Oxford Living Physics year plan

This is a summary of the learning content for Physics Grade 12 and suggested year plan.

General objectives: The general objectives from the syllabus are listed at the start of each sub-topic in the Learner's Book and also at the start of each topic in the Teacher's Guide.

Topic, sub-topic and specific objectives	Lessons	LB Pages	TG pages
Theme 1: General physics	**90**	**2–135**	**19–55**
Topic 1.1: Physical quantities and units	9	4–23	19–24
Sub-topic 1.1.1: Physical quantities and units • Recall that all physical quantities consist of a numerical magnitude and a unit • Make reasonable estimates of physical quantities included within the syllabus		5–6	19
Sub-topic 1.1.2: SI units • Recall and use the following SI base quantities and their units: mass (kg), length (m), time (s), current (A), temperature (K), amount of substance (mol) • Express derived units as products or quotients of the SI base units and use the named units listed in this syllabus as appropriate • Use SI base units to check the homogeneity of physical equations • Use the following prefixes and their symbols to indicate decimal submultiples or multiples of both base and derived units: pico (p), nano (n), micro (μ), milli (m), centi (c), deci (d), kilo (k), mega (M), giga (G), tera (T)		7–15	20–22
Sub-topic 1.1.3: Scalars and vectors • Distinguish between scalar and vector quantities » A scalar as a quantity which has a magnitude, but no direction » A vector as a quantity which has both magnitude and direction • State examples of scalar (e.g. mass) and vector (e.g. velocity) quantities • Add and subtract coplanar vectors (vectors in the same plane) • Represent a vector as two perpendicular components		16–20	22–23
Topic 1.2: Measurement techniques	9	24–45	25–29
Sub-topic 1.2.1: Measurements • Use techniques for the measurement of length, volume, angle, mass, time, temperature and electrical quantities appropriate to the ranges of magnitude implied by the relevant parts of the syllabus. In particular, learners should be able to: » measure lengths using rulers, callipers and micrometers » measure weight and hence mass using balances » measure an angle using a protractor » measure time intervals using clocks, stopwatches and the calibrated time-base of a cathode-ray oscilloscope (c.r.o.) » measure temperature using a thermometer » use ammeters and voltmeters with appropriate scales » use a galvanometer in null methods » use a cathode-ray oscilloscope (c.r.o.) » use both analogue scales and digital displays » use calibration curves		25–35	25–27

Sub-topic 1.2.2: Errors and uncertainties
• Explain the effects of systematic errors (including zero errors) and random errors in measurements
• Distinguish between precision and accuracy
  » Precise measurements are all close to one another
  » An accurate measurement is close to the true value
• Assess the uncertainty in a derived quantity by simple addition of absolute, fractional or percentage uncertainties (a rigorous statistical treatment is not required)
		36–41	27–28

Topic 1.3: Kinematics	15	46–65	30–34

Sub-topic 1.3.1: Equations of motion
• Define and use distance, displacement, speed, velocity and acceleration
  » Distance as a measure of how far an object travels along a particular path (without considering direction)
  » Displacement as a vector which has a magnitude equal to the shortest distance between the initial and final points and a direction from the initial to the final point
  » Speed as a rate of change of distance
  » Instantaneous velocity as a “rate of change of displacement” or speed in a given direction
  » Average velocity as the total displacement divided by the time taken
  » Acceleration as the rate of change of velocity
• Use graphical methods to represent distance, displacement, speed, velocity and acceleration
• Determine displacement from the area under a velocity–time graph
• Determine velocity using the gradient of a displacement–time graph
• Determine acceleration using the gradient of a velocity–time graph
• Recall and use the equations of motion $v = u + \Delta t$; $a = \frac{v - u}{\Delta t}$; $s = \frac{v + u}{2 \times \Delta t}$
• Derive, from the definitions of velocity and acceleration, equations that represent uniformly accelerated motion in a straight line
• Solve problems using equations that represent uniformly accelerated (constant acceleration) motion in a straight line, including the motion of bodies falling in a uniform gravitational field without air resistance
• Describe an experiment to determine the acceleration of free fall using a falling body
• Describe and explain motion due to a uniform velocity in one direction and a uniform acceleration in a perpendicular direction
		47–62	30–34

