KINEMATICS (1-term)

Straight-line motion

$\upsilon = \frac{S}{t}$ (υ = const)	$a = \frac{\upsilon - \upsilon_0}{t}$	$a = \frac{\upsilon^2 - \upsilon_0^{\ 2}}{2S}$	$S = \upsilon_0 t + \frac{at^2}{2}$	$S = \frac{(\upsilon + \upsilon_0)\cdot t}{2}$ (a = const)

Free fall

$\upsilon = \upsilon_0 + gt$ (g = 9,81m/s^2)	$h = \upsilon_0 t + \frac{gt^2}{2}$	$h = \frac{\upsilon^2 - \upsilon_0^{\ 2}}{2g}$	**(if** $\upsilon_0 = 0$**)** $\upsilon = gt$ **;** $h = \frac{gt^2}{2}$**;** $t = \sqrt{\frac{2h}{g}}$

Projectile motion

$\upsilon_x = \upsilon_0 cos\alpha$ $\upsilon_y = \upsilon_0 sin\alpha - gt$	Time of rising max.height $t_R = \frac{\upsilon_0 \sin\alpha}{g}$	Time of flight $t_f = \frac{2\upsilon_0 \sin\alpha}{g}$	$h_{\max} = \frac{\upsilon_0^{\ 2} \sin^2\alpha}{2g}$	$S = \frac{\upsilon_0^2 \sin 2\alpha}{g}$

Circular motion

$\upsilon = \frac{2\pi r}{T}$; $\upsilon = 2\pi r f$; $\upsilon = \omega R$	$\omega = \frac{\varphi}{t}$; $\omega = \frac{2\pi}{T}$; $\omega = 2\pi f$	$a_n = \frac{\upsilon^2}{R}$; $a_n = \omega^2 R$; $a_n = \frac{4\pi^2 R}{T^2}$

FLUIDS AT REST

Density: $\rho = \frac{m}{V}$	Pressure: $p = \frac{F}{A}$	Hydrostatic pressure: $p = \rho g h$	Upthrust = Weight of fluid displaced $F = \rho_{\text{fluid}} \times V_{\text{displaced}} \times g$	Hydraulic jack: $\frac{F_1}{A_1} = \frac{F_2}{A_2}$

KINEMATICS OF FLUIDS

The equation of continuity: $A_1 v_1 = A_2 v_2$	**Bernoulli's equation:** $p + \frac{1}{2}\rho v^2 + \rho g h = constant$
For horizontal flow, h is constant, so Bernoulli's equation becomes: $p + \frac{1}{2}\rho v^2 = constant$	Torricelli's equation**:** $v = \sqrt{2gh}$

DEFORMING SOLIDS (2-term)

Hooke's law: $F = k\Delta l$	$\varepsilon = \frac{\Delta l}{l_0}$; $strain = \frac{extension}{original\ \ length}$	$\sigma = \frac{F}{A}$; $stress = \frac{force}{cross\text{-}sectional\ \ area}$

$A = \pi \times r^2 = \pi \times d^{\ 2}/4$	$E = \frac{\sigma}{\varepsilon}$; $Young\ modulus = \frac{stress}{strain}$	Strain energy and work done: $E = \frac{F\Delta l}{2} = \frac{k\Delta l^2}{2}$; $W = \frac{F\Delta l}{2} = \frac{k}{2}(\Delta l_2^2 - \Delta l_1^2)$

GRAVITATIONAL FIELD

Gravitational force $F = \frac{GMm}{r^2}$	Gravitational field strength $g = \frac{F}{m}$ $g = \frac{GM}{r^2}$	Gravitational potential energy $E_P = -\frac{GMm}{r}$	Gravitational potential $\varphi = -\frac{GM}{r}$

Circular orbits: $F = ma$ $F = \frac{GMm}{r^2}$ and $a = \frac{v^2}{r}$ $\frac{GMm}{r^2} = \frac{mv^2}{r}$ ➡ $v = \sqrt{\frac{GM}{r}}$	The orbital period: $\frac{4\pi^2 r^2}{T^2} = \frac{GM}{r}$ $v = \frac{2\pi r}{T}$ $v^2 = \frac{4\pi^2 r^2}{T^2}$ and $v^2 = \frac{GM}{r}$ $T^2 = \frac{4\pi^2 r^3}{GM}$

Geostationary orbit is the equatorial orbit in which satellites has period 24 hours and rotate from west to east.	$T^2 = (\frac{4\pi^2}{GM}) \times r^3$	T = 24 hours = 86400 s; M= 6.0×10^{24} kg;G = 6.67×10^{-11} Nm^{2}kg^{-2}

The escape velocity (υ) from a point in a gravitational field is the minimum velocity of projection for any small mass to escape from the field to infinity.	$\frac{1}{2}mv^2 = \frac{CMm}{r}$ ➡ $v = \sqrt{\frac{2GM}{r}}$

