Physics formula booklet

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Link to revision folder

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Constants and unit conversions

Gas constant	$R = 8.314\ \mathrm{J/(mol\ K)}$ $= 0.082057\ \dfrac{\mathrm{L\ atm}}{\mathrm{mol\ K}}$
Converting between rpm and rad/s	$1\ \mathrm{rpm} = \dfrac{2\pi}{60}\ \mathrm{rad/s}$
Gravitational constant	$G = 6.67 \cdot 10^{-11}\ \mathrm{Nm^2/kg^2}$
Converting between Kelvin and Celsius temperatures	$T_K = T_C + 273.15$
Converting between atmospheres and Pascals	$1\ \mathrm{atm} = 1.013 \cdot 10^5\ \mathrm{Pa}$
Stefan-Boltzmann constant	$\sigma = 5.67 \cdot 10^{-8}\ \mathrm{W/(m^2K^4)}$
Avogadro's number	$N_A = 6.02 \cdot 10^{23}\ \mathrm{mol^{-1}}$
Boltzmann constant	$k = 1.38 \cdot 10^{-23}\ \mathrm{J/K} = \dfrac{R}{N_A}$

Vectors (Chapter 1)

Scalar/dot product	$\vec{\boldsymbol{A}} \cdot \vec{\boldsymbol{B}} = \lvert\vec{\boldsymbol{A}}\rvert\lvert\vec{\boldsymbol{B}}\rvert \cos(\theta) = A_x B_x + A_y B_y + A_z B_z$
Vector/cross product	$\vec{\boldsymbol{A}} \times \vec{\boldsymbol{B}} = \begin{bmatrix} A_y B_z - A_z B_y \\ A_z B_x - A_x B_z \\ A_x B_y - A_y B_x \end{bmatrix}$ $\lvert\vec{\boldsymbol{A}} \times \vec{\boldsymbol{B}}\rvert = \lvert\vec{\boldsymbol{A}}\rvert\lvert\vec{\boldsymbol{B}}\rvert \sin(\theta)$

1D motion (Chapter 2)

Average and instantaneous velocity	$\langle v \rangle = \frac{\Delta x}{\Delta t}$ $v = \frac{dx}{dt}$ The angle brackets denote an average
Average and instantaneous acceleration	$\langle a \rangle = \frac{\Delta v}{\Delta t}$ $a = \frac{dv}{dt}$
Equations for straight line motion with constant acceleration	$v_x = v_{0x} + a_x t$ $x = x_0 + v_{0x} t + \frac{1}{2} a_x t^2$ $v_x^2 = v_{0x}^2 + 2a_x(x - x_0)$ $x - x_0 = \frac{1}{2}(v_{0x} + v_x)t$
Straight line motion with varying acceleration	$v_x = v_{0x} + \int_0^t a_x \, dt$ $x = x_0 + \int_0^t v_x \, dt$

2D motion (Chapter 3)

Projectile motion	$x = v_{0x} t$ $y = v_{0y} t - \frac{1}{2} g t^2$ $v_y = v_{0y} - gt$
Centripetal acceleration	$a_c = \frac{v^2}{R} = \frac{4\pi^2 R}{T^2}$ where R is the radius of the circle in which the object is moving

Relative velocity	$v_{P/A-x} = v_{P/B-x} + v_{B/A-x}$ $\vec{\boldsymbol{v}}_{P/A} = \vec{\boldsymbol{v}}_{P/B} + \vec{\boldsymbol{v}}_{B/A}$ where $\vec{\boldsymbol{v}}_{P/A}$ means the velocity of P relative to A

Newton's Laws (Chapters 4 and 5)

Net force	$\vec{\boldsymbol{F}}_{net} = \vec{\boldsymbol{F}}_1 + \vec{\boldsymbol{F}}_2 + \vec{\boldsymbol{F}}_3 + \cdots$
Newton's second law	$\vec{\boldsymbol{F}}_{net} = m\vec{\boldsymbol{a}}$ $F_{net,x} = ma_x$ $F_{net,y} = ma_y$ $F_{net,z} = ma_z$
Gravitational force (weight)	$F_g = mg$
Newton's third law	$\vec{\boldsymbol{F}}_{A\ on\ B} = -\vec{\boldsymbol{F}}_{B\ on\ A}$
Kinetic friction	$F_k = \mu_k N$ where μ_k is the coefficient of kinetic friction and N is the normal force acting on the object
Static friction	$F_s \le \mu_s N$ where μ_s is the coefficient of static friction and N is the normal force acting on the object

