Physics A Level - Personal Learning Checklist

OCR Physics A Topics 1 to 20

Topic 1 - Practical Skills		R	A	G
Practical Skills	**1.1.1 a** Can you design experiments, including ones to solve problems set in a practical context?			
	1.1.1 b Can you identify the variables that must be controlled in an experiment?			
	1.1.1 c Can you evaluate whether an experimental method is appropriate to meet expected outcomes?			
	1.1.2 a Can you use a wide range of practical apparatus and techniques correctly?			
	1.1.2 b Can you use appropriate units to take measurements?			
	1.1.2 c Can you present observations and data in an appropriate format?			
	1.1.3 a Can you process, analyse and interpret qualitative and quantitative experimental results?			
	1.1.3 b Can you use appropriate mathematical skills for analysis of quantitative data?			
	1.1.3 c Can you use significant figures appropriately?			
	1.1.3 d Can you plot and interpret suitable graphs from experimental results?			
	1.1.3 d i Can you select and label axes with appropriate scales, quantities, and units?			
	1.1.3 d ii Can you measure gradients?			
	1.1.4 a Can you evaluate results and draw conclusions?			
	1.1.4 b Can you identify anomalies in experimental measurements?			
	1.1.4 c Can you explain the limitations in experimental procedures?			
	1.1.4 d Can you be precise and accurate with measurements and data, including margins of error, percentage errors and uncertainties in apparatus?			
	1.1.4 e Can you refine experimental design by suggesting improvements to the procedures and apparatus?			

Topic 2 - Foundations of physics		R	A	G
Foundations of physics	**2.1.1 a** Can you explain that physical quantities have a numerical value and a unit?			
	2.1.1 b Can you estimate physical quantities?			
	2.1.2 a Can you describe the Système Internationale (S.I.) base quantities and their units – mass (kg), length (m), time (s), current (A), temperature (K), amount of substance (mol)?			
	2.1.2 b Can you use derived units of S.I. base units?			
	2.1.2 c Can you use the all the units you have encountered in the course?			
	2.1.2 d Can you check the homogeneity of physical equations using S.I. base units?			
	2.1.2 e Can you use prefixes and their symbols to indicate decimal submultiples or multiples of units – pico (p), nano (n), micro (μ), milli (m), centi (c), deci (d), kilo (k), mega (M), giga (G), tera (T)?			
	2.1.2 f Can you use conventions for labelling graph axes and table columns?			
	2.2.1 a Can you identify systematic errors (including zero errors) and random errors in measurements?			
	2.2.1 b Can state the difference between precision and accuracy?			
	2.2.1 c Can you explain absolute and percentage uncertainties when data are combined by addition, subtraction, multiplication, division and raising to powers?			
	2.2.1 d Can you identify graphical treatment of errors and uncertainties; line of best fit; worst line; absolute and percentage uncertainties; percentage best fit; worst line; absolute and percentage uncertainties; percentage difference?			
	2.3.1 a Can you use scalar and vector quantities?			
	2.3.1 b Can you use vector addition and subtraction?			
	2.3.1 c Can you use a vector triangle to determine the resultant of any two coplanar vectors?			
	2.3.1 d Can you resolve a vector into two perpendicular components;			

Topic 3 - Motion		R	A	G
Motion	**3.1.1 a** Can you define displacement, instantaneous speed, average speed, velocity, and acceleration?			
	3.1.1 b Can you interpret graphical representations of displacement, speed, velocity, and acceleration?			
	3.1.1 c Can you draw displacement–time graphs and calculate velocity from the gradient?			
	3.1.1 d Can you interpret velocity–time graphs, where acceleration is the gradient and displacement is the area under the graph?			
	3.1.2 a I Can you use the equations of motion for constant acceleration in a straight line, including motion of bodies falling in a uniform gravitational field without air resistance?			
	3.1.2 a ii Can you list and describe techniques and procedures used to investigate the motion and collisions of objects?			
	3.1.2 b i Can you define acceleration g of free fall?			
	3.1.2 b ii Can you list and describe techniques and procedures used to determine the acceleration of free fall using a trapdoor and electromagnet arrangement or light gates and a timer?			
	3.1.2 c Can you define what is meant by reaction time and thinking distance; and calculate braking distance and stopping distance for a vehicle?			
	3.1.3 a Can you explain the independence of the vertical and horizontal motion of a projectile?			

