is independent of the path taken. Example: gravity
- A *non-conservative force* is a force for which the work done depends on the path taken; the process is irreversible. Example: friction. The work done by friction is represented as ΔE_{th} (change in thermal energy) because the energy goes into heating the objects.
- Understand how the work done by non-conservative forces affects the conservation of energy equation

  $$\Delta E_{system} = \Delta K + \Delta U + \Delta E_{source} + \Delta E_{th} = W_{ext}$$
- You should know how to represent conservation of energy problems using energy bar charts. Be sure to label the type of energy that each bar represents and whether it is initial or final energy.

1.8 Rotational Motion (Ch 12)

- Center of mass (vector) - for a uniform object (which will always be the case for us), the center of mass is at the geometric center of the object. (This is where you would apply the force of gravity when making an extended free-body diagram.)

- Moment of interia (scalar), or rotational inertia, is a measure of how difficult it is to rotate an object. Think of this as the rotational equivalent of mass/inertia, which is a measure of how difficult it is to accelerate an object.

- We will give you the moment of inertia for common extended objects like a sphere, disk, hoop, and rod. You should know how to calculate the moment of intertia for discrete masses (like Jack and Jill on the seesaw) - you multiply each mass by the square of its distance from the point of rotation, and then add this for all masses:

$$I = \sum m_i r_i^2 \tag{1.1}$$

- parallel axis theorem - allows you to convert a moment of inertia about an object's center of mass to the moment of inertia about a parallel axis.

- You should know the symbol and definition for angular displacement ($\theta \equiv theta$), angular velocity ($\omega \equiv omega = \Delta\theta/\Delta t$), and angular acceleration ($\alpha \equiv alpha = \Delta\omega/\Delta t$).

- You should understand the connection between angular and linear kinematic quantitites and be comfortable converting between the two.

- You should understand how to convert among rpm, rad/s, rev/s, and period. These are really just unit conversions.

- Angular quantities (displacement, velocity, acceleration, torque) are positive for counterclockwise and negative for clockwise rotation.

1.8.1 Rotational Energy

In previous energy considerations, we only considered the kinetic energy associated with an object's motion through space, also referred to as the motion of the center of mass. We did problems where a box slides down a frictionless incline. In this case, the initial potential energy (mgh) is equal to the final kinetic energy ($\frac{1}{2}mv^2$).

If we change the box to a ball, the motion is different. The ball is moving down the incline, just like the box, but the ball is also rolling. Thus, we have a new energy term to consider: the energy associated with rolling.

We can break up the motion into two parts:

1. the kinetic energy associated with the ball moving down the incline ($\frac{1}{2}mv^2$), and

2. the kinetic energy associated with the ball rotating about its axis ($\frac{1}{2}I\omega^2$).

Thus, when an object rolls down an incline, its initial potential energy goes into moving the object down the incline *and* rolling the object. The speed at the bottom of the incline is given by:

$$U_i^G = K_f$$

$$U_i^G = K_{translation} + K_{rotation}$$

$$mgh = \frac{1}{2}mv_{cm}^2 + \frac{1}{2}I\omega^2$$

The moment of inertia, I, always has an r^2 term. For an object that is rolling without slipping, $\omega = v/r$, so $\omega^2 = v^2/r^2$. Thus the radius cancels out when we multiply I and ω^2. This allows us to rewrite $K_{rotation}$ in terms of velocity, v, and we can then combine the two kinetic energy terms.

1.8.2 Angular Momentum, Conservation of Angular Momentum

- Objects that have motion about a point have angular momentum, $\vec{L}$.
- Analogous to linear momentum, angular momentum can be defined as the moment of inertia times the angular velocity:
$$\vec{L} = I\vec{\omega}$$
- For point particles, we can also define the angular momentum as the cross-product of the radius and momentum vectors:
$$\vec{L} = \vec{r} \times \vec{p}$$
The magnitude of this angular momentum is given by:
$$L = rmvsin\theta$$
where θ is the angle between $\vec{r}$ and $\vec{v}$.
- Angular momentum can change if an object is experiencing a net torque
$$\vec{\tau}_{net} = \frac{d\vec{L}}{dt}$$
- The angular momentum of a system is conserved if there is no net torque. We can solve this type of problem just like we would for a conservation of momentum problem:
$$\vec{L}_i = \vec{L}_f$$
We demonstrated this in class when a student spinning on a stool brings his/her arms in and starts to rotate faster. In this case, the student's moment of intertia decreased (her mass moved closer to the axis of rotation), and her angular velocity increased so that the product of $I\omega$ remains constant.
- The direction of angular momentum is given by the right-hand-rule, where you curl your fingers in the direction of rotation and your thumb shows the direction of angular momentum. (This is the same as the direction of angular velocity.)