Work and kinetic energy (Chapter 6)

Work	$W = \vec{\boldsymbol{F}} \cdot \vec{\boldsymbol{s}} = Fs\cos(\theta)$ where $\vec{\boldsymbol{s}}$ is the displacement vector and θ is the angle between the force and displacement vectors
Kinetic energy	$E_{kin} = \frac{1}{2}mv^2$
Work-energy theorem	$W_{tot} = \Delta E_{kin}$
Work done by a varying force or on a curved path	$W = \int_{x_1}^{x_2} F_x\, dx$ $W = \int_{P_1}^{P_2} \vec{\boldsymbol{F}} \cdot d\vec{\boldsymbol{s}} = \int_{P_1}^{P_2} F\cos(\theta)\, ds = \int_{P_1}^{P_2} F_{\parallel}\, ds$ where P_1 is the initial position, P_2 is the final position, and $\vec{\boldsymbol{s}}$ is displacement

Power	$$\langle P \rangle = \frac{\Delta W}{\Delta t}$$ $$P = \frac{dW}{dt}$$ $$P = \vec{\boldsymbol{F}} \cdot \vec{\boldsymbol{v}} = F \cdot v \cdot \cos(\theta)$$ where $\langle P \rangle$ is average power and P is instantaneous power

Potential energy (Chapter 7)

Gravitational potential energy	$$E_{pot,g} = mgh$$
Elastic potential energy	$$E_{pot,s} = \frac{1}{2}kx^2$$ where k is the spring constant and x is the displacement from the equilibrium position
Work done by gravity or a spring	$$W_g = -\Delta E_{pot,g}$$ $$W_s = -\Delta E_{pot,s}$$
Mechanical energy	$$E_{mec} = E_{kin} + E_{pot}$$ where E_{pot} is the sum of all the different potential energies involved
Work-mechanical energy theorem	$$\Delta E_{mec} = W_{nc}$$ $$E_{mec,i} + W_{nc} = E_{mec,f}$$ where W_{nc} is the work done by non-conservative forces. “i” means initial and “f” means final

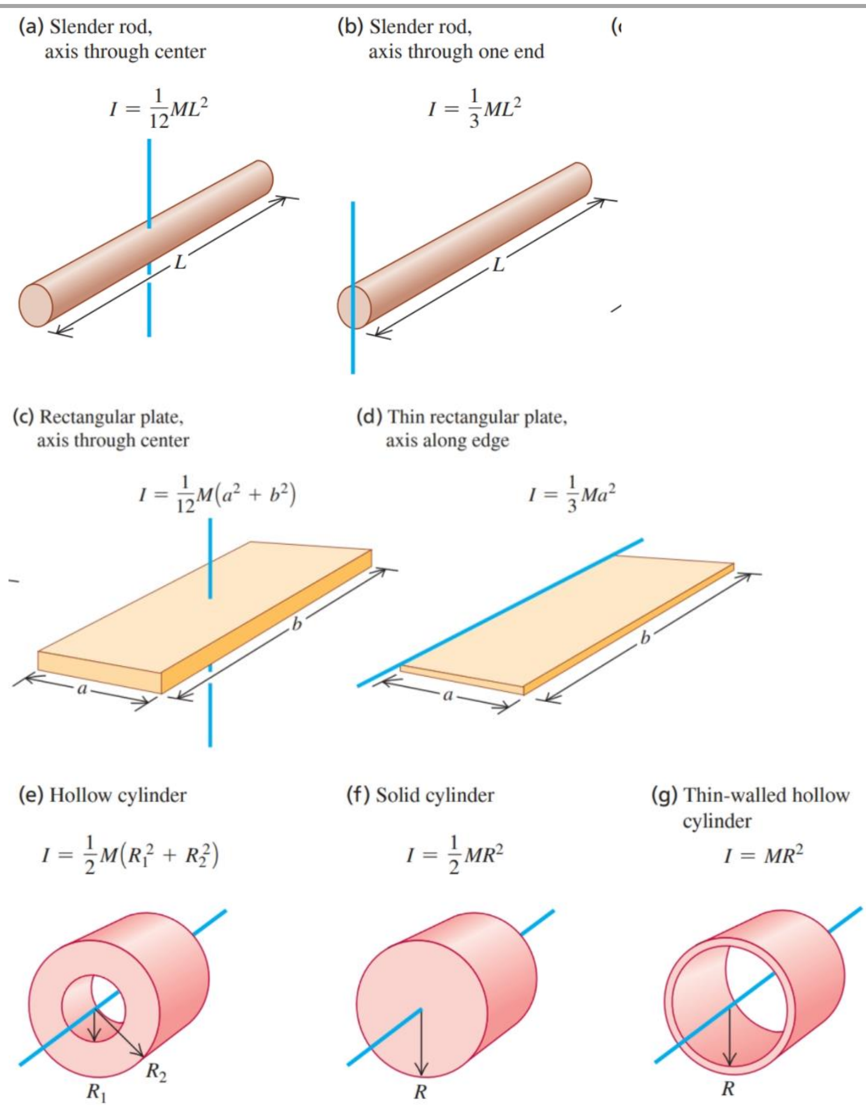
Momentum (Chapter 8)

