

Chapter 13 (sections 1-4, 6-9)

What is temperature?

What is heat?

Temperature scales: $T_C = \frac{5}{9}(T_F - 32)$, $T_C = \frac{5}{9}(T_F - 32)$, and $T_K = T_C + 273$

Thermal Expansion: $\frac{\Delta L}{L} = \alpha \Delta T$

Ideal gas law: $pV = nRT$ (absolute pressure and temperature).

Chapter 14 (sections 1-5)

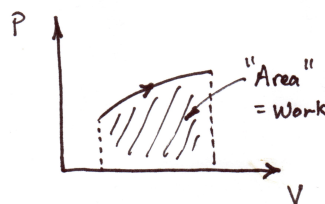
Heat transfer: $Q = mc\Delta T$ and $Q = mL$.

Calorimetry: $Q_{in} = Q_{out}$ (watch signs of temperature changes).

Chapter 15 (sections 1-6)

Know $p - V$ diagrams.

Thermodynamic work: $W = \int pdV$.



Sign of work:

$\Delta V > 0$ means $\int pdV > 0 \rightarrow W > 0$ and work is done by the system

$\Delta V < 0$ means $\int pdV < 0 \rightarrow W < 0$ and work is done on the system

First law of thermodynamics $\Delta U = Q - W$. Signs: Work is described above; Heat: $Q > 0$ means heat goes into the system; $Q < 0$ means heat leaves the system.

Internal energy of a monatomic ideal gas is $U = \frac{3}{2}nRT$.

Some Thermodynamic processes: isothermal, adiabatic, isobaric, isovolumetric.

Second law of thermodynamics: 1) Heat does not flow from cold to hot without work being done. 2) Heat cannot be converted completely into work.

Engines + Refrigerators and Heat Pumps:

Engines, refrigerators, and heat pumps: $Q_H - Q_L = W$.

Ideal engine, refrigerator, or heat pump: $\frac{Q_L}{Q_H} = \frac{T_L}{T_H}$.

Definitions and ideal results for efficiencies and COP's:

$$e = \frac{W}{Q_H}; \quad e_{ideal} = 1 - \frac{T_L}{T_H}$$

$$COP = \frac{Q_L}{W}; \quad COP_{ideal} = \frac{T_L}{T_H - T_L}$$

$$COP = \frac{Q_H}{W}; \quad COP_{ideal} = \frac{T_H}{T_H - T_L}$$

Chapter 16 (sections 1-9)

Electric Force: $F_E = k \frac{q_1 q_2}{r^2}$ (know directions).

Definition of electric field: $\mathbf{E} = \frac{\mathbf{F}}{q}$.

Superposition: Electric forces and electric fields add as vectors.

Electric field of a single point charge: $E = k \frac{q}{r^2}$

The electric field due to many charges: $\mathbf{E}_{net} = \sum \mathbf{E}_i$.

The force on a charge in an electric field is $\mathbf{F}_q = q\mathbf{E}$.

Chapter 17 (sections 1-5, 7, 9)

Electric Potential Energy: $PE_b - PE_a = -W_E = +W_{ext}$

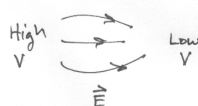
For two point charges: $PE = k\frac{qQ}{r}$

Energy Conservation: $W_{nc} = \Delta PE + \Delta KE$

Electrical Potential: $\Delta V_{ba} = V_b - V_a \equiv \frac{PE_b - PE_a}{q} = -\frac{W_E}{q}$; $\Delta PE = q\Delta V$

Potential Energy and Potential: $\Delta PE = q\Delta V$

Electric field and Electric Potential: $E = -\frac{\Delta V}{\Delta x}$



Remember: Electric potential and Electric field are defined using *positive* test charges.

Electric potential of a point charge: $V = k\frac{q}{r}$ ($V(\infty) \equiv 0$).

Superposition: Electric potential for many charges is $V_{tot} = \sum V_i$

Capacitance: $C = \frac{Q}{V}$; $PE = \frac{1}{2}QV$.

Parallel plate capacitor: $C = \epsilon_0 \frac{A}{d}$; $E = \frac{V}{d}$.

Chapter 18 (sections 1-3 and 5-7)

Electric Current: $I \equiv \frac{\Delta Q}{\Delta t}$; $\Delta Q = I\Delta t$

Ohm's Law: $V = IR$

Electric Power: $P = \frac{W}{t} = IV$ $P_R = IV = I^2 R = \frac{V^2}{R}$

Alternating Current: $V(t) = V_0 \sin \omega t$; $I(t) = I_0 \sin \omega t$; $I_0 = \frac{V_0}{R}$ (for a resistor).

RMS Values: $V_{rms} = \frac{V_0}{\sqrt{2}}$; $I_{rms} = \frac{I_0}{\sqrt{2}}$.