Topic 4 - Forces in action		R	A	G
Forces in action	**3.2.1 a** Can you recall and understand the formula net force = mass × acceleration (F = m a)?			
	3.2.1 b Can you recall the newton as the unit of force?			
	3.2.1 c Can you explain why the weight of an object, W = m g?			
	3.2.1 d Can you define and use the terms tension, normal contact force, upthrust, and friction?			
	3.2.1 e Can you draw and interpret free-body diagrams?			
	3.2.1 f Can you explain one- and two-dimensional motion under constant force?			
	3.2.2 a Can you explain drag as the frictional force experienced by an object travelling through a fluid?			
	3.2.2 b Can you describe the factors affecting drag for an object travelling through air?			
	3.2.2 c Can you describe the motion of objects falling in a uniform gravitational field in the presence of drag?			
	3.2.2 d i Can you define terminal velocity?			
	3.2.2 d ii Can you list and describe techniques and procedures used to determine terminal velocity in fluids?			
	3.2.3 a Can you define the moment of a force?			
	3.2.3 b Can you describe a couple and the torque of a couple?			
	3.2.3 c Can you define and use the principle of moments?			
	3.2.3 d Can you describe centre of mass/centre of gravity, and describe how to determine the centre of gravity experimentally?			
	3.2.3 e Can you describe the conditions for equilibrium of an object under the action of forces and torques?			
	3.2.3 f Can you explain the conditions for equilibrium of three coplanar forces?			
	3.2.4 a Can you define density?			
	3.2.4 b Can you describe pressure for solids, liquids, and gases?			
	3.2.4 c Can you apply Archimedes' principle and use the equation p = h ρ g to calculate the upthrust acting on an object in a fluid?			

Topic 5 - Work, energy, and power		R	A	G
Work, energy, and power	**3.3.1 a** Can you define work done by a force and recall that the unit for work done is the joule?			
	3.3.1 b Can you use W = F x cos θ to calculate the work done by a force?			
	3.3.1 c Can you define and apply the principle of conservation of energy?			
	3.3.1 d Can you describe and carry out calculations for situations involving the transfer of energy between different forms?			
	3.3.1 e Can you explain how transfer of energy is equal to work done?			
	3.3.2 a Can you define and calculate the kinetic energy of an object?			
	3.3.2 b Can you define and calculate the gravitational potential energy of an object in a uniform gravitational field?			
	3.3.2 c Can you describe the exchange between gravitational potential energy and kinetic energy?			
	3.3.3 a Can you define and calculate power, and recall that the unit for power is the watt?			
	3.3.3 b Can you use the equation P = F v?			
	3.3.3 c Can you calculate the efficiency of a mechanical system?			

Topic 6 - Materials		R	A	G
Materials	**3.4.1 a** Can you define and describe tensile and compressive deformation, and extension and compression?			
	3.4.1 b Can you state Hooke's law?			
	3.4.1 c Can you determine the force constant k of a spring or wire using F = k x?			
	3.4.1 d i Can you sketch and interpret force–extension (or compression) graphs for springs and wires?			
	3.4.1 d ii Can you describe techniques and procedures used to investigate force– extension characteristics for arrangements which may include springs, rubber bands, and polythene strips?			
	3.4.2 a Can you use a force–extension (or compression) graph to determine the work done in extending (or compressing) the material?			
	3.4.2 b Can you calculate elastic potential energy using E = 2 1 F x and E = 2 1 k x2 ?			
	3.4.2 c Can you define stress, strain, and ultimate tensile strength?			
	3.4.2 d i Can you calculate the Young modulus of a material using tensile stress and tensile strain?			
	3.4.2 d ii Can you describe techniques and procedures used to determine the Young modulus for a metal?			
	3.4.2 e Can you interpret and sketch stress–strain graphs for typical ductile, brittle, and polymeric materials?			
	3.4.2 f Can you describe elastic and plastic deformations of materials			