Momentum	$$\vec{\boldsymbol{p}} = m\vec{\boldsymbol{v}}$$
Newton’s second law in terms of momentum	$$\vec{\boldsymbol{F}}_{\boldsymbol{net}} = \frac{d\vec{\boldsymbol{p}}}{dt}$$
Impulse	$$\vec{\boldsymbol{J}} = \Delta\vec{\boldsymbol{p}}$$ $$\vec{\boldsymbol{J}} = \langle \vec{\boldsymbol{F}}_{net} \rangle \Delta t$$ $$\vec{\boldsymbol{J}} = \int_{t_1}^{t_2} \vec{\boldsymbol{F}}_{net} dt$$ where $\langle \vec{\boldsymbol{F}}_{net} \rangle$ is the average net force and $\vec{\boldsymbol{F}}_{net}$ is the instantaneous net force

Conservation of momentum	$\vec{\boldsymbol{P}} = \vec{\boldsymbol{p}}_A + \vec{\boldsymbol{p}}_B + \cdots = m_A\vec{\boldsymbol{v}}_A + m_B\vec{\boldsymbol{v}}_B + \cdots$ $\vec{\boldsymbol{P}}_i = \vec{\boldsymbol{P}}_f$ The sum of the momenta of the objects that make up a system is constant if the net external force on the system is 0. "i" means initial and "f" means final
Kinetic energy in terms of momentum	$E_{kin} = \frac{p^2}{2m}$
Center of mass	$\vec{\boldsymbol{r}}_{cm} = \frac{\sum_i m_i\vec{\boldsymbol{r}}_i}{\sum_i m_i}$
Total momentum and net force using center of mass	$\vec{\boldsymbol{P}} = M\vec{\boldsymbol{v}}_{cm}$ $\vec{\boldsymbol{F}}_{net,external} = M\vec{\boldsymbol{a}}_{cm}$
Force of thrust on a rocket	$F_{thrust} = -v_{ex}\frac{dm}{dt}$ where v_{ex} is the exhaust *speed* (positive) and $\frac{dm}{dt}$ is the rate of change of mass of the rocket as it loses fuel (negative)
Speed of a rocket after launch	$v_f = v_i + v_{ex}\ln\left(\frac{m_i}{m}\right)$ where v_i is the initial speed, v_{ex} is the exhaust speed (positive), m_i is the initial mass of the rocket, and m is the mass of the rocket at the time when you want to find its speed

Rotation of rigid bodies (Chapter 9)

Angular velocity	$\omega_z = \frac{d\theta}{dt}$
Angular acceleration	$\alpha_z = \frac{d\omega_z}{dt}$
Equations for angular motion with constant angular acceleration	$\theta = \theta_0 + \omega_{0z}t + \frac{1}{2}\alpha_z t^2$ $\theta - \theta_0 = \frac{1}{2}(\omega_{0z} + \omega_z)t$ $\omega_z = \omega_{0z} + \alpha_z t$ $\omega_z^2 = \omega_{0z}^2 + 2\alpha_z(\theta - \theta_0)$
Linear speed and angular speed	$v = r\omega$ where r is the distance of a particle from the rotation axis
Tangential acceleration and angular acceleration	$a_{tan} = r\alpha$