1.9 Torque and Static Equilibrium (Ch 12)

- Torque ($\vec{\tau}$; the greek letter tau) is the effectiveness of a force to cause rotation.
- Torque is a vector.
- Torque is the *cross-product* of the radius vector or level arm $\vec{r}$ and the force $\vec{F}$, where $\vec{r}$ is drawn from the point of rotation to where the force is applied..

$$\vec{\tau} = \vec{r} \times \vec{F}$$

- The magnitude of the torque is given by the lever arm (the distance from the point of rotation to where the force is applied) times the component of the force that is perpendicular to the lever arm.

$$\tau = rF_{\perp} = rFsin\phi$$

  where ϕ (phi) is the angle between the radius and force vectors. The best approach for applying this is to choose ϕ to be the smallest angle between $\vec{r}$ and $\vec{F}$, and then determine the direction of the torque as described below.
- The direction of the torque is given by the right-hand-rule (using right hand: fingers in the direction of $\vec{r}$, curl fingers into the direction of $\vec{F}$, thumb shows direction of torque).
- You can also just say that a torque that wants to rotate an object counter-clockwise is positive, clockwise is negative.
- The rotational version of Newton's Second Law states that the net torque on an object is equal to the moment of intertia times the angular acceleration:

$$\vec{\tau} = I\vec{\alpha}$$

- Static equilibrium requires that the net force is zero (so that there is no acceleration) and the net torque is zero (so that there is no rotation):

$$\vec{F}_{net} = 0 \quad \text{and} \quad \vec{\tau}_{net} = 0$$

- Note that $\vec{F}_{net} = 0$ is really two equations: $\vec{F}_{net,x} = 0$ and $\vec{F}_{net,y} = 0$
- In static equilibrium, the torque measured about *any point* must be zero. This means you can choose your origin at any point when calculating the net torque. Choose wisely! You almost always want to place the origin at the point where one of the forces is applied, and the force at the origin will drop out of the torque equation. If you have two unknown forces (like the activity we did in class where you had to predict the scale readings when the pendulum was placed on a board between the scales), you should put the origin at the position of one of the unknown forces.

1.10 How to Study

- Read through all the slides and your notes.
- Refer to book for sections that you don't remember well.
- Work through whiteboard problems and think-pair-share questions.

- Work through homework problems. Be sure to compare your work to the solutions that I have posted online. Make sure you understand how to complete each problem from start to finish, without refering to the solution!
- Work through exam questions. This means that you should be able to solve each problem *without* referring to the solution! You may need to solve a problem several times using the solution before you are able to solve it on your own. Practice, practice, practice!
- Review your labs.

Chapter 2

Phys 140

2.1 Electrostatics

- Electric Force
  - carriers of charge; triboelectric series
  - know how to use Coulomb's law to calculate the force between charged particles
  - conductors and insulators
  - know how to calculate the net force from multiple charges (superposition of charges); remember that force is a vector!
- Electric Field (Ch 25-27)
  - electric field is the force per charge; it is also a vector!
  - be able to draw electric field lines around various charge distributions
  - know how to calculate the net electric field from multiple charges (superposition of charges); remember that electric field is a vector!
  - electric field of a capacitor
  - know how to calculate the electric field inside and outside a long wire using Gauss' Law
- Electric Potential Energy (W and U_{elec}) (Ch 28)
  - electric potential energy is the energy stored in a charge configuration
  - if you have to do work to bring the charges together from infinity, then the configuration has positive potential energy
  - electric potential energy is a scalar, so you can add the potential from various charges by just adding the numbers
  - comparison of electric potential energy and gravitational energy
  - you should be able to calculate the net electric potential energy from multiple charges
- Electric Potential (V) (Ch 28-29)
  - electric potential is the electric potential energy per charge
  - electric potential is a scalar, so you can add the potential from various charges by just adding the numbers