Topic 7 - Laws of motion and momentum		R	A	G
Laws of motion and momentum	**3.1.2 a** I Can you use the equations of motion for constant acceleration in a straight line, including motion of bodies falling in a uniform gravitational field without air resistance?			
	3.5.1 a Can you explain Newton's three laws of motion?			
	3.5.1 b Can you calculate linear momentum and understand the vector nature of momentum?			
	3.5.1 c Can you understand that net force = rate of change of momentum?			
	3.5.1 d Can you describe and calculate the impulse of a force?			
	3.5.1 e Can you recall that impulse is equal to the area under a force–time graph?			
	3.5.2 a Can you define the principle of conservation of momentum?			
	3.5.2 b Can you describe and carry out calculations for collisions and interactions of bodies in one dimension and in two dimensions?			
	3.5.2 c Can you describe perfectly elastic collisions and inelastic collisions?			

Topic 8 - Charge and current		R	A	G
Charge and current	**4.1.1 a** Can you define electric current as rate of flow of charge?			
	4.1.1 b Can you describe the coulomb as the unit of charge?			
	4.1.1 c Can you recall the elementary charge e equals 1.6 × 10−19C?			
	4.1.1 d Can you explain why the net charge on a particle or an object is quantised and a multiple of e?			
	4.1.1 e Can you explain current as the movement of electrons in metals and movement of ions in electrolytes?			
	4.1.1 f Can you describe the difference between conventional current and			
	4.1.1 g Can you recall and apply Kirchhoff's first law?			
	4.1.2 a Can you describe what is meant by mean drift velocity of charge carriers?			
	4.1.2 b Can you carry out calculations using I = A n e v, where n is the number density of charge carriers?			
	4.1.2 c Can you explain the distinction between conductors, semiconductors, and insulators in terms of n?			

Topic 9 - Energy, power, and resistance		R	A	G
Energy, power, and resistance	**4.2.1 a** Can you recognise and draw circuit symbols?			
	4.2.1 b Can you draw circuit diagrams using circuit symbols?			
	4.2.2 a Can you define potential difference (p.d.) and the unit volt?			
	4.2.2 b Can you describe the electromotive force (e.m.f.) of a source such as a cell or a power supply?			
	4.2.2 c Can you explain the distinction between e.m.f. and p.d. in terms of energy transfer?			
	4.2.2 d Can you describe and calculate energy transfer using W = V Q and W = E Q?			
	4.2.2 e Can you describe and calculate energy transfer using eV = m v2 for electrons and other charged particles?			
	4.2.3 a Can you define resistance and the unit ohm?			
	4.2.3 b Can you explain Ohm's law?			
	4.2.3 c i Can you describe the I–V characteristics of the resistor, filament lamp, thermistor, diode, and light-emitting diode (LED)?			
	4.2.3 c ii Can you list and describe techniques and procedures used to investigate the electrical characteristics for a range of ohmic and non-ohmic components?			
	4.2.3 d Can you explain the variation of resistance with light intensity for a light dependent resistor (LDR)?			
	4.2.4 a i Can you explain the resistivity of a material and use the equation A ρL R = ?			
	4.2.4 a ii Can you list and describe techniques and procedures used to determine the resistivity of a metal?			
	4.2.4 b Can you explain how resistivity varies with temperature for metals and semiconductors?			
	4.2.4 c Can you explain how resistance varies with temperature for a negative temperature coefficient (NTC) thermistor?			
	4.2.5 a Can you use the equations P = V I, P = I 2R and R V P = ?			
	4.2.5 b Can you describe energy transfer using the equation W = V I t?			
	4.2.5 c Can you describe the kilowatt-hour (kW h) as a unit of energy and			