<table>
<tr><td>Radial (centripetal) acceleration and angular speed</td><td>$$a_{rad} = \frac{v^2}{r} = \omega^2 r$$</td></tr>
<tr><td>Moment of inertia</td><td>$$I = \sum_i m_i r_i^2$$</td></tr>
<tr><td>Rotational kinetic energy</td><td>$$E_{\text{kin, rot}} = \frac{1}{2} I \omega^2$$</td></tr>
<tr><td>Moment of inertia for various shapes</td><td>


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	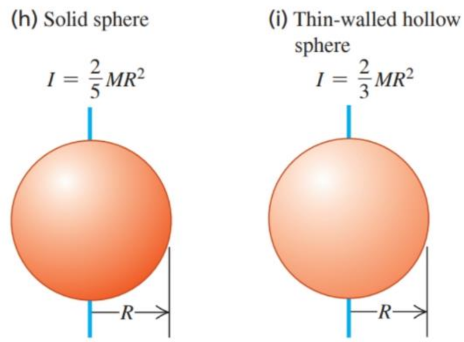
Parallel-axis theorem	$$I_P = I_{cm} + Md^2$$ where I_{cm} is the moment of inertia around an axis through the center of mass, I_P is the moment of inertia around an axis parallel to that axis, d is the distance between the two axes, and M is the mass of the body

Dynamics of rotational motion (Chapter 10)

Torque	$$\tau = Fl = rF\sin(\phi) = F_{tan}r$$ l is the length of the lever arm r is the distance of the point where the force is applied from the axis of rotation ϕ is the angle between the force vector and the position vector $\vec{\boldsymbol{r}}$ of the point where the force is applied with respect to the axis of rotation F_{tan} is the tangential force component In vector form, $$\vec{\boldsymbol{\tau}} = \vec{\boldsymbol{r}} \times \vec{\boldsymbol{F}}$$
Rotational analog of Newton's second law	$$\tau_{\text{z, net}} = I\alpha_z$$
Kinetic energy in combined translation and rotation	$$E_{kin} = \frac{1}{2}Mv_{cm}^2 + \frac{1}{2}I_{cm}\omega^2$$
Condition for rolling without slipping	$$v_{cm} = R\omega$$
Work done by a torque	$$W = \int_{\theta_1}^{\theta_2} \tau_z \, d\theta$$ For a constant torque, $$W = \tau_z \Delta\theta$$

Work-kinetic energy theorem for rotational motion	$$W_{tot} = \frac{1}{2}I\omega_f^2 - \frac{1}{2}I\omega_i^2$$
Power of a torque	$$P = \tau_z\omega_z$$
Angular momentum	For a particle: $$\vec{\boldsymbol{L}} = \vec{\boldsymbol{r}} \times \vec{\boldsymbol{p}} = \vec{\boldsymbol{r}} \times m\vec{\boldsymbol{v}}$$ $$L_z = rp\sin(\theta) = rmv\sin(\theta)$$ For a rigid body rotating about its axis of symmetry: $$\vec{\boldsymbol{L}} = I\vec{\boldsymbol{\omega}}$$ $$L_z = I\omega_z$$
Rotational analog of Newton's second law with angular momentum	$$\vec{\boldsymbol{\tau}}_{net} = \frac{d\vec{\boldsymbol{L}}}{dt}$$
Precession angular speed for a gyroscope	$$\Omega = \frac{F_g r}{I\omega}$$ F_g is the gravitational force acting on the gyroscope and r is the radius of precession

Equilibrium and elasticity (Chapter 11)

Conditions for equilibrium	$$\vec{\boldsymbol{F}}_{net} = \boldsymbol{0}$$ $\vec{\boldsymbol{\tau}}_{net} = \boldsymbol{0}$ about any point
Hooke's law in general	$$\text{Elastic modulus} = \frac{\text{Stress}}{\text{Strain}}$$
Tensile and compressive stress	$$Y = \frac{\sigma}{\varepsilon} = \frac{F_\perp/A}{\Delta l/l_0}$$ where Y is Young's modulus, σ is tensile/compressive stress, ε is tensile/compressive strain, and $F_\perp$ is the normal force component applied to opposite sides
Bulk stress	$$B = -\frac{\Delta p}{\Delta V/V_0}$$ where B is the bulk modulus and Δp is the pressure change