- net electric potential from multiple charges
- calculating potential from electric field and vice versa
- electric potential of a capacitor

- Circuits (Ch 31)
  - Kirchkoff's loop law for potential - the sum of the potential difference must be zero around any closed loop
  - Kirchkoff's junction law for current - the current flowing into a junction (where wires split) must be the same as the current flowing out of a junction
  - Ohm's Law: $\Delta V = IR$
  - be able to draw a circuit based on a description or picture
  - rules for parallel and series circuits including current, voltage and resistance
    - current is the same through all parts of a series circuit
    - the voltage drop across branches of a parallel circuit is the same
  - power dissipation by a resistor; $P = IV = I^2R$
  - household circuits - review *Spring Break Circuits* lab

2.2 Magnetism

- Magnetic Field (Ch 32)
  - magnetic field lines point away from North and toward South
  - Be sure to specify directions and/or rotations clearly. Use the symbols for "into the page" ($\otimes$) and "out of the page" ($\odot$).
  - Review the Magnetism worksheets 1-5.
  - Cross product: $mag(\vec{A} \times \vec{B}) = ABsin\theta$, where θ is the angle between the two vectors and the direction the direction is given by the right-hand-rule: fingers in direction of u, curl into w, and the cross-product is in the direction indicated by thumb
  - The force on a charged object moving in a magnetic field is given by the Lorentz force law: $\vec{F}_m = q\vec{v} \times \vec{B}$ The direction is given by the right-hand-rule for the cross product, where your fingers go in the direction of $q\vec{v}$, curl into direction of $\vec{\mathrm{B}}$, and thumb shows direction of force.
  - Note the units of the B-field $\vec{\mathrm{B}}$ is Tesla, where 1T = 1(N/C)/(m/s).
  - When a charged particle enters a *uniform* magnetic field, it will undergo circular motion, with the magnetic force, $\vec{F}_m$, providing the centripetal force:

    This is always the case for circular motion: $\sum \vec{F} = ma = m\dfrac{v^2}{r}$

    The net force is just the magnetic force: $\vec{F}_m = m\dfrac{v^2}{r}$

    $q\vec{v} \times \vec{B} = m\dfrac{v^2}{r}$

    If you want to figure out how long a charged particle takes to complete one orbit, use the relation: $v = \dfrac{distance}{time} = \dfrac{2\pi r}{T}$ where T (period) is the time to complete one orbit/rotation/revolution.

- Magnets and Currents (Ch 32)
  - A magnetic field can exert a force on a current-carrying wire. The force on a wire segment that is located within a magnetic field is: $\vec{F}_{m,seg} = I\vec{\ell} \times \vec{B}$ where ℓ is the length of wire in the magnetic field and I is the current.
  - You can represent a current-carrying loop as a bar magnet (a magnetic dipole). If you curl your fingers in the direction of the current, your thumb shows the direction of North.
  - A current-carrying loop will rotate in a magnetic field so that the North pole of the loop aligns with the external magnetic field lines.
  - Motors take advantage of this fact; they run current through a wire loop that is sitting in a magnetic field, and the wire loop will rotate. We did a lab on this - go over it!
- Currents Create Magnetic Fields (Ch 32)
  - In 1820, Hans Oersted discovered that moving charges create magnetic fields.
  - Similarly, current-carrying wires also create a magnetic field.
  - The magnetic field of a long current-carrying wire is given by: $B = \dfrac{\mu_0}{2\pi}\dfrac{I}{r}$ where I is the current, and r is the distance from the wire where you want to measure the magnetic field.
  - The magnetic field at the center of a current-carrying loop is given by: $B = \dfrac{\mu_0 I}{2R}$ The magnetic field curls around the wire, and the direction is given by the right-hand-rule. Put your right-hand thumb in the direction of the current, and your fingers curl in the direction of the magnetic field.
  - As far as we know, all magnetism is created from moving charges.
- Electromagnetic Induction (Ch 33)
  - Faraday's law says that a changing magnetic flux through a closed wire loop induces a current in that loop: $\mathcal{E} = -\dfrac{d\Phi_m}{dt}$
  - The magnetic flux is the dot product of the magnetic field and the area of the loop, so the flux can change by: changing the strength of the magnetic field, changing the size of the loop, and/or changing the orientation of the loop. A current is only induced when the magnetic flux is changing!
  - Lenz's Law states that the current induced by Faraday's law seeks to **oppose** the change in the magnetic flux.
  - It's useful to draw the magnetic flux at the beginning and end of the problem to determine the direction of the induced current.