MOMENTUM. CONSERVATION OF MOMENTUM

Momentum : ***p* = *m·υ***	Impulse: $\boldsymbol{Ft = m\Delta v}$ *Impulse = change in momentum*	**Conservation of momentum:** *In a closed system, the total momentum remains constant.* $m_1 u_1 + m_2 u_2 = m_1 \upsilon_1 + m_2 \upsilon_2$

Inelastic collision. A collision in which the momentum is conserved is called *inelastic collision*. $m_1 u_1 + m_2 u_2 = m_1 \upsilon_1 + m_2 \upsilon_2$	**Elastic collision.** Collisions in which both momentum and total kinetic energy are conserved are called *elastic collision*. $m_1 u_1 + m_2 u_2 = m_1 \upsilon_1 + m_2 \upsilon_2$; $\frac{m_1 u_1^2}{2} + \frac{m_2 u_2^2}{2} = \frac{m_1 \upsilon_1^2}{2} + \frac{m_2 \upsilon_2^2}{2}$

OSCILLATIONS (SIMPLE HARMONIC MOTION/SHM) (3-term)

$T = \frac{1}{f}$ or $f = \frac{1}{T}$	$T = \frac{t}{N}$; $Period = \frac{time}{number\ of\ oscillations}$	$f = \frac{N}{t}$; $frequency = \frac{number\ of\ oscillations}{time}$
Angular frequency: $\omega = \frac{2\pi}{T}$ or $\omega = 2\pi f$	Equation of SHM: $a = -\omega^2 x$ The acceleration a is directly proportional to displacement x; and the minus sign shows that it is in the opposite direction.	$x = A\sin\omega t$ $v = A\omega\cos\omega t$ or $v = v_{max}\cos\omega t$ $a = -\omega^2 A\sin\omega t$ or $a = -\omega^2 x$

The period of a mass-spring system: $T = 2\pi\sqrt{\frac{m}{k}}$	The period of a simple pendulum: $T = 2\pi\sqrt{\frac{l}{g}}$

MOLECULAR PHYSICS

Number of molecules: $N = nN_A$	The mass of a single molecule: $m_0 = \frac{M}{N_A}$	The kinetic theory equation $pV = \frac{1}{3}Nm_0v^2$	$p = \frac{1}{3}\frac{Nm_0}{V}v^2 = \frac{1}{3}\rho v^2$

The root mean square (rms) speed $v_{rms} = \sqrt{\overline{v^2}} = \sqrt{\frac{v_1^2+v_2^2+\cdots+v_N^2}{N}}$	An ideal gas equation: $pV = nRT$
$pV = nRT = \frac{N}{N_A}RT = N\frac{R}{N_A}T = NkT$	$R = N_A \times k$ 8.31 J mol^{-1} K^{-1} = 6.02·10^{23} mol^{-1}×1.38·10^{-23} J K^{-1}
An ideal gas obeys the law $\frac{PV}{T} = const$ at all values of P, V, and T.	Mean K.E of a gas molecule: $E = \frac{3kT}{2}$

Boyle's-Mariotte law: $p \times V$ = const	Charles law (Pressure Law): $\frac{V}{T} = const$	Gay-Lussac law: $\frac{p}{T} = const$

Absolute zero (T=0 K). The absolute zero of temperature is –273.15 °C or 0 K. This is the lowest temperature any substance can have. At absolute zero of temperature, the substance has minimum internal energy.

The internal energy of a substance is the sum of the kinetic and potential energies of the molecules in the substance: $U = E_K + E_P$	Work done by the gas in an isobaric process (p=const): $W = p(V_2 - V_1) = p\Delta V$

The first law of thermodynamics: $\Delta U = Q + W_{\text{on the system}}$

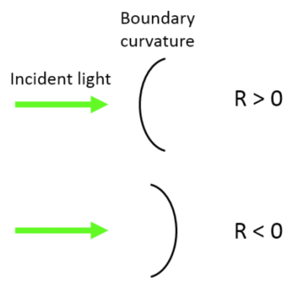
Increase in internal energy = Heat supplied to system + Work done on the system

The second law of thermodynamics can be phrased in different equivalent statements. Some of these are:
- *It is impossible to completely convert thermal energy into work. In other words, no heat engine can have an efficiency of 100 percent.* - *Heat cannot, by itself, flow from a colder object to a hotter object.*

Efficiency of a heat engine: $\eta = \frac{Q_H - Q_C}{Q_H} \times 100\%$; $W = Q_H - Q_C$	The efficiency of a Carnot engine: $\eta = \frac{T_H - T_C}{T_H} \times 100\%$

GEOMETRICAL AND WAVE OPTICS (4-term)