Shear stress	$$S = \frac{\tau}{\gamma} = \frac{F_{\parallel}/A}{x/h}$$ S is the shear modulus τ is shear stress γ is shear strain $F_{\parallel}$ is the parallel force component applied to opposite sides x is the displacement of one side h is the transverse dimension, or height

Fluid mechanics (Chapter 12)

Density	$$\rho = \frac{m}{V}$$
Pressure at a point in a fluid	$$p = \frac{dF_{\perp}}{dA}$$ where $F_{\perp}$ is the normal force applied on both sides of the area A
Pressure in a fluid at rest	$$p_2 - p_1 = -\rho g(h_2 - h_1)$$ where h_1 and h_2 are elevations $$p = p_0 + \rho g h$$ where p_0 is the pressure at the surface of the fluid and h is the distance from the surface
Force of buoyancy	$$F_B = F_{\text{g, fluid}} = V_{\text{object}}\rho_{\text{fluid}}g$$ The force of buoyancy on an object is the weight of the fluid that was displaced, or the volume of the object times the fluid density times g
Continuity equation for a fluid in motion	$$A_1 v_1 = A_2 v_2$$
Volume flow rate	$$\dot{V} = \frac{dV}{dt} = Av$$
Bernoulli's equation	$$p + \rho g h + \frac{1}{2}\rho v^2 = \text{constant}$$ where h is elevation
Pressure difference required for viscous flow in a circular tube	$$\Delta P = \frac{8\eta L}{\pi r^4} \cdot \dot{V}$$ where r is the radius of the flow tube, L is its length, and η is the fluid viscosity

Reynold's number for determining flow type in a circular tube	$$N_R = \frac{2r\rho v}{\eta}$$ where r is the radius of the flow tube and η is the fluid viscosity If $N_R < 2000$, the flow is laminar If $N_R > 3000$, the flow is turbulent If $2000 < N_R < 3000$, it needs to be tested

Gravitation (Chapter 13)

Law of gravitation	$$F_g = \frac{Gm_1m_2}{r^2}$$ G is the gravitational constant, $6.67 \cdot 10^{-11}\ \mathrm{Nm^2/kg^2}$ m_1 and m_2 are the masses of two objects r is the distance between the two objects
Acceleration due to gravity at the surface of a planet	$$g = \frac{GM}{R^2}$$ where M is the mass of the planet and R is its radius
Gravitational potential energy	$$E_{\mathrm{pot,\,g}} = -\frac{Gm_1m_2}{r}$$
Speed in circular orbit	$$v = \sqrt{\frac{GM}{r}}$$ where M is the mass of the planet and r is the radius of orbit
Period in circular orbit	$$T = \frac{2\pi r}{v} = \frac{2\pi r^{\frac{3}{2}}}{\sqrt{GM}}$$ where v is the speed of orbit, M is the mass of the planet, and r is the radius of orbit

Periodic motion (Chapter 14)

Period and frequency	$$T = \frac{1}{f}$$
Angular frequency	$$\omega = 2\pi f = \frac{2\pi}{T}$$
Condition for simple harmonic motion (SHM)	$$F_x = -kx$$