Topic 10 - Electrical circuits		R	A	G
Electrical circuits	**4.3.1 a** Can you explain Kirchhoff's second law and the conservation of energy?			
	4.3.1 b Can you describe Kirchhoff's first and second laws applied to electrical circuits?			
	4.3.1 c Can you determine the total resistance of two or more resistors in series using R = R1 + R2 + …?			
	4.3.1 d Can you determine the total resistance of two or more resistors in parallel using … 1 +1+ 1=….? R+R+ R2			
	4.3.1 e Can you analyse circuits with components both in series and in parallel			
	4.3.1 e Can you analyse circuits with components both in series and in parallel?			
	4.3.1 f Can you analyse circuits with more than one source of e.m.f.?			
	4.3.2 a Can you define source of e.m.f. and internal resistance?			
	4.3.2 b Can you define terminal p.d. and 'lost volts'?			
	4.3.2 c i Can you use the equations Ɛ = I (R + r) and Ɛ = V + I r?			
	4.3.2 c ii Can you list and describe techniques and procedures used to determine the internal resistance of a chemical cell or other source of e.m.f.?			
	4.3.3 a Can you analyse a potential divider circuit with components?			
	4.3.3 b Can you use potential divider circuits with variable components, e.g.LDRs and thermistors?			
	4.3.3 c i Can you use potential divider equations V out = R x V in and V1= R1 ? R,+R2 V2 R2			
	4.3.3 c ii Can you list and describe techniques and procedures used to investigate potential divider circuits which may include a sensor such as a thermistor or a LDR?			

Topic 11 - Waves 1		R	A	G
Waves 1	**4.4.1 a** Can you describe progressive waves, both longitudinal and transverse?			
	4.4.1 b i Can you define displacement, amplitude, wavelength, period, phase difference, frequency, and speed of a wave?			
	4.4.1 b ii Can you list and describe techniques and procedures used to use an oscilloscope to determine frequency?			
	4.4.1 c Can you use the equation $f = \frac{1}{T}$?			
	4.4.1 d Can you use the wave equation $v = f\lambda$?			
	4.4.1 e Can you produce graphical representations of transverse and longitudinal waves?			
	4.4.1 f i Can you describe reflection, refraction, polarisation, and diffraction of all waves?			
	4.4.1 f ii Can you list and describe techniques and procedures used to demonstrate wave effects using a ripple tank?			
	4.4.1 f iii Can you list and describe techniques and procedures used to observe			
	4.4.1 g Can you describe and determine the intensity of a progressive wave using $I = \frac{P}{A}$ and intensity $\propto$ (amplitude)2 ?			
	4.4.2 a Can you describe the electromagnetic spectrum and the properties of electromagnetic waves?			
	4.4.2 b Can you describe the orders of magnitude of wavelengths of the principal radiations from radio waves to gamma rays?			
	4.4.2 c Can you describe plane polarised waves and polarisation of electromagnetic waves?			
	4.4.2 d i Can you describe refraction of light with reference to the refractive index?			
	4.4.2 d i Can you carry out calculations using the refraction law $n \sin\theta = k$?			
	4.4.2 d ii Can you list and describe techniques and procedures used to investigate Can you list and describe techniques and procedures used to investigate refraction and total internal reflection of light using ray boxes, and transparent rectangular and semi-circular blocks?			
	4.4.2 e Can you define and calculate the critical angle using $\sin C = \frac{1}{n}$?			
	4.4.2 e Can you describe the conditions needed for total internal reflection to occur?			

Topic 12 - Waves 2		R	A	G
Waves 2	**4.4.3 a i** Can you explain the principle of superposition of waves?			
	4.4.3 a ii Can you list and describe techniques and procedures used for superposition experiments using sound, light, and microwaves?			
	4.4.3 b Can you use graphical methods to illustrate the principle of superposition?			
	4.4.3 c Can you define interference, coherence, path difference, and phase difference?			
	4.4.3 d Can you describe constructive interference and destructive interference in terms of path difference and phase difference?			
	4.4.3 e Can you describe two-source interference for sound and microwaves?			
	4.4.3 f Can you explain the Young double-slit experiment using visible light?			
	4.4.3 g i Can you use $a \times \lambda = D$ for all waves where $a \ll D$?			
	4.4.3 g ii Can you list and describe techniques and procedures used to determine the wavelength of light using a double-slit and a diffraction grating?			
	4.4.4 a Can you describe stationary (standing) waves using microwaves, stretched strings, and air columns?			
	4.4.4 b Can you interpret and produce graphical representations of a stationary wave?			
	4.4.4 c Can you describe the similarities and the differences between stationary			
	4.4.4 d Can you describe nodes and antinodes?			
	4.4.4 e i Can you describe stationary wave patterns for a stretched string, and air columns in closed and open tubes?			
	4.4.4 e ii Can you list and explain techniques and procedures used to determine the speed of sound in air by formation of stationary waves in a resonance tube?			
	4.4.4 f Can you explain the idea that the separation between adjacent nodes (or antinodes) is equal to $\frac{2}{\lambda}$, where λ is the wavelength of the progressive wave?			
	4.4.4 g Can you define the fundamental mode of vibration (1st harmonic) and describe different harmonics?			