Topic 1.4: Dynamics	18	66–85	35–40

Sub-topic: 1.4.1: Momentum and Newton’s laws of motion
• State that mass is the property of a body that resists change in motion
• Recall the relationship $F = ma$ and solve problems using it, appreciating that acceleration and resultant force are always in the same direction
• Define and use linear momentum as the product of mass and velocity (recall $p = mv$)
• Define and use force as rate of change of momentum
• State and apply each of Newton’s laws of motion:
  » Newton’s first law (the law of inertia): an object at rest continues in a state of rest or if moving continues moving with constant velocity unless it is acted on by a resultant force
  » Newton’s second law: the resultant force exerted on a body is directly proportional to the rate of change of linear momentum of that body; and recall use $\Delta F = \frac{\Delta p}{\Delta t}$
		67–74	35–37

» Newton's third law: when two bodies interact, they exert forces on each other, these forces have the same magnitude but are in opposite directions			
Sub-topic 1.4.2: Non-uniform motion • Describe and use the concept of weight as the effect of a gravitational field on a mass and recall that the weight of a body is equal to the product of its mass and the acceleration of free fall • Describe and explain qualitatively the motion of bodies falling in a uniform gravitational field with air resistance (including reference to terminal velocity) • Recall that acceleration is constant even when the motion is non-uniform		75–76	37–38
Sub-topic 1.4.3: Linear momentum and its conservation • Define impulse as $F\Delta t$ • Relate impulse to change in momentum ($F\Delta t = \Delta p$) • Use the relationship between impulse and change in momentum to calculate the force exerted, time for which the force is applied and change in momentum for a variety of situations involving the motion of an object in one dimension • Apply the concept of impulse to safety considerations in everyday life, e.g. airbags, seatbelts and arrestor beds • State the principle of conservation of momentum, that when bodies in a system interact, the total momentum remains constant (momentum is always conserved) provided that no external force acts on the system • Apply the principle of conservation of momentum to solve simple problems, including elastic and inelastic interactions between bodies in both one and two dimensions (knowledge of the concept of coefficient of restitution is not required) » In elastic interactions, kinetic energy is conserved » In inelastic interactions, kinetic energy is not conserved • Recognise that, for a perfectly elastic collision, the relative speed of approach is equal to the relative speed of separation • Explain that, while momentum of a system is always conserved in interactions between bodies, some change in kinetic energy may take place		77–81	38–39
Topic 1.5: Forces, density and pressure	12	86–102	41–46
Sub-topic 1.5.1: Types of forces • Describe the force on a mass in a uniform gravitational field and on a charge in a uniform electric field • Explain the origin of the up-thrust acting on a body in a fluid (due to the difference in hydrostatic pressure) • Explain frictional forces and viscous forces including air resistance (no treatment of the coefficients of friction and viscosity is required) • Apply the concept that the weight of a body may be taken as acting at a single point known as its centre of gravity		87–88	42
Sub-topic 1.5.2: Turning effects of forces • Define moment as the product of force and perpendicular distance through the line of action from the pivot • Apply the moment of a force to everyday examples such as crowbar, wheelbarrow, pliers, scissors, tweezers or tongs • State that a couple is a pair of (equal but opposite) forces (acting along parallel but different lines) that tends to produce rotation only • Define and apply the torque of a couple (torque as the product of the magnitude of one of the forces and the distance of separation)		89–91	42–43

Sub-topic 1.5.3: Equilibrium of forces • State and apply the principle of moments • Recall and apply the principle that, when there is no resultant force and no resultant torque, a system is in equilibrium • Use a vector triangle to represent three coplanar forces in equilibrium		92–95	43–44
Sub-topic 1.5.4: Density and pressure • Define and use density (density as the mass per unit volume) • Define and use pressure (pressure as the perpendicular force per unit area) • Derive, from the definitions of pressure and density, the equation $\Delta p = \rho g \Delta h$ • Use the equation for hydrostatic pressure $\Delta p = \rho g \Delta h$		96–99	44–45
Topic 1.6: Work, energy and power	12	103–118	47–51
Sub-topic 1.6.1: Energy conversion and conservation • Give examples of energy in different forms, its conversion and conservation, and apply the principle of conservation of energy to simple examples (e.g. the kinetic energy changing to potential energy in a pendulum and the sum of the two is constant if air resistance is negligible)		104–106	47–48
Sub-topic 1.6.2: Work and efficiency • Explain the concept of work in terms of the product of a force and displacement in the direction of the force • Calculate the work done in a number of situations including the work done by a gas that is expanding against a constant external pressure: $W = p\Delta V$ • Recall and apply that the efficiency of a system is the ratio (which can be expressed as percentage) of useful energy output from the system to the total energy input • Discuss the implications of energy losses in practical devices and use the concept of efficiency to solve problems		107–109	48–49
Sub-topic 1.6.3: Potential energy and kinetic energy • Derive, from the equations of motion, the formula for kinetic energy $E_k = \frac{1}{2}mv^2$ • Recal and apply the formula $E_k = \frac{1}{2}mv^2$ • Distinguish between gravitational potential energy and elastic potential energy » Gravitational potential energy as energy of a mass due to its position in a gravitational field » Elastic potential energy as energy stored in an object as a result of reversible (elastic) deformation • Apply the relationship between force and potential energy in a uniform field to solve problems • Derive, from the defining equation $W = Fs$, the formula $\Delta E_p = mg\Delta h$ for gravitational potential energy changes near the Earth's surface • Recall and use the formula $\Delta E_p = mg\Delta h$ for gravitational potential energy changes near the Earth's surface		110–113	49–50
Sub-topic 1.6.4: Power • Define power as work done per unit time • Derive power as the product of force and velocity • Recall and use the relationships $P = \frac{W}{\Delta t}$ and $P = Fv$		114	50