Acceleration in SHM as a function of position	$a_x = -\frac{k}{m}x$
Angular frequency, frequency, and period in SHM	$\omega = \sqrt{\frac{k}{m}}$ $f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$ $T = 2\pi\sqrt{\frac{m}{k}}$
Position, velocity, and acceleration in SHM as functions of time	$x = A\cos(\omega t + \phi)$ $v_x = -\omega A\sin(\omega t + \phi)$ $a_x = -\omega^2 A\cos(\omega t + \phi)$ where A is the amplitude and ϕ is the phase angle. v_x oscillates between ωA and $-\omega A$, and a_x oscillates between $\omega^2 A$ and $-\omega^2 A$
Energy in SHM	$E_{mec} = \frac{1}{2}mv_x^2 + \frac{1}{2}kx^2 = \frac{1}{2}kA^2 = \text{constant}$
Angular SHM	$\omega = \sqrt{\frac{\kappa}{I}}$ $f = \frac{1}{2\pi}\sqrt{\frac{\kappa}{I}}$ where κ is the torsion constant and I is the moment of inertia
Simple pendulum	$\omega = \sqrt{\frac{g}{L}}$ $f = \frac{1}{2\pi}\sqrt{\frac{g}{L}}$ $T = 2\pi\sqrt{\frac{L}{g}}$
Physical pendulum	$\omega = \sqrt{\frac{mgd}{I}}$ $T = 2\pi\sqrt{\frac{I}{mgd}}$ where d is the distance between the center of gravity and the axis of rotation and I is the moment of inertia about the axis

Damped oscillations	$$x = Ae^{-\left(\frac{b}{2m}\right)t}\cos(\omega' t + \phi)$$ $$\omega' = \sqrt{\frac{k}{m} - \frac{b^2}{4m^2}}$$ A is the initial amplitude b is the damping constant ω' is the angular frequency of the damped oscillations ϕ is the phase angle k is the force constant of the restoring force
Types of damped oscillations	Underdamping: $b < 2\sqrt{km}$ Critical damping: $b = 2\sqrt{km}$ Overdamping: $b > 2\sqrt{km}$
Resonance	$$A = \frac{F_{max}}{\sqrt{(k - m\omega_d^2)^2 + b^2\omega_d^2}}$$ ω_d is the driving frequency k is the force constant of the restoring force b is the damping constant

Temperature and Heat (Chapter 17)

Thermal expansion	Linear: $$\Delta L = \alpha L_0 \Delta T$$ Volume: $$\Delta V = \beta V_0 \Delta T$$ where α is the coefficient of linear thermal expansion and β is the coefficient of volume thermal expansion. In solids, $$\beta = 3\alpha$$
Tensile stress from thermal expansion	$$\sigma = \frac{F}{A} = -Y\alpha\Delta T$$ where Y is Young's modulus
Heat required for a temperature change	$$Q = mc\Delta T$$ $$Q = nC\Delta T$$ where Q is heat, c is specific heat capacity, C is molar heat capacity, and n is number of moles

Heat required for a phase change	$$Q = \pm mL$$ where L is the latent heat of fusion, vaporization, or sublimation. If only part of the substance undergoes a phase change, $$Q = \pm xmL$$ where x is the fraction that undergoes a phase change
Calorimetry equation	$$\sum Q = 0$$ for heat flow between objects isolated from their surroundings
Heat current in conduction	$$H = \frac{dQ}{dt} = kA\frac{T_H - T_C}{L}$$ H is heat current A is the area through which the heat flows L is the length of the heat flow path T_H is the temperature of the hot end T_C is the temperature of the cold end k is the thermal conductivity of the material
Heat current through materials in series	$$H_1 = H_2 = H_3 = \cdots$$
Heat current through materials in parallel	$$H_{total} = H_1 + H_2 + H_3 + \cdots$$
Heat current in radiation	$$H = Ae\sigma T^4$$ $$H_{net} = Ae\sigma(T^4 - T_s^4)$$ A is the surface area of the object e is the emissivity of the object σ is the Stefan-Boltzmann constant, $5.67 \cdot 10^{-8}\ \mathrm{W/(m^2K^4)}$ T is the temperature of the object T_s is the temperature of the surroundings

Thermal properties of matter (Chapter 18)

Ideal gas equation	$$pV = nRT$$
Comparing two states of a constant mass of ideal gas	$$\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$$