Topic 13 - Quantum physics		R	A	G
Quantum physics	**4.5.1 a** Can you explain the particulate nature (photon model) of electromagnetic radiation?			
	4.5.1 b Can you define a photon as a quantum of energy of electromagnetic			
	4.5.1 c Can you describe and calculate the energy of a photon using E = h f and E = $\frac{hc}{\lambda}$?			
	4.5.1 d Can you define the electronvolt (eV) as a unit of energy?			
	4.5.1 e i Can you use LEDs and the equation λ eV = $\frac{hc}{\lambda}$ to estimate the value of the Planck constant h			
	4.5.1 e ii Can you determine the Planck constant using different coloured LEDs?			
	4.5.2 a i Can you explain the photoelectric effect, including a simple experiment to demonstrate this effect?			
	4.5.2 a ii Can you demonstrate the photoelectric effect using, for example, a gold leaf electroscope and zinc plate?			
	4.5.2 b Can you describe the one-to-one interaction between a photon and a surface electron			
	4.5.2 c Can you explain Einstein's photoelectric equation h f = ϕ + KEmax?			
	4.5.2 d Can you define work function and threshold frequency?			
	4.5.2 e Can you explain the idea that the maximum kinetic energy of the photoelectrons is independent of the intensity of the incident radiation?			
	4.5.2 f Can you explain the idea that a rate of emission of photoelectrons above photoelectrons is independent of the intensity of the incident radiation?			
	4.5.3 a Can you explain electron diffraction, including experimental evidence of this effect?			
	4.5.3 b Can you describe diffraction of electrons travelling through a thin slice of polycrystalline graphite?			
	4.5.3 c Can you use the de Broglie equation $\lambda = \frac{h}{p}$?			

Topic 14 - Thermal physics		R	A	G
Thermal physics	**5.1.1 a** Can you describe thermal equilibrium?			
	5.1.1 b Can you explain the absolute scale of temperature?			
	5.1.1 c Can you state temperature measurements in degrees Celsius and kelvin?			
	5.1.1 d Can you calculate T(K) ≈ θ(°C) + 273?			
	5.1.2 a Can you describe solids, liquids, and gases in terms of spacing, ordering, and motion of atoms or molecules?			
	5.1.2 b Can you describe the simple kinetic model?			
	5.1.2 c Can you explain Brownian motion?			
	5.1.2 d Can you explain internal energy as the sum of kinetic and potential energies in a system?			
	5.1.2 e Can you describe absolute zero (0 K)?			
	5.1.2 f Can you explain increase in internal energy with temperature?			
	5.1.2 g Can you describe changes in internal energy during changes of phase?			
	5.1.2 g Can you explain constancy of temperature during changes of phase?			
	5.1.3 a Can you calculate the specific heat capacity of a substance – E = mcΔθ?			
	5.1.3 d i Can you describe an electrical experiment to determine the specific heat capacity of a metal or a liquid?			

Topic 15 - Ideal gases		R	A	G
Ideal gases	**5.1.4 a** Can you understand an amount of substance, measured in moles?			
	5.1.4 a Can you explain the Avogadro constant, NA?			
	5.1.4 b Can you describe the model of the kinetic theory of gases and its assumptions?			
	5.1.4 c Can you describe pressure in terms of the model of the kinetic theory of gases?			
	5.1.4 d i Can you calculate the equation of state of an ideal gas pV = nRT, where n is the number of moles?			
	5.1.4 d ii Can you understand techniques and procedures used to investigate Pv = constant (Boyle's law) and $\frac{P}{T}$ = constant?			
	5.1.4 d iii Can you calculate an estimation of absolute zero using variation of gas temperature with pressure?			
	5.1.4 e Can you explain the equation pV = 1_3Nmn □ relating the number of particles and the mean square speed?			
	5.1.4 f Can you understand root mean square speed and mean square speed? Can you understand the Boltzmann constant, k= $\frac{R}{Na}$?			
	5.1.4 h Can you calculate Pv = $\frac{1}{2}$ mc2 = $\frac{3}{2}$ Kt?			
	5.1.4 I Can you describe the internal energy of an ideal gas?			