Topic 1.7: Deformation of solids	15	119–135	52–55
Sub-topic 1.7.1: Stress and strain • Outline that deformation is caused by a force and that, in one dimension, the deformation can be tensile or compressive • Use the terms load, extension and compression • Explain and use the terms limit of proportionality, elastic limit, yield point and the spring constant (i.e. force per unit extension) • Obtain and draw force–extension, force–compression, and tensile/compressive stress–strain graphs • Recall and use Hooke's law ($F = kx$) • Define and use the terms stress, strain and the Young modulus: » Stress as the force per unit area of a material » Strain as extension per unit length » Young's modulus as the ratio of stress to strain • Describe an experiment to determine the Young modulus of a metal in the form of a wire		120–127	52–53
Sub-topic 1.7.2: Elastic and plastic behaviour • Distinguish between elastic and plastic deformation of a material » Elastic deformation being reversible when the stress is removed » Plastic deformation being permanent as a result of dislocations • Relate the area under the force-extension graph to the work done (the area under the force–extension graph = work done) • Determine the elastic potential (strain) energy in a deformed material from the area under the force-extension graph • Recall and use $E_p = \frac{1}{2}Fx = \frac{1}{2}kx^2$ for a material deformed within its limit of proportionality		128–132	54
Theme 2: Waves	**28**	**136–203**	**56–73**
Topic 2.1: Progressive waves	4	138–149	56–58
Sub-topic 2.1.1 Understand progressive waves • Describe what is meant by wave motion (propagation), an oscillation which transfers energy from one place to another without any net movement of the medium, as illustrated by vibration in ropes, springs and by experiments using water waves • Describe and use the terms displacement, amplitude, phase difference, period, frequency, wavelength and speed • Derive, from the definitions of speed, frequency and wavelength, the wave equation $v = f\lambda$ • Recall and use the equations $v = f\lambda$ and $f = \frac{1}{T}$ • Describe that energy is transferred by a progressive wave • Recall and use the relationship intensity = $\frac{\text{power}}{\text{area}}$ and intensity $\propto$ (amplitude)^2		139–149	56–58
Topic 2.2: Transverse and longitudinal waves	4	150–157	59–60
Sub-topic 2.2.1 The difference between transverse and longitudinal waves • Compare transverse and longitudinal waves » For a transverse wave, the oscillations are perpendicular to the direction of travel of the energy of the wave » For a longitudinal wave, the oscillations are parallel to the direction of travel of the energy of the wave • Analyse and interpret graphical representations of transverse and longitudinal waves		151–157	59–60

