

## **Science**

### **Physics**

#### **Core Texts:**

**Physics Concepts and Connections, Hobson**

**Understanding Physics, Asimov**

#### **Core Concepts**

### **Trimester One**

#### **Measurement**

- Units of length, time, mass; in particular the SI system
- Unit checking
- Changing units
- Systems of coordinates

#### **Vectors**

- Vectors vs. scalars
- Magnitude, direction, Cartesian components
- Unit vectors
- Addition and subtraction by geometric and algebraic methods
- Multiplication by a scalar
- Scalar (dot) product
- Vector (cross) product

#### **Motion along a straight line**

- Position and displacement
- Average velocity and average speed
- Instantaneous velocity and instantaneous speed
- Average acceleration and instantaneous acceleration
- Kinematics of constant acceleration
- Freely falling bodies
- Motion in two and three dimensions
- Position and displacement
- Average velocity and average speed
- Instantaneous velocity and instantaneous speed
- Average acceleration and instantaneous acceleration
- Projectile motion
- Uniform circular motion
- Relative velocity and acceleration (it is sufficient to do only the one-dimensional case)

#### **Newton's laws of motion**

- Newton's first law and inertial frames of reference
- Newton's second law and concepts of force and mass
- Newton's third law

#### **Applications of Newton's laws**

- Free-body diagrams
- Tension and pulleys
- Static and kinetic friction

- Inclined planes
- Uniform circular motion and centripetal force

## Trimester Two

### Work and Kinetic Energy

- Work as a scalar product
- Work done by weight
- Work done by a variable force
- Hooke's law and work done by a spring
- Kinetic energy and the work-energy theorem
- Power

### Potential energy and conservation of energy

- Conservative forces and potential energy
- Examples:  $mgh$  and  $(1/2)kx^2$
- Conservation of mechanical energy
- Work done by nonconservative forces and  $W_{\text{noncon}} = \Delta E$
- Conservation of energy (including internal energy)

### Systems of Particles

- Center of mass
- Newton's second law for a system of particles
- Linear momentum of a particle and of a system
- Conservation of momentum

### Collisions

- Impulse and the impulse-momentum theorem
- Elastic and inelastic collisions in one dimension
- Collisions in two dimensions

### Rotation

- Kinematics of fixed-axis rotation
- Linear and angular variables
- Moment of inertia and rotational kinetic energy
- Torque (including definition as a cross product) and rotational dynamics
- Rolling; translational and rotational kinetic energy;
- conservation of energy  
of angular momentum

## Trimester Three

### Gravitation

- Newton's law of universal gravitation
- Gravitational potential energy and escape speed
- Planets and satellites
- Kepler's laws and their relation to conservation laws

### Oscillations

- Simple harmonic motion resulting from Newton's second law and Hooke's law

- Position, velocity, and acceleration in simple harmonic motion
- Energy considerations in simple harmonic motion
- Simple pendulum

### **Mechanical Waves**

- Transverse and longitudinal waves
- Wavelength and frequency
- Speed of a traveling wave
- Waves on a stretched string
- Speed, energy, and power of a traveling wave on a stretched string
- Principle of superposition; interference
- Standing waves
- Sound waves
- Speed of sound
- Interference of sound waves
- Doppler effect

### **Kinetic Theory of Gases**

- Ideal gases
- Pressure, temperature, and rms speed
- Translational kinetic energy
- Internal energy of an ideal gas
- Internal energy and the first law of thermodynamics
- Distribution of molecular speeds
- Specific heats of an ideal gas
- Degrees of freedom
- Statistical view of entropy