Spherical mirror $f = \frac{r}{2}$	The mirror formula $\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} = \frac{2}{r}$	Linear magnification $m = \frac{h_i}{h_o} = -\frac{d_i}{d_0}$	Snell's law: $n_1 \sin i = n_2 \sin r$ $n_1 v_1 = n_2 v_2$ $n_1 = \frac{c}{v_1}$ and $n_2 = \frac{c}{v_2}$

The lens formula: $\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$ The power of a lens : $P = \frac{1}{f}$ Magnification of a compond lens system: $m = m_1 \cdot m_2$	The lens maker's equation $\frac{1}{f} = (\frac{n_L}{n_M} - 1)\cdot(\frac{1}{R_1} - \frac{1}{R_2})$ f = focal length of the lens (m); n_L = index of refraction of the lens material; n_M = index of refraction of the medium; R_1= radius of curvature of surface the light hits first (m); R_2= radius of curvature of the second surface the light passes (m);	Sign conventions  converging lens : f > 0 diverging lens : f < 0

Wave speed $v = f \cdot \lambda$	**For constructive interference:** *path difference* = 0, λ, 2λ, 3λ, or *path difference* =$n\lambda$ **For destructive interference:** *path difference*=0,5λ,1,5λ,2,5λ, or *path difference* = (n+ 0,5)λ	The double-slit experiment: $\lambda = \frac{ax}{D}$ A diffraction grating: $d \cdot \sin\theta = n\lambda$ (n=0,1,2,…)

Waves (4-term)

✓ Mechanical waves are produced by vibrating objects.
✓ A progressive wave carries energy from one place to another.
✓ Two points on a wave separated by a distance of one wavelength have a phase difference of 0° or 360°.
✓ There are two types of wave – longitudinal and transverse. Longitudinal waves have vibrations parallel to the direction in which the wave travels, whereas transverse waves have vibrations at right angles to the direction in which the wave travels. Surface water waves, waves on a string and light waves are all examples of transverse waves. Sound is a longitudinal wave.
✓ The frequency f of a wave is related to its period T by the equation: $f=1/T$
✓ The frequency of a sound wave can be measured using a calibrated cathode-ray oscilloscope.
✓ The speed of all waves is given by the wave equation: *wave speed = frequency × wavelength* ($v=f\cdot\lambda$)
✓ The intensity of a wave is defined as the wave power transmitted per unit area at right angles to the wave velocity. Hence intensity = power/cross-sectional area. Intensity has the unit Wm^{-2}.The intensity I of a wave is proportional to the square of the amplitude A ($I \propto A^2$).
✓ All electromagnetic waves travel at the same speed of 3.0×10^8 ms^{-1} in a vacuum, but have different wavelengths and frequencies.
✓ The regions of the electromagnetic spectrum in order of increasing wavelength are: γ-rays, X-rays, ultraviolet, visible, infrared, microwaves and radio waves.
✓ Polarisation is a phenomenon which is only associated with transverse waves. A plane polarised wave has oscillations in only one plane.

Superposition of waves

✓ The principle of superposition states that when two or more waves meet at a point, the resultant displacement is the algebraic sum of the displacements of the individual waves.
✓ When waves pass through a slit, they may be diffracted so that they spread out into the space beyond. The diffraction effect is greatest when the wavelength of the waves is similar to the width of the gap.
✓ Interference is the superposition of waves from two coherent sources. Two sources are coherent when they emit waves that have a constant phase difference. (This can only happen if the waves have the same frequency or wavelength.)
✓ For constructive interference the path difference is a whole number of wavelengths: path difference = 0, λ, 2λ, 3λ, etc. or path difference $=n\lambda$
✓ For destructive interference the path difference is an odd number of half wavelengths: path difference= 0,5λ, 1,5λ, 2,5λ, etc. or path difference$=(n+0,5)\lambda$
✓ When light passes through a double slit, it is diffracted and an interference pattern of equally spaced light and dark fringes is observed. This can be used to determine the wavelength of light using the equation: $\boldsymbol{\lambda = a\cdot x/D}$

This equation can be used for all waves, including sound and microwaves.
✓ A diffraction grating diffracts light at its many slits or lines. The diffracted light interferes in the space beyond the grating.
✓ The equation for a diffraction grating is: $\boldsymbol{d\sin\theta = n\lambda}$

Stationary waves (Standing waves)

✓ Stationary waves are formed when two identical waves travelling in opposite directions meet and superimpose. This usually happens when one wave is a reflection of the other.
✓ A stationary wave has a characteristic pattern of nodes and antinodes.
✓ A node is a point where the amplitude is always zero.
✓ An antinode is a point of maximum amplitude.
✓ Adjacent nodes (or antinodes) are separated by a distance equal to half a wavelength.
✓ We can use the wave equation $v=f\cdot\lambda$ to determine the speed v or the frequency f of a progressive wave.
✓ The wavelength λ is found using the nodes or antinodes of the stationary wave pattern.