Topic 16 - Circular motion		R	A	G
Circular motion	**5.2.1 a** Can you describe the radian as a measure of angle?			
	5.2.1 b Can you explain the period and frequency of an object in circular			
	Can you explain the period and frequency of an object in circular motion?			
	5.2.1 c Can you understand angular velocity ω, ω = $\frac{2\pi}{T}$, or ω = 2πf?			
	5.2.2 a Can you calculate a constant net force perpendicular to the velocity of an object, which causes it to travel in a circular path?			
	5.2.2 b Can you describe constant speed in a circle, v = rω?			
	5.2.2 c Can you understand centripetal acceleration, a = $\frac{v2}{}$ and a w2r?			
	5.2.2 d i Can you explain centripetal force, F = $\frac{mv2}{}$ and F = mω2 r? **5.2.2 d ii** Can you describe techniques and procedures used to investigate circular motion?			

Topic 17 - Oscillations		R	A	G
Oscillations	**5.3.1 a** Can you describe displacement, amplitude, period, frequency, angular frequency, and phase difference?			
	5.3.1 b Can you calculate angular frequency ω = 2π/T or ω = 2πf?			
	5.3.1 f Can you understand isochronous oscillators (the period of a simple harmonic oscillator is independent of its amplitude)?			
	5.3.1 c i Can you calculate simple harmonic motion, a = −ω x?			
	5.3.1 c ii Can you describe techniques and procedures used to determine the period and frequency of simple harmonic oscillations?			
	5.3.1 d Can you calculate solutions to the equation a = −ω x?			
	5.3.1 e Can you calculate velocity v = ±ω 2 2 A x , hence vmax = ωA?			
	5.3.1 g Can you explain graphical methods to relate the changes in displacement, velocity, and acceleration during simple harmonic motion?			
	5.3.2 a Can you describe the interchange between kinetic and potential energy during simple harmonic motion?			
	5.3.2 b Can you describe energy–displacement graphs for a simple harmonic oscillator?			
	5.3.3 b i Can you explain the effects of damping on an oscillatory system?			
	5.3.3 a Can you define free and forced oscillations?			
	5.3.3 c Can you explain natural frequency and resonance?			
	5.3.3 b ii Can you describe observing forced and damped oscillations for a range of systems?			
	5.3.3 d Can you describe amplitude-driving frequency graphs for forced oscillators?			
	5.3.3 e Can you explain practical examples of forced oscillations and resonance			

Topic 18 - Gravitational fields		R	A	G
Gravitational fields	**5.4.1 a** Can you understand gravitational fields being due to mass?			
	5.4.1 b Can you state the mass of a spherical object modelled as a point mass at its centre?			
	5.4.1 c Can you describe gravitational field lines to map gravitational fields?			
	5.4.1 d Can you calculate gravitational field strength; g = $\frac{F}{m}$?			
	5.4.1 e Can you explain the concept of gravitational fields as one of a number of forms of field giving rise to a force?			
	5.4.2 a Can you state Newton's law of gravitation?			
	5.4.2b Can you calculate gravitational field strength g = $\frac{GM}{r2}$ for a point mass?			
	5.4.2 c Can you understand the uniformity of gravitational field strength close to the surface of the Earth and its numerical equivalence to the acceleration of free fall?			
	5.4.3 a Can you explain Kepler's three laws of planetary motion?			
	5.4.3 b Can you calculate the centripetal force on a planet from the gravitational force between it and the Sun			
	5.4.3 c Can you calculate the equation T2 = $\frac{(4\pi2)}{GM}$ R2?			
	5.4.3 d Can you describe the relationship for Kepler's third law T 2 ∝ r applied to systems other than our Solar System?			
	5.4.3 e Can you explain geostationary orbit and the uses of geostationary satellites?			
	5.4.4 a Can you describe gravitational potential at a point as the work done in bringing unit mass from infinity to the point?			
	5.4.4 b Can you calculate the expression for gravitational potential at a distance r from a point mass M?			
	5.4.4 c Can you describe a force–distance graph for a point or spherical mass; work done as area under graph?			
	5.4.4 d Can you describe changes in gravitational potential?			
	5.4.4 e Can you explain escape velocity			

Topic 19 - Stars		R	A	G
Stars	**5.5.1 a** Can you explain the terms planets, planetary satellites, comets, solar systems, galaxies, and the Universe?			
	5.5.1 b Can you describe the formation of a star from interstellar dust and gas in terms of gravitational collapse, fusion of hydrogen into helium, radiation, and gas pressure?			
	5.5.1 c Can you describe the evolution of a low-mass star like our Sun into a red giant and white dwarf?			
	5.5.1 c Can you define a planetary nebula?			
	5.5.1 d Can you describe the characteristics of a white dwarf; electron degeneracy pressure; and the Chandrasekhar limit?			
	5.5.1 e Can you explain the evolution of a massive star into a red supergiant and then either a neutron star or black hole; and a supernova?			
	5.5.1 f Can you describe the characteristics of neutron stars and black holes?			
	5.5.1 g Can you understand the Hertzsprung–Russell (HR) diagram as luminosity–temperature plot?			
	5.5.1 g Can you explain the main sequence, red giants, red supergiants, and white dwarfs?			
	5.5.2 a Can you calculate the energy levels of electrons in isolated gas atoms?			
	5.5.2 b Can you explain the idea that energy levels have negative values?			
	5.5.2 c Can you describe emission spectral lines from hot gases in terms of transition of electrons between discrete energy levels and emission of photons?			
	5.5.2 d Can you demonstrate the equations $hf = \Delta E$ and $\frac{hc}{\lambda} = \Delta$?			
	5.5.2 e Can you explain that different atoms have different spectral lines, which can be used to identify elements within stars?			
	5.5.2 f Can you describe continuous spectra, emission line spectra, and absorption line spectra?			
	5.5.2 g Can you demonstrate the use of a transmission diffraction grating to determine the wavelength of light?			
	5.5.2 h Can you understand the condition for maxima $d \sin\theta = n\lambda$, where d is the grating spacing?			
	5.5.2 i Can you demonstrate the use of Wien's displacement law $\lambda_{max} \propto \frac{1}{T}$ to estimate the peak surface temperature of a star?			
	5.5.2 j Can you calculate the luminosity L of a star using Stefan's law $L = 4\pi r^2 \Sigma t$, where σ is the Stefan constant?			
	5.5.2 k Can you demonstrate the use of Wien's displacement law and Stefan's law to estimate the radius of a star?			

Topic 20 - Cosmology (the Big Bang)		R	A	G
Cosmology (the Big Bang)	**5.5.3 a** Can you calculate distances measured in astronomical units, light-years, and parsecs?			
	5.5.3 b Can you define stellar parallax?			
	5.5.3 c Can you understand the equation relating the parallax p in seconds of arc and the distance d in parsec?			
	5.5.3 e Can you explain the Doppler effect?			
	5.5.3 e Can you describe the Doppler shift of electromagnetic radiation?			
	5.5.3 f Can you demonstrate the Doppler equation for a source of electromagnetic radiation moving relative to an observer $\frac{\Delta\lambda}{\lambda} = \frac{\Delta f}{f} = \frac{v}{c}$?			
	5.5.3 g Can you demonstrate Hubble's law, $v \approx H_0 d$, for receding galaxies?			
	5.5.3 h Can you explain galactic red shift and the model of an expanding Universe?			
	5.5.3 i Can you explain Hubble constant H_0 in km s^{-1} Mpc^{-1} and s^{-1}?			
	5.5.3 j Can you explain the Big Bang theory?			
	5.5.3 k Can you describe the experimental evidence for the Big Bang theory from microwave background radiation?			
	5.5.3 l Can you explain the idea that the Big Bang gave rise to the expansion of space-time?			
	5.5.3 m Can you explain the estimation of the age of the Universe			
	5.5.3 m Can you demonstrate that $t \approx H_0^{-1}$?			
	5.5.3 n Can you describe the evolution of the Universe after the Big Bang to the present?			
	5.5.3 o Can you explain current ideas about the composition of the Universe in terms of dark energy, dark matter, and a small percentage of ordinary matter?			