CHAPTER REVIEWS

Chap. 1:  THE LAWS OF MOTION, Part I
-inertia (mass): the property of objects that resists changes in motion
-speed = distance/time; velocity involves speed and direction
-NEWTON'S FIRST LAW: objects at rest remain at rest, objects in motion remain in motion in a straight line...unless acted on by outside influences (forces)
-acceleration: how fast velocity changes with time (speed or direction may change)
-NEWTON'S SECOND LAW: to make something accelerate requires a force (a push or pull), force = mass x acceleration; (F = ma)
-falling objects: all objects fall at the same rate (without air resistance): g = 9.8 m/s/s
velocity = acceleration x time; (v = at)
distance = ½ (accel) x (time)²; (d = ½ at²)
-projectile motion: horizontal motion and vertical motions are independent
-weight: force of gravity: weight = (mass) x (accel. of gravity) = (mass) x (9.8 m/s/s)
-NEWTON'S THIRD LAW: for every action there is an equal and opposite reaction
-net force: the sum of all forces acting on an object determines its motion
-potential energy (PE): stored energy
-kinetic energy (KE): energy of motion
-ENERGY IS CONSERVED!!!
-work: transfers energy; work = (force) x (distance moved)

Chap. 2:  THE LAWS OF MOTION, Part II
-rotational inertia: resists changes in rotational motion
-rotational speed: how fast something rotates (revolutions per second, for example)
-NEWTON'S FIRST LAW OF ROTATION: objects not rotating don't start rotating, objects rotating continue to rotate...unless acted on by an outside influence (torque)
-torque: required to make something rotate: torque = (force) x (lever arm)
-center-of-mass: "average" center of an object; a freely spinning object rotates about its center-of-mass
-NEWTON'S SECOND LAW OF ROTATION: torque = (rotational inertia) x (rotational accel.)
-friction: always opposes motion; depends on surfaces, weight, relative motion
- static: surfaces at rest; sliding: surfaces move relative to each other
(sliding friction is smaller than static friction)
-friction transforms kinetic energy into thermal energy (energy conserved!)
-momentum: mass and velocity determine how hard it is to start or stop something
-momentum = mass x velocity
-relationship to force and time: force x time = change in momentum; (Ft = change in mom.)
in collisions: MOMENTUM IS CONSERVED!!!
-spinning objects: ROTATIONAL MOMENTUM IS CONSERVED!!!
-NEWTON'S THIRD LAW OF ROTATION: for every torque, there is an equal and opposite torque
-kinetic energy: increases as velocity squared; (KE = ½ mv²)
Chap. 3: MECHANICAL OBJECTS, Part I
- springs: force required to stretch (or compress) a spring is proportional to how much it is stretched (or compressed) - true for nearly anything that is stretched or compressed.
  - spring constant = (spring force)/(stretch)
- elastic potential energy: PE energy stored in a spring that can be converted to KE
- bouncing balls: experience a "spring" force when they strike something
  - gravitational PE → KE (collision energy) → (elastic PE + thermal energy)
  - elastic PE → KE (rebound energy) → gravitational PE
  so...... final height < initial height
- coefficient of restitution = outgoing speed/incoming speed
  = √(final height/initial height)
- balls bouncing from moving surfaces (e.g., a bat or a tennis racket) – allows increase in return speed
- "sweet spots" (for bats, tennis racquets, etc.):  
  - center of percussion: bat or racquet rotates about end of handle when struck at this point
  - vibrational node: no vibration when struck at this point
- circular motion: anything moving in a circle experiences a centripetal acceleration and, consequently, a centripetal force
  - magnitude of centripetal acceleration: accel. = (speed)^2/radius
  - centrifugal force (outward force) is a "fictitious" force – reaction to inward force (applicable to: roller coasters, loop-the-loops, etc.)

Chap. 5: FLUIDS (liquids and gases) – Sec. 5.1
- pressure = force/area
- air pressure: due to weight of air above us (about 15 lbs/in^2 = 100,000 Pascals)
- pressure depends on altitude (in air) or depth (in a liquid)
- density = mass/volume
- Ideal Gas Law: (press) × (volume) = (density) × (temperature)
- buoyancy: reduction in weight when an object is immersed in a fluid
- Archimedes' principle: buoyant force = weight of displaced fluid (applicable to: helium balloons, hot-air balloons, floating objects)