2.3 Maxwell's Equations

- $\oint \vec{E} \cdot d\vec{A} = \frac{Q_{enc}}{\epsilon_0}$
  Gauss's law - charges create electric fields and create a net electric flux through a closed surface.

- $\oint \vec{B} \cdot d\vec{A} = 0$Gauss's law for magnetism
  Gauss's law for magnetism - There are no magnetic monopoles. Flux out of the surface (from the north pole) equals flux back into the surface(into the south pole).
- $\oint \vec{E} \cdot d\vec{l} = -\frac{\partial \Phi_B}{\partial t}$
  Faraday's Law - changing magnetic flux creates an electric field.
- $\oint \vec{B} \cdot d\vec{l} = \mu_0 I_{\mathrm{enc}} + \mu_0 \epsilon_0 \frac{\partial \Phi_E}{\partial t}$
  Ampere-Maxwell's Law - current or a changing electric flux creates a magnetic field.

2.4 Simple Harmonic Motion and Waves (Ch 14 and Ch 20)

- Simple Harmonic Motion and Waves (Ch 14)
  - mass on a spring
  - calculation of potential energy, kinetic energy, angular frequency, frequency, period, amplitude
  - calculation of position, velocity, and acceleration as a function of time
- Waves (Ch 20)
  - be able to identify longitudinal vs transverse waves
  - know the characteristics of waves: frequency, period, wavelength, wave speed
  - know how the characteristics of waves are related to each other. For example, for all waves, $speed = frequency \times wavelength$.
- Standing Waves (Ch 21)
  - know how to calculate frequency and wavelength for strings and open/closed pipes
  - understand superposition principle for waves and how this leads to constructive and destructive interference
  - understand how waves undergo reflection and refraction

2.5 Optics (Ch 22 -23)

- Wave Optics (Ch 22)
  - understand the principles of interference and diffraction
  - You should be very familiar with Young's two-slit interference experiment; the condition for bright (interference) fringes is: $\sin\theta_m = m\lambda/d$, where d is the slit spacing and m is the *order* of the fringe
  - Understand how light diffracts through a single-slit; the angular position of the dark fringes is given by $\sin\theta_m = m\lambda/a$, where a is the slit width

  - diffraction gratings produce a similar pattern as the two-slit experiment, but the resulting constructing interference bands are much narrower. Diffraction gratings are used to analyze the spectra of all sorts of things. In class, we looked at the spectrum of the Sun and the spectrum of emission-line tubes that contains gasses such as hydrogen, helium, argon and neon.
  - dispersion (e.g., through a prism) occurs because the index of refraction for many materials varies with the wavelength of light. This means that red light follows a different path than violet light.

- Ray Optics (Ch 23)
  - law of reflection: angle of incidence equals angle of reflection. Remember that all angles are measured from the normal.
  - index of refraction: $n = c/v$
  - law of refraction (also known as Snell's law): $n_1 sin\theta_1 = n_2 sin\theta_2$
  - be able to identify convex vs concave lenses and mirrors
  - focal length - when parallel light rays enter a lens, they will converge at the focal point. The focal length is the distance from the lens to this point.
  - radius of curvature
  - understand how magnification is measured from the heights of the image and object.
  - Know how to do graphical ray tracing for a simple convex lens
  - real vs virtual images - understand the difference between these two and how to know when a lens will produce a real or virtual image.
  - thin lens formula: $\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$. Know how to use this formula and how distances are measured.

Chapter 3

Phys 220

Chapter 4

Phys 250

Chapter 5

Phys 260

Chapter 6

Phys 310

Chapter 7

Phys 370

Chapter 8

Phys 410

Chapter 9

Phys 440