Topic 2.3: Determination of frequency and wavelength of sound waves	4	158–167	61–63
Sub-topic 2.3.1 Determine frequency and wavelength of sound waves • Determine the frequency of sound using a calibrated cathode-ray or PC oscilloscope • Determine the wavelength of sound using stationary waves (e.g. use of sonometer, resonance tubes, tuning forks)		159–167	61–63
Topic 2.4: Doppler effect	3	168–176	64–66
Sub-topic 2.4.1 The Doppler effect • Explain that when a source (of waves) moves relative to a stationary observer, there is a change in observed frequency • Use the expression $f_o = \frac{f_s v}{(v \pm v_s)}$ for the observed frequency when a source of sound waves moves relative to a stationary observer • Explain that Doppler shift is observed with all waves, including sound and light		169–176	64–65
Topic 2.5: Electromagnetic spectrum	3	177–185	67–68
Sub-topic 2.5.1 The electromagnetic spectrum • State that all electromagnetic waves are transverse waves that travel with the same speed in free space • Recall the orders of magnitude of the wavelengths of the principal regions of the electromagnetic spectrum from radio waves to gamma rays		178–185	67–68
Topic 2.6: Superposition	10	186–203	69–73
Sub-topic 2.6.1: Stationary waves • Explain and use the principle of superposition in simple application • Describe experiments that demonstrate stationary waves using microwaves, stretched strings and air columns • Explain the formation of a stationary wave using a graphical method and identify nodes and antinodes		187–191	69–71
Sub-topic 2.6.2: Diffraction • Explain the meaning of the term diffraction • Describe experiments that demonstrate diffraction, including the qualitative effect of the gap width relative to the wavelength of the wave, for example diffraction of water waves in a ripple tank		192–193	71
Sub-topic 2.6.3: Interference and two-source interference • Define the terms interference and coherence » Coherence: when two waves both have the same frequency (and wavelength) and a constant phase difference » Interference: when two or more waves overlap/superpose, the resultant displacement is the sum of the displacements of each wave • Describe experiments that demonstrate two-source interference using water ripples, light (monochromatic light source e.g. laser) and microwaves • Discuss the conditions required if two-source interference fringes are to be observed • Recall and solve problems using the equation $\lambda = \frac{ax}{D}$ for double-slit interference using light		194–198	71–72

Sub-topic 2.6.4: Diffraction gratings • Recall and solve problems using the formula $d\sin\theta = n\lambda$ • Describe the use of a diffraction grating to determine the wavelength of light (the structure and use of the spectrometer are not included)		199–200	72
Theme 3: Electricity	29	**204–245**	**74–86**
Topic 3.1: Electric fields	5	206–214	74–77
Sub-topic 3.1.1: Concept of an electric field • Define and use electric field strength as force per unit positive charge (point charge) $\left(E = \frac{F}{Q}\right)$ • Explain the concept of an electric field as an example of a field of force (a region in which an electric charge experiences a force due to another charge) • Represent an electric field by means of field lines		207–209	74–75
Sub-topic 3.1.2: Uniform electric fields • Recall and use $E = \frac{\Delta V}{\Delta d}$ to calculate the field strength of the uniform field between charged parallel plates in terms of potential difference and separation • Calculate the forces on charges in uniform electric fields • Describe the effect of a uniform electric field on the motion of charged particles		210–212	75–76
Topic 3.2: Current electricity	15	215–229	78–82
Sub-topic 3.2.1: Electric current • Explain that electric current is a flow of charge carriers • Recall that the charge on charge carriers is quantised • Define the coulomb as the SI unit of electric charge, equal to the quantity of charge conveyed in one second by a current of one ampere • Recall and use $Q = I\Delta t$ • Derive and use, for a current-carrying conductor, the expression $I = Anvq$, where A is the cross sectional area, n is the number density of charge carriers (number of electrons per unit volume), v is drift velocity and q is the charge carried by the individual charge carrier		216–217	78–79
Sub-topic 3.2.2: Potential difference and power • Define potential difference and the volt • Potential difference (p.d) (V) as energy transferred (work done) per unit charge • The volt (the SI unit for of both potential difference and electromotive force) as the ratio of joule to coulomb • Recall and use $V = \frac{W}{Q}$ • Recall and use $P = VI$, $P = \frac{V^2}{R}$ and $P = I^2R$		218–219	79–80
Sub-topic 3.2.3: Resistance and resistivity • Define resistance of a conductor as the ratio of the potential difference across it to the current through it • Define the ohm (the SI unit for of electrical resistance) as the ratio of volt to ampere, transmitting a current of one ampere when subjected to a potential difference of one volt • Recall and use $V = IR$ • Sketch and discuss the I-V characteristics of a metallic conductor at constant temperature, a semiconductor diode and a filament lamp • Explain that the resistance of a filament lamp increases as current increases because its temperature increases		220–226	80–81