Chap. 6: FLUIDS AND MOTION – Sec. 6.2
- Bernoulli's principle: pressure in a fluid corresponds to potential energy (PE)
- velocity of fluid corresponds to kinetic energy (KE)
  loosely stated: pressure decreases with increased velocity
  or..... KE(velocity of fluid) + PE(pressure of fluid) = constant energy (this is conservation of energy)
- laminar airflow: smooth orderly flow of air
- turbulent airflow: rough, random motion of air
Chap. 9: RESONANCE AND MECHANICAL WAVES – Secs. 9.1 and 9.2
- natural frequencies: the frequencies at which an object oscillates when struck
- resonance: occurs when an object is made to oscillate at its natural frequency
- clocks: characterized by period (T) of oscillation – time for one complete oscillation
  \( \text{period} = \frac{1}{\text{frequency}} \)
  - pendulum: period depends only on length
  - mass on a spring (balance clocks): period depends only mass (or rotational inertia)
  - electronic (quartz) crystals: designed to oscillate at 32,768 Hz
  \( \text{(period of all clocks is independent of the amplitude of oscillation)} \)
- sound and music:
  - sound results from oscillations of air molecules (like a Slinky)
  - human hearing: 20 Hz – 20,000 Hz (1 Hz = 1 cycle/second)
  - octave: sounds that differ by a factor of 2 in frequency (pitch)
- violins and guitars:
  - frequency (pitch) depends on: mass, length, tension of strings
  - vibrates in fundamental frequency and higher harmonics at the same time
  - bowing and plucking
  - audible sound comes from coupling the strings to the soundbox
- organ pipes:
  - sound comes from oscillations of air inside the pipe
  - frequency determined by length of air column
- drums: sound results from oscillations of a two-dimensional surface (compared to one-dimensional oscillating strings and air columns)

Chap. 10: ELECTRICITY – Secs. 10.1 and 10.3 (“Electricity and the Flashlight’s Electric Circuit”)
- electric charges: - positive and negative (protons and electrons)
  - like charges repel, unlike charges attract
  - charge is conserved
  - charge is quantized (always some multiple of the charge on an electron)
  - objects become charged by transferring electrons (usually)
- three categories of materials: conductors, insulators, semiconductors
- electric force: increases with charge and decreases with separation between charges
- voltage: measures electrical PE, similar to gravity or a spring
- electric circuits (example: a flashlight)
  - closed circuit: continuous path for charges (electrons) to flow from a battery
  - open circuit: no continuous path for charges to flow (switch open)
  - short circuit: occurs when wire is connected directly across a battery

Chap. 11: MAGNETISM AND ELECTRODYNAMICS
- magnetic poles: - north and south
  - like poles repel, unlike poles attract
  - magnetic poles always occur in pairs
- magnetic materials: soft (easily magnetized), hard (difficult to magnetize)
- CONNECTIONS BETWEEN ELECTRICITY AND MAGNETISM: moving electric charges produce magnetism; changing magnetism (moving magnetic poles) produces electricity
- transformers: used to increase or decrease AC voltages;
  \( \text{principle of operation: changing current in primary coil } \Rightarrow \text{ changing magnetic field } \Rightarrow \text{ changing current in secondary coil with higher or lower voltage} \)
- applications of changing electric and magnetic fields:
  - loudspeakers and microphones: opposites of one another
  - airport security
  - triggering of traffic signals
Chap. 12: ELECTROMAGNETIC WAVES
- EM (electromagnetic) waves: produced by making charges “run” up and down an antenna
  - consist of electric and magnetic parts that are perpendicular to each other (Fig. 13.1.4)
  - electric and magnetic parts continuously regenerate each other in empty space
  - travel at the speed of light (light is an EM wave!) = 186,000 miles/second
- reception of EM waves: (1) conducting rod – responds to electric part of wave (causes charges to oscillate)
  (2) conducting loop – responds to magnetic part of wave (induces current)
- audible information (20 –20,000 Hz) carried by modulation (variation) of carrier wave:
  - AM: amplitude modulation: 550 – 1600 kHz (kilocyclest)
  - FM: frequency modulation: 88 – 108 MHz (megahertz)
  - TV: video carried by AM, audio by FM
- cell phones: transmit and receive EM waves
- microwave ovens:
  - EM waves produced by a magnetron, directed into cooking chamber by a waveguide
  - H₂O molecules forced to twist (rotate) by EM waves of 2.45 GHz (gigahertz)
  - collisions (friction) between H₂O molecules cause them (and food) to get hot

Chap. 14: OPTICS AND ELECTRONICS – Sec. 14.2, pp. 475-483
- digital recording: sound wave is “sampled” at regular time intervals (44,100 times/second for a CD, up to 96,000 times per second for a DVD); amplitude (air pressure) of wave is assigned a number between +32,768 and –32,768 (= 2¹⁶ bits)
- information stored on a reflective layer (gold, aluminum) as “pits” and “land” (flat) areas
- information read by bouncing laser light from the reflective layer (Fig. 15.2.2)
- optical system: focuses laser light and determines amount of reflected light (Fig. 15.2.3)