Moles	$$m_{total} = nM$$ $$M = N_A m_{molecule}$$ where n is the number of moles, M is molar mass, and N_A is Avogadro's number, $6.02 \cdot 10^{23}\ \mathrm{mol}^{-1}$
Total translational kinetic energy of the molecules in an ideal gas	$$E_{\text{kin, tr}} = \frac{3}{2}nRT$$
Average translational kinetic energy of a single molecule in an ideal gas	$$\langle E_{\text{kin, tr}} \rangle = \frac{1}{2}m\langle v^2 \rangle = \frac{3}{2}kT$$ where $\langle v^2 \rangle$ is the average squared speed and k is the Boltzmann constant, $1.38 \cdot 10^{-23}\ \mathrm{J/K} = R/N_A$
Root-mean-square speed of molecules in an ideal gas	$$v_{rms} = \sqrt{\langle v^2 \rangle} = \sqrt{\frac{3kT}{m}}$$
Mean free path of molecules in an ideal gas	$$\lambda = vt_{mean} = \frac{V}{4\pi\sqrt{2}r^2N}$$ where t_{mean} is the mean free time, r is the molecular radius, and N is the number of molecules
Theoretical heat capacities	Monatomic gas: $$C_V = \frac{3}{2}R$$ Diatomic gas: $$C_V = \frac{5}{2}R$$ Monatomic solid: $$C_V = 3R$$ where R is the gas constant, $8.314\ \mathrm{J/(mol\ K)}$

First law of thermodynamics (Chapter 19)

Work in a thermodynamic process	$$W = \int_{V_1}^{V_2} p\, dV$$
The first law of thermodynamics	$$\Delta E_{int} = Q - W$$ where E_{int} is the internal energy of a system, Q is the heat added to the system, and W is the work done **by** the system

Types of thermodynamic processes	Adiabatic: No heat transfer, $Q = 0$ Isochoric: Constant volume, $W = 0$ Isobaric: Constant pressure, $W = p\Delta V$ and $Q = nC_p\Delta T$ Isothermal: Constant temperature
Work/heat in an isothermal process in an ideal gas	$W = Q = nRT\ln\left(\frac{V_2}{V_1}\right) = nRT\ln\left(\frac{p_1}{p_2}\right)$
Internal energy change in an ideal gas	$\Delta E_{int} = nC_v\Delta T$
Relationship between heat capacities in an ideal gas	$C_p = C_V + R$ where C_p is the molar heat capacity at constant pressure, C_V is the molar heat capacity at constant volume, and R is the gas constant, $8.314\ \mathrm{J/K\ mol}$
Ratio of heat capacities	$\gamma = \frac{C_p}{C_V}$ For air, $\gamma = 1.4$
Adiabatic processes in ideal gases	$T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1}$ $p_1V_1^{\gamma} = p_2V_2^{\gamma}$ $p_1^{1-\gamma}T_1^{\gamma} = p_2^{1-\gamma}T_2^{\gamma}$
Work done in an adiabatic process in an ideal gas	$W = nC_V(T_1 - T_2)$ $= \frac{C_V}{R}(p_1V_1 - p_2V_2)$ $= \frac{1}{\gamma - 1}(p_1V_1 - p_2V_2)$

Second law of thermodynamics (Chapter 20)

Efficiency in a heat engine	$e = \frac{W}{Q_H} = 1 + \frac{Q_C}{Q_H} = 1 - \left\lvert\frac{Q_C}{Q_H}\right\rvert$
Efficiency in the Otto cycle	$e = 1 - \frac{1}{r^{\gamma-1}}$
Coefficient of performance of a refrigerator	$K = \frac{\lvert Q_C\rvert}{\lvert W\rvert} = \frac{\lvert Q_C\rvert}{\lvert Q_H\rvert - \lvert Q_C\rvert}$
Heat transfer in a Carnot engine	$\frac{Q_C}{Q_H} = -\frac{T_C}{T_H}$
Efficiency of a Carnot engine	$e_{Carnot} = 1 - \frac{T_C}{T_H} = \frac{T_H - T_C}{T_H}$

Coefficient of performance of a Carnot refrigerator	$$K_{Carnot} = \frac{T_C}{T_H - T_C}$$
Entropy change for a reversible process	$$\Delta S = \int_1^2 \frac{dQ}{T}$$ where 1 and 2 are the initial and final states. If the process is isothermal, $$\Delta S = \frac{Q}{T}$$
Entropy change for an object undergoing a temperature change	$$\Delta S = mc \ln\left(\frac{T_2}{T_1}\right)$$
Entropy in terms of microstates	$$S = k \ln(w)$$ where k is the Boltzmann constant, $1.38 \cdot 10^{-23}$ J/K and w is the number of microstates
Entropy change in terms of microstates	$$\Delta S = k \ln\left(\frac{w_2}{w_1}\right)$$