AC Power: $P = IV$; $\langle P \rangle = I_{rms} V_{rms} = \frac{1}{2} I_0 V_0$

Chapter 19 (sections 1-3)

A real battery: $V_{ba} = -IR + \varepsilon$ or $V_{ba} = +IR + \varepsilon$

Equivalent Resistance: $R_{eq} = R_1 + R_2 + R_3 + \dots$ and $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots$

Kirchhoff's rules: $\sum_{loop} \Delta V_i = 0$ and $I_{in} = I_{out}$ (at a junction).

(Use correct signs for voltage changes, be sure to label currents.)

Chapter 20 (sections 1-7)

Magnetic Forces: $F_B = qvB \sin \theta$; $F_B = I\ell B \sin \theta$

The direction of a magnetic force is determined using a right hand rule (RHR-3 and RHR-2 in text).

Circular motion in a constant magnetic field: $qvB = m\frac{v^2}{r}$ $r = \frac{mv}{qB}$

Magnetic field for a long wire: $B = \frac{\mu_0 I}{2\pi r}$

The direction is given by a right hand rule (RHR-1 in text).

Superposition: For many wires or sources of magnetic field: $\mathbf{B}_{tot} = \mathbf{B}_1 + \mathbf{B}_2$

Force Between Wires: $F_{21} = \frac{\mu_0 I_1 I_2 \ell}{2\pi r}$

Mass Spectrometer: $v = \frac{E}{B}$; $qvB' = m\frac{v^2}{r}$; $m = \frac{qB'r}{v} = \frac{qB'Br}{E}$

Chapter 21 (Sections 1-7)

Magnetic Flux: $\Phi_B = BA \cos \theta$.

Faraday's law: $\varepsilon = -N \frac{\Delta \Phi_B}{\Delta t}$

Moving loop (into or out of a uniform B -field): $\varepsilon = Bv\ell$

Magnitude of induced current: $I = \frac{\varepsilon}{R}$

Direction of induced current flow is given by Lenz's law: 1. Identify direction of B_{ext} ; 2. Determine if external flux is increasing or decreasing; 3. Direction of B_{ind} opposes change in flux; 4. Use RHR to determine direction of current that causes B_{ind} .

Generator: $\varepsilon = NBA\omega \sin \omega t$; $V_{peak} = \sqrt{2}V_{rms}$.

Transformers: $\frac{V_s}{V_p} = \frac{N_s}{N_p}$ $P = IV$ $I_s V_s = I_p V_p$

Electric power grids use transformers to step up ($N_s > N_p$) and step down ($N_s < N_p$) voltage. There is also power loss in the power lines due to the wire's resistance R . The power loss = $I_p^2 R$.

Chapter 22 (sections 1- 4)

Electromagnetic waves are consequences of the following laws: A changing magnetic field causes an electric field (Faraday) and a changing electric field causes a magnetic field (Maxwell).

Electromagnetic wave properties: $c = 3 \times 10^8$ m/s; $\mathbf{E} \perp \mathbf{B} \perp \mathbf{v}$; $E = cB$ $\lambda f = c$.

Visible light: 400nm to 750nm (1nm = 1×10^{-9} m).

Chapter 23 (Sections 1-9)

Geometric Optics: $\theta_r = \theta_i$ and $n_2 \sin \theta_2 = n_1 \sin \theta_1$

Total Internal Reflection: $\sin \theta_c = \frac{n_2}{n_1}$

The Plane Mirror: $d_i = d_o$ and $h_i = h_o$

Curved Mirrors (with large radii): $f = \frac{r}{2}$; $\frac{1}{d_i} + \frac{1}{d_o} = \frac{1}{f}$; $m = \frac{h_i}{h_o} = -\frac{d_i}{d_o}$

Know the principle rays for both types of mirrors.

Thin lenses: $\frac{1}{d_i} + \frac{1}{d_o} = \frac{1}{f}$; $m = \frac{h_i}{h_o} = -\frac{d_i}{d_o}$

Know the principle rays for both types of lenses.

Chapter 24 (Sections 1-4; 6; 8)

Phase shift due to path difference: $\Delta\phi = k\Delta x$; $k = \frac{2\pi}{\lambda}$

Constructive interference: $\Delta\phi = m\pi$ ($m = 0, \pm 1, \pm 2, \dots$)

Destructive interference: $\Delta\phi = (2m' + 1)\pi$ ($m' = 0, \pm 1, \pm 2, \dots$)

Double-slit experiment and gratings: $d \sin \theta = m\lambda$ (constructive)

$d \sin \theta = (m' + \frac{1}{2})\lambda$ (destructive)

Small angles: $y \ll L$ means $\tan \theta \approx \sin \theta = \frac{y}{L}$.

Wavelength and index of refraction: $\lambda_n = \frac{\lambda}{n}$.

Thin films: $\Delta x = 2t$; Account for phase shift due to reflections. Use wavelength in the film.

Reflection phase shift: high n to low n means $\phi_r = 0$; low n to high n means $\phi_r = \pi$.

Reflection phase shift at one surface: $2t = (m + \frac{1}{2})\lambda$ constructive

Reflection phase shift at both surfaces or none: $2t = m\lambda$ constructive