• Explain that the resistance of a light-dependent resistor (LDR) decreases as the light intensity increases • Explain that the resistance of a thermistor decreases as temperature increases (negative temperature coefficient [NTC] thermistor only) • State and use Ohm's law • Define resistivity of a material as a product of the resistance and cross-sectional area per length of the specimen • Recall and use $\rho = \frac{RA}{l}$, where R is the resistance, ρ is the resistivity of the material, l is the length of the conductor and A is the cross-sectional area			
Topic 3.3: DC circuits	9	230–245	83–86
Sub-topic 3.3.1: Practical circuits • Recall and use appropriate circuit symbols • Draw and interpret circuit diagrams containing sources, switches, resistors, ammeters, voltmeters, and/or any other type of component referred to in the syllabus • Define electromotive force (e.m.f.) of a source as energy transferred per unit charge in driving charge round a complete circuit • Distinguish between e.m.f. and potential difference • Discuss the effects of the internal resistance of a source of e.m.f. on the terminal potential difference and output power • Recall and use the equation $V = E - Ir$, where V is the p.d., E is the e.m.f, I is the current and r is the internal resistance		231–233	83–84
Sub-topic 3.3.2: Kirchhoff's laws • Recall Kirchhoff's first law and appreciate the link to conservation of charge • Recall Kirchhoff's second law and appreciate the link to conservation of energy • Derive, using Kirchhoff's laws, a formula for the combined resistance of two or more resistors in series • Solve problems using the formula for the combined resistance of two or more resistors in series • Derive, using Kirchhoff's laws, a formula for the combined resistance of two or more resistors in parallel • Solve problems using the formula for the combined resistance of two or more resistors in parallel • Apply Kirchhoff's laws to solve simple circuit problems		234–237	84–85
Sub-topic 3.3.3: Potential dividers • Explain the principle of a potential divider circuit as a source of variable p.d • Recall and use $V_{out} = V_{in}\frac{R_2}{(R_1 + R_2)}$ • Solve problems using the principle of the potentiometer as a means of comparing potential differences • Explain the use of thermistors (negative temperature coefficient [NTC] thermistors only), light-dependent resistors (LDR) in potential dividers to provide a potential difference that is dependent on the temperature and illumination respectively		238–241	85–86

Theme 4: Modern physics	9	**246–266**	**87–91**
Topic 4.1: Atoms, nuclei and radiation	5	248–260	87–89
Sub-topic 4.1.1 Atoms, nuclei and radiation • Describe and explain the simple structure of the nucleus • Recall that radioactive decay is the random and spontaneous emission of particles and/or electromagnetic radiation from an unstable nucleus • Recall the nature and properties of α, β and γ radiations (both β^- and β^+ are included) • Distinguish between proton number and nucleon number (mass number) and proton number (atomic number) and use standard nuclide notation (${}_{AZ}X$) » Proton number (atomic number), denoted by Z » Nucleon number (mass number), denoted by A • State that an element can exist in various isotopic forms each with a different number of neutrons • Describe and explain the transformation of nuclei when they emit radiation • Appreciate that nucleon number, proton number and energy are all conserved in nuclear processes • Represent simple alpha and beta decay by equations of the form ${}^{234}_{92}\mathrm{U} \rightarrow {}^{230}_{90}\mathrm{Th} + {}^{4}_{2}\alpha$ ${}^{214}_{82}\mathrm{Pb} \rightarrow {}^{214}_{83}\mathrm{Bi} + {}^{0}_{-1}\beta$ • Deduce the mass number and proton number of the daughter and granddaughter products in a decay series • Recall that during beta decay that beta particles are emitted with a range of kinetic energies • Recognise the effects of a uniform electric field on the path of alpha and beta particles and gamma rays • Calculate the force on alpha and beta particles when passing through a uniform electric field $\left(\text{e.g using } F = EQ;\ E = \frac{\Delta V}{\Delta d}\right)$ • Use the unified atomic mass unit and/or the mass of an electron in calculations involving forces on alpha and beta particles (e.g. using $F = ma$ and equations of motion) • Deduce from the results of the α-particle scattering experiment the existence and small size of the nucleus • State that (electron) antineutrinos and (electron) neutrinos are produced during β^- and β^+ decay		249–260	87–89
Topic 4.2: Fundamental particles	4	261–266	90–91
Sub-topic 4.2.1 Fundamental particles • Appreciate that protons and neutrons are not fundamental particles since they consist of quarks • Describe a simple quark model of hadrons in terms of up, down and strange quarks and their respective antiquarks • Describe protons and neutrons in terms of a simple quark model • Appreciate that there is a weak interaction between quarks, giving rise to β decay • Describe β^- and β^+ decay in terms of a simple quark model • Appreciate that electrons and neutrinos are leptons		262